THE EFFECT OF INDIVIDUAL DIFFERENCES ON EMOTION RECOGNITION FROM FACES AND VOICES

A Thesis Submitted for the Degree of Doctor of Philosophy

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Abstract

Childhood trauma is a serious public health issue with 1 in 5 adults experiencing childhood abuse and 1 in 10 adults experiencing neglect in the UK. Abuse and neglect in childhood can lead to various cognitive deficits which persist into adulthood, with emotion recognition abilities being a key one. This is an issue as emotion recognition deficits can lead to inappropriate behaviour and poor quality relationships, and as social beings we rely on our social networks for our health and well-being. Childhood trauma can also lead to the development of alexithymia (difficulties identifying own emotions) and psychopathy traits. These traits are also associated with emotion deficits which makes it difficult to pinpoint which individual difference the deficits originate from. Thus, it is unclear whether the relationship between childhood trauma and emotion recognition is influenced by these co-morbid traits. It is also unclear how universal this relationship is across various situations. Therefore, the thesis explores the relationship between childhood trauma and emotion recognition, whilst controlling for alexithymia and psychopathy traits, across various stimulus-based factors. The research methodology will contribute to and extend the current literature by employing more realistic (e.g., moving expressions) and comprehensive stimuli (e.g., across various modalities, intensities, and emotions expressed).

The thesis presents 4 experiments: Experiment 1 explores the relationship between childhood trauma and emotion recognition, intensity ratings, and sensitivity to intensity and how these were influenced by alexithymia and psychopathy traits and the stimulus-based factors of modality, emotion expressed, and intensity; Experiment 2 explores whether the relationship between childhood trauma, emotion recognition and eye movements was influenced by alexithymia and psychopathy traits and the stimulus-based factors of modality (stimulus presentation), emotion expressed, and intensity; Experiment 3 explores whether the relationship between childhood trauma and emotion recognition and intensity ratings, when integrating emotion cues, was influenced by alexithymia and psychopathy traits and the stimulus-based factors of modality focus, emotion expressed, and congruence; Experiment 4 explores whether (4a) the effect of childhood trauma, whilst controlling for alexithymia and psychopathy traits, or (4b) an ethnicity match/mismatch and attitudes towards masks influenced emotion recognition of masked and unmasked faces varying in emotion expressed.

The overall findings suggest that the significant relationship between childhood trauma and poorer emotion recognition was reduced or non-significant after controlling for

alexithymia and psychopathy traits. Also, the effect of childhood trauma on emotion recognition accuracy was relatively consistent across stimulus-based factors. The findings indicate that the effect of childhood trauma varies across different stages of the emotion recognition process. Specifically, it may impact later processes, involving higher-level perceptions, such as integrating emotion cues and labelling of expressions, but no significant impact on earlier lower-level processes, such as where we look within the face to recognise an expression. The findings have theoretical and practical implications of updating current models to include alexithymia as a key influence on the relationship between childhood trauma and emotion deficits, as well as informing interventions to focus on later stages/higher-level perceptions as this is where the difficulites lie. Future research should continue controlling for co-morbid traits as well as utilising more realistic stimuli of moving emotional expressions to enhance generalisability and ecological validity of emotion recognition findings.

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1. Introduction to individual differences and emotion recognition

Childhood trauma can be seen as a serious public health issue. The Crime Survey for England and Wales estimates that 1 in 5 adults have experienced at least one form of child abuse (either emotional abuse, physical abuse, sexual abuse, or witnessing domestic violence/abuse) before the age of 16 years old (Office for National Statistics, 2020). It is also estimated that around 1 in 10 children aged 11 to 17 years old have experienced neglect in the United Kingdom (UK) (NSPCC, 2021). Research exploring experience of childhood trauma have reported long-lasting effects into adulthood regarding social cognition (Pollak et al., 2000). An aspect of social cognition which can be affected is the ability to accurately recognise emotional expressions (Bérubé et al., 2023). Studies have linked emotion recognition to the development of social competence in children and adolescents (Wagner et al., 2015). As emotion recognition is crucial in our everyday interactions and relationship maintenance (Surcinelli et al., 2006) it is important to explore how those with experience of childhood trauma may be hindered.

The purpose of this chapter is to introduce the topic of this thesis, discuss previous methods and findings, and explain why the following research is an important addition to the literature. The review is divided into 4 sections: Emotion recognition overview, Childhood trauma and emotion recognition, Interrelated traits of alexithymia and psychopathy, and Thesis aims and studies.

1.1. Emotion recognition overview

The emotion literature concurs that emotions play an important role in our everyday lives and establishing and maintaining a range of relationships (peer, parent, romantic) (Pfaltz et al., 2022). However, there is no definitive answer of what an emotion is and how to empirically measure emotion recognition (Thanapattheerakul et al., 2018). One broad definition is that an emotion is a physiological response to either external or internal stimuli that lead us to adapt our behaviour (Krause et al., 2021). Emotion recognition represents the ability to encode a variety of sensory information to help identify and attribute an emotion to an expression (Ferretti & Papaleo, 2019). There are various modalities of emotion recognition: facial and vocal expressions, hand gestures, and body language (Haq & Jackson, 2011). Darwin and Prodger (1998) suggested that facial expressions of emotion are the product of evolutionary processes and play a fundamental role in our survival. Hampson et al. (2006) also suggested that our ability to identify emotions has evolved due to its importance for creating and maintaining social networks and preserving our safety. For example, threatening expressions of anger tell us to avoid an individual as they seem dangerous or confrontational.

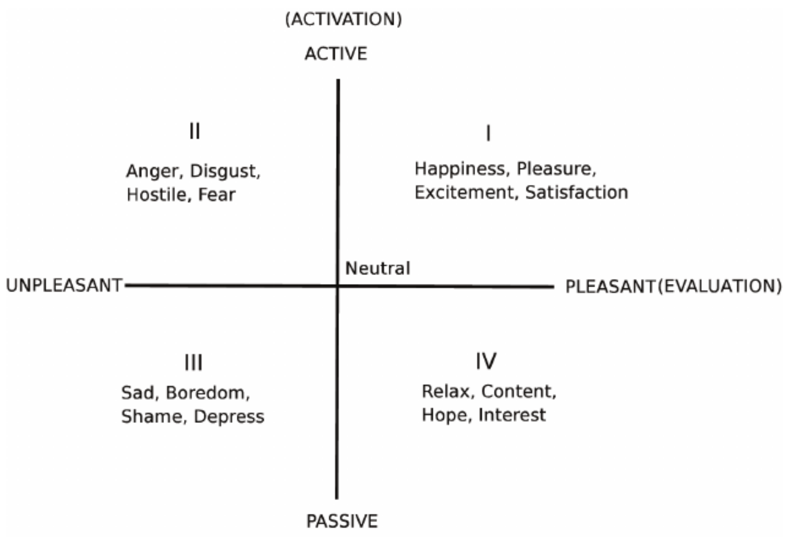
There are social advantages of more accurate emotion recognition, with individuals who are better at recognising expressions being rated as more likeable (Kavanagh et al., 2022). As social beings, our socialisation and relationships are fundamental to our health and well-being (Helliwell & Putnam, 2004). Facial expressions of emotion are a core function of social interactions and facilitate appropriate responding in social situations (Grundmann et al., 2021). Our perception and classification of facial expressions of emotion influence our behaviour (the emotions as social information model; Van Kleef, 2009) by providing cues about our social context. For example, recognising a negative expression (e.g., sadness or anger) potentially alerts us that we are behaving insensitively, leading us to modify our future behaviour. Hence, accurate emotion recognition is a useful ability, as misclassification may lead to an inappropriate response.

There are two main emotion recognition theories: discrete and dimensional theories. Discrete theories are based on the premise that the basic six emotions (happiness, sadness, anger, fear, disgust, and surprise) exist and are recognised similarly across different cultures (Ortony & Turner, 1990). This concept was supported by Ekman and Friesen (1971) who studied individuals from New Guinea, who had minimal to no experience of Western facial expressions. They found participants were able to recognise the basic six emotions even when displayed by a culture they had limited, or no, contact with. There is research exploring Western Caucasians and East Asians which opposes universality and the discrete theory as it was found that the recognition of emotions was culturally specific (Jack et al., 2012). Recent research using genetic algorithms to explore facial expressions of emotion found variability in how we categorise emotions (Binetti et al., 2022). Participants viewed 3D avatars expressing happiness, fear, anger, and sadness. There were 10 random expressions presented and participants selected which expression was the closest match to the target expression. On the final trial they selected one facial expression which was their preferred expression of that emotion. They found substantial variability in templates chosen for different facial expressions of emotion. This suggests that individuals vary in how they categorise, and therefore perceive, emotional expressions, differing from the discrete theory.

On the contrary, the dimensional theory describes emotions based on fundamental dimensions, such as evaluation and activation, rather than discrete categories (Russell et al., 1981; Scherer, 2005). The evaluation dimension measures human feeling, ranging from pleasant to unpleasant. The activation dimension measures how likely someone is to take action in that emotional state, ranging from active to passive. An example of the emotion distribution in these quadrants is presented in Figure 1 from Haq and Jackson's (2011) paper and is based on Russell et al. (1981) and Scherer's (2005) research. However, there are limitations regarding the dimensional emotion theory. Even though it makes it possible for individuals to label a range of emotions within the two-dimensional space, there can be a loss of information (Haq & Jackson, 2011). For example, it becomes difficult to differentiate between emotions (e.g., fear and anger) whilst other emotions are not included in the two-dimensional space altogether (e.g., surprise) (Douglas-Cowie et al., 2000; Haq & Jackson, 2011). Also, the individuals using this approach need training (Feeltrace system; Douglas-Cowie et al., 2000) to label the emotions as the representation is not very clear and there may be more inconsistent labelling compared to the discrete approach (Haq & Jackson, 2011).

Figure 1

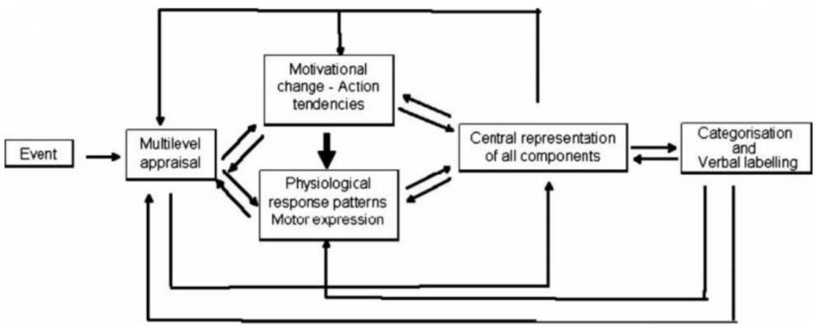
The distribution of emotions in each quadrant: evaluating human emotions from pleasant and unpleasant and how likely action will be taken. This figure is from Haq and Jackson (2011) and based on Russell et al. (1981) and Scherer's (2005) research.



A more dynamic approach to recognising emotions was presented by Scherer (2005) with the component process model (presented in Figure 2). This was developed as central features of emotions were under researched. In particular, the dynamic nature of emotion processing, the processing of antecedent events and response options, and the essential role of individual differences in emotion processing. The model suggests that the event and its consequences are appraised with a set of criteria on multiple levels of processing. The result of the appraisal will often modify the motivational state before the occurrence of the event. This leads to changes in the autonomic nervous system (e.g., heartrate or breathing) and somatic nervous system (e.g., motor expression in the face, voice, and body). These components are centrally represented and fused in a multimodal integration area (continuously updating as events and appraisals change). This central representation may then become conscious and assigned to an emotion category. Ultimately, the model suggests that different appraisal checks across various criteria occur sequentially and the emotion experience is altered every time a new appraisal modifies the overall evaluation (Gentsch et al., 2015). The main differences between this model and other appraisal theories is the importance on the focus on individual differences in emotional reactions. All appraisal models suggest they predict individual differences as appraisal are subjective and therefore differ per individual (Scherer, 2009). However, Scherer (2009) claims that only the component process model is able to account for individual differences in such detail, with predictions per individual across motor expressions, action tendencies, and physiological changes.

Figure 2

The dynamic architecture of the component process model by Scherer (2009).



1.1.1. Facial and vocal expressions of emotion

The opposing theories highlight the conflicting ideas on how emotions may be processed and recognised. Similarly, there are two conflicting explanations of emotion. The unimodal explanation of emotions (Allman & Meredith, 2007) states that there is a distinct brain area for each modality (how the emotion is expressed: facial or vocal expressions of emotion). For example, one area would respond to visual information only and a different area would respond to audio information only. This would suggest that performance for recognising facial and vocal expressions would differ. However, there is also the multimodal explanation of emotions (Allman & Meredith, 2007) which states that there is one brain area which is responsible for more than one modality. For example, this area would respond to both visual and audio information. This would predict similar performance for recognising facial and vocal expressions of emotion.

Previous literature has explored similarities between modalities through behavioural experiments, neurological disorders, and the development path of both. Kuhn and colleagues (2017) investigated whether there were similarities in facial and vocal emotion recognition by asking participants to rate the intensity of the six basic emotions. Confusion patterns were analysed to distinguish emotion representation in each modality. They suggested that the basic six emotions are similarly represented across faces and voices. There were also similar or shared coding mechanisms for emotions which may act independently of modality despite their distinct perceptual inputs. Ultimately, participants associated specific emotion-stimuli with specific emotion-labels, and this pattern was consistent across modalities, supporting the unimodal model. Further analyses explored the variance of low-level visual and/or acoustic properties of the stimuli and reported that these factors did not account for most of the shared variance between facial and vocal emotion recognition.

Supporting this, Keane and colleagues (2002) explored frontal variant frontotemporal dementia (fvFTD). They explored whether deficits associated with fvFTD affected face processing generally, emotion processing generally, or facial expressions of emotion only. A sample of six males at different stages of fvFTD completed facial and vocal emotion recognition tasks. The vocal expressions of emotion stimuli included non-verbal sounds: laughter (happy), crying (sad), growling (anger), screaming (fear), gasps (surprise), and retching (disgust). They reported deficits for both facial and vocal expressions of emotion. This suggests fvFTD affects emotion recognition generally, regardless of the modality the emotion is expressed in, further supporting the unimodal model.

Support for the unimodal model from neuroimaging studies report an overlap between brain areas for facial and vocal expressions of emotion. Morningstar and colleagues (2020) asked participants aged from 8 to 19 years old to complete facial and vocal emotion recognition tasks during a magnetic resonance imaging (MRI) experiment. The stimuli displayed either anger, fear, happiness, sadness, or neutral expressions. They found that both facial and vocal expressions of emotion increased activation in a network of subcortical regions (insula, thalamus, and dorsal striatum), prefrontal regions (inferior frontal cortex and dorsomedial prefrontal cortex), visual-motor areas, and the right superior temporal gyrus. The activation of similar regions suggests a shared area for both modalities. However, it was found that an increase in age was associated with greater frontal activation to vocal, but not facial, expressions of emotion. This suggests there are changes in activation dependent on the modality. As age has been associated with differing emotion processing and recognition abilities, caution is required when generalising this result to an older sample (Rodger et al., 2015). This suggests that even though there has been exploration into facial and vocal expressions, and shared/separate areas, a definitive conclusion is yet to be drawn.

On the contrary, there is also support for the multimodal model with studies indicating distinct differences between performance for facial and vocal expressions of emotion. Chronaki and colleagues (2015) explored the development of modalities by comparing emotion recognition performance and processing biases. A child (4 to 11 years old) and adult sample viewed/listened to vocal expressions (interjection ‘ah’) and facial expressions of emotion displaying angry, happy, or sad expressions at three varying intensities of 50%, 75%, and 100%. For facial expressions of emotion, adult-level performance was reached by 11 years old. Differing from this, vocal emotion performance continued its development into later ages and showed a more prolonged developmental trajectory compared to facial emotion processing. However, it is unclear whether surprise, fear, or disgust follow this pattern as these emotions were omitted.

Further support of the multimodal model is by Nelson and Russell (2011). They asked 144 pre-schoolers (aged 3 to 5 years old) to complete an emotion recognition task including the expressions of happiness, sadness, anger, and fear across four conditions: face, voice, body posture, and multi-cue (all three combined). They reported that expressions in the face, body posture, and multi-cue conditions were recognised with a higher accuracy than the voice condition. This was seen for all emotions, except for sadness which showed high accuracy for vocal expressions. The difference in performance between facial and vocal expressions of emotion may suggest two distinct areas for processing faces and voices. Regarding the development of emotion recognition performance, Nelson and Russell (2011) also reported that pre-schoolers could accurately recognise facial expressions of emotion earlier than vocal expressions of emotion. This is in line with Chronaki et al.’s (2015) findings which also found a delayed trajectory of vocal expressions. A strength of the Nelson and Russell's (2011) methodology is the inclusion of free labelling emotions. Previous research has suggested that emotion recognition performance can be inflated or exaggerated by using fixed choice format (e.g., the only response options are the emotions included in the study) due to the limited options (Russell, 1995; Nelson & Russell, 2011).

Lastly, in favour of the multimodal model, performance does seem to differ, with an average accuracy of 75% for facial expressions of emotion and an average accuracy between 55% and 65% for vocal expressions of emotion (Scherer, 2003). If there was a shared area responsible for the processing of facial and vocal expressions of emotion then we would assume that performance for both would be similar. As it is not, it suggests two distinct areas as described by the multimodal model. Scherer (2003) did suggest that the difference could be due to the majority of emotion research using static photographs of emotional expressions, whereas vocal expressions of emotion are dynamic and therefore less likely to generate stable patterns. This may suggest that we are unable to generalise facial expressions of emotion to vocal expressions of emotion as they seem to differ in performance as well as how they are presented (e.g., static versus dynamic). This may pose a potential issue as the majority of research exploring emotion recognition has focused on facial expressions of emotion. This leaves unanswered questions regarding the processing and recognition patterns of vocal expressions of emotion: are vocal expressions processed or recognised similar to facial expressions?

Also, the limited research which does explore vocal expressions of emotion typically used non-verbal utterances (such as crying, laughing, gasping, etc). To increase the ecological validity, and enhance the generalisability of findings to real-life interactions, sentences should be used for vocal expressions and dynamic expressions should be used for facial expressions. It also appears that the majority of studies in this area have recruited younger samples which makes generalising to adult samples difficult. The studies discussed show that, even though the area may seem well researched, there are no concrete or consistent conclusions that can yet be drawn to either support or oppose the unimodal or multimodal model.

1.1.2. Static and dynamic facial expressions

As discussed above, the two stimulus types used to explore emotion recognition have been static and dynamic facial expressions. The majority of previous research tends to use static facial expressions. Typical methods to explore static stimuli include eye tracking and the tile method (sequentially uncovering tiles until recognition of emotion; Wegrzyn et al., 2017). Eisenbarth and Alpers (2011) explored which specific regions of the face were relevant/useful for processing emotional expressions. They recorded eye movements for where (fixations) and how long (duration) participants looked on the face to recognise an expression. Black and white static faces displaying afraid, angry, happy, sad, and neutral expressions were included. Participants rated how positive or negative the picture was, as well as how emotionally arousing it was. Across all emotions, the initial fixations were mostly directed to either the eyes or the mouth. For sad and angry facial expressions, participants focused more on the eye region than the mouth region. For happy facial expressions, participants fixated on the mouth region the longest. For fear and neutral expressions, both the eyes and mouth were equally important for recognition. This suggests different processing patterns depending on which emotion is expressed.

For the tile method, Wegrzyn et al. (2017) showed participants 48 tiles which were sequentially uncovered until participants could recognise and label the facial expression as one of the basic six emotions or neutral. Overall, participants relied on the eye and mouth regions for accurate emotion recognition. Specifically, sad, fear, and anger expressions relied on the eyes and disgust and happiness relied on the mouth. This follows Eisenbarth and Alpers' (2011) findings and suggests agreement across various methods for sadness and anger relying on the eyes and happiness relying on the mouth. However, whether the findings would stay consistent if the expressions were dynamic is unclear. Previous research has suggested a potential advantage of dynamic stimuli compared to static expressions due to greater ecological validity (Alves, 2013; Johnston et al., 2013). It has been suggested that still photographs may not engage 'authentic' mechanisms used to recognise facial expressions in everyday life and interactions (Alves, 2013; Johnston et al., 2013). Therefore, this may suggest potential difficulties for generalising findings from research using static images to dynamic stimuli, which closer resemble our experience with everyday emotion recognition. However, even with the noted disadvantages, previous research employing static stimuli have proved useful in advancing our understanding of how we process and recognise static emotional expressions.

There has been research directly comparing performance for static and dynamic facial expressions of emotion. If research reports performance is similar across static and dynamic stimuli then it would be more likely that we can generalise static findings to more realistic methods of emotion recognition. Blais et al. (2017) employed eye tracking and the Bubble task to explore performance for static and dynamic expressions of the basic six emotions, pain, and neutral. The Bubble task (Gosselin & Schyns, 2001) is a method typically used to explore static stimuli and is a way to isolate certain visual information. The expressions were either unobscured or had isolated information depending on the Bubbles (e.g., a facial expression with just the mouth region unobscured). The eye tracking results reported differing gaze patterns for static compared to dynamic facial expressions. For static expressions, the left eye and mouth were fixated on more. Whereas, for the dynamic expressions, the middle of the face was fixated on more. This suggests different processing patterns depending on how the expressions were presented (e.g., static or dynamic). The Bubble method findings reported that the mouth area was more useful for surprise expressions for static stimuli compared to dynamic stimuli. For dynamic stimuli the eye area was more useful for anger and surprise expressions, and the mouth area was more useful for anger and sad expressions, compared to static stimuli. The overall findings from Blais et al. (2017), across the eye tracking and Bubble techniques, suggest that participants spent more time fixating in the centre of the face for dynamic faces and more time fixating on the eyes and mouth for static faces. The findings suggest that the processing of static and dynamic stimuli differ due to where we fixate on the face, and for how long. This may suggest a difficulty of generalising static findings to dynamic expressions, including real-world interactions (Johnston et al., 2013; Richoz et al. 2018).

There are also neurobiological studies comparing static and dynamic stimuli performance. When comparing static versus dynamic stimuli in general, Pitcher et al. (2011) suggested they are processed differently. Participants were presented dynamic movie clips (either faces, bodies, scenes, objects, or scrambled objects) or static images from these clips whilst in a functional magnetic resonance imaging (fMRI) scanner. They found that the face-selective (preference for faces over objects) region in the right posterior superior temporal sulcus (STS) responded nearly three times as strong to dynamic faces compared to static faces. Also, the face-selective region in the right anterior STS responded only to dynamic faces. This suggests that static and dynamic stimuli are processed in different areas. Thus, it is unlikely to be able to generalise from static to dynamic stimuli.

Kessler et al. (2011) explored the brain areas involved in the perception of static and dynamic facial expressions of emotion. Whilst undergoing fMRI, 30 participants viewed 48 static faces and 48 dynamic faces displaying either fear, happiness, sadness, or disgust. The dynamic stimuli (neutral expressions morphing into one of the emotions) lasted 1000 milliseconds, the same presentation time as the static pictures. Participants rated how positive or negative the expression was, as well as how intense the expression was. Regardless of specific emotion expressed, dynamic expressions activated bilateral STS, visual area V5, fusiform gyrus, thalamus, and other frontal and parietal areas. For static happy expressions there was greater activity in the medial prefrontal cortex. However, as anger and surprise expressions were not included, it is uncertain where they would be processed. These findings are somewhat in line with Pitcher et al.'s (2011) as the STS was activated for dynamic expressions as well.

However, Johnston and colleagues (2013) reported similar activation for static and dynamic emotional expressions. Participants discriminated static and moving expressions whilst undergoing fMRI. The static stimuli included faces displaying fear and surprise expressions and the dynamic stimuli included morphed pictures from neutral to either fear or surprise lasting 1 second. Emotion discrimination was associated with widespread activation in the regions of occipito-temporal, parietal and frontal cortex. These regions were activated by both static and dynamic emotional expressions, indicating a general role in emotion recognition. The findings suggest that static and dynamic expressions are processed in similar areas.

A reason for why Johnston et al.'s (2013) findings differ from Kessler et al. (2011) could be the different emotional expressions explored. Johnston et al. (2013) explored fear and surprise and Kessler et al. (2011) explored fear, happiness, sadness, and disgust. The differences in emotions included makes any direct comparisons for findings difficult, further leaving gaps in our knowledge regarding how the omitted emotions are processed. This is a common limitation in the emotion recognition literature, and in particular the studies described here (Rodger et al., 2015). Future research should include the basic six emotions and neutral to ensure an appropriate range of emotions. Ultimately, the neuroimaging data is similar to the behavioural data when comparing static to dynamic stimuli as it is also inconsistent and hard to draw definitive conclusions from.

1.1.3. Perceived intensity of emotional expressions

Beyond the typically explored accuracy measures, research has explored alternative methods of emotion recognition, such as intensity ratings. Matsumoto and Ekman (1989) asked American and Japanese students to view Caucasian and Japanese facial expressions, depicting the basic six emotions, and rate how intense the expressions are. They reported that Japanese participants rated stimuli as less intense compared to American participants. They also found the ordering of highest to lowest intensity ratings differed. For American participants, intensity ratings were highest for happy expressions, then anger, disgust, surprise, and sadness had the lowest. For Japanese participants, the highest rating was for disgust expressions, then happy, anger, surprise, and sadness had the lowest rating still. Even though the order of the intensity ratings for specific emotional expressions differed, there seems to be agreement that surprise and sadness are rated as low intensity most frequently.

During the COVID-19 pandemic, masks were made mandatory (indoors) in the UK. Previous research reported that face masks impaired emotion recognition accuracy (Carbon, 2020; Cooper et al., 2022; Noyes et al., 2022), but there was little known about how masks affected intensity ratings. Tsantani et al. (2022) used an emotion intensity rating task, including the basic six emotions, and explored perceived intensity of expressions and whether surgical face masks influenced this. There were lower intensity ratings for masked faces compared to unmasked faces for all expressions except for anger. For unmasked faces the highest intensity ratings were for happy expressions, followed by surprise, disgust, sad, anger, and fear. For masked faces this differed, the highest rating was for happy expressions, followed by surprise, anger, sad, fear, and disgust. They also found that face masks increased the confusion of certain expressions, in line with previous research (Carbon, 2020; Cooper et al., 2022). The findings suggest that intensity ratings do differ depending on the emotion expressed and can be influenced by perceptual factors.

There is also evidence of intensity ratings being influenced by how stimuli are presented. Biele and Grabowska (2006) explored static and dynamic emotional expressions and intensity ratings. The expressions of happiness and anger were presented as static facial expressions or dynamic facial expressions (morphed expressions from neutral expressions to 100% of the expression, going up in 20% increments). Participants rated the expressions from low intensity (1) to high intensity (4). The findings report a significant effect of stimulus presentation and emotion type on intensity ratings: angry expressions were perceived and rated as more intense than happy expressions, and dynamic expressions were rated as more intense than static expressions. The authors suggested that dynamic characteristics of emotional expressions play an important role in how we perceive the intensity of expressions. This suggests that dynamic stimuli can influence not only emotion recognition accuracy but also alternative measures such as intensity ratings.

1.1.4. Variation in emotion performance

As well as the discussed factors of modality (e.g., facial and vocal expressions) and stimulus-presentation (e.g., static and dynamic), there is also a plethora of research suggesting various individual differences also impact emotion recognition (Bowen et al., 2014; Jongen et al., 2014; Bérubé et al., 2023). Individual differences in this context means internal or external factors (e.g., characteristics, traits, or experiences) associated with an individual which influences their behaviour or performance to differ from others. In the context of emotion recognition specifically, it means an individual will be better or poorer at recognising emotional expressions as a result of what makes them different to others (e.g., exhibiting different traits or having a different upbringing). The previously discussed Binetti et al. (2022) research concluded that individuals varied substantially in how they categorise and perceive different emotional expressions. Supporting this, Palermo et al. (2013) developed two new tests to account for individual differences: one for expression perception (matching task: select one of three faces which displays a different expression) and one for expression identification (labelling a facial or vocal expression). The findings reported substantial variation in performance for these tasks and suggest that individuals have varying abilities when it comes to recognising and labelling emotions.

In support of this, Green and Guo (2018) asked 104 healthy adults to complete a facial expression categorisation task whilst tracking eye movements. Participants viewed black and white static facial expressions (the basic six emotions) at three intensity levels (low: 20%, medium: 40%, and high: 100%). They reported variation in emotion recognition accuracy across emotion expressed: happy performance ranged from 43% to 100% accuracy, sadness ranged from 55% to 100%, anger ranged from 30% to 93%, fear ranged from 7% to 67%, disgust ranged from 37% to 83%, and surprise ranged from 27% to 77%. For the eye movements, proportion of fixation at the eyes, nose and mouth were recorded. Across all expressions, the proportion of fixation differed from 2% to 87% for the eye region, 4% to 95% for the nose, and 0% to 64% for the mouth. This suggests there is variation in individuals' performance for emotion abilities, from recognising and labelling expressions to where we look on the face to process these emotions. However, it is difficult to explore why this variation occurs (e.g., which traits or experiences are causing this variation). The main challenge with individual differences is that the majority of them co-occur (Rosen et al., 2018). Although surprisingly, the majority of previous research has not included various individual differences in one homogenous sample. By exploring various individual differences together, we may include and control for co-occurring factors to ensure the isolated measuring of the main individual difference. For example, in this case, the ability to explore childhood trauma's unique effect by controlling for the co-occurring traits of alexithymia and psychopathy.

Regarding all the research discussed so far, there are key methodological changes which would greatly improve the emotion recognition literature: (1) exploring various modalities (as there is little research regarding vocal expressions of emotion) to get a broader understanding of emotion recognition, (2) as the majority of research uses static images, it would be beneficial to include dynamic expressions, (3) including all the basic six emotions and neutral so no gaps in knowledge remain for how certain emotions are processed or recognised, (4) adding additional response options of "I don't know" and the option to free label, so genuine recognition is measured and avoiding exaggerated or inflated performance scores, and (5) including and accounting for various interrelated individual differences in one study.

1.2. Childhood trauma and emotion recognition

Childhood trauma is a prevalent issue (Office for National Statistics, 2020; NSPCC, 2021) and has been associated with poorer social abilities, especially emotion recognition (McLaughlin et al., 2020), persisting into adulthood. This may suggest that for social interactions, where emotion recognition is key, those with experience of childhood trauma are more likely to be hindered compared to those without experience of childhood trauma. However, to what extent emotion recognition is influenced by childhood trauma is yet to be elucidated. The existing literature includes a great variation of emotion recognition tasks (detailed in Table 1) which are fairly inconsistent, often not standardised, and have limitations which could be easily addressed. Another inconsistency is that a great deal of research has reported childhood trauma as 'early adversity' but these are two different constructs. Childhood trauma strictly encompasses abuse and neglect whereas early adversity is broader and incorporates family or environmental hardship. Also, the differences concerning the use of a total score of childhood trauma, or splitting its dimensions into the facets (emotional, sexual, and physical abuse, and emotional and physical neglect), needs to be addressed.

As a result of the varying methods, the conclusions are inconsistent (Table 1). The overall pattern expected to see with childhood trauma and emotion recognition is better emotion recognition accuracy for negative expressions and poorer emotion recognition accuracy for positive or neutral expressions (Dodge et al., 1995). Individuals with childhood trauma experience supposedly develop a heightened sensitivity to angry expressions as a form of adapting to an adverse environment where threat signals predict the occurrence of abuse (Shackman et al., 2007). However, the actual research tends to find either no association or similar recognition for other expressions, which does not fit this expected pattern (e.g., across all expressions, not just negative) (detailed in Table 1).

1.2.1. Childhood trauma and facial expressions of emotion

The association between childhood trauma experience and recognition of facial expressions of emotion have been explored in both child and adult samples (various studies described in Table 1). Pollak et al. (2000) conducted two experiments: (1) matching a facial expression to an emotional situation and (2) rating the similarity of emotion pairs (e.g., angry-happy, sad-fearful, happy-disgust, etc.). For experiment 1, a child sample (categorised as physically neglected, physically abused, or non-maltreated) was presented five stories where the protagonist experienced either happiness, sadness, disgust, fear, or anger. They had to match the facial expression to the story. They found that physically neglected children had more difficulty discriminating between emotional expressions than control or physically abused children. Also, physically neglected children showed a lower standard for selecting sad facial expressions and physically abused children had a lower standard for selecting angry faces (e.g., expressions were more readily labelled as sad or angry).

For experiment 2 (Pollak et al., 2000), a child sample (categorised as physically neglected, physically abused, or non-maltreated) were shown two photographs of different emotional expressions (either anger, happiness, sadness, fear, disgust, or neutral expressions) and asked whether they were expressing the same or different feeling. They found that physically neglected children perceived fewer differences in angry, sad, and fearful expressions than physically abused and non-maltreated children. Also, physically abused and physically neglected children rated the emotional expressions of anger and sadness similar to a neutral expression. The authors suggested this could be due to those with experience of childhood trauma attributing negative expressions to happy or neutral faces as they are misinterpreted as more malevolent (e.g., a smile would be interpreted as mocking rather than happy).

Looking to the long-term effects, Young and Widom (2014) explored the effects of child abuse and neglect on emotion processing in adulthood. Children with documented abuse and neglect during 1967-1971 were matched with non-maltreated children and followed up into adulthood. Participants completed interviews and took part in a study using the international affective picture system which measured emotion processing. This included a set of photographs depicting positive, negative, or neutral content. They found that those who experienced childhood trauma had worse recognition for positive and neutral pictures, and overall. Physical abuse predicted poorer accuracy for neutral pictures. Sexual abuse and neglect predicted poorer accuracy for positive pictures. In summary, childhood abuse, specifically neglect and sexual abuse, predicted deficits in positive, but not negative, picture recognition. The authors suggested a possible explanation may be that previously abused and neglected individuals have developed negative world views. They may have received and perceived fewer positive emotions during their lives which has made it difficult to recognise positive expressions. The findings suggest that childhood abuse and neglect cause emotion deficits which continue into adulthood.

Further evidence for the association between childhood trauma and processing biases for certain emotions is from Gibb et al. (2009). Participants completed a modified dot-probe task to explore attentional biases. The static facial expressions included anger, happy, or sad and were paired with a neutral expression from the same actor. Participants were asked what emotion was being expressed. The findings reported an association between childhood trauma experience and attention and interpretation biases for angry faces. Participants categorised as moderate to severe experience of childhood trauma preferentially allocated their attention to angry faces, but not happy or sad faces. There was also an increased sensitivity in the detection of angry expressions at lower levels of emotional intensities. However, there may have been other negative expressions which showed similar biases, such as fear, but this is unknown as not all the basic six emotions were studied.

In support of this, Pollak and Tolley-Schell (2003) explored selective attention to facial expressions of emotion in physically abused children (8 to 11 years old) through behavioural and psychophysiological measures. Children (14 physically abused and 14 non-maltreated) viewed static facial expressions conveying either happy, angry, or neutral expressions. Participants saw a fixation in the centre of the screen, then one of the facial expressions was presented, then the target (a star). A visual cue indicated the correct (valid trials) or incorrect target location (invalid trials). The findings reported that physically abused children showed increased attention to valid angry trials and slower disengagement from angry faces on invalid trials. Also, the event-related potential (ERP) data showed an increase in P3b (an ERP component reflecting the central nervous system activity involved in allocating attention) on invalid angry trials. This suggests that physically abused children struggled to disengage from angry faces.

Further support for increased attention to threatening social cues is by Lakshman et al. (2020). A sample of 31 African American children (8 to 14 years old), who had childhood trauma experience, completed a dot-probe task. They also found that childhood trauma was associated with greater attention bias towards angry faces compared to happy faces. The findings discussed (Pollak & Tolley-Schell, 2003; Gibb et al., 2009; Lakshman et al., 2020) suggest that childhood trauma may lead to processing biases, and selective attention, for threat-related social cues, such as angry faces. This is likely to affect accurate emotion processing and recognition of emotions outside of this preference (e.g., positive or neutral expressions).

On the contrary, there is also evidence of childhood trauma experience leading to the avoidance of negative expressions. Bodenschatz and colleagues (2019) explored attentional biases and childhood trauma in individuals with major depressive disorder using an eye tracker. Participants (n=31 with major depressive disorder and n=31 controls) viewed static facial expressions expressing either happiness, sadness, anger, or neutral expressions. Dwell time was used as a measure of attention allocation. They reported that childhood trauma was associated with reduced attention for angry and sad facial expressions in the depressed sample. It seems that individuals with major depressive disorder, as well as a history of childhood trauma, tend to avoid the processing of negative emotions. However, only a small sample of individuals with moderate experience of childhood trauma were studied. Other effects may have emerged if the sample was larger and showed a greater severity of trauma.

In support of the avoidance of threatening social cues, Hoepfel and colleagues (2022) explored the relationship between childhood trauma and attention to facial expressions of emotion. A female sample completed a dot-probe task where facial expressions depicting either happiness, sadness, or disgust were paired with neutral faces. The level of alexithymia (difficulty identifying own emotions) in individuals was controlled for. They used initial gaze and dwell time on expressions as a measure of attention allocation. They found an association between childhood trauma and shorter initial gaze to emotional expressions compared to neutral expressions and shorter dwell time on disgust expressions. The findings suggest that childhood trauma is associated with heightened early vigilance to emotional social signals overall (positive and negative) compared to neutral expressions. Childhood trauma was also associated with attention avoidance of hostile expressions at later stages of attention allocation. This may further suggest an initial vigilance to threat cues are to assess the dangers of the situation and then an avoidance of threat cues later on to avoid possible conflicts. Similar to the conclusions from Pollak et al. (2000), attention to all faces, positive and negative, could be due to positive emotions being perceived as more malicious (e.g., happy being interpreted as being mocked or laughed at).

Mohr (2016) explored childhood trauma's association with eye gaze to specific facial features, rather than emotional versus neutral expressions. Participants were categorised in either the general abuse group (emotional, physical, sexual abuse, and emotional neglect), the physical neglect group, or the comparison group. Static facial expressions displaying happy, angry, sad, or neutral were presented. The specific facial regions focused on for eye gaze (areas of interest) were the eyes, mouth, face overall, and brow region. The findings reported that participants initially gazed to the eye region more often than the other regions for all emotions, except happiness. For happiness, participants gazed towards the eyes and mouth the same amount. However, the different types of childhood trauma (emotional abuse, physical abuse, sexual abuse, emotional neglect, and physical neglect) did not affect where individuals looked on the face when trying to recognise the expression or the ability to identify emotional expressions correctly.

In a recent review, Bérubé et al. (2023) explored childhood trauma and facial emotion recognition across 24 studies, using an adult sample. They reported that childhood trauma was associated with varying performance for the emotions of happiness, anger, and fear. Specifically, happy expressions were less accurately recognised, but anger and fear were recognised faster and at a lower intensity for adults with experience of childhood trauma compared to adults with no experience of childhood trauma. However, Saarinen et al. (2021) explored early adversity (indexed by various assessment methods) and emotion processing of facial expressions and reported different findings. Children's and adults' neurophysiological and behavioural responses (including accuracy and reaction time) were explored. They included 29 behavioural studies and found that early adversity was associated with faster reaction times, but comparable accuracy, to controls for sad and angry facial expressions. Early adversity was also associated with poorer accuracy for fearful and happy facial expressions, but only if individuals had recent (within the last 2 years) experience of early adversity. Therefore, the findings suggest that only the child samples included in the analysis showed variation in accuracy across emotion portrayed.

Even though the literature surrounding childhood trauma and facial expressions of emotion seems well-researched, there are still salient inconsistencies and answered questions which need further investigation. This makes it difficult to draw definitive conclusions regarding whether there is an association between childhood trauma and emotion recognition, and if these effects persist into adulthood. For example, Saarinen et al. (2021) explored early adversity in general (including topics such as homelessness and parental conflict) rather than just exploring childhood trauma using the Childhood Trauma Questionnaire as previous research discussed did. Also, the different studies exploring various early adversities used different methods (self-report questionnaires, interviews, records, etc.) as well as exploring either only one emotion (typically fear) or up to seven emotions.

A key explanation for why research has reported a varying effect of childhood trauma across specific emotions expressed (Pollak et al., 2000; Pollak & Tolley-Schell, 2003; Gibb et al., 2009; Bérubé et al., 2023) is explained by the social information processing mechanism (Dodge et al., 1995). This states that children who experienced trauma display social information biases that prioritise identifying potentially threatening social cues. Therefore, they are more likely to perceive or classify cues as threatening, even if they are not. These children would recognise anger and fear with less perceptual information than those who have not experienced trauma. Research has reported that when children are learning to predict potential threats they over generalise fear responses (McLaughlin et al., 2020). Thus, they are more likely to misclassify and mislabel positive or neutral expressions as negative expressions (Dodge et al., 1995; Pollak & Kistler, 2002).

Childhood trauma is also linked to emotion processing abnormalities. The emotional processing mechanism (McLaughlin et al., 2020) states that trauma is linked to heightened emotional reactivity, low emotional awareness, and difficulties in regulating emotions. As the severity of trauma increases, as does the heightened emotional reactivity to threatening social cues (McLaughlin et al., 2020). This means that those with experience of childhood trauma will have greater emotional responses to negative cues (e.g., anger or fear expressions) in the environment compared to those without childhood trauma experience. Glaser et al. (2006) explored this by asking participants with childhood trauma to keep a structured diary assessing subjective stress to daily life and emotional reactivity conceptualised as changes in negative affect (average scores of how irritated, lonely, anxious, or down you feel). They reported that childhood trauma significantly increased emotional reactivity to daily life stress as reflected in an increase in negative affect. The associated low emotional awareness means that those with experience of childhood trauma have more difficulties identifying and differentiating their own emotions (McLaughlin et al., 2020).

Neurobiological research supports these explanations. Fang et al. (2019) explored whether childhood trauma was associated with emotion processing of facial expressions of emotion. Participants included 17 young adults with childhood trauma experience and 17 matched non-maltreated participants. They used electroencephalogram (EEG) to measure ERPs P100 and N170 (electrical activity in the brain) when viewing static facial expressions displaying happy or negative (anger, fear, disgust) expressions paired with a neutral expression. The findings reported that individuals with childhood trauma had larger N170 amplitudes than the non-maltreated group when processing angry, fearful, and happy faces. This suggests that experience of childhood trauma can alter the neural processing of facial expressions of emotion. In line with the social information processing mechanism (Dodge et al., 1995), there was altered processing for threatening emotions of anger and fear as a result of being "hypervigilant" to threat cues (McCrory et al., 2013). However, differing from the model's suggestions, processing was also altered for happy expressions. A possible explanation could be the uneven number of stimuli per emotion: 54 neutral and happy expressions, and 54 negative expressions split into 18 anger, fear, and disgust expressions. So, there were three times more happy expressions compared to anger, fear, or disgust. Other research exploring the association between childhood trauma and overall emotion recognition reported increased activation in the prefrontal cortex and hippocampus (Jedd et al., 2015; Demers et al., 2018) and the amygdala (van Harmelen et al., 2013; Jedd et al., 2015). The increased activation of these brain areas compared to non-maltreated participants suggests that childhood trauma is associated with long-lasting alterations to certain areas of the brain, which in turn affect the processing and recognition of emotional expressions (Jedd et al., 2015).

Childhood trauma has been associated with heightened sensitivities, which may suggest an association with alternative measures of emotion recognition, such as intensity ratings. A heightened sensitivity, so less perceptual information needed to identify a negative expression, may result in majority of expressions being perceived as more intense even if it is an average intensity expression. This would be theorised in line with the social information processing mechanism (Dodge et al., 1995). There is very limited research exploring this. In fact, the closest research exploring childhood trauma and intensity ratings was focused on the trustworthiness of faces. Neil et al. (2022) explored whether childhood trauma influenced trust judgements, but also explored emotion recognition accuracy and intensity ratings of fearful or joyful facial expressions across three intensities (low, medium, high). The community based sample was comprised of 75 children with documented trauma and 70 non-maltreated children. There was no significant association between childhood trauma and intensity ratings. They found that intensity ratings of the facial expressions were similar regardless of childhood trauma experience. However, the only emotions being explored were joy and fear, so there may have been associations across other emotions (e.g., the typically explored threatening expression of anger). This seems to be the only study so far to explore childhood trauma and intensity ratings so more is needed, and with a wider range of emotions, to see whether childhood trauma is associated with perceived intensity of stimuli.

1.2.2. Childhood trauma and vocal expressions of emotion

There seems to be limited research exploring childhood trauma and vocal expressions of emotion (as discussed in Table 1). Although, Nazarov et al. (2015) reported a significant link between childhood trauma and vocal expressions. A female sample (n=29 with post-traumatic stress disorder (PTSD) related to childhood abuse and n=21 health controls) completed two computer-based discrimination tasks assessing affective prosody (patterns in voices). There were sixteen vocal clips (four semantically neutral sentences expressed in four different ways: happiness, sadness, fear, or anger). Those with PTSD as a result of childhood abuse were slower than controls at identifying happiness, sadness, and fear, but not anger. The social information processing mechanism (Dodge et al., 1995) may explain this as it states a processing bias for threatening cues (e.g., angry expressions). However, the severity of childhood trauma was associated with reduced accuracy on the discrimination task and slower reaction times across all emotions. The results show that exposure to childhood trauma has long-term atypical effects on recognising emotions from voices. These findings are similar to the facial emotion recognition results as they found an emotion deficit as a result of childhood trauma too (Young & Widom 2014). Although, the sample was solely females, and due to sex differences in emotion recognition performance, these findings may not generalise well to men (Lambrecht et al., 2014).

The lack of exploration across modality, especially vocal expressions, makes it difficult to explore whether the effect of childhood trauma on emotion recognition accuracy varies depending on whether the emotion is expressed facially or vocally (studies in Table 1). However, childhood trauma affects neurobiological responses when viewing negative stimuli, with greater activation in the amygdala and anterior insula (McLaughlin, 2019). Thus, negative expressions may show a similar processing and recognition advantage across modalities (e.g., childhood trauma's effect on emotion recognition accuracy will stay consistent regardless of whether the emotion is expressed facially or vocally). We are also unsure how differing intensities (e.g., normal vs strong intensity expressions) will affect the heightened sensitivities associated with childhood trauma. This could affect accuracy as well as subjective intensity ratings.

Childhood trauma research tends to focus on psychopathology (e.g., PTSD, depression, anxiety) rather than other interrelated individual differences, even though childhood trauma co-occurs with many other variables (Zlotnick et al., 2001; Craparo et al., 2013). However, few studies have explicitly taken these into account when assessing the effect of childhood trauma on emotion recognition accuracy. Therefore, childhood trauma's unique contribution to emotion recognition performance becomes difficult to distinguish if not including and controlling for these co-occurring individual differences. A table with further childhood trauma research is presented in Table 1 which details the samples, the measure used, the modality and emotional expressions explored, the task employed, and a summary of the research findings. The overall interpretation of the research in Table 1 is that the findings are inconsistent regarding whether there is a significant effect of childhood trauma on emotion recognition performance as well as which specific emotional expressions are impacted.

Table 1

A table including research exploring childhood trauma across facial and vocal expressions of emotion.

Authors	Sample	Childhood trauma measure	Modality	Emotions expressed	Task	Conclusions
Bérubé et al., 2023 (review)	24 studies	Varied per study. 16 / 24 used Childhood Trauma Questionnaire	Static faces	Varied per study	Varied per study - examples are dot-probe task, matching task (faces and shapes),	Association between childhood trauma and poorer overall accuracy. Anger and fear recognised quicker and at lower intensity but happy is less well recognised.

					and emotion discrimination.	
Dunn et al., 2018	6,506 (parents and children)	Avon Longitudinal Study of Parents and Children	Static faces	Happy, sad, anger, fear	Diagnostic Assessment of Non-Verbal Accuracy (DANVA); child facial expressions shown and asked what emotion is depicted.	No association found between childhood trauma experience and emotion recognition accuracy.
Mirman et al., 2021	36 (17 low and 19 high childhood trauma scores)	Childhood Trauma Questionnaire	Static faces	Anger, fear	Negative emotional face-matching task; match the facial expression at the top with one of the two expressions presented at the bottom.	Association between childhood trauma and slower response times. No differences in low and high scores for accuracy.
Pollak & Kistler, 2002	40 children (17 non-abused; 23 physically abused)	Review of clinical and legal records	Static faces (morphed to create a continuum of images)	Happy, fear, angry, sad	Discrimination task (selected the expression	Accuracy and discrimination was similar for abused and control children, except anger.

					which matched the target expression) and identification task (select which emotion is depicted).	
Pollak et al., 2000 (experiment 1)	48 children (16 physically neglected; 17 physically abused; 15 non-maltreated)	Child protective service, clinical, and medical records	Static faces	Happy, sad, disgust, fear, anger	Listened to a story and selected the appropriate picture of the facial expression described.	Neglected children had poorest accuracy and a response bias for sad expressions. Physically abused children had a response bias for angry expressions.
Saarinen et al., 2021 (review)	29 behavioural studies (8555 participants)	Varied per study (questionnaires, records, interviews)	Static faces	Varied per study	Included behavioural, fMRI, and EEG studies.	Associations between childhood trauma and faster reaction times for angry and sad faces (but normal accuracy), poorer accuracy for fearful and happy faces for recent trauma (< 2 years ago).
Tognin et al., 2020	360 (309 clinical high risk psychosis; 51 controls)	Childhood Experience of Care and Abuse questionnaire; Childhood	Static faces	Anger, happy, fear, neutral	Degraded facial affect recognition; select which emotion was	Association between emotional abuse and poorer accuracy overall and for neutral.

		Trauma Questionnaire			depicted from facial expressions with reduced visual resolution.	
Young & Widom, 2014	547 (295 abuse/neglect ; 252 control	Court-substantiated cases	Emotion eliciting photographs (variety of different photographs - not emotional faces)	Positive, negative, neutral content	International affective picture system (IAPS); shown images initially and then shown more images and indicated which were previously shown.	Association between childhood trauma and poorer accuracy overall, and for positive and neutral pictures. Physical abuse predicted poorer accuracy for neutral pictures and sexual abuse and neglect predicted poorer accuracy for positive pictures.
Nazarov et al., 2015	50 (29 childhood trauma PTSD; 21 controls)	Childhood Trauma Questionnaire	Emotional prosody	Happy, sad, fear, anger	Emotion recognition (select which expression was depicted) and discrimination tasks (identify if	Association between increased severity of childhood trauma and slower reaction times across all emotions and poorer ability to discriminate.

					the same emotion was being expressed).	

1.3. Interrelated traits of alexithymia and psychopathy

Individuals with experience of childhood trauma typically have higher levels of alexithymia (Zlotnick et al., 2001) and psychopathy traits (Craparo et al., 2013). Typical alexithymia characteristics include difficulties identifying and describing your own feelings, and an external oriented style of thinking (preventing reflection of emotions and paying more attention to external stimuli; Taylor et al., 1999). Typical psychopathy characteristics include interpersonal traits (e.g., manipulation), affective traits (e.g., callousness), lifestyle traits (e.g., impulsivity), and antisocial traits (Anderson et al., 2015).

Childhood trauma experience is linked to the development of these traits (Zlotnick et al., 2001; Craparo et al., 2013). Alexithymia may be used as a defence mechanism for childhood trauma (Fang et al., 2020). Fang et al. (2020) suggests that by adopting alexithymia traits individuals can alleviate overwhelming emotional distress by preventing access to internal feelings. For psychopathy, Craparo et al. (2013) suggests that early exposure to trauma may lead to a reduced ability to experience and respond with empathy which leads the child to become desensitised to future painful or stressful experiences. This results in them becoming less emotionally and physiologically responsive to the needs of others (Weiler & Widom, 1996). This may lead to the development of typical psychopathy traits of callousness and lack of empathy, remorse, and guilt (Weiler & Widom, 1996). As a result of the strong links to childhood trauma, this section explores the association between alexithymia and psychopathy traits with emotion recognition accuracy.

1.3.1. Alexithymia and emotion recognition

Alexithymia loosely translates to ‘no words for feelings’ (Taylor et al., 1999). The Toronto model (Taylor et al., 1999) (referred to this name by Preece et al., 2017) includes the characteristics of difficulty identifying own feelings, difficulties describing own feelings, an externally oriented thinking style, and reduced imagination. This model is currently the most widely used definition of alexithymia within the literature (Preece et al., 2017). Another model, The Amsterdam model (Vorst & Bermond, 2001) (referred to this name by Preece et al., 2017), contains an additional component of reduced emotional reactivity. It suggested that individuals with higher levels of alexithymia traits may not experience emotions as intensely as those with lower levels of alexithymia traits. The Amsterdam model organises the components into cognitive and affective alexithymia. Cognitive alexithymia includes difficulty identifying feelings, difficulty describing feelings, and an external style of thinking (Vorst & Bermond, 2001; Preece et al., 2017). Affective alexithymia includes restricted imagination and reduced reactivity (Vorst & Bermond, 2001; Preece et al., 2017). This links closely with research by Vorst and Bermond (2001). They stated there are subtypes of alexithymia: type I and type II alexithymia. Type I alexithymia includes traits associated with both cognitive and affective facets of alexithymia. Whereas type II alexithymia includes traits associated with just the cognitive facet of alexithymia.

A third model (Preece et al., 2017) tried to resolve the on-going debate regarding the definition and measurement of alexithymia. Preece et al. (2017) formulated the attention-appraisal model. This suggests that alexithymia is associated with difficulties focusing on emotional expressions and accurately evaluating them. It states that difficulties in identifying and describing feelings can be conceptualised as difficulties at the appraisal stage. Also, external thinking can be conceptualised as difficulty at the attention stage. It is suggested that the extent of difficulties is associated with the development of emotion schemas (Preece et al., 2017). If the schema is underdeveloped then this is presented as difficulties organising and differentiating emotions (Preece et al., 2017). Preece et al. (2017) tested the attention-appraisal model and reported support for the three suggested components only: external style of thinking, difficulty identifying own feelings, and difficulty describing own feelings. In further support, these three components are the sub-categories included in the widely used and supported self-report questionnaire, the Toronto Alexithymia Scale (TAS-20) (Bagby et al., 1994).

By exploring alexithymia, we can investigate whether deficits in recognising one's own emotions extend to a deficit in recognising others' emotions. The effects of alexithymia traits on emotion recognition accuracy has been established in both clinical populations (e.g., a diagnosis of alexithymia; Grynberg et al., 2012), as well as in typical populations (e.g., traits of alexithymia; Jongen et al., 2014). The shared circuits model (Keysers & Gazzola, 2006) provides a possible explanation for the emotion deficits. This states there are shared circuits between recognising others' emotions and feeling them ourselves. Therefore, this may work the other way round too.

Another model is the self to other model of empathy (Bird & Viding, 2014). This defined empathy as a shared emotional experience occurring when someone feels a similar emotion to another due to perceiving their emotional state (Bird & Viding, 2014). The model ultimately suggests that your own emotional state can be activated and shaped by someone else's emotional expression (Rijnders et al., 2021). Specifically linked to alexithymia, this model (Bird & Viding, 2014) suggests that alexithymia is associated with an impairment in the affective representation system (responsible for representing your current emotional state). An impairment in this system would mean difficulty identifying your emotional state, similar to the key alexithymia facet. Due to the model suggesting an association between identifying emotional expressions in yourself and identifying them in others, it may explain why those with alexithymia (and therefore difficulty identifying own emotions) struggle with identifying other people's emotions.

Research exploring alexithymia typically measures alexithymia traits using a self-report questionnaire (e.g., the TAS-20) (Bagby et al., 1994). When exploring alexithymia traits, those who are scored highly typically report more difficulty in identifying and discriminating emotions compared to those who are scored low. Studies which have found an association between alexithymia and emotion recognition typically report poorer emotion recognition overall/across all emotions (a general deficit) as well as poorer emotion recognition for negative emotions specifically (a specific deficit) (Taylor, 1994; Parker et al., 2005). There are inconsistent findings regarding alexithymia and emotion recognition accuracy (Table 2), which makes it difficult to identify the influence of alexithymia, if any, on emotion performance.

Previous research exploring alexithymia and emotion recognition accuracy tends to use the 'Reading the Mind in the Eyes' task (Baron-Cohen et al., 2001). This is because alexithymia is typically explored alongside autism (Pisani et al., 2021). It is relatively recent that alexithymia has been studied as an individual difference in its own right. There has been exploration using more typical emotion recognition methods, such as recognising and labelling an expression. However, similar to the childhood trauma literature, it typically uses static facial expressions and a variety of inconsistent methods (e.g., morphed faces, affect tasks, and emotion labelling) (detailed in Table 2). Also, there is a lack of exploration across voices, leaving a gap in knowledge regarding how alexithymia influences recognition of vocal expressions.

1.3.1.1. Alexithymia and facial expressions

Research exploring alexithymia traits and facial expressions of emotion typically used static facial expressions of emotion at one intensity level. Jongen et al. (2014) compared emotion recognition accuracy across two extreme groups: those with high levels of alexithymia traits versus those with low levels. Participants completed an emotion recognition task showing Japanese and Caucasian facial expressions. It was found that the low alexithymia group had significantly better recognition of facial expressions than the high group. In support of this, Prkachin et al. (2009) asked participants to complete the TAS-20 and a facial emotion recognition task. They had to respond “yes” if the face shown depicted the target emotion and stay silent if it did not. They found high scores on the TAS-20, indicating a higher level of alexithymia traits, corresponded with poorer emotion recognition. This was found for anger, sadness, and fear.

Research has reported that higher levels of alexithymia traits are associated with poorer recognition of threat-related stimuli (Vermeulen et al., 2008; Donges & Suslow, 2017). Therefore, individuals with alexithymia traits struggle with angry and/or fearful expressions. Starita et al. (2018) asked participants to view morphed static facial expressions at six emotional intensity levels (0% up to 100% in increments of 20%) and classify the perceived emotion from neutral, happiness, fear, and disgust. The authors called their measure the ‘point of subjective equality’, which was described as the percentage of intensity needed to identify an emotion as emotional rather than neutral. Individuals with higher levels of alexithymia traits showed a higher proportion of fear being required in order to reliably recognise the fearful expressions (e.g., participants needed more emotional cues before accurately recognising fear). This was not found for disgust or happiness. This suggests that those with high levels of alexithymia traits needed more perceptual information to identify fearful facial expressions. However, these findings might only apply to static images. When dynamic stimuli were used in experiment 2 (Starita et al., 2018), there were no significant differences between low levels and high levels of alexithymia traits and the amount of emotional intensity needed to identify the expressions. The differences between experiment 1 and 2, due to the stimuli used, suggests it may not be possible to generalise alexithymia’s effect on static stimuli to dynamic stimuli. However, as noted, the majority of previous research employed static images.

There is research exploring alexithymia and eye fixations for facial expressions of emotion. Bird and colleagues (2011) explored alexithymia and autism's relationship with eye gaze for emotional facial expressions. Participants (n=13 adults with autism and n=13 controls) viewed four video clips (two from a TV drama showing an emotional social interaction and two from a newsreader reading news). The areas of interest were the eye and mouth regions. The results showed that attention to the eyes and mouth was predicted by level of alexithymia, not autism symptom severity. The authors suggested that atypical scan paths of the eyes and mouth may be unrelated to autism but are determined by the amount of alexithymia traits. This suggests that alexithymia influences attention to important areas for emotion recognition (e.g., the eyes) and may explain the emotion deficits. Cuve et al. (2018) further supported that atypical gaze patterns are attributed to alexithymia, rather than autism. They explored emotion recognition and eye tracking in young adults with autism and concluded that arousal and gaze mechanisms may be modulated by alexithymia. Further research by Fujiwara (2018) investigated the role of visual attention in identifying facial expressions in individuals high and low in alexithymia. The emotion recognition task included blended emotions (e.g., two emotional expressions blended into one face). They found that individuals with high alexithymia traits showed less attention to the eye region compared to individuals with low alexithymia traits, Thus, suggesting that alexithymia is associated with attentional avoidance of eyes. They concluded that eye contact may be difficult for those with alexithymia, which may disrupt the processing of facial expressions. This predicts that those with high alexithymia traits may focus on different features when recognising expressions, which may in-turn affect accuracy.

Neuroimaging has also been used to explore alexithymia and emotion recognition. Deng et al. (2013) explored the neural activity of female participants. The stimuli were selected due to their pleasantness (positive, negative, or neutral) and emotional intensity (high or low arousal). The stimuli included emotional content rather than emotional facial expressions. A large female sample (n = 432) completed the TAS-20 and viewed emotion pictures whilst undergoing fMRI. Significant neural activation differences were found between individuals with high and low levels of alexithymia traits when viewing positive or negative emotional stimuli; specifically in the anterior cingulate, mediofrontal cortices, insula, and temporal lobe. Also, there were comparable patterns of brain activity for individuals with high and low levels of alexithymia traits when viewing neutral stimuli. This suggests that the differences in activation were specifically for emotional stimuli.

The findings follow the alexithymia models' assumptions as alexithymia was associated with emotion recognition deficits. An issue with the all-female sample is gender differences in the neural processing of emotional expressions exist (Hofer et al., 2006), meaning the findings may not be able to generalise to males. However, there is support for Deng et al.'s (2013) activation patterns in the amygdala and superior temporal gyrus. Grynberg et al. (2012) reported that individuals with high levels of alexithymia showed reduced superior temporal gyrus activity during implicit processing of surprise facial expressions (Duan et al., 2010) as well as happy and sad facial expressions (Reker et al., 2010). Also, there was an association between alexithymia and reduced activation in the amygdala during implicit and explicit processing of facial expressions of emotion (Leweke et al., 2004; Kugel et al., 2008).

There is also evidence of alexithymia influencing alternative measures of emotion recognition, such as intensity ratings. Prkachin et al. (2009) explored alexithymia traits and perceived intensity of emotional expressions. Participants (n= 43 students) completed the TAS-20 questionnaire and an emotion recognition task, involving emotion labelling and rating how intense expressions were. They found that individuals who reported higher levels of alexithymia traits rated emotional expressions as less intense, especially for fear expressions, supporting the relationship between alexithymia and perceived intensity of expressions. The limited research potentially suggests that alexithymia does influence alternative measures of emotion recognition.

A possible reason for the relationship between alexithymia and intensity ratings is due to the associated blunted responses to emotional stimuli. This suggests that individuals reporting higher levels of alexithymia traits have reduced behavioural and neurological responses to emotional stimuli. For example, if an individual viewed an emotion-provoking stimuli (e.g., an extreme positive or negative stimulus) the reaction would be blunted/reduced compared to someone reporting less alexithymia traits. There is support from neuroimaging research for the blunted responses associated with alexithymia by showing reduced neural activation (indicating a blunted/lower emotional response) in brain areas when viewing emotion-provoking stimuli for individuals with more alexithymia traits (Grynberg et al., 2012; Deng et al., 2013; Goerlich-Dobre et al., 2014). Due to this blunted response, it may suggest that individuals reporting a higher level of traits may perceive the emotional stimuli as less intense than individuals reporting a lower level of traits, which in turn leads to lower intensity ratings. However, the literature surrounding this is still limited.

1.3.1.2. Alexithymia and vocal expressions

There is limited data exploring alexithymia traits and vocal expressions of emotion compared to facial expressions. Lane et al. (1996) asked participants to match verbal and non-verbal emotion stimuli: sentences and words (verbal-verbal), faces and words (nonverbal-verbal), sentences and faces (verbal-nonverbal), and faces and photographs of scenes (nonverbal-nonverbal). The findings reported that alexithymia was associated with poorer emotion recognition for both verbal and nonverbal stimuli. Goerlich-Dobre et al. (2014) explored alexithymia and vocal expressions of emotion. The stimuli included two syllable pseudowords and participants responded to either emotional (explicit task – categorised pseudowords as spoken with neutral, angry, or surprised intonation) or non-emotional (implicit task – metrical stress evaluation: whether emphasis was on the first or second syllable) tasks whilst undergoing fMRI. They reported that individuals with higher alexithymia scores showed reduced activity in the right superior temporal gyrus and the bilateral amygdala for angry, surprised, and neutral expressions during implicit and explicit processing. For those with difficulty describing their feelings, there was a stronger deactivation of the left superior temporal gyrus and the bilateral amygdala for neutral stimuli compared to angry. The results suggest the blunted processing (a lower reactivity) of vocal expressions which may be localised to the superior temporal gyrus and the amygdalae.

There is also evidence by Grynberg et al. (2012) of the same areas being less responsive to facial expressions in individuals with higher levels of alexithymia traits (Grynberg et al., 2012), specifically reduced activity in the amygdalae and superior temporal gyrus. As exploration of vocal expressions is limited, is difficult to explore alexithymia's effect across modalities. However, alexithymia is associated with underdeveloped emotion schemas and difficulties organising and differentiating emotions (Preece et al., 2017). This may suggest the deficits associated with alexithymia are modality-general (performance is similar across modality) rather than modality-specific due to visuo-perceptual deficits. In support of this, the neuroimaging research identified similar activation patterns across facial (Grynberg et al., 2012) and vocal expressions of emotion (Goerlich-Dobre et al., 2014). Therefore, this may suggest that the effect of alexithymia across facial and vocal expressions of emotion may be similar. Further alexithymia research is presented in Table 2 discussing the samples, the measure used, the modality and emotional expressions explored, the task employed, and a summary of the research findings. The general conclusion of the research in Table 2 suggests that alexithymia does in fact negatively impact overall emotion recognition for static stimuli.

Table 2

A table including research exploring alexithymia traits across facial and vocal expressions of emotion.

Authors	Sample	Alexithymia measure	Modality	Emotions expressed	Task	Conclusions
Jongen et al., 2014	37 (17 high, 20 low degree of alexithymia)	Toronto Alexithymia Scale	Static faces	Anger, disgust, fear, happy, sad, surprise	Facially Expressed Emotion Labelling Test; select a label which depicts the facial expression.	Higher degree of alexithymia was associated with poorer accuracy.
Montebarocci et al., 2011	91	Toronto Alexithymia Scale	Static faces	Happy, sad, fear, anger, surprise, disgust, neutral	Select the appropriate label for the facial expression presented.	Higher levels of alexithymia traits were associated with poorer accuracy, but when including verbal IQ there were no differences between low and high number of traits.
Prkachin et al., 2009	128	Toronto Alexithymia Scale	Static faces	Happy, sad, anger, disgust, surprise, fear	Pictures of Facial Affect; shown a target expression and had to	Alexithymia traits were associated with poorer detection of anger, sadness, and fear expressions.

					identify whether other faces expressed the same expression.	
Rosenberg et al., 2020	49	Toronto Alexithymia Scale; Bermond-Vorst Alexithymia Questionnaire; Toronto Structured Interview for Alexithymia	Static faces	Neutral, happy, angry, fear	Affective priming paradigm; prime and masked stimuli presented, participants label the expression and evaluate as positive or negative.	Alexithymia traits were associated with reduced involuntary attention and processing of emotional faces.
Starita et al., 2018 (study 1)	40 (20 low, 20 high level of alexithymia traits)	Toronto Alexithymia Scale	Static faces	Happy, fear, disgust, neutral	Identify and label morphed static facial expressions (from 0 to 100% intensity).	Participants with higher scores of alexithymia traits needed more perceptual information to identify fear.
Starita et al., 2018 (study 2)	40 (20 low, 20 high level of alexithymia traits)	Toronto Alexithymia Scale	Dynamic faces	Happy, fear, disgust	Identify the morphed dynamic facial expression	No significant differences between low and high levels of alexithymia

					(starting neutral and ending in an emotional expression) as soon as able to.	
Lane et al., 1996	380	Toronto Alexithymia Scale	Verbal (sentences, words); non-verbal (faces, scenes)	Happy, sad, fear, anger, surprise, disgust, neutral	Perception of Affect Task; four subtasks: (1) verbal stimuli - verbal response options, (2) non-verbal – verbal, (3) verbal – non-verbal, (4) non-verbal – non-verbal	Alexithymia was associated with impaired verbal and nonverbal recognition of emotion stimuli.

1.3.2. Psychopathy and emotion recognition

As well as the four facets (interpersonal, affective, lifestyle, antisocial traits; Anderson et al., 2015), psychopathy is also associated with attentional abnormalities, emotional dysfunction, and increased risk of antisocial behaviour (Blair & Mitchell, 2009). Psychopathy has been described as part of the ‘dark triad’ of personality (Paulhus & Williams, 2002). This refers to interrelated personality constructs including Machiavellianism (manipulative personality), narcissism (believing you are superior), and psychopathy. They all share similar characteristics of being callous, manipulative, and dishonest. The effects of psychopathy traits on emotion recognition accuracy has been established in clinical populations (Blair et al., 2004), as well as in typical populations (e.g., trait level; Bowen et al., 2014).

A limitation of the psychopathy literature is that the majority of samples are incarcerated males (detailed in Table 3). Previous research has suggested we cannot generalise to females as they present psychopathy related emotion deficits differently to males (Efferson & Glenn, 2018). More gender balanced community samples are needed to examine how psychopathy traits may hinder emotion recognition in everyday social interactions. Typically, research exploring the association between psychopathy and emotion recognition has reported poorer accuracy across all emotions as well as specific emotion deficits in sadness and fear (Blair, 2001). However, there are inconsistent findings regarding whether this association goes beyond just sad and fear expressions (e.g., some have reported deficits in happiness) (detailed in Table 3).

1.3.2.1. Psychopathy and facial expressions

The literature on psychopathy and emotion recognition is somewhat inconsistent. While the majority concurs, that psychopathy is associated with emotion recognition deficits overall, the specific emotions affected vary (details in Table 3). Bowen et al. (2014) explored psychopathy and emotion recognition in 63 young male offenders (13 to 17 year olds with criminal behaviour) and their matched controls (matched on age, IQ, and socio-economic status). They completed self-report questionnaires of Youth Self Report (measuring conduct disorder) and Young Psychopathy Inventory (measuring psychopathic and callous-unemotional traits) and completed a facial emotion recognition task. This included the basic six emotions across four intensity levels (25%, 50%, 75%, 100% intensity) and neutral. They found that, compared to the controls, the young offenders were significantly worse at identifying sadness, low intensity disgust, and high intensity fear. The offenders, compared to controls, also showed poorer recognition for low intensity anger but better recognition for high intensity anger (Bowen et al., 2014). The young offenders' level of conduct disorder and psychopathic traits explained the variance in sadness and disgust recognition and their offense severity explained the variance in anger recognition (Bowen et al., 2014). These results suggest that offenders have specific emotion deficits for negative expressions.

Hastings et al. (2008) supports Bowen et al.'s (2014) findings in incarcerated male adults. Psychopathy was explored in 145 male inmates using the Hare Psychopathy Checklist. They completed a facial emotion recognition task including the conditions of happiness, sadness, fear, anger, and shame, at either 60% or 100% intensity. Psychopathy was associated with poorer recognition of sadness, lower intensity stimuli, and general emotion recognition. Unexpectedly, there was also a negative correlation between psychopathy and the recognition of happiness. The specific deficit for sadness is consistent with Bowen et al.'s (2014) findings. However, the specific deficit for happiness, but not a deficit for fear, was surprising. Although, a possible limitation is the fear stimuli. Fearful expressions were misidentified as surprise expressions, which could explain why a fear deficit was not found. This frequent confusion between fear and surprise has been previously reported (Zhao et al., 2017). Another limitation could be the use of a male felon only sample. The results cannot be generalised to females as research reported sex differences in psychopathy related emotion deficits (Efferson & Glenn, 2018).

Pera-Guardiola et al. (2016) supported an association between psychopathy and a happiness deficit. A male sample, 29 with a history of severe criminal offense and psychopathy and 20 non-offender males, completed a facial emotion recognition task whilst undergoing fMRI. Each trial started with a neutral face that gradually morphed through ten stages (in 10% increments) into one of the basic six emotions. They found that psychopaths, compared to the control group, showed deficits in sadness, happiness, and fear recognition. Psychopaths showed lower grey matter volumes in the prefrontal cortex, somatosensory cortex, anterior insula, cingulate cortex, and the posterior lobe of the cerebellum. Previous neuroimaging research also supported association between psychopathy and these brain areas (Deeley et al., 2006; Decety et al., 2013). Although, Blair et al. (2008) reported additional areas of the amygdala and ventromedial prefrontal cortex. The amygdala, through stimulus-reinforcement learning, creates an association between our actions which harm others with the aversive reinforcement of the victims' distress (Blair, 2007). Through this association people learn to avoid behaviours which cause these aversive consequences. Thus, linking a dysfunction of the amygdala to psychopathy traits of unemotional and antisocial behaviour.

Although limited, there is research using an adult community sample. Prado et al. (2015) explored the association between psychopathy and facial expressions of emotion in a community sample (n=479 participants in total). They completed a self-report questionnaire of psychopathy traits (Levenson self-report psychopathy scale; Levenson et al., 1995). The participants were split into either primary or secondary psychopathy. Primary traits include being selfish and uncaring and are thought to be a genetic predisposition. Secondary traits include being impulsive and antisocial and are thought to develop due to adverse environments (e.g., childhood trauma; Prado et al., 2015). Participants viewed static facial expressions of emotion expressing anger, sadness, happiness, fear, disgust, or shame at five different intensity levels (20%, 40%, 60%, 80%, 100%). They reported that both primary and secondary psychopathy traits were associated with poorer emotion recognition accuracy overall. Individuals reporting higher levels of primary psychopathy traits showed poorer accuracy for anger, disgust, sad, fear, and shame expressions as well as poorer accuracy for low and high intensity expressions. Those reporting high levels of secondary primary traits showed poorer accuracy for shame and disgust expressions as well as poorer accuracy for high intensity expressions. Montagne et al. (2005) also explored a community sample and asked participants scoring high and low on psychopathy personality characteristics to view morphed static facial expressions of the basic six emotions (starting at a neutral expression (0%) going up to a high intensity expression (100%)). They found that individuals reporting higher levels of psychopathy traits were associated with poorer recognition of fear expressions.

There is eye tracking research supporting the fear deficit. Dadds et al. (2008) explored whether psychopathic traits (callous-unemotional traits and antisocial behaviour) were associated with reduced attention to the eye region of facial expressions. A male adolescent sample viewed child, teen, and adult faces depicting happiness, sadness, anger, disgust, fear, and neutral expressions. They found a higher level of psychopathy traits was associated with poorer recognition accuracy for fear expressions as well as a lower number of fixations and duration of gaze to the eye region. They also found that gaze to the eye region correlated positively with accurate fear recognition in the high psychopathy group. This suggests that attention to the eye region is reduced in young people with high psychopathy traits, which could contribute to explaining the fear deficit. Dadds et al.(2006) supported that reduced gaze to the eye region negatively affects emotion recognition of fear. It was found that the deficit could be temporarily corrected by asking participants to look at the eye region. Therefore, the association between psychopathy and atypical eye gaze (e.g., avoidance of the eye region) can negatively affect fear recognition.

This effect was also reflected in an adult sample, as seen in Gillespie et al. (2015). They explored the relationship between psychopathic traits (primary: selfish/uncaring traits uninfluenced by the environment; and secondary: impulsive/antisocial traits influenced by the environment) and attention to the eyes in adult male non-offenders for the basic six emotions. They reported an association between primary psychopathy traits and reduced fixations to the eyes compared to the mouth region across the emotions expressed. This suggests that the findings from a younger sample are reflected in adult samples too.

Further support from an adult sample is from Gehrer et al. (2019). They investigated eye gaze to the eye region in male incarcerated psychopathic and non-psychopathic offenders. Participants completed a gender discrimination task and an emotion recognition task (including the basic six emotions). They found that non-psychopathic offenders clearly focused on the eye region during emotion recognition, whereas psychopaths showed significantly less attention towards the eye region across all emotional expressions. Psychopaths had significantly shorter dwell time on the eye region as well as less initial fixations. The studies discussed have shown that the association between psychopathy and reduced eye gaze to the eye region for facial expressions is consistent across different age groups and across incarcerated and non-incarcerated psychopaths. This atypical gaze could negatively impact emotion recognition accuracy as the eyes have been reported as key for accurate recognition (Schmidtmann et al., 2020).

As psychopathy is associated with emotion recognition accuracy, it may also be associated with alternative measures, such as intensity ratings of expressions. Surprisingly, there has not been a study directly exploring the relationship between psychopathy and intensity ratings of emotional expressions. Typically, emotion recognition research explores accuracy of stimuli varying in intensity rather than subjective ratings. The closest study of intensity ratings was Book et al. (2007). This study explored how similar participants' intensity ratings were to the validated stimuli intensities (e.g., did participants identify and rate a high intensity expression as high intensity to match the databases' intensity ratings). A sample of 59 prison inmates and 60 community members with psychopathy traits viewed facial expressions depicting happy, sad, anger, fear, disgust, and neutral. Individuals reporting higher levels of psychopathy traits showed better accuracy for judging intensity ratings of facial expressions compared to individuals reporting lower levels. This is somewhat unexpected as emotion recognition accuracy tends to be negatively affected by psychopathy yet it was reported to be associated with higher accuracy of intensity levels by Book et al. (2009). This study did not explore perceived intensity relative to intensity ratings, but it does provide support for an association between psychopathy and emotional stimuli ratings.

Similar to alexithymia, psychopathy is also associated with blunted emotional responses to emotional stimuli. Research using emotion-provoking stimuli (pictures of people in pain) and measuring startle responses have reported that individuals with a higher level of psychopathy traits showed reduced emotional responses compared to individuals with a lower level of psychopathy traits (Anderson et al., 2011). There is also neural work reporting that adolescents with conduct disorder and a higher level of callous-unemotional traits, which are thought to be precursors of psychopathy (Vasconcelos et al., 2021), show less amygdala activation when viewing fearful expressions compared to adolescents with conduct disorder and a lower level of callous-unemotional traits (Puzzo et al., 2016). This blunted/reduced emotional response may result in perceiving and rating emotional expressions as less intense. However, as this has not been previously explored, robust conclusions cannot be drawn.

There are two main models that attempt to explain the emotion dysfunction associated with psychopathy: the Violence Inhibition Model (VIM) and the low-fear model. The VIM proposed by Blair et al. (2001) states that the emotional impairments associated with psychopathy are due to a lack of empathy and can lead to violent behaviour (Sun et al., 2023). The VIM is a system activated when viewing distress, sadness, and fearful expressions in others. Typically, once an individual recognises these emotions they adapt their behaviour to avoid evoking them. However, those with psychopathy have a disrupted system, so they fail to recognise fear and sadness in other people as aversive. Consequently, they do not learn to avoid these behaviours and, therefore, they continue to evoke these emotions in others. This model attempts to explain the fear and sadness deficit (detailed in Table 3).

Another psychopathy model is the low-fear model (Patrick, 1994). This suggests the emotion deficits associated with psychopathy are due to the reduced ability to experience fear themselves. This reduced ability leads to failed socialisation and the inability to adapt behaviour in response to negative consequences. Also, the self to other model of empathy (Bird & Viding, 2014), explained earlier for alexithymia, could also explain the emotion deficits associated with psychopathy. The model predicts that those with psychopathy would lack the appropriate arousal response to distressing or negative emotions. Also, individuals with psychopathy have a selective impairment for fear and sadness expressions. Thus, they cannot associate these expressions with cues to recognise and label them in others.

1.3.2.2. Psychopathy and vocal expressions

Psychopathy seems to be better researched across modalities. A meta-analysis by Dawel et al. (2012), including 26 studies involving 29 experiments, explored psychopathy traits and emotion recognition across various modalities (including faces, voices, and postural).

Regarding vocal expressions of emotion, there was an association between psychopathy and poorer accuracy of fear, happiness, and surprise. This suggests the effect of psychopathy may extend beyond just sadness and fear. Regarding facial expressions of emotion, performance was poorer for the same expressions as for vocal expressions, as well as for sadness. This suggests that performance differs depending on which modality the emotion is expressed as poorer accuracy for sadness was only found for facial expressions. As the majority of previous research has used static faces when exploring emotion recognition, it can make it difficult to see if psychopathy's effect is universal across modalities or intensities. Another gap highlighted by the review was the samples used; all but two studies exploring adults used a forensic sample and all but six studies used a male-only sample (similar pattern found in Table 3). This demonstrates the lack of research surrounding mixed-gender adult community samples.

Blair et al. (2002) investigated psychopathy and vocal expressions of emotion. A male incarcerated sample completed the Hare Psychopathy Checklist-Revised and a vocal emotion task. This included neutral words spoken with emotional expressions of either happiness, disgust, sadness, anger, and fear. They had to identify the emotion being expressed vocally. The results reported an association between psychopathy and poorer recognition of fear and sad expressions. Further support for the sadness deficit associated with psychopathy is provided by Stevens et al. (2001) in a child sample (n=9 with high psychopathic traits and n=9 control). They were presented two facial expressions and two vocal tone tests. These included sad, fearful, happy, and angry expressions. They found that children with psychopathic tendencies displayed poorer accuracy for recognising sad vocal tones. However, the two groups did not differ in their recognition of happy, fearful, or angry vocal expressions. The lack of fear deficit found could be due to the different ages tested.

The findings discussed support the psychopathy models mentioned as well as the facial expression literature. Although there seems to be more research on psychopathy across modalities compared to childhood trauma and alexithymia, additional research is needed with a community sample composed of an equal gender balance (as females are not typically included; Dawel et al., 2012). A table with further psychopathy research is presented in Table 3 which details the samples, the measure used, the modality and emotional expressions explored, the task employed, and a summary of the research findings. The overall conclusion of the studies discussed in Table 3 is that the effect of psychopathy extends beyond just sadness and fear to impact other emotional expressions too.

Table 3

A table including research exploring psychopathy traits across facial and vocal expressions of emotion.

Authors	Sample	Psychopathy measure	Modality	Emotions expressed	Task	Conclusions
Bowen et al., 2014	100 (63 young offenders; 37 controls)	Youth Self Report; Youth Psychopathic Traits Inventory	Static faces	Happy, sad, fear, anger, disgust, surprise, neutral	Identify and label morphed static facial expressions.	Young offenders have poorer recognition of sadness, low intensity disgust, low intensity anger, and high intensity fear.
Hastings et al., 2008	145 jail inmates	Hare Psychopathy Checklist: Screening Version	Static faces	Happy, anger, sad, shame, fear	Facial affect recognition emotion task; rate each facial expression for how much it displayed one of the emotions.	Higher psychopathy scores were associated with poorer accuracy overall and with happy and sad expressions.
Pera-Guardiola, 2016	39 (19 psychopathic criminals, 20 controls)	Psychopathy Checklist-Revised	Static faces	Happy, surprise, fear, sad, disgust, anger	Identify the morphed expression (starting neutral and morphing into an emotional expression) as soon as recognised.	psychopathy was associated with poorer recognition of sad, happy, and fear expressions.

Stevens et al., 2001	18 children (9 with psychopathic tendencies; 9 controls)	Psychopathy Screening Device	Faces and voices	Sad, fear, happy, angry	DANVA; identify the emotion expressed from child and adult facial and vocal expressions of emotion.	Psychopathic tendencies were associated with poorer accuracy for sad and fearful facial expressions and poorer sad vocal expressions.
Dawel et al., 2012 (review)	26 studies (1376 participants)	Varied per study. Majority used Psychopathy Checklist Revised	Faces, voices, postural	Anger, disgust, fear, happy, sad, surprise	Emotion recognition tasks - varied per study.	Found poorer recognition across faces and voices for not just fear and sadness but also for positive emotions.
Blair et al., 2002	39 incarcerated males (19 psychopathic, 20 non-psychopathic)	Psychopathy Checklist-Revised	Voices	Happy, disgust, anger, sad, fear	Vocal Affect Recognition Test; listened to two syllable words and identified the emotion expressed.	Psychopathy was associated with poorer recognition of fearful vocal expressions.
Long & Titone, 2007	55 (25 high, 25 low psychopathy score)	Psychopathic Personality Inventory – Short Form	Voices	Positive, negative, affect-neutral	Verbal emotion processing tasks: lexical decision task (is the word real), negative word decision	Higher psychopathy scores were associated with poorer processing of negatively valenced words, across abstractness.

					task (is the word neutral or negative), positive word decision task (is the word neutral or positive).	

Previously, research has explored and analysed childhood trauma, alexithymia, and psychopathy separately. However, due to the reported links, previous research has also recommended future studies explore them together (Krvavac & Jansson, 2021). Individuals who have experienced childhood trauma are more likely to exhibit higher levels of alexithymia and psychopathy traits (Zlotnick et al., 2001; Craparo et al., 2013). Thus, regarding emotion recognition research, it is important to explore these traits together as alexithymia and psychopathy traits are also associated with poorer emotion recognition performance (Blair, 2001; Parker et al., 2005). Hence it becomes difficult to distinguish which individual difference is responsible for the poorer emotion recognition accuracy. Therefore, by including and controlling for alexithymia and psychopathy traits alongside childhood trauma, it can increase confidence that childhood trauma's unique effect on emotion recognition accuracy is being explored, rather than the interrelated traits.

1.4. Thesis aims and experiments

Whether childhood trauma would remain significantly associated with emotion recognition after controlling for the interrelated alexithymia and psychopathy traits is unclear. By exploring the related traits, it can enhance understanding of which of the related individual differences is responsible for the emotion recognition deficits. For example, in autism research it has been found that alexithymia may be responsible for the associated emotion recognition difficulties (Bird & Cook, 2013). Therefore, a similar concept is possible with childhood trauma – the associated deficits are due to interrelated traits rather than childhood trauma itself. This would challenge the theories directly exploring childhood trauma and emotion recognition deficits to consider other related traits which may be playing a role. This could also in-turn impact interventions as they are based on the theories. For example, by suggesting childhood trauma interventions incorporate other proven techniques from the alexithymia and psychopathy interventions, if they significantly influencing the relationship, to enhance the effectiveness.

There has been little reported on how childhood trauma's relationship with emotion recognition is influenced by stimulus-based factors of modality, intensity, and emotion expressed. It can shed light on the universality of the association between childhood trauma and emotion recognition to determine whether certain situations or environments can exacerbate or ameliorate the emotion recognition deficits. For example, if individuals with childhood trauma struggle with vocal expressions of emotion then performance may be further impaired in environments which are dark or where the facial expression is obscured (e.g., COVID-19 face masks). Also, as everyday conversations include a range of intensities – both subtle and more exaggerated expressions – this can explore whether individuals struggle with certain intensities (e.g., if subtle expressions are a struggle then a large number of daily conversations may be hindered). Typically, static facial expressions are used but, as everyday expressions are dynamic and audio-visual, it does not tell us much about how individuals are impacted in real-life interactions. It may be possible that individuals' difficulties across specific expressions, in particular positive and neutral expressions, are just for static expressions. Thus, audio-visual expressions, which we have more practice and exposure to, may attenuate any previously reported difficulties. Exploring across stimulus-based factors can improve understanding of how robust the association between childhood trauma and emotion recognition is across various situations.

The thesis is comprised of 4 experiments:

1. Experiment 1 (Chapter 2) explores childhood trauma's association, when controlling for alexithymia and psychopathy traits, with emotion recognition accuracy across modality (faces, voices, audio-visual), intensity (normal, strong), and emotion expressed (happy, sad, fear, anger, disgust, surprise, neutral), as well as alternative measures of intensity ratings and sensitivity to intensity.
2. Experiment 2 (Chapter 3) explores more deeply the association of childhood trauma, when controlling for alexithymia and psychopathy traits, and emotion recognition across modality (static faces, dynamic faces, audio-visual), intensity, and emotion expressed by using eye tracking software to measure where, and how frequently, participants gazed in certain areas of the face when recognising expressions.

3. Experiment 3 (Chapter 4) explores childhood trauma, when controlling for alexithymia and psychopathy traits, and the integration of facial and vocal emotion cues using audio-visual congruent (e.g., happy face, happy voice) and incongruent (e.g., happy face, sad voice) emotional stimuli varying across modality (facial focus, vocal focus) and emotion expressed.
4. Experiment 4 (Chapter 5) explores emotion recognition accuracy in the context of the COVID-19 pandemic and was split into two: Experiment 4a explored childhood trauma, when controlling for alexithymia and psychopathy traits, and emotion recognition accuracy across masks (masked and unmasked facial expressions) and emotion expressed; Experiment 4b explored whether a match or mismatch of participant and stimuli ethnicity or attitudes towards masks were associated with emotion recognition accuracy across masks and emotion expressed.

The overall aim of the thesis is to explore how individual differences, in particular childhood trauma, can influence emotion recognition performance using more realistic (e.g., moving and audio-visual expressions) and comprehensive stimuli (e.g., exploring across various modalities, intensities, and emotions) to increase the generalisability of the results to real-world social contexts.

2. The effect of childhood trauma on emotion recognition and the influence of related traits and stimulus-based factors.

This Chapter has been published in *Scientific Reports.* The content has been adapted to be more thesis appropriate.

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2.1. Introduction

As discussed in Chapter 1, there is good evidence to suggest that, although we engage in emotion recognition on a daily basis, individuals vary in their emotion recognition performance. In particular, previous research exploring childhood trauma reported better and faster recognition of negative expressions and poorer recognition of positive and neutral expressions – as these are misinterpreted as negative (Pollak et al., 2000; Bérubé et al., 2023). There is little exploration of the universality of the relationship between childhood trauma and emotion recognition (e.g., is the relationship still significant across various conditions?). Alongside childhood trauma, key related individual differences identified are alexithymia and psychopathy (Zlotnick et al., 2001; Craparo et al., 2013). Due to their links, by exploring them together it can help identify which individual difference explains the variance in emotion performance.

The majority of research exploring emotion recognition has primarily focused on facial expressions of emotion. Thus, research comparing performance across modalities is limited. Therefore, it is unclear whether previous findings are modality-specific (e.g., specific to facial expressions) or modality-general (e.g., universal – across both facial and vocal expressions). This may pose an issue because, as noted in Chapter 1, the literature has previously made broad claims about emotion processing generally which would suggest modality-general or universal deficits as opposed to modality-specific deficits. By measuring performance across modalities, the two conflicting emotion explanations – unimodal and multimodal – can be addressed. It can also provide information of emotion recognition in situations which are not ideal. For example, in dark environments where the facial expression is obscured or in noisy environments when the vocal expression is obscured. However, it cannot be assumed that the findings for facial expressions of emotion will be mirrored for vocal expressions.

Research comparing facial and vocal expressions of emotion in typical populations found that facial expressions are more accurately recognised than vocal expressions (Bänziger et al., 2009; Morningstar et al., 2020). A possible reason for this finding could be because faces have an emotion processing advantage, as physical facial features indicating an expression can be processed instantaneously, yet the acoustic cues in vocal expressions unfold with time (Paulmann & Pell, 2011). The literature for vocal expressions of emotion is scarce relative to face based studies and is typically explored independently to facial emotion expressions. There is also limited research using audio-visual expressions. As we express, process, and recognise audio-visual expressions in everyday conversations, emotion recognition should be investigated in this way too in order to generalise these findings to real-life interactions. Consequently, the current study investigates emotion recognition in several modalities (faces, voices, and audio-visual).

2.1.1. Childhood trauma and emotion recognition

Due to the prevalence of childhood trauma (Office for National Statistics, 2020; NSPCC, 2021), and the reported links to poorer emotion recognition abilities, it may suggest a good proportion of individuals are hindered when it comes to social interactions (Nanda et al., 2016).

A review of the literature in Chapter 1 shows conflicting findings for whether there is an association between childhood trauma and emotion recognition. A review of adult samples reported a significant association between childhood trauma and poorer recognition of happiness, but faster and more accurate recognition of anger and fear (Bérubé et al., 2023). There is further support of this pattern using a child sample (Pollak et al., 2000) and longitudinal design (Young & Widom, 2014) reporting better accuracy for angry expressions and poorer recognition of positive and neutral emotional cues. This common pattern reported for childhood trauma is supported by the social information processing mechanism (Dodge et al., 1995). A possible reason for this pattern, suggested by previous research, is a greater vigilance to threat cues (e.g., negative expressions) in the environment (McCrory et al., 2013; Hoepfel et al., 2022), leading to increased accuracy of negative expressions. On the other hand, a possible reason why happiness was poorly recognised could be because it was misinterpreted as something more malevolent, such as being mocked or laughed at rather than a smile (Pollak et al., 2000).

On the contrary, a meta-analysis (Saarinen et al., 2021) exploring childhood trauma and emotion recognition reported that childhood trauma was associated with poorer accuracy for fearful and happy facial expressions but only if exposure was within the last two years. This suggests conflicting findings regarding whether the effect of childhood trauma, if any, on emotion recognition persists into adulthood. Although, a possible reason for the discrepancy could be because 'early adversity' was explored (e.g., homelessness, victimisation/bullying, interparental conflict, as well as childhood trauma) rather than specifically childhood trauma like previous research. Another possible reason could be the differences in how they assessed childhood trauma (ranging from self-report measures to interviews, to records) and how many emotions were explored (ranging from just 1 emotion to 7 emotions). This highlights the lack of standardisation used in emotion recognition tasks and the issues it poses for comparing findings.

Although methods do vary when exploring emotion recognition accuracy, the most common procedure is the forced-choice format. This method asks participants to select which emotion is depicted from a set of response options. The main concerns are that participants can use response strategies to answer (e.g., using process of elimination rather than genuine recognition) and using one option as a "default" button if they are unsure of the expression (Russell, 1993; Nelson & Russell, 2011; Cassels & Birch, 2014). This could lead to exaggerated or inflated accuracy and impact the validity of the results (Nelson & Russel, 2011). It can also force agreement, a study reported that when the option of "surprise" was removed, participants recognised surprise as happy by 61% of observers (Frank & Stennett, 2001). Some research has suggested that free labelling responses would be best. Research in individuals with and without autism reported differing performance for free labelling compared to fixed choice format responses (Betz et al., 2019; Cassels & Birch, 2014). However, these criticisms do not invalidate this method completely and suggest that all performance is exaggerated. There are situations where the forced-choice method might be most appropriate. For example, forced-choice formats are easy for participants to grasp and understand which is essential for online studies. Although, to improve upon the forced-choice format previous research suggested to add a default option, for example, "I don't know" or "none of the above" (Frank & Stennett, 2001). To further extend this, the current study will have the basic six emotions, neutral, “I don’t know”, and “other” (which will give participants the option to free label an emotion which is not presented).

As discussed in Chapter 1, there is limited direct exploration of childhood trauma and vocal expressions of emotion. Previous research exploring women with PTSD related to childhood trauma and affective prosody (patterns in voices) reported the severity of childhood trauma was associated with poorer accuracy and slower reaction times across all expressions (Nazarov et al., 2015). Although, a key difference to be noted is that participants were selected based on a pre-existing psychopathology (PTSD) whereas this did not occur in the majority of the facial expression research described. Therefore, it makes it difficult to compare the findings due to the key difference in samples. So, it is unclear whether similar patterns in vocal expressions of emotion exist as there is currently little exploration of vocal expressions of emotion. Although, brain activation findings suggest greater activation in certain areas (amygdala and anterior insula) when viewing negative expressions (McLaughlin, 2019). This may suggest that the processing of these expressions may go beyond modality-specific performance (e.g., consistent performance regardless of whether the emotion is expressed facially or vocally). The current study aims to address this gap in knowledge by exploring both facial and vocal expressions of emotion.

As childhood trauma is associated with emotion recognition, there is reason to suspect an association with alternative measures of emotion recognition, such as intensity ratings (Book et al., 2007; Gibb et al., 2009). Further, childhood trauma is associated with heightened sensitivities, as well as needing less perceptual information, for negative expressions (McLaughlin, 2020). This may suggest that individuals with childhood trauma experience will perceive emotional expressions as more intense than individuals without childhood trauma experience. However, one of the only studies to explore this did not report a significant association between childhood trauma and intensity ratings when exploring fear and joy expressions (Neil et al., 2022). Although, the authors mention a limitation of the study was that only a subsample completed the emotion recognition task – including the intensity ratings - instead of the whole sample. Another limitation was that only one negative expression was explored. So, we are unsure if there would be an association across other emotions; in particular for anger as individuals with childhood trauma experience adapt a greater vigilance to angry expressions to help them identify threat signals which may predict the onset of abuse (Shackman et al., 2007).

Another way to explore the heightened sensitivities associated with childhood trauma is by exploring the difference in intensity ratings between normal and strong intensity expressions. If an individual was highly sensitive to changes in intensity they would perceive larger differences between normal or strong intensity expressions (e.g., perceive normal intensity expressions as less intense and strong intensity expressions as very intense). However, if an individual was insensitive to intensity differences of expressions they may perceive smaller differences between normal and strong intensity expressions (e.g., perceive normal and strong intensity expressions similarly). Previous research of this area is lacking, future research should explore childhood trauma and the individual's perception of the intensity of the expression. This would provide information on whether certain individuals are more susceptible to emotional cues across a range of intensities. For example, can individuals interpret and discriminate between a normal intensity anger expression and a strong intensity anger expressions or are both expressions perceived similarly. As we express a mixture of subtle (less intense) and more intense expressions in real-life interactions, we may identify certain aspects of social interactions which individuals struggle to interpret (e.g., mainly subtle/less intense expressions).

2.1.2. Interrelated traits of alexithymia and psychopathy

Also discussed in Chapter 1, there are strong links between childhood trauma experience and the development of alexithymia and psychopathy traits (Zlotnick et al., 2001; Craparo et al., 2013). As well as links to childhood trauma, these related traits also have links with poorer emotion recognition performance (Bowen et al., 2014; Jongen et al., 2014). However, it is unclear whether childhood trauma is still significantly associated with emotion recognition performance after controlling for these related traits, which also hinder emotion recognition. Typically, research explores them separately despite their links. This study examined these factors together to ensure that childhood trauma's unique association with emotion recognition variability is measured, rather than the related traits.

2.1.2.1. Alexithymia and emotion recognition

To reiterate from the previous chapter, alexithymia is associated with difficulties identifying and describing your own feelings (Taylor et al., 1999; Vorst & Bermond, 2001; Preece et al., 2017). When exploring alexithymia traits, those reporting high levels of traits typically report more difficulty in identifying and discriminating emotions compared to those reporting low levels of traits. Research exploring alexithymia using static facial expressions reported an association with poorer emotion recognition overall (Jongen et al., 2014) and specifically for fearful expressions (Starita et al., 2018). However, research using dynamic facial expressions reported no significant relationship between alexithymia and emotion recognition performance (Starita et al., 2018). Although, the dynamic stimuli were created using morphed static expressions, rather than using genuine dynamic expressions. This makes it difficult to generalise to real-world interactions as the stimuli are not realistic.

Similar to the facial expression findings, Lane et al. (1996) explored alexithymia and vocal expressions of emotion and reported that alexithymia was associated with poorer accuracy for verbal and nonverbal stimuli. To our knowledge there is no futher research exploring vocal expressions making it difficult to understand the effect of alexithymia across modalities. Although, studies exploring alexithymia and brain activation reported similar patterns for both facial and vocal expressions of emotion (Grynberg et al., 2012; Goerlich-Dobre et al., 2014). This may suggest the deficits are modality-general rather than modality-specific due to visuo-perceptual deficits.

Due to alexithymia's association with emotion recognition, it is possible alternative measures, such as intensity ratings, will also be affected. Alexithymia has been associated with blunted or weaker responses to emotional expressions (Goerlich-Dobre et al., 2014). This may suggest that individuals exhibiting higher levels of alexithymia traits will perceive emotional expressions as less intense than individuals exhibiting lower levels of traits. Prkachin et al. (2009) supports this and reported that alexithymia was associated with lower intensity ratings for fearful expressions. Within the current literature, there is still more research needed regarding alexithymia's effect on intensity ratings as well as for emotion performance across modalities (due to the lack of vocal expression research).

2.1.2.2. Psychopathy and emotion recognition

Also associated with childhood trauma and poorer emotion recognition is psychopathy (Craparo et al., 2013; Bowen et al., 2014). Psychopathy is associated with emotion deficits, lack of empathy, and poor behavioural control (Anderson et al., 2015). Those reporting high levels of psychopathy traits show a greater lack of empathy and more antisocial behaviour, manipulation, or hurting others than those with lower psychopathy levels (Gordts et al., 2017). Psychopathy is typically reported to have specific facial recognition deficits in fear and sadness (Dodge et al., 1995; Blair et al., 2002). Although, previous research has suggested this extends beyond these expressions; for sadness, low intensity disgust, high intensity fear, and low intensity anger (Bowen et al., 2014) as well as fear, happiness, sadness, and surprise (Dawel et al., 2012).

There is better exploration of vocal expressions in the psychopathy literature, with psychopathy being associated with poorer recognition of fearful vocal expressions (Blair et al., 2002) and poorer recognition overall when exploring audio-visual expressions (Mackenzie, 2018). However, Mackenzie (2018) may be one of the few to explore facial and vocal expressions in the same study, but it does not help us draw conclusions regarding performance across different modalities as all stimuli were audio-visual. As discussed previously (Chapter 1) an explanation for the specific deficit of fear and sadness is described by the VIM (Blair, 2001) and the low-fear hypothesis (Lykken, 1995).

Research investigating psychopathy and intensity levels is limited. Similar to alexithymia, psychopathy has been associated with blunted responses to emotional stimuli (Anderson et al., 2011) which may suggest an association between psychopathy and lower intensity ratings of emotional expressions. To our knowledge there is no direct exploration of psychopathy and intensity ratings of emotional expressions. The closest research explored the accuracy of intensity ratings (e.g., did participants recognise and rate low intensity expressions as low). There was an association between psychopathy and better accuracy of intensity ratings overall as well as specifically for fearful expressions (Book et al., 2007). Although, this may not provide information for how the current study is measuring intensity ratings. A key limitation of the psychopathy literature is that the majority of the samples are incarcerated males (Dawel et al., 2012). Therefore, it is unclear as to whether these findings can be generalised to women and community samples. As a result of this, the current study aimed to collect a mix of genders from a community sample.

2.1.3. The current study

There are two main research questions for emotion recognition accuracy, intensity ratings, and sensitivity to intensity: (1) is there still a significant association between childhood trauma and performance after controlling for alexithymia and psychopathy traits? (2) is there a significant association between childhood trauma and performance across different modalities, emotions expressed, and intensities of stimuli?

Previous emotion recognition studies typically used static facial expressions of one intensity level. Therefore, previous findings may not generalise to the current study employing moving stimuli as there are different brain activation (Kessler et al., 2011; Pitcher et al., 2014) and attention patterns (Prunty et al., 2021) between static and dynamic stimuli. This may suggest caution regarding hypotheses based on previous research.

It was hypothesised that more experience of childhood trauma would be significantly associated with poorer emotion recognition overall, in line with previous research (Pollak et al., 2000; Bérubé et al., 2023). However, due to the strong links between childhood trauma, alexithymia, and psychopathy, it is unclear whether the effects of childhood trauma on emotion recognition would still be significant when controlling for these traits.

Regarding the stimulus-based factors, it is hypothesised that the effect of childhood trauma would stay consistent across modalities due to the similar brain activation patterns across facial and vocal expressions of emotion (Grynberg et al., 2012; Goerlich-Dobre et al., 2014). This may suggest that emotion processing goes beyond modality-specific performance and will show comparable findings across modality. Also, the fact individuals with childhood trauma learn to quickly and accurately identify expressions which predict the occurrence of abuse may suggest that, regardless of whether the expression was expressed facially or vocally, individuals would learn to recognise it (Shackman et al., 2007).

For emotion expressed, it is hypothesised that the effect of childhood trauma on emotion recognition accuracy will vary across emotion expressed. This hypothesis is based on the social information processing mechanism (Dodge et al., 1995). This suggests better accuracy for negative expressions and poorer recognition of positive and neutral expressions (as they are often mislabelled as negative). It is likely that the effects will be most pronounced for anger as this expression is most likely to predict potential abuse (Shackman et al., 2007).

For intensity of stimuli, it is hypothesised that individuals with experience of childhood trauma may have better accuracy across intensities compared to individuals without childhood trauma experience. Childhood trauma has been associated with needing less perceptual information to identify expressions (McLaughlin et al., 2020) so may show better accuracy. Individuals without trauma (who possibly need more perceptual information) may show poorer accuracy for normal intensity expressions compared to strong intensity expressions, as typical populations usually report (Montirosso et al., 2010).

Regarding intensity ratings, it could be hypothesised that more experience of childhood trauma will be associated with higher intensity ratings. Similar to above, childhood trauma's heightened sensitivities to negative expressions (Dodge et al., 1995) may result in higher intensity ratings overall compared to individuals without reported childhood trauma.

However, the literature is limited. It is also unclear whether the relationship between childhood trauma and intensity ratings will be influenced by the related traits of alexithymia and psychopathy or if any interactions with the stimulus-based factors will occur. For sensitivity to intensity, there has been no exploration of this measure before so we are unsure whether there is a relationship with childhood trauma and what patterns may emerge (e.g., whether childhood trauma would show more or less sensitivity to intensity change).

Ultimately, the study explores how childhood trauma contributes to emotion performance (accuracy, intensity ratings, and sensitivity), independently of alexithymia and psychopathy traits, and whether the effect varies across different modalities, emotions expressed, or intensity level.

2.2. Methods

2.2.1. Participants

The final sample consisted of 122 participants (50 female; 71 male; 1 nonbinary, M_{age} = 28 years (18 - 64), *SD* = 9.42). Data for 144 participants was originally collected but 22 participants were excluded; 11 due to incomplete data, 10 due to their native language not being English, and 1 due to excessively fast reaction times (over 10% of trials had a reaction time of <300ms). Participants were recruited from an online participation site (Testable Minds) in exchange for 9.50 USD, and from the undergraduate psychology cohort at Brunel University London in exchange for 4 course credits. The inclusion criteria were: above 18 years old, normal or corrected-to-normal vision, no significant hearing loss that would render daily tasks and conversations difficult, and English as a first language (as the verbal intelligence quotient (IQ) test included in the test battery uses unusually spelt English words). Ethical approval was granted by the Research Ethics Committee for the College of Health, Medicine, and Life Sciences at Brunel University London.

2.2.2. Design

The experimental task variables were modality (face, voice, audio-visual), emotion expressed (happy, sad, anger, fear, disgust, surprise, neutral), and intensity level (normal, strong). The individual differences were childhood trauma, alexithymia and psychopathy. The outcome variables were emotion recognition accuracy, intensity ratings, and sensitivity to intensity (strong intensity rating – normal intensity rating). A higher sensitivity score would reflect a larger difference between intensity ratings for normal intensity and strong intensity expressions compared to a lower sensitivity score.

2.2.3. Materials

2.2.3.1. Questionnaires

Participants completed four self-report questionnaires to assess: a) childhood trauma, b) alexithymia, and c) psychopathy, d) personality.

Childhood trauma: Childhood Trauma Questionnaire Short Form (CTQ-SF)

The CTQ-SF (Bernstein et al., 2003) has 28 items each rated from 1 (never true) to 5 (very often true). Higher scores indiciate more childhood trauma experience. The subscales are emotional, physcial, and sexual abuse, emotional and physical neglect, and minimisation/denial. Some example items are “when I was growing up people in my family hit me so hard that it left me with bruises or marks”, and “when I was growing up people in my family said hurtful or insulting things to me”. Participants were asked to indicate how often they had experienced these situations growing up as a child and teenager. Participants were informed they could skip questions due to the sensitivity of the topic. The CTQ-SF has good internal consistency with high Cronbach Alpha scores across different countries and groups (Kongerslev et al., 2019). This was scored according to Bernstein et al. (1998). A multinational community sample reported an average total CTQ-SF score of 38.78 (*SD* = 14.98) (MacDonald et al., 2016). The reliability of the CTQ-SF in previous research was Cronbach’s alpha 0.852 (Peng et al., 2023) and the reliability for the current sample was Guttman’s λ_2 = .828.

Alexithymia: Toronto Alexithymia Questionnaire (TAS-20)

The TAS-20 (Bagby et al., 1994) has 20 items each rated from 1 (strongly disagree) to 5 (strongly agree). A higher score indicates a higher amount of alexithymia traits; individuals would struggle more with identifying and describing their feelings and would have an external style of thinking. The subscales are difficulty identifying feelings, difficulty describing feelings, and externally oriented thinking. Some example items are “I am able to describe my feelings easily”, “I have feelings that I cannot quite identify”, and “I prefer to analyse problems rather than just describe them”. Participants selected the option based on how accurately the statements described them. The TAS-20 has high validity, ease of use, and succinctness (Lumley et al., 2007). It was scored according to Bagby et al. (1994). A study exploring the TAS-20 in a community sample reported an average total TAS-20 score of 45.57 (*SD* = 11.35) (Parker et al., 2003). The reliability reported for the TAS-20 in previous research was Cronbach's alpha 0.81 (Parker et al., 2003) and the reliability of the TAS-20 in the current sample was Guttman's λ_2 = .803.

Psychopathy: Self Report Psychopathy Scale – Short Form (SRP-SF)

The SRP-SF (Paulhus et al., 2016) has 29 items each rated from 1 (disagree strongly) to 5 (agree strongly). A higher score would indicate a higher level of psychopathy traits; individuals are likely to show less remorse, guilt, or empathy, and more callousness and antisocial behaviour. The subscales are: interpersonal, affective, lifestyle, and antisocial items. Some example items are "I am a rebellious person", "I love violent sports and movies", and "I never feel guilty over hurting others". Participants were asked to select the option reflecting the extent the statements apply to them. The SRP-SF was chosen as it demonstrates a 'satisfactory' to 'excellent' internal consistency and test-retest reliability (Neumann & Pardini, 2014; Gordts et al., 2017). This was scored according to the Multi-Health Systems Inc. (2016). A study exploring the validity of the Self-Report Psychopathy scales and the short versions (e.g., SRP-SF) in a community sample reported an average total SRP-SF score of 52.50 (*SD* = 11.81) (Gordts et al., 2017). The reliability reported for the SRP-SF total scale in previous research was Cronbach's alpha 0.87 (Seara-Cardoso et al., 2019) and the reliability for the current sample was Guttman's λ_2 = .888.

Personality: The Mini Personality Questionnaire (Mini-IPIP)

The Mini-IPIP has 20 items each rated from 1 (very inaccurate) to 5 (very accurate). There are five subscales: openness, conscientiousness, extraversion, agreeableness, and neuroticism. A higher score in one of the subscales would indicate possession of similar personality traits. Example items include "I am the life of the party", "I have frequent mood swings" and "I like order". Participants were asked to select the option which describes the extent the statement applies to them. The reliability for the Mini-IPIP scales across five studies reported Cronbach's alpha scores well above .60 (Donnellan et al., 2006) and the reliability for the Mini-IPIP in the current sample was Guttman's λ_2 = .888. Personality was not explored as a variable in this study. As childhood trauma was the main individual difference being investigated, we wanted to include and control for interrelated traits. Childhood trauma has a strong justification for including and controlling for alexithymia and psychopathy as it is linked to the development of these traits (Zlotnick et al., 2001; Craparo et al., 2013).

However, previous research did not provide a strong enough justification for also including and controlling for personality.

The total scores from each questionnaire were standardised and used in the analyses. The total scores, instead of subscales, were used due to: 1) needing considerable power for the analyses chosen, and 2) the hypotheses do not specify subscales, it is the overall effect of the individual differences on emotion recognition accuracy that is of interest.

2.2.3.2. Intelligent Quotient Verbal task:

Wechsler Test of Adult Reading (WTAR)

The WTAR (Wechsler, 2001) is a verbal IQ test which includes fifty unusually spelt words. Examples of some of the words are “gnat”, “lugubrious”, and “insouciant”. Participants were asked to read the words out loud as they believe they are said. For the online version of the task, words were presented over two pages and participants were audio recorded as they said the words aloud. There was no time limit and scoring followed standard procedure and stopped scoring after 12 wrong pronunciations. The WTAR was chosen because it had been co-normed with the third edition of the Wechsler Adult Intelligence and Memory scales which makes it the preferred alternative to the National Adult Reading Test (Mathias et al., 2007). IQ was included to ensure all participants had an IQ score of 80 and above. Participants would have been excluded if their IQ score was categorised as “borderline” or “extremely low”.

2.2.3.3. Emotion recognition task

The stimuli were selected from the Ryerson Audio-Visual Database of Emotional Speech and Song (RAVDESS), a validated database (Livingstone & Russo et al., 2018). This database includes audio-visual clips of actors expressing the six basic emotions (happy, sad, angry, fear, surprise, disgust) at two emotional intensity levels of normal and strong, and a neutral condition, across three modalities (faces, voices, and audio-visual). A total of four identities (2 male, 2 female: actors 2, 7, 12, 15) were used in the main task. Three different identities (2 male, 1 female: actors 8, 17, 23) were used for the practice trials. The stimuli in the main task consisted of 13 videos (6 emotions at two intensity levels, plus one neutral) for each modality per actor. The stimuli were videos (the visual and audio-visual conditions) or audio clips (audio condition). The videos show the actor’s faces and the top of their shoulders with black t-shirts on a white background (Figure 3). For all stimuli the actors recited the sentence "dogs are sitting by the door", the videos ranged from 3:06 to 4:23 seconds (M = 3.65 seconds) in duration. In the face condition, participants watched a silent video of one of the actors expressing an emotional or a neutral expression. In the voice condition, no video was presented, participants listened to a voice displaying an emotional or neutral expression. In the audio-visual condition, participants saw and heard the actors displaying an emotional or neutral expression. The face and voice stimuli were isolated from the audio-visual clip. For example, the happy facial expression would be the audio-visual video but display the visual only, and the happy vocal expression would be the audio-visual video but display the audio only. Therefore, there is no potential difference in expression between the clips. There were a total of 156 trials (13 videos x 4 actors x 3 modalities; 52 trials per modality). Three practice trials preceded the main testing block (with actors not used in the main experiment). The order of the main and practice trials were randomised.

2.2.4. Procedure

The task was completed online via Qualtrics (for demographics) and Testable (main task, questionnaires, and IQ test). For programming purposes each questionnaire was paired with one condition of the emotion recognition task. The facial expression and vocal expression conditions (and their associated questionnaires) were counterbalanced. The audio-visual condition was always presented last to ensure that the extra emotion cues provided by bimodal expressions (audio and visual) did not affect recognition for the unimodal expressions (either just the audio or just the visual).

All the emotion tasks had the same procedure, response options, and screens. During the emotion tasks, each stimulus was presented in the middle of the screen along with the response options (Happy, Sad, Fear, Anger, Disgust, Surprise, None/Neutral, I don't know, and Other) displayed underneath (depicted in Figure 3). Instructions were displayed above the stimuli and differed per modality: "Which emotion is the face displaying?" (facial expression), "Which emotion is the voice expressing?" (vocal expression), and "Which emotion are they displaying?" (audio-visual expression). Participants selected their response by clicking on the appropriate response option.

If participants chose a non-emotional answer (i.e., None/Neutral or I don't know) then the next trial was initiated. If 'Other' was chosen they were given the option to free label with the instructions: "Please type what other emotion you think is being expressed in the box". If one of the basic six emotions was chosen (or after free labelling following an "Other" response), the next screen repeated the video and asked participants to provide an intensity rating. Participants provided their intensity ratings on a 1-10 continuous Likert scale (1: low intensity and 10: high intensity), and responses were provided by clicking on the bar above the number or dragging the slider to the number. On the initial response and intensity rating screens, the stimuli repeated in a loop until the participant responded, there was no time limit. Breaks were offered after each emotion task. The final slide of the main study redirected participants to an audio calibration to check their microphone was working prior to the audio recording of the WTAR task.

Figure 3

Examples of actor 2 in the face modality (left), the voice modality (right) and the response options.

2.2.5. Data analysis

Reaction times were not included in the main analyses as the dynamic emotional expressions varied in duration and onset. Certain expressions finished quickly (e.g., fear) and others took longer to complete the expression (e.g., sadness). This variation makes it difficult to accurately analyse reaction times. Also, our hypotheses were focused on emotion recognition accuracy rather than reaction times. Thus, as a result of the inappropriateness of using dynamic stimuli for reaction time, and the lack of focus and hypotheses for reaction time, it was not explored throughout the thesis. When calculating accuracy scores in the emotion recognition task, free labelled responses and responses of "I don't know" were classified as incorrect to ensure consistency with how the database labelled the emotions. Less than 1% of responses were free labelled responses and roughly 1% of all responses were "I don't know".

Generalised mixed models were performed to examine the role of childhood trauma alone, and whilst controlling for alexithymia and psychopathy traits, on emotion recognition accuracy, and whether the effect varied across modality, emotion expressed, or intensity of stimuli. As four identities were included in the study, generalised mixed models were used to analyse the data to account for any item effects. Cumulative link mixed models were performed to examine the same as above but for intensity ratings. This analysis was chosen to explore Likert responses while still including random effects. Linear mixed models were performed to examine this for sensitivity to intensity. This was chosen to examine continous responses which included random effects and accounted for item effects.

The stimulus-based variables had to have a reference group. When exploring emotion recognition, they were audio-visual for modality, neutral for emotion expressed, and normal intensity for intensity. For intensity ratings, the reference categories were the same for modality and intensity but the reference group for emotion expressed was anger. This was because neutral was not included as it is a non-emotional answer, so the intensity screen was skipped if it was chosen. Therefore, the reference category became the emotion with the highest average intensity rating, which was anger. For sensitivity ratings, the reference categories were the same as for intensity ratings. Sensitivity was calculated by subtracting the strong intensity stimuli intensity rating from the normal intensity stimuli intensity rating (e.g., if the strong fear expression intensity rating for actor 2 was 9 and the normal fear expression intensity rating was 4 then the sensitivity for the actor 2 fear expression would be 5). A higher sensitivity score would indicate a larger difference in intensity ratings between normal and strong intensity expressions and suggest more sensitive perceptions of intensity.

2.3. Results

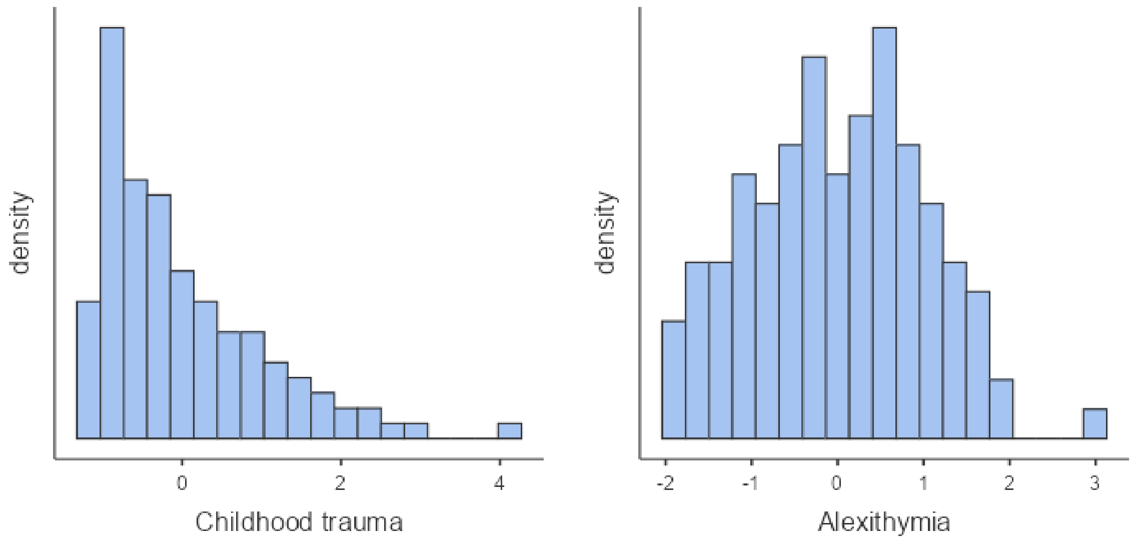
1.4.3 Emotion recognition accuracy

The distribution of different questionnaire scores are presented in Figure 4 and the average emotion recognition accuracy across the stimulus-based factors of modality, intensity, and emotion expressed are presented in Figure 5.

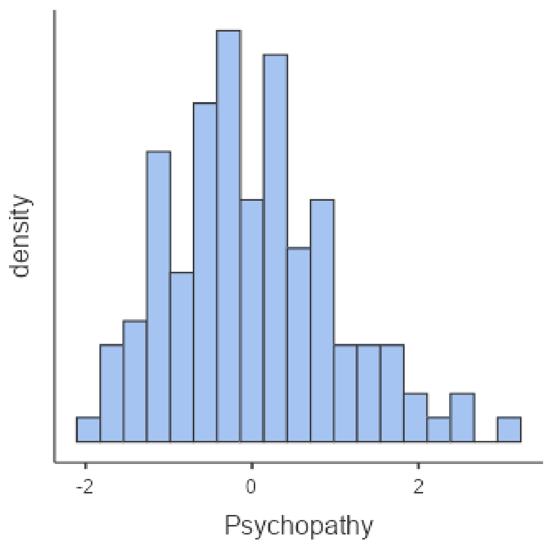
Figure 4

The distribution of (a) childhood trauma, (b) alexithymia, and (c) psychopathy in the sample.

a) b)



c)

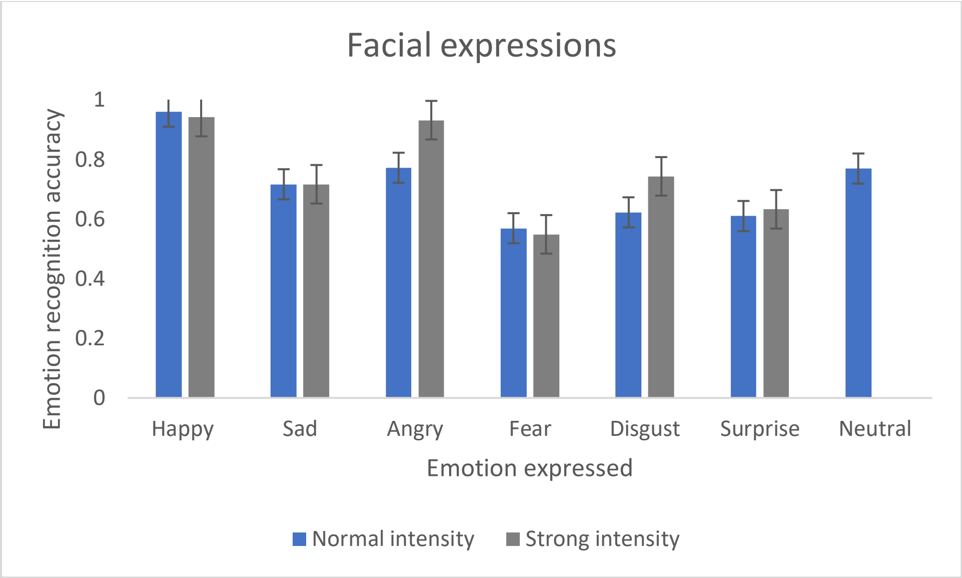


.

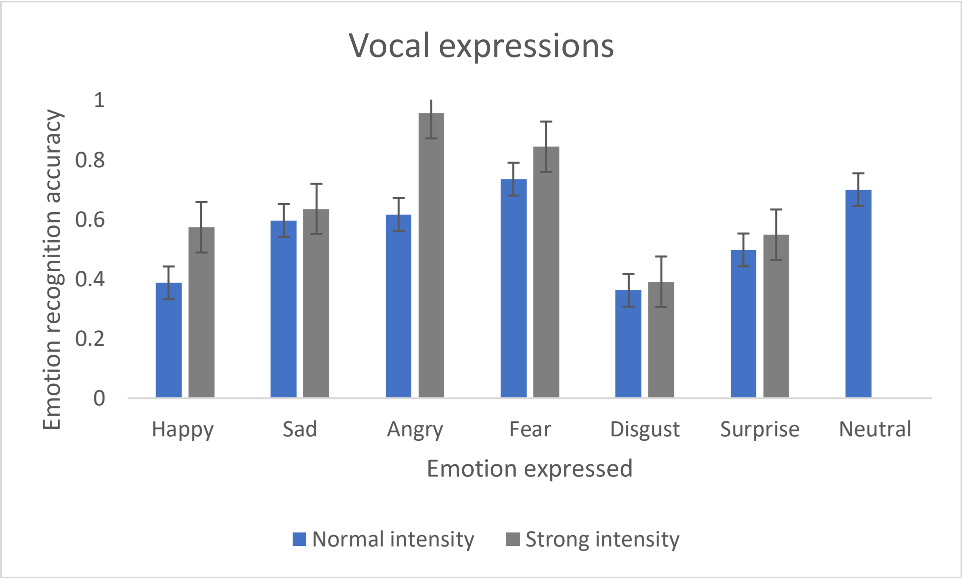
Figure 5

The average emotion recognition accuracy (proportion correct) across intensity and emotion expressed for (a) facial expressions, (b) vocal expressions, and (c) audio-visual expressions.

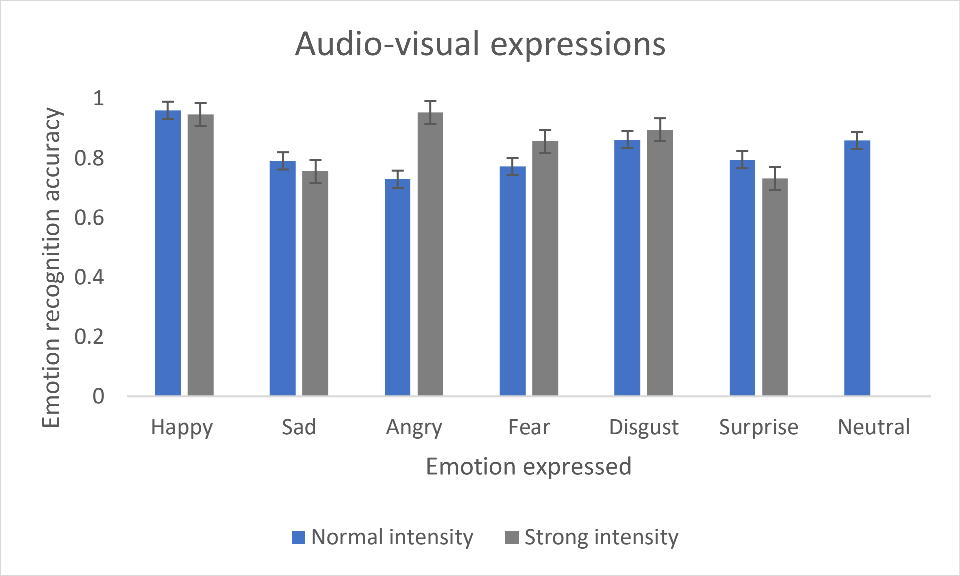
a)


Facial expressions
Emotion recognition accuracy
1
0.8
0.6
0.4
0.2
0
Happy
Sad
Angry
Fear
Disgust
Surprise
Neutral
Emotion expressed
Normal intensity
Strong intensity

b)


Vocal expressions
Emotion recognition accuracy
1
0.8
0.6
0.4
0.2
0
Happy
Sad
Angry
Fear
Disgust
Surprise
Neutral
Emotion expressed
Normal intensity
Strong intensity

c)



The descriptives for the experimental task variables and the individual differences variables are presented in Table 4.

Table 4

Descriptives table for childhood trauma, alexithymia, and psychopathy displaying the mean score, standard deviation, and range of the raw total questionnaire scores. Descriptives for modality (faces, voices, audio-visual), emotion expressed (happy, sad, anger, fear, disgust, surprise, neutral), and intensity (normal, strong) displaying the mean score, standard deviation, and range of emotion recognition accuracy (proprotion correct).

Variables	Mean score	Standard deviation	Range
Childhood trauma	42.30	14.15	75 (25 – 100)
Alexithymia	49.81	12.25	60 (25 – 85)
Psychopathy	55.90	14.65	74 (29 – 103)
Emotion Tasks			
(Response Accuracy)			
Modality:			
Faces	0.73	0.44	0.54 (0.40 – 0.94)
Voices	0.60	0.49	0.52 (0.31 – 0.83)
Audio-visual	0.84	0.37	0.60 (0.38 – 0.98)
Emotion:			
Happy	0.80	0.40	0.67 (0.33 – 1.00)
Sad	0.70	0.46	0.83 (0.17 – 1.00)
Anger	0.83	0.38	0.79 (0.21 – 1.00)
Fear	0.72	0.45	0.87 (0.13 – 1.00)
Disgust	0.65	0.48	0.71 (0.25 – 0.96)
Surprise	0.63	0.48	0.71 (0.21 – 0.92)
Neutral	0.77	0.42	0.83 (0.17 – 1.00)
Intensity:			
Normal	0.70	0.46	0.46 (0.43 – 0.89)
Strong	0.75	0.43	0.52(0.42 – 0.94)

2.3.1.1. Is childhood trauma alone associated with emotion recognition accuracy?

For all models, the random effects were participant and actor.

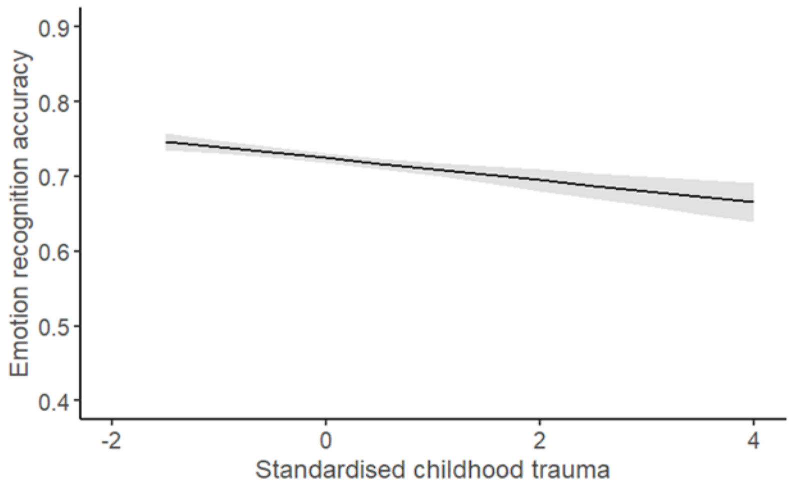
Does the relationship vary across modality?

A generalised mixed model was employed to explore the effect of childhood trauma on emotion recognition accuracy. The fixed factors were childhood trauma and modality. The fixed factors had a significant main effect of childhood trauma, X^2 (1) = 4.33, p = .038, β = −0.09, exp(B) = 0.92, and modality, X^2 (2) = 121.67, p < .001, with β = −0.71 and exp(B) = 0.49 for faces and β = −1.35 and exp(B) = 0.26 for voices compared to audio-visual. These are small effect sizes according to Chen et al. (2010), who suggested an odds ratio (in this case exp(B)) below 1.68 was small. Higher scores on the CTQ, indicating more childhood trauma experience, was associated with poorer accuracy, z = - 2.08, p = .038 (Figure 6).

Accuracy was significantly better for audio-visual expressions compared to facial expressions, z = - 9.49, $p < .001$, and vocal expressions, z = 5.98, $p < .001$. An additional analysis showed significant differences between facial expressions and vocal expressions, with significantly better accuracy for facial expressions, t (121) = 16.01, $p < .001$. There was not a significant interaction between childhood trauma and modality, X^2 (2) = 2.79, $p = .248$, with β = 0.08 and exp(B) = 1.09 for childhood trauma * faces – audio-visual and β = 0.06 and exp(B) = 1.06 for childhood trauma * voices – audio-visual. This suggests the effect of childhood trauma did not vary significantly across modalities.

Figure 6

The average emotion recognition accuracy (proportion correct) for the standardised total score of childhood trauma (derived from the CTQ-SF). The shaded area represents the 95% confidence interval.



Does the relationship vary across emotion expressed?

A generalised mixed model was employed to explore the effect of childhood trauma on emotion recognition accuracy. The fixed factors were childhood trauma and emotion expressed. The fixed factors had a significant main effect of childhood trauma, X^2 (1) = 5.71, $p = .017$, β = −0.10, exp(B) = 0.90, and emotion expressed, X^2 (6) = 83.87, $p < .001$. The only significant emotion expressed was Fear (Fear – Neutral) with β = −0.52 and exp(B) = 0.60. More experience of childhood trauma was associated with poorer emotion recognition accuracy overall, z = -2.39, $p = .017$. There was only a significant difference in accuracy for fear expressions compared to neutral expressions, with fear expressions having significantly poorer accuracy, z = -2.73, $p = .006$. There was not a significant interaction between childhood trauma and emotion expressed overall, X^2 (6) = 3.99, p = .678, or between any of the specific emotions. This suggests the effect of childhood trauma did not vary significantly across emotions.

Does the relationship vary across intensity?

A generalised mixed model was employed to explore the effect of childhood trauma on emotion recognition accuracy. The fixed factors were childhood trauma and intensity of stimuli. The fixed factors had a significant main effect of childhood trauma, X^2 (1) = 4.02, p = .045. β = −0.08, exp(B) = 0.92. There was not a significant main effect of intensity, X^2 (1) = 2.35, p = .125, β = 0.34, exp(B) = 1.40. More experience of childhood trauma experience was associated with poorer emotion recognition accuracy, z = - 2.00, p = .045. However, emotion recognition accuracy was comparable whether the stimuli were normal or strong intensity, z = 1.53, p = .125. There was not a significant interaction between childhood trauma and intensity, X^2 (1) = 0.00, p = .967, β = −0.00, exp(B) = 1.00. This suggests the effect of childhood trauma did not vary significantly depending on whether the stimuli were normal or strong intensity.

2.3.1.2. Is childhood trauma associated with emotion recognition accuracy when controlling for alexithymia and psychopathy traits?

For all models, the random effects were participant and actor.

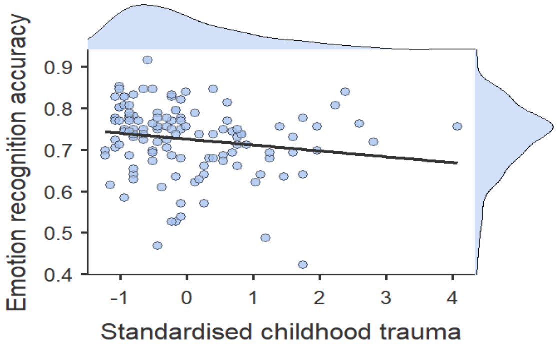
Does the relationship vary across modality?

A generalised mixed model was employed to explore the effect of childhood trauma on emotion recognition accuracy. The fixed factors were childhood trauma and modality and the covariates were alexithymia and psychopathy. After controlling for alexithymia and psychopathy, childhood trauma was no longer significant, X^2 (1) = 2.96, p = .085 (Figure 7). Also not significant were alexithymia, X^2 (1) = 3.81, p = .051, and psychopathy, X^2 (1) = 2.10, p = .148 (Figure 7). However, modality was still significant, X^2 (2) = 121.32, p < .001, with significantly better accuracy for audio-visual emotions compared to facial and vocal emotions. There was no significant interaction between childhood trauma and modality. This suggests the effect of childhood trauma did not vary significantly across the three modalities (Figure 8). Fixed effects parameter estimates are presented in Table 5.

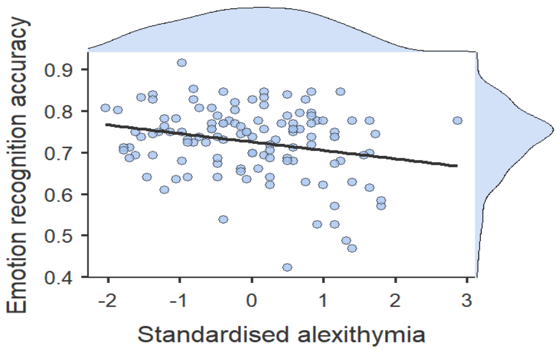
Figure 7

Plots showing the average emotion recognition accuracy for the standardised total scores of (a) childhood trauma (derived from the CTQ-SF), (b) alexithymia (derived from the TAS-20), and (c) psychopathy (derived from the SRP-SF): higher scores indicating more experience of childhood and a higher level of traits of alexithymia and psychopathy.

a)



b)



c)

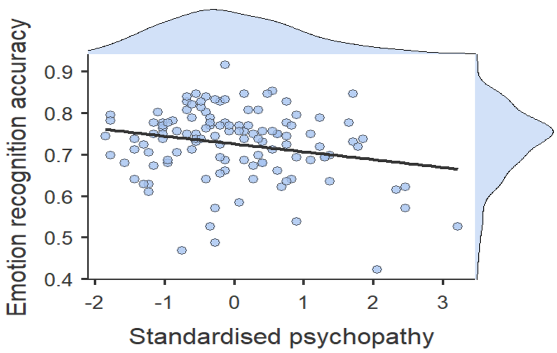


Table 5

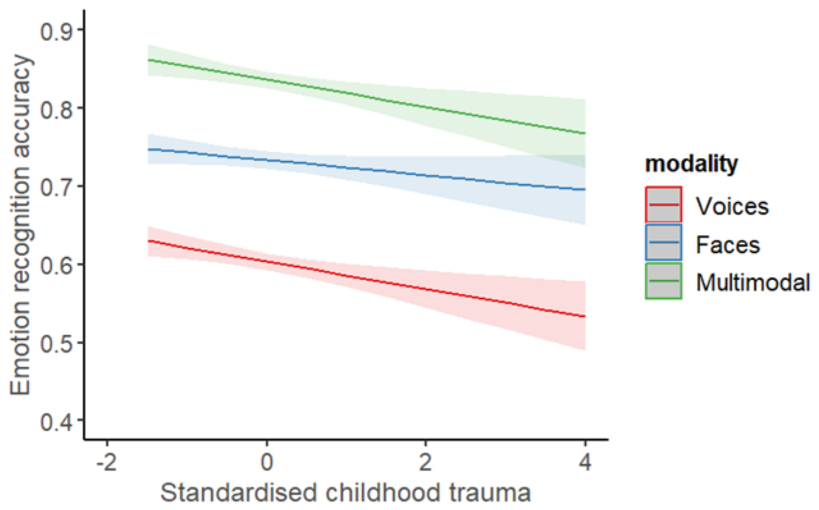
The Fixed Effects Parameter Estimates table for emotion recognition accuracy for childhood trauma, modality, alexithymia, and psychopathy.

Fixed effects	Estimate	Standard Error	exp(B)	95% CI (lower, upper)		z	*p*
Intercept	1.10	0.15	3.01	2.26	4.00	7.57	**< .001***
Childhood trauma	-0.07	0.04	0.93	0.86	1.01	-1.72	.085
Faces (Faces – Audio-visual)	-0.71	0.07	0.49	0.42	0.57	-9.48	**< .001***
Voices (Voices – Audio-visual)	-1.35	0.23	0.26	0.17	0.40	-5.98	**< .001***
Alexithymia	-0.07	0.04	0.93	0.86	1.00	-1.95	.051
Psychopathy	-0.06	0.04	0.95	0.88	1.02	-1.45	.148
Childhood trauma * Faces	0.08	0.05	1.09	0.99	1.20	1.67	.096
Childhood trauma * Voices	0.06	0.05	1.06	0.96	1.17	1.15	.248

*** represents significant values (*p* < .05)**

Figure 8

Average emotion recognition accuracy of the standardised total score for childhood trauma (derived from the CTQ-SF), when controlling for alexithymia and psychopathy traits, across modalities. The shaded area represents the 95% confidence interval.



Does the relationship vary across emotion expressed?

A generalised mixed model was employed to explore the effect of childhood trauma on emotion recognition accuracy. The fixed factors were childhood trauma and emotion expressed and the covariates were alexithymia and psychopathy. After controlling for alexithymia and psychopathy, childhood trauma was still significant, X^2 (1) = 4.27, p = .039. There was also a significant main effect of emotion expressed, X^2 (6) = 85.12, p < .001. There was not a significant effect of alexithymia, X^2 (1) = 1.44, p = .230, or psychopathy, X^2 (1) = 1.33, p = .249. There was not a significant interaction between childhood trauma and emotion expressed, X^2 (6) = 3.99, p = .678. This suggests the effect of childhood trauma did not vary significantly across which emotion was expressed (Figure 9). Fixed effects parameter estimates are presented in Table 6.

Figure 9

Average emotion recognition accuracy of a standardised total score for childhood trauma (derived from the CTQ-SF), when controlling for alexithymia and psychopathy traits, across emotion expressed.

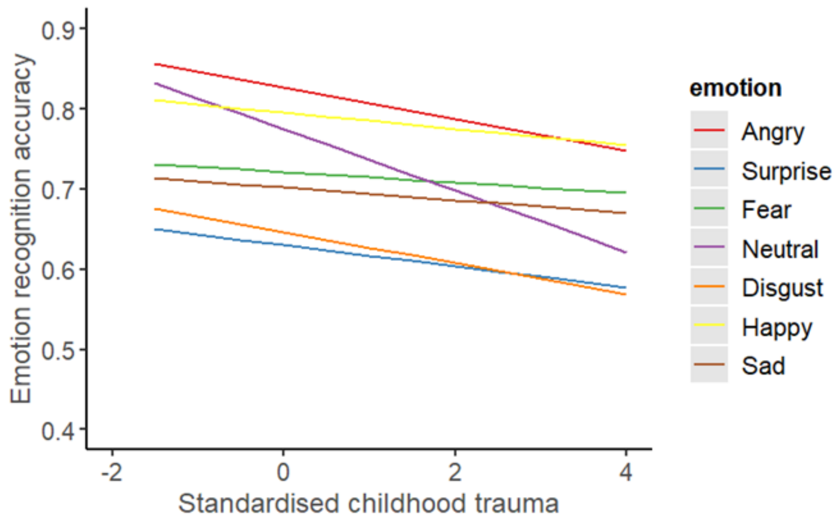


Table 6

The Fixed Effects Parameter Estimates table for emotion recognition accuracy for childhood trauma, emotion expressed, alexithymia, and psychopathy.

Fixed effects	**Estimate**	**Standard Error**	**exp(B)**	**95% CI (lower, upper)**		**z**	***p***
Intercept	1.21	0.12	3.37	2.66	4.26	10.09	**<.001***
Childhood trauma	-0.09	0.04	0.91	0.84	1.00	-2.07	**.039***
Happy (Happy – Neutral)	-0.13	0.17	0.88	0.63	1.24	-0.73	.465
Sad (Sad – Neutral)	-0.55	0.39	0.58	0.27	1.25	-1.39	.164
Angry (Angry – Neutral)	0.40	0.64	1.50	0.43	5.27	0.63	.528
Fear (Fear – Neutral)	-0.52	0.19	0.60	0.41	0.86	-2.76	**.006***
Disgust (Disgust – Neutral)	-0.89	0.61	0.41	0.13	1.35	-1.46	.143
Surprise (Surprise – Neutral)	-0.93	0.66	0.39	0.11	1.43	-1.41	.157
Alexithymia	-0.06	0.05	0.95	0.86	1.04	-1.20	.230
Psychopathy	-0.06	0.05	0.95	0.86	1.04	-1.15	.249
Childhood trauma * Happy	0.18	0.14	1.20	0.91	1.59	1.29	.197
Childhood trauma * Sad	0.19	0.15	1.21	0.90	1.63	1.26	.206
Childhood trauma * Angry	0.09	0.15	1.10	0.81	1.48	0.61	.545
Childhood trauma * Fear	0.22	0.14	1.24	0.94	1.64	1.53	.125
Childhood trauma * Disgust	0.14	0.13	1.15	0.89	1.50	1.07	.283
Childhood trauma * Surprise	0.17	0.14	1.19	0.91	1.55	1.24	.215

*** represents significant values (*p* < .05)**

Does the relationship vary across intensity?

A generalised mixed model was employed to explore the effect of childhood trauma on emotion recognition accuracy. The fixed factors were childhood trauma and intensity and the covariates were alexithymia and psychopathy. After controlling for alexithymia and psychopathy, childhood trauma was no longer significant, X^2 (1) = 2.56, *p* = .110. Intensity was not significant, X^2 (1) = 2.35, *p* = .125, and neither was psychopathy, X^2 (1) = 2.06, *p* = .151. However, alexithymia was significant, X^2 (1) = 4.19, *p* = .041 (Figure 10). There was not a significant interaction between childhood trauma and intensity, X^2 (1) = 0.00, *p* = .969. This suggests the effect of childhood trauma did not vary significantly depending on whether the stimuli were normal or strong intensity (Figure 11). Fixed effects parameter estimates are presented in Table 7.

Figure 10

The average emotion recognition accuracy for the standardised total score of alexithymia (derived from the TAS-20). The shaded area represents the 95% confidence interval.

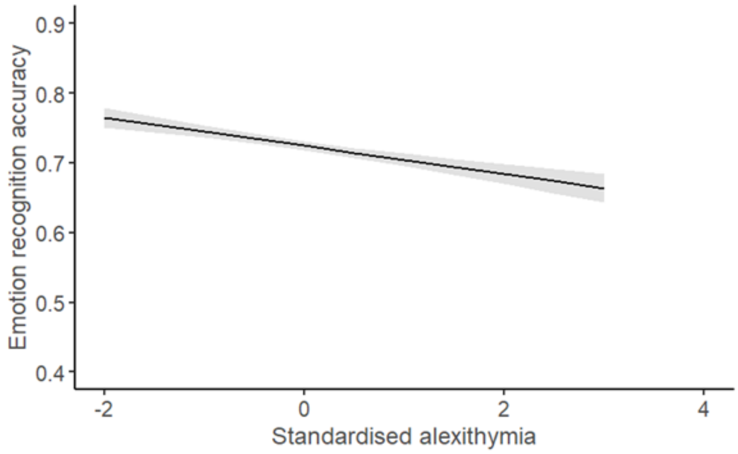


Table 7

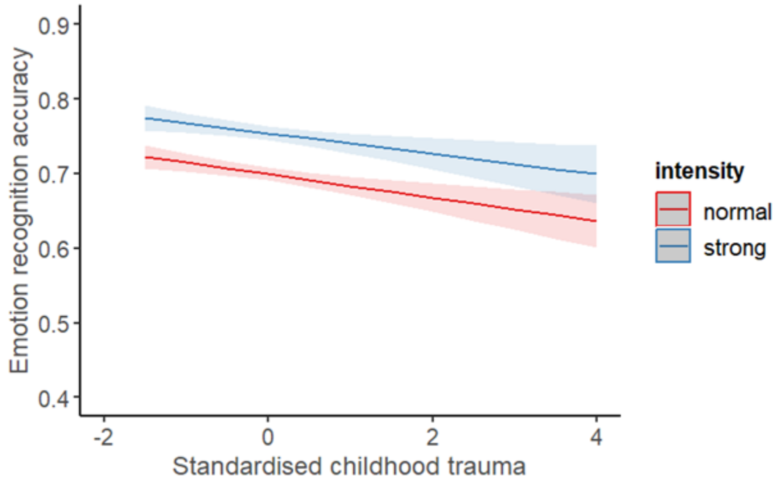
The Fixed Effects Parameter Estimates table for emotion recognition accuracy for childhood trauma, intensity, alexithymia, and psychopathy.

Fixed effects	**Estimate**	**Standard Error**	**exp(B)**	**95% CI (lower, upper)**		**z**	***p***
Intercept	1.04	0.14	2.84	2.17	3.71	7.58	**<.001***
Childhood trauma	-0.06	0.04	0.94	0.87	1.01	-1.60	.110
Intensity (Strong – Normal)	0.34	0.22	1.40	0.91	2.16	1.53	.125
Alexithymia	-0.08	0.04	0.92	0.86	1.00	-2.05	**.041***
Psychopathy	-0.06	0.04	0.95	0.88	1.02	-1.44	.151
Childhood trauma * Intensity	-0.00	0.03	1.00	0.93	1.07	-0.04	.969

*** represents significant values (*p* < .05)**

Figure 11

Average emotion recognition accuracy of a standardised total score for childhood trauma (derived from the CTQ-SF), when controlling for alexithymia and psychopathy traits, across intensity. The shaded area represents the 95% confidence interval.



Linear regressions were also conducted to rule out any of the emotion recognition findings being due to any psychopathology (current or past diagnoses), IQ, age, or sex. Additional linear regressions were run to explore whether there was a significant relationship between childhood trauma and psychopathology, IQ, age, or sex. All analyses reported no significant relationship between emotion recognition accuracy or childhood trauma with psychopathology, IQ, age, or sex.

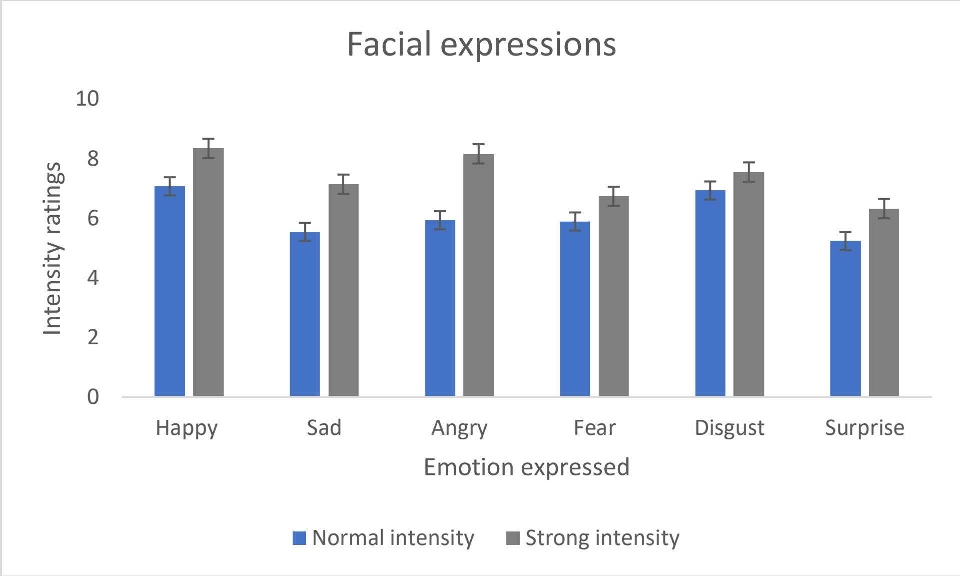
2.4.3 Intensity ratings

The average intensity ratings across the stimulus-based factors of modality, intensity, and emotion expressed are presented in Figure 12.

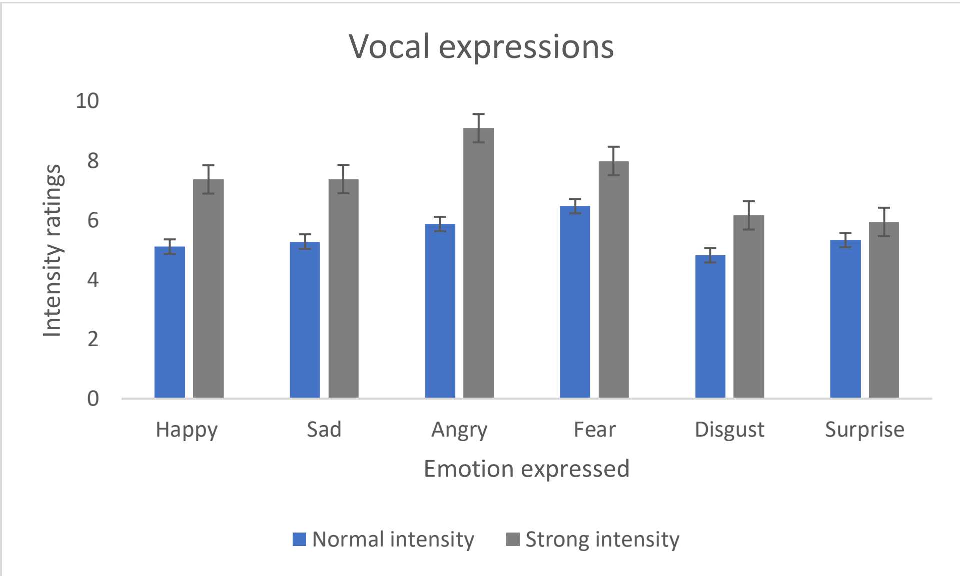
Figure 12

The average intensity ratings across intensity and emotion expressed for (a) facial expressions, (b) vocal expressions, and (c) audio-visual expressions.

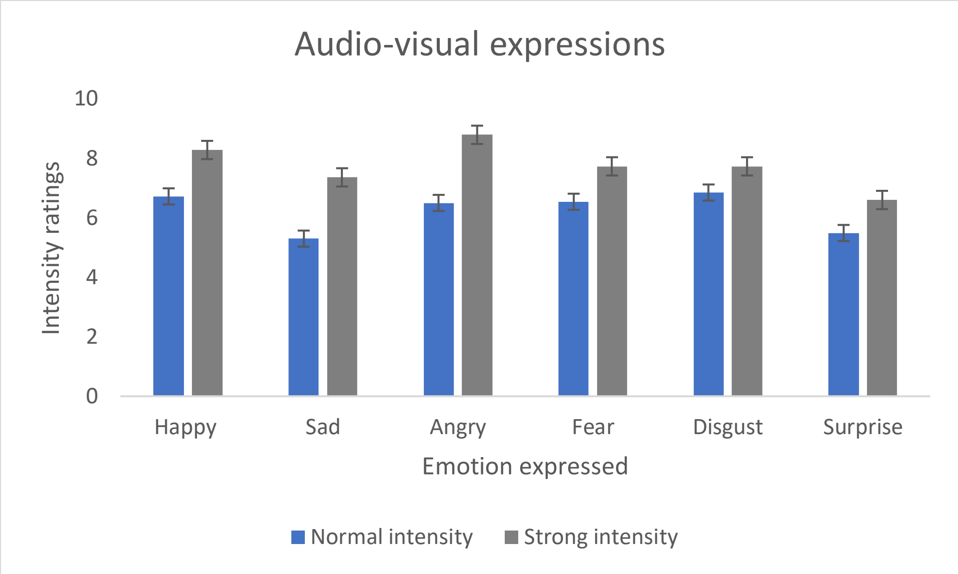
a)


Facial expressions
10
8
6
4
2
0
Intensity ratings
Happy
Sad
Angry
Fear
Disgust
Surprise
Emotion expressed
Normal intensity
Strong intensity

b)


Vocal expressions
10
8
6
4
2
0
Intensity ratings
Happy
Sad
Angry
Fear
Disgust
Surprise
Emotion expressed
Normal intensity
Strong intensity

c)



The descriptives for the experimental task variables and the individual differences variables are presented in Table 8.

Table 8

Descriptives table for modality (faces, voices, audio-visual), emotion expressed (happy, sad, anger, fear, disgust, surprise, neutral), and intensity (normal, strong) displaying the mean and standard deviation of intensity ratings. All emotion task ranges were 10 (0 – 10) (except anger, disgust, and surprise which were 9 (1 – 10)).

Variables	Mean score	Standard deviation
Emotion Tasks (Intensity rating)		
Modality:		
Faces	6.78	2.29
Voices	6.57	2.42
Audio-visual	7.02	2.19
Emotion:		
Happy	7.32	2.17
Sad	6.42	2.42
Anger	7.42	2.30
Fear	6.90	2.13
Disgust	6.78	2.16
Surprise	5.85	2.28

Intensity:		
Normal	6.02	2.26
Strong	7.50	2.11

2.3.2.1. Is childhood trauma alone associated with intensity ratings?

For all models, the random effects were participant and actor.

Does the relationship vary across modality?

A cumulative link mixed model was employed to explore the effect of childhood trauma on intensity ratings, across modality. There was not a significant effect of childhood trauma on intensity ratings (Figure 13), but there was a significant effect of modality (Table 6). Intensity ratings were significantly higher for audio-visual emotions compared to facial and vocal expressions of emotion. There was not a significant interaction between childhood trauma and modality. This suggests the effect of childhood trauma on intensity ratings stayed consisent across modalities.

Table 6

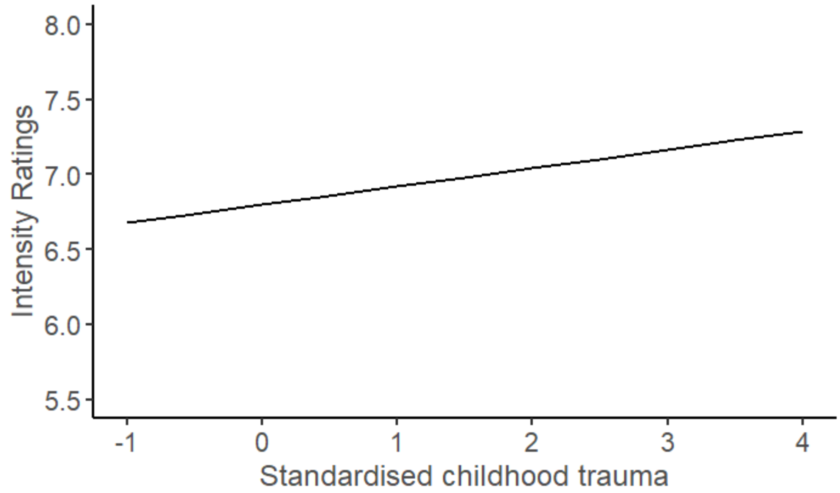
The fixed effects and threshold coefficients are presented for intensity ratings for childhood trauma and modality.

	B	**Standard Error**	**exp(B)**	**z**	***p***
Childhood trauma	0.17	0.11	1.19	1.58	.113
Faces (Faces – Audio-visual)	-0.22	0.06	0.80	-3.65	**< .001***
Voices (Voices – Audio-visual)	-0.40	0.07	0.67	-5.43	**< .001***
Childhood trauma * Faces	-0.04	0.05	0.96	-0.74	.462
Childhood trauma * Voices	-0.07	0.07	0.93	-1.00	.315
Threshold coefficients:					
1|2	-5.02	0.13	0.01	-38.30	
2|3	-3.62	0.12	0.03	-31.06	
3|4	-2.74	0.11	0.06	-24.22	
4|5	-2.02	0.11	0.13	-18.08	
5|6	-1.39	0.11	0.25	-12.48	
6|7	-0.64	0.11	0.53	-5.78	
7|8	0.16	0.11	1.17	1.43	
8|9	1.09	0.11	2.97	9.79	
9|10	2.08	0.11	8.00	18.51	

*** represents significant values ($p < .05$)**

Figure 13

The average intensity ratings for the standardised total score of childhood trauma (derived from the CTQ-SF).



Does the relationship vary across emotion expressed?

A cumulative link mixed model was employed to explore the effect of childhood trauma on intensity ratings, across emotion expressed. There was not a significant effect of childhood trauma on intensity ratings, but there was a significant effect of emotion expressed (Table 7). Intensity ratings were significantly lower for all emotional expressions compared to anger, except for happy expressions. There was only one significant interaction between childhood trauma and sad (Sad – Anger). As reported childhood trauma increased as did the intensity ratings for sad expressions. There were no other significant interactions reported. The lack of significance for other emotions suggest childhood trauma's effect is somewhat consistent across those expressions.

Table 7

The fixed effects and threshold coefficients are presented for intensity ratings for childhood trauma and emotion expressed.

	B	Standard Error	exp(B)	z	*p*
Childhood trauma	0.06	0.10	1.06	0.61	.540
Happy (Happy – Anger)	-0.11	0.08	0.90	-1.39	.165
Sad (Sad – Anger)	-0.98	0.09	0.38	-10.64	**< .001***
Fear (Fear – Anger)	-0.57	0.07	0.57	-8.00	**< .001***
Disgust (Disgust – Anger)	-0.62	0.10	0.54	-6.44	**< .001***
Surprise (Surprise – Anger)	-1.44	0.09	0.24	-15.16	**< .001***
Childhood trauma * Happy	0.05	0.07	1.05	0.61	.540
Childhood trauma * Sad	0.16	0.06	1.17	2.62	**.009***
Childhood trauma * Fear	0.09	0.05	1.09	1.78	.075
Childhood trauma * Disgust	0.04	0.05	1.04	0.82	.415
Childhood trauma * Surprise	0.11	0.07	1.12	1.48	.138
Threshold coefficients:					
1|2	-5.48	0.14	0.00	-38.64	
2|3	-4.06	0.13	0.02	-31.68	
3|4	-3.17	0.13	0.04	-25.33	
4|5	-2.43	0.12	0.09	-19.62	
5|6	-1.78	0.12	0.17	-14.41	
6|7	-1.00	0.12	0.37	-8.18	
7|8	-0.18	0.12	0.84	-1.45	
8|9	0.78	0.12	2.18	6.35	
9|10	1.80	0.12	6.05	14.55	

*** represents significant values (*p* < .05)**

Does the relationship vary across intensity?

A cumulative link mixed model was employed to explore the effect of childhood trauma on intensity ratings, across intensity of stimuli. There was not a significant effect of childhood trauma on intensity ratings, but there was a significant effect of emotion expressed (Table 8). Intensity ratings were significantly higher for stronger intensity expressions compared to normal intensity expressions. There was not a significant interaction between childhood trauma and intensity of stimuli. This suggests the effect of childhood trauma stayed consistent regardless of whether the stimuli were normal or strong intensity.

Table 8

The fixed effects and threshold coefficients are presented for intensity ratings for childhood trauma and intensity of stimuli.

	B	**Standard Error**	**exp(B)**	**z**	***p***
Childhood trauma	0.19	0.11	1.21	1.64	.101
Intensity (normal – strong)	1.43	0.06	4.18	24.87	**< .001***
Childhood trauma * Intensity	-0.08	0.07	0.92	-1.47	.143
Threshold coefficients:					
1|2	-4.33	0.14	0.01	-31.98	
2|3	-2.90	0.12	0.06	-23.91	
3|4	-1.99	0.12	0.14	-16.88	
4|5	-1.24	0.12	0.29	-10.56	
5|6	-0.56	0.12	0.57	-4.77	
6|7	0.25	0.12	1.28	2.18	
7|8	1.12	0.12	3.06	9.59	
8|9	2.13	0.12	8.41	18.07	
9|10	3.19	0.12	24.29	26.70	

*** represents significant values (p < .05)**

2.3.2.2. Is childhood trauma associated with intensity ratings when controlling for alexithymia and psychopathy traits?

For all models, the random effects were participant and actor.

Does the relationship vary across modality?

A cumulative link mixed model was employed to explore the effect of childhood trauma on intensity ratings, across modality, with the covariates of alexithymia and psychopathy traits. When controlling for alexithymia and psychopathy traits, childhood trauma was not significant. There was also not a significant effect of alexithymia or psychopathy. However, there was a significant effect of modality, with significantly higher intensity ratings for audio-visual emotions compared to facial and vocal expressions of emotion (Table 9). There was a significant interaction, Childhood trauma * Voices (Voices – Audio-visual) (Figure 14). This suggested that individuals with more reported experience of childhood trauma gave significantly higher intensity ratings for audio-visual emotions compared to vocal expressions than individuals reporting less childhood trauma experience. There was no significant interaction reported for childhood trauma and faces compared to audio-visual expressions.

Table 9

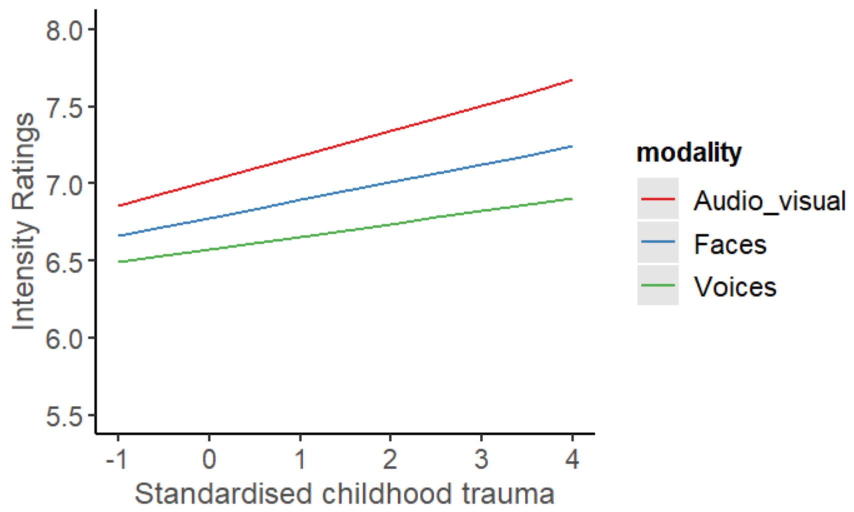
The fixed effects and threshold coefficients are presented for intensity ratings for childhood trauma, modality, alexithymia, and psychopathy.

	B	**Standard Error**	**exp(B)**	**z**	***p***
Childhood trauma	0.18	0.10	1.20	1.81	.071
Alexithymia	-0.10	0.10	0.90	-0.93	.350
Psychopathy	-0.01	0.10	0.99	-0.13	.895
Faces (Faces – Audio-visual)	-0.21	0.03	0.81	-6.28	< **.001***
Voices (Voices – Audio-visual)	-0.39	0.04	0.68	-10.99	< **.001***
Childhood trauma * Faces	-0.04	0.03	0.96	-1.12	.264
Childhood trauma * Voices	-0.07	0.03	0.93	-2.18	**.030***
Threshold coefficients:					
1|2	-4.87	0.12	0.01	-39.56	
2|3	-3.48	0.11	0.03	-32.33	
3|4	-2.62	0.10	0.07	-25.12	
4|5	-1.91	0.10	0.15	-18.58	
5|6	-1.29	0.10	0.28	-12.60	
6|7	-0.55	0.10	0.58	-5.43	
7|8	0.23	0.10	1.26	2.26	
8|9	1.14	0.10	3.13	11.18	
9|10	2.12	0.10	8.33	20.46	

*** represents significant values (p < .05)**

Figure 14

Average intensity ratings of the standardised total score for childhood trauma (derived from the CTQ-SF), when controlling for alexithymia and psychopathy traits, across modalities.



Does the relationship vary across emotion expressed?

A cumulative link mixed model was employed to explore the effect of childhood trauma on intensity ratings, across emotion expressed, with the covariates of alexithymia and psychopathy traits. When controlling for alexithymia and psychopathy traits, childhood trauma was not significant. There was also not a significant effect of alexithymia or psychopathy. However, there was a significant effect of emotion expressed (Table 10). Intensity ratings were significantly lower for all emotional expressions compared to anger, except for happy expressions. There was only one significant interaction between childhood trauma and sad (Sad – Anger). As reported childhood trauma increased as did the intensity ratings for sad expressions. There were no other significant interactions reported. The lack of significance for other emotions suggest childhood trauma's effect is somewhat consistent across those expressions (Figure 15).

Table 10

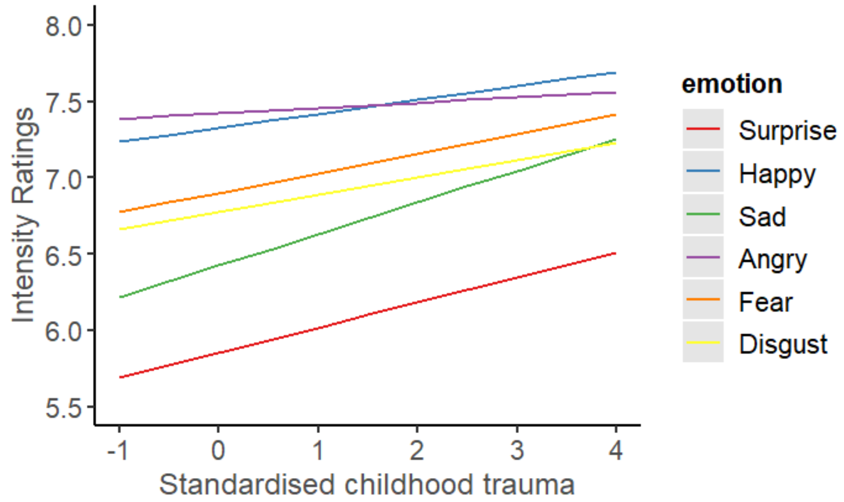
The fixed effects and threshold coefficients are presented for intensity ratings for childhood trauma, emotion expressed, alexithymia, and psychopathy.

	B	Standard Error	exp(B)	z	*p*
Childhood trauma	0.08	0.10	1.08	0.79	.431
Alexithymia	-0.15	0.10	0.86	-1.41	.160
Psychopathy	-0.04	0.10	0.96	-0.39	.695
Happy (Happy – Anger)	-0.13	0.08	0.88	-1.71	.086
Sad (Sad – Anger)	-1.01	0.09	0.36	-11.76	< **.001***
Fear (Fear – Anger)	-0.59	0.07	0.55	-8.92	< **.001***
Disgust (Disgust – Anger)	-0.65	0.09	0.52	-7.40	< **.001***
Surprise (Surprise – Anger)	-1.46	0.09	0.23	-16.29	< **.001***
Childhood trauma * Happy	0.05	0.07	1.05	0.80	.425
Childhood trauma * Sad	0.16	0.06	1.17	2.64	**.008***
Childhood trauma * Fear	0.09	0.05	1.09	1.77	.077
Childhood trauma * Disgust	0.04	0.05	1.04	0.85	.397
Childhood trauma * Surprise	0.11	0.07	1.12	1.49	.137
Threshold coefficients:					
1|2	-5.55	0.14	0.00	-40.41	
2|3	-4.13	0.12	0.02	-33.51	
3|4	-3.23	0.12	0.04	-26.96	
4|5	-2.49	0.12	0.08	-21.02	
5|6	-1.84	0.12	0.16	-15.57	
6|7	-1.06	0.12	0.35	-9.06	
7|8	-0.24	0.12	0.79	-2.03	
8|9	0.72	0.12	2.05	6.15	
9|10	1.74	0.12	5.70	14.75	

*** represents significant values (p < .05)**

Figure 15

Average intensity ratings of a standardised total score for childhood trauma (derived from the CTQ-SF), when controlling for alexithymia and psychopathy traits, across emotion expressed.



Does the relationship vary across intensity?

A cumulative link mixed model was employed to explore the effect of childhood trauma on intensity ratings, across intensity of stimuli, with the covariates of alexithymia and psychopathy traits. When controlling for alexithymia and psychopathy traits, childhood trauma was not significant. There was also not a significant effect of alexithymia or psychopathy. However, there was a significant effect of intensity (Table 11). Intensity ratings were significantly higher for stronger intensity expressions compared to normal intensity expressions. There was not a significant interaction between childhood trauma and intensity of stimuli (Figure 16). This suggests the effect of childhood trauma stayed consistent regardless of whether the stimuli were normal or strong intensity.

Table 11

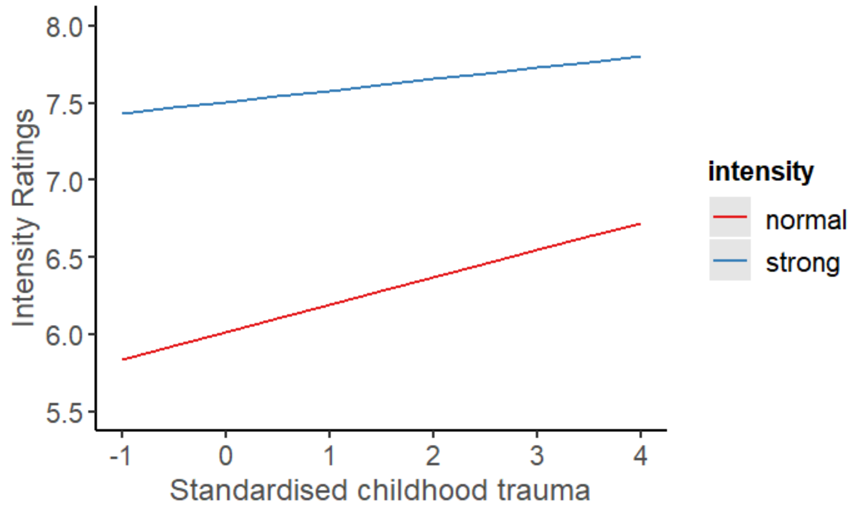
The fixed effects and threshold coefficients are presented for intensity ratings for childhood trauma, intensity of stimuli, alexithymia, and psychopathy.

	B	**Standard Error**	**exp(B)**	**z**	***p***
Childhood trauma	0.20	0.12	1.22	1.73	.084
Alexithymia	-0.12	0.11	0.89	-1.07	.284
Psychopathy	-0.03	1.1	0.97	-0.26	.795
Intensity (normal – strong)	1.42	0.06	4.14	-24.81	< **.001***
Childhood trauma * Intensity	-0.08	0.06	0.92	-1.47	.142
Threshold coefficients:					
1|2	-4.34	0.13	0.01	-38.30	
2|3	-2.91	0.12	0.05	-31.06	
3|4	-2.01	0.11	0.13	-24.22	
4|5	-1.25	0.11	0.29	-18.08	
5|6	-0.57	0.11	0.57	-12.48	
6|7	0.24	0.11	1.27	-5.78	
7|8	1.11	0.11	3.03	1.43	
8|9	2.11	0.11	8.25	9.79	
9|10	3.17	0.11	23.81	18.51	

*** represents significant values (p < .05)**

Figure 16

Average intensity ratings of a standardised total score for childhood trauma (derived from the CTQ-SF), when controlling for alexithymia and psychopathy traits, across intensity of stimuli.



3.4.3 Sensitivity to intensity

The descriptives for the experimental task variables and the individual differences variables are presented in Table 9.

Table 9

Descriptives table for modality (faces, voices, audio-visual) and emotion expressed (happy, sad, anger, fear, disgust, surprise) displaying the mean, standard deviation, and range of sensitivity.

Variables	Mean score	Standard deviation	Range
Emotion Tasks (Sensitivity)			
Modality:			
Faces	1.34	2.25	17 (-8 – 9)
Voices	2.01	2.48	18 (-9 – 9)
Audio-visual	1.54	2.07	16 (-7 – 9)
Emotion:			
Happy	1.69	2.04	14 (-6 - 8)
Sad	2.05	2.37	18 (-9 – 9)
Anger	2.62	2.09	16 (-7 – 9)
Fear	1.19	2.41	16 (-8 – 8)
Disgust	0.90	2.15	16 (-7 – 9)
Surprise	1.11	2.01	14 (-6 – 8)

2.3.3.1. Is childhood trauma alone associated with sensitivity?

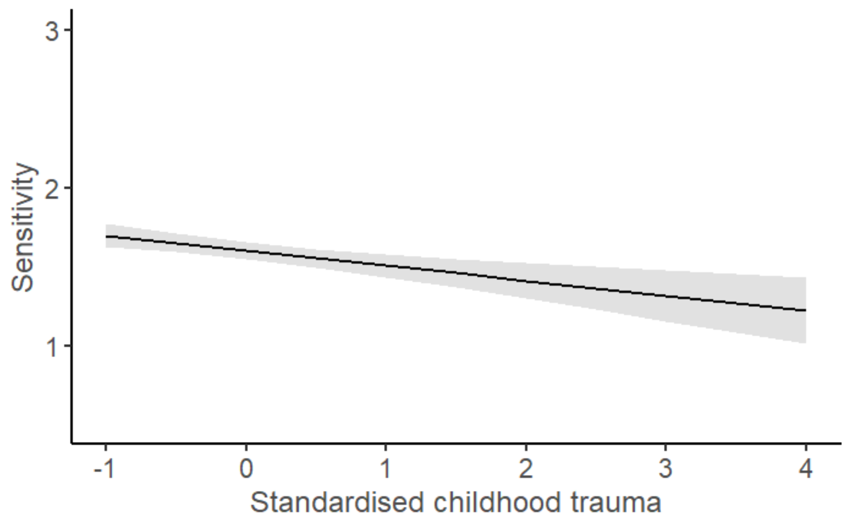
For all models, the random effects were participant and actor.

Does the relationship vary across modality?

A mixed model was employed to explore the effect of childhood trauma on sensitivity. The fixed factors were childhood trauma and modality. There was not a significant main effect of childhood trauma, F (1) = 1.57, p = .213, with β = −0.08 and exp(B) = 0.92 (Figure 17). There was a significant main effect of modality, F (2) = 15.85, p = .011, with β = −0.21 and exp(B) = 0.81 for faces and β = 0.46 and exp(B) = 1.58 for voices compared to audio-visual. Sensitivity was significantly higher for audio-visual expressions compared to facial expressions, t = -3.32, p = .004. There was not an overall significant interaction between childhood trauma and modality, F (2) = 2.99, p = .052, with β = 0.14 and exp(B) = 1.15 for childhood trauma * faces – audio-visual and β = 0.04 and exp(B) = 1.04 for childhood trauma * voices – audio-visual. This suggests the effect of childhood trauma did not vary significantly across modalities.

Figure 17

The average sensitivity for the standardised total score of childhood trauma (derived from the CTQ-SF). The shaded area represents the 95% confidence interval.



Does the relationship vary across emotion expressed?

A mixed model was employed to explore the effect of childhood trauma on sensitivity. The fixed factors were childhood trauma and emotion expressed. There was not a significant main effect of childhood trauma, F (1) = 1.63, p = .204, with β = −0.08 and exp(B) = 0.92.

There was a significant main effect of emotion, F (5) = 21.33, p = .007, there was significant difference between happy and angry expresions, β = -0.93 and exp(B) = 0.39, disgust and angry expressions, β = -1.71 and exp(B) = 0.18, and surprise and angry expressions, β = -1.50 and exp(B) = 0.22. Sensitivity was significantly lower for happy, disgust, and surprise expressions compared to angry expressions. There was not a significant interaction between childhood trauma and emotion expressed, F (5) = 0.46, p = .806. This suggests the effect of childhood trauma did not vary significantly across emotion expressed.

2.3.3.2. Is childhood trauma associated with sensitivity when controlling for alexithymia and psychopathy traits?

For all models, the random effects were participant and actor.

Does the relationship vary across modality?

A mixed model was employed to explore the effect of childhood trauma on sensitivity. The fixed factors were childhood trauma and modality and the covariates were alexithymia and psychopathy. There was not a significant main effect of childhood trauma, F (1) = 1.14, p = .289, alexithymia, F (1) = 0.33, p = .568, or psychopathy, F (1) = 0.38, p = .540. However, modality was still significant, F (2) = 13.11, p = .012, with significantly higher sensitivity for audio-visual expressions compared to facial expressions. There was also a significant interaction between childhood trauma and modality, F (2) = 3.03, p = .050. This may suggest that individuals reporting more childhood trauma are less sensitive to audio-visual expressions than facial expressions alone (Figure 18). There was no significant interaction between childhood trauma and voices compared to audio-visual expressions. Fixed effects parameter estimates are presented in Table 10.

Figure 18

Sensitivity of the standardised total score for childhood trauma (derived from the CTQ-SF), when controlling for alexithymia and psychopathy traits, across modalities. The shaded area represents the 95% confidence interval.

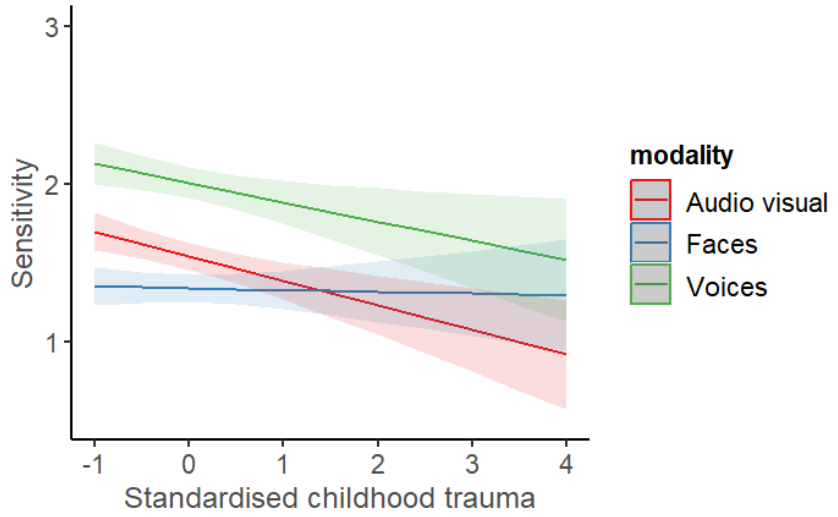


Table 10

The Fixed Effects Parameter Estimates table for sensitivity for childhood trauma, modality, alexithymia, and psychopathy.

Fixed effects	**Estimate**	**Standard Error**	**exp(B)**	**95% CI (lower, upper)**		***t***	***p***
Intercept	1.62	0.19	5.05	1.24	2.00	8.42	**.002***
Childhood trauma	-0.07	0.06	0.93	-0.19	0.06	-1.07	.062
Faces (Faces – Audio-visual)	-0.21	0.06	0.81	-0.33	-0.09	-3.43	**.002***
Voices (Voices – Audio-visual)	0.46	0.17	1.58	0.14	0.79	2.78	.062
Alexithymia	-0.04	0.06	0.96	-0.16	0.09	-0.57	.568
Psychopathy	-0.04	0.06	0.96	-0.17	0.09	-0.61	.540
Childhood trauma * Faces	0.14	0.06	1.15	0.03	0.26	2.43	**.015***
Childhood trauma * Voices	0.04	0.07	1.04	-0.09	0.17	0.67	.504

*** represents significant values (p < .05)**

Does the relationship vary across emotion expressed?

A mixed model was employed to explore the effect of childhood trauma on sensitivity. The fixed factors were childhood trauma and emotion expressed and the covariates were alexithymia and psychopathy. There was not a significant main effect of childhood trauma, *F* (1) = 0.98, *p* = .325, alexithymia, *F* (1) = 0.88, *p* = .349, or psychopathy, *F* (1) = 1.64, *p* = .202. However, emotion expresed was still significant, *F* (5) = 21.31, *p* = .007, with significantly lower sensitivity for happy, disgust, and surprise expressions compared to angry expressions. There was not a significant interaction between childhood trauma and emotion expressed, *F* (5) = 0.45, *p* = .810 (Figure 19). Fixed effects parameter estimates are presented in Table 11.

Figure 19

Average sensitivity of a standardised total score for childhood trauma (derived from the CTQ-SF), when controlling for alexithymia and psychopathy traits, across emotion expressed.

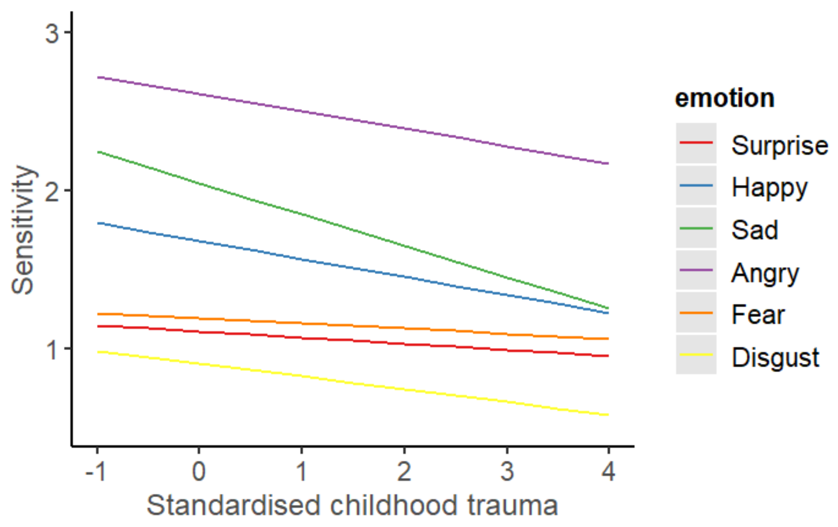


Table 11

The Fixed Effects Parameter Estimates table for sensitivity for childhood trauma, emotion expressed, alexithymia, and psychopathy.

Fixed effects	**Estimate**	**Standard Error**	**exp(B)**	**95% CI (lower,**	**upper)**	***t***	***p***
Intercept	1.59	0.18	4.90	1.24	1.94	8.90	**<.001***
Childhood trauma	-0.06	0.06	0.94	-0.18	0.06	-0.99	.325
Happy (Happy – Anger)	-0.94	0.28	2.56	-1.48	-0.39	-3.34	**.042***
Sad (Sad – Anger)	-0.60	0.43	0.55	-1.45	0.25	-1.38	.257
Fear (Fear – Anger)	-1.45	0.75	0.23	-2.92	0.02	-1.94	.147
Disgust (Disgust – Anger)	-1.71	0.53	0.18	-2.76	-0.67	-3.22	**.047***
Surprise (Surprise – Anger)	-1.50	0.38	0.22	-2.25	-0.75	-3.93	**.027***
Alexithymia	-0.05	0.05	0.95	-0.15	0.05	-0.94	.349
Psychopathy	-0.07	0.05	0.93	-0.18	0.04	-1.28	.202
Childhood trauma * Happy	0.00	0.09	1.00	-0.16	0.17	0.05	.963
Childhood trauma * Sad	-0.06	0.10	0.94	-0.25	0.12	-0.66	.508
Childhood trauma * Fear	0.08	0.09	1.08	-0.09	0.24	0.89	.375
Childhood trauma * Disgust	0.03	0.09	1.03	-0.15	0.21	0.34	.734
Childhood trauma * Surprise	0.07	0.10	1.07	-0.12	0.26	0.71	.479

*** represents significant values (*p* < .05)**

2.3.4. Summary

When exploring childhood trauma alone there was a significant association between childhood trauma and poorer emotion recognition accuracy. However, after controlling for alexithymia and psychopathy traits, childhood trauma was no longer significant when exploring across modality and intensity. For the intensity analysis, alexithymia was significantly associated with poorer accuracy. There were no significant interactions between childhood trauma and the stimulus-based factors. There was a significant effect of stimulus-based factors with better accuracy for audio-visual expressions compared to faces and voices, neutral compared to fear, and strong compared to normal intensity expressions.

When exploring intensity ratings, there was no significant effect of childhood trauma, alexithymia, or psychopathy reported. However, there was a significant interaction between childhood trauma and vocal expressions, and childhood trauma and sad expressions. As reported experience of childhood trauma increased, as did intensity ratings for audio-visual expressions compared to vocal expressions, and for sad expressions compared to angry expressions. Regarding stimulus-based factors overall, there was a significant effect of modality, emotion expressed, and intensity. There were higher intensity ratings for audio-visual expressions compared to faces and voices, for angry expressions compared to sad, fear, disgust, and surprise, and strong intensity compared to normal intensity expressions.

When exploring sensitivity to intensity, there was no significant effect of childhood trauma, alexithymia, or psychopathy. However, there was a significant interaction between childhood trauma and facial expressions. Childhood trauma's effect on sensitivity differed across audio-visual and facial expressions. As more reported childhood trauma increased, the sensitivity of audio-visual expressions decreased, but facial expressions were consistent across childhood trauma experience. There was a significant effect of modality and emotion, with higher sensitivity scores for audio-visual than facial and vocal expressions, and for angry expressions compared to happy, disgust, and surprise expressions.

2.4. Discussion

The current study addressed literature limitations by using stimuli which closer resembled everyday interactions (dynamic and audio-visual), exploring the effect of childhood trauma and emotion recognition performance across stimulus-based factors (modality, emotion expressed, and intensity), as well as including and controlling for related traits (alexithymia and psychopathy). This explored the unique contribution childhood trauma made to emotion recognition and tested the universality of the relationship by exploring across various conditions. The main aim of the study was to investigate whether childhood trauma, when controlling for alexithymia and psychopathy traits, was associated with emotion performance (emotion recognition accuracy, intensity ratings, and sensitivity). Furthermore, we were interested in how this effect might vary across modality, emotion expressed, and intensity of stimuli.

2.4.1. Childhood trauma and emotion recognition accuracy

The emotion recognition accuracy analyses explored the effects of childhood trauma alone on emotion recognition accuracy across modality, emotion expressed, and intensity of stimuli. There was a significant association between childhood trauma and emotion recognition accuracy across all three analyses. In line with previous research (Pollak et al., 2000; Bérubé et al., 2023), individuals who reported more experience of childhood trauma showed significantly poorer emotion recognition accuracy compared to those reporting less experience of childhood trauma. This poorer accuracy may be due to an avoidance of negative expressions. Hoepfel et al. (2022) suggested an initial vigilance to negative expressions, to assess the dangers of a situation, but then these expressions were avoided to avoid possible conflict. This avoidance could lead to poorer accuracy as expressions are not thoroughly processed. Another explanation is by Pollak et al. (2000) who suggested poorer accuracy, but specifically to positive and neutral expressions, because these are misinterpreted as negative. For example, a happy smiling face would be misinterpreted as being mocked or laughed at, leading to incorrect labelling and poorer accuracy.

Also, the effects of childhood trauma on accuracy whilst controlling for alexithymia and psychopathy traits were examined in three analyses: exploring the effects of modality, emotion expressed, and intensity. Once we controlled for the related traits, the association between childhood trauma and emotion recognition was reduced or non-significant. In the emotion expressed analysis, childhood trauma was still significant, but in the modality and intensity analyses there was no longer a significant association. Although, there was a significant association between alexithymia and poorer emotion recognition accuracy when exploring intensity of stimuli. Individuals who reported higher levels of alexithymia traits were associated with poorer emotion recognition accuracy, following previous findings (Jongen et al., 2014; Starita et al., 2018).

The fact that childhood trauma was no longer significant, but alexithymia was, may suggest that the original analysis, exploring childhood trauma alone, was reporting alexithymia's effect instead. This may suggest that the relationship between childhood trauma and emotion deficits is significantly influenced by alexithymia. This suggests the importance of including related individual differences. Bird and Cook (2013) suggested that the emotion deficits associated with autism are actually the result of the co-morbid alexithymia traits. A similar concept may be happening here, with the emotion deficits associated with childhood trauma being the result of the co-morbid alexithymia traits. It may suggest that the emotion deficits associated with childhood trauma and alexithymia can be explored similarly, and this may in turn provide clues to alleviate the deficits. If this is the case, it may suggest that current theories or models exploring childhood trauma and emotion recognition deficits may need to account and include other individual differences which may also be at play.

In the analysis exploring childhood trauma and accuracy across modality, after controlling for the traits, there was not a significant effect of childhood trauma, alexithymia, or psychopathy. This suggests a different factor may have been influencing the relationship between childhood trauma and emotion recognition. Based on previous research it may be that psychopathology or IQ of participant may be influencing the relationship (Young & Widom, 2014). However, this possibility was considered in the current study and there were no significant findings. Also, previous research has suggested that childhood trauma influences emotion recognition accuracy independently from diagnosed disorders (Catalana et al., 2018). This may suggest that another related factor, which was not included in the study, may have played a role in the relationship between childhood trauma and emotion recognition accuracy.

2.4.2. Childhood trauma and intensity measures

For intensity ratings, childhood trauma alone, and when controlling for alexithymia and psychopathy traits, was explored in three analyses (across modality, emotion expressed, and intensity of stimuli). The hypothesis predicted more experience of childhood trauma would be associated with higher intensity ratings, due to the associated heightened sensitivities (Dodge et al., 1995). However, childhood trauma was not significantly associated with intensity ratings in any of the analyses. This suggests that participants rated the intensity of the stimuli similarly whether they reported less or more experience of childhood trauma. Although, in support of the current findings, Neil et al.'s (2022) also reported no association between childhood trauma and intensity ratings. From the limited findings available it may suggest that intensity ratings are similar regardless of childhood trauma experience.

For sensitivity, we examined the effects of childhood trauma alone, and when controlling for traits, across modality and emotion expressed. The analyses revealed that childhood trauma was not significantly associated with sensitivity of intensity. This may suggest that childhood trauma does not influence how sensitive to emotional intensities we are. As previous research has not explored sensitivity to intensity we cannot compare the current findings with other research directly.

2.4.3. Modality

A major addition to the literature includes the exploration across various modalities. The findings suggested that the effect of childhood trauma was consistent regardless of whether individuals were presented facial, vocal, or audio-visual expressions. This may suggest that if individuals with childhood trauma experience are in environments where one modality is unavailable (e.g., dark or noisy environments) they are not further hindered than individuals without childhood trauma. When exploring emotion recognition accuracy across modality, there was better accuracy for audio-visual expressions compared to faces and voices, and better accuracy for faces compared to voices. This performance difference between facial and vocal expressions of emotion provides further evidence for the multimodal explanation of emotion (explained in Chapter 1). It suggests two distinct areas for each modality: one for facial expressions and one for vocal expressions. If faces and voices shared the same area then it would be assumed that performance would be similar.

Also, the fact audio-visual expressions were recognised significantly better than unimodal expressions may suggest performance differs depending on amount of information available. This is somewhat expected as audio-visual expressions contain both facial and vocal emotion cues whereas unimodal expressions only contain one cue (e.g., either a facial or vocal cue). This could suggest that other expressions with less information, such as static expressions, will be processed and recognised significantly differently to audio-visual expressions. However, as we did not include static images in the current study we cannot confidently conclude this is the case. Future research would benefit from exploring across static and audio-visual expressions, and possibly including additional measures, such as eye tracking, to explore processing patterns. This would provide insight into whether static findings can generalise to more realistic stimuli, as well as real-world interactions.

When exploring intensity ratings, there were higher intensity ratings for audio-visual expressions compared to facial and vocal expressions. To our knowledge there has not been previous research exploring intensity ratings between unimodal (facial or vocal expressions) and bimodal conditions (audio-visual expressions). However, previous findings reported higher intensity ratings for dynamic compared to static stimuli (Biele & Grabowska, 2006). A possible reason for this finding could be the extra cues presented in dynamic stimuli (seeing the onset and duration of the whole expression from neutral to emotional) may increase our perception of how intense the expression is. This theory would also fit the current findings of higher intensity ratings for audio-visual expressions (which present more cues) compared to the unimodal expressions.

Although childhood trauma was not significant, it did interact with vocal expressions to influence intensity ratings. Individuals reporting more experience of childhood trauma rated the intensity of audio-visual expressions significantly higher than vocal expressions compared to individuals reporting less childhood trauma. This may suggest evidence of the reported heightened sensitivities (McLaughlin, 2020), but they are mainly salient when comparing audio-visual expressions to vocal expressions. One possible explanation, for why audio-visual expressions received significantly higher intensity ratings, may be because they more closely resemble the individuals' adverse experiences growing up compared to vocal cues alone (Ambadar et al., 2005). Therefore, this may increase how intense the individuals perceive audio-visual expressions compared to vocal expressions and result in higher intensity ratings.

When exploring sensitivity to intensity across modality, there were higher sensitivity scores (indicating a larger perceived difference between normal and strong intensity stimuli) for audio-visual expressions compared to facial and vocal expressions. This suggests that as the cues increased (bimodal) the perceived differences in normal and strong expressions increased. There was no significant effect of childhood trauma, but it interacted with facial expressions to influence sensitivity. For facial expressions the effect of childhood trauma seems consistent across experience. Whereas, for audio-visual expressions, as reported childhood trauma experience increased, the sensitivity reduced (e.g., smaller differences in normal and strong intensity ratings). This suggests that individuals with experience of childhood trauma are less sensitive to intensities in audio-visual expressions compared to individuals with less experience of childhood trauma. Similar to the intensity ratings interpretation, this could be due to previous experiences being audio-visual than just one emotion cue (facial expressions). Thus, resulting in higher intensity ratings of both normal and strong intensity audio-visual expressions (and therefore a smaller difference in ratings) compared to facial expressions.

The differences in findings for the accuracy and intensity measures (intensity ratings and sensitivity) suggest the effect of childhood trauma on emotion performance, when exploring across modality, differs. The accuracy findings suggest that individuals with childhood trauma are not further impacted depending on how the expression is presented – in this case modality wise. However, the intensity measures suggest that experience of childhood trauma influences our perception of how intense an expression is. In particular, for audio-visual expressions compared to unimodal conditions.

2.4.4. Emotion expressed

When exploring childhood trauma and accuracy across emotion expressed, there was poorer accuracy for fear compared to neutral expressions. This is somewhat surprising as research has reported an advantage of fast and accurate fear recognition to highlight a possible violent situation in order to avoid it (Masten et al., 2008). A possible reason for the difference in findings could be the difference in stimuli, specifically the inclusion of dynamic expressions. Also, there was a significant relationship between childhood trauma and poorer emotion recognition, even after controlling for the alexithymia and psychopathy traits. This suggests the emotion expressed analyses were definitely reporting childhood trauma's unique effect on accuracy, and not the related traits' effect.

There was no significant interaction between childhood trauma and emotion expressed, differing from the hypothesis and previous research (Pollak et al., 2000; Bérubé et al., 2023). This is surprising as previous research exploring childhood trauma has suggested a recognition advantage of anger and fear expressions, as anger in the abuser and fear in people around you can predict an occurrence of abuse (Masten et al., 2008). Again, this difference may be due to the use of dynamic stimuli. They are easier to recognise as they closer represent real-world expressions. They also provide more emotion cues than a static face, such as more and moving frames of the expression over a longer duration (Ambadar et al., 2005). Therefore, it may have attenuated some of the difficulties associated with specific emotions. Also, Pollak et al. (2000) suggested that positive expressions are interpreted as more malevolent (e.g., a smile interpreted as being mocked or laughed at). If this was the case then individuals may have interpreted all emotions negatively and shown a similar effect across all emotions and this would explain the lack of interaction.

Although, the lack of interaction is somewhat supported by a meta-analysis (Saarinen et al., 2021) which reported poorer accuracy for fearful and happy expressions only if childhood trauma was recent (less than 2 years ago). As we tested an adult sample, it is unlikely that experience of childhood trauma would be recent. The current findings suggest that experience of childhood trauma is associated with poorer accuracy across all emotions, not just positive or neutral. This could suggest the social information processing mechanism (Dodge et al., 1995), which states a negative expression advantage, may need updating to better reflect childhood trauma's effect across all emotions.

An interesting visualisation shown in Figure 9 was that as reported childhood trauma increased, the emotion recognition accuracy of neutral expressions decreased more evidently than the emotional expressions. It is possible that a significant effect of childhood trauma across neutral expressions was missed in the reported statistics as it was the reference category. This means that childhood trauma's effect was explored across the basic six emotional expressions in comparison to neutral expressions (e.g., childhood trauma * anger –

neutral), rather than directly exploring childhood trauma's effect on neutral expressions. This could mean that information regarding neutral expressions was missed. However, for the current data there was a stronger justification to use neutral expressions as the reference category as it is the only unemotional expression and therefore emotion recognition research had deemed it a 'baseline' which is ideal for a reference category (Phillips et al., 1997; Sonia et al., 2023). Although, the current findings may suggest there is a relationship between childhood trauma and neutral expressions, so future research should consider using happy expressions as the reference category, as this emotion seems to plateau across experience of childhood trauma and may present a better reference category. This would help to better understand the relationship between childhood trauma and neutral expressions.

When exploring intensity ratings across emotion expressed, there were higher intensity ratings for angry expressions compared to sad, fear, disgust, and surprise expressions. This is in line with previous findings which also reported angry expressions are rated as most intense (Biele & Grabowska, 2006). There is also partial occlusion work (using face masks) which reported that the perceived intensity of all expressions was reduced, except for anger which was still perceived as intense (Tsantani et al., 2022). This suggests that even in suboptimal conditions (e.g., the lower half of the face is covered) anger is still perceived as intense. Although childhood trauma was not significant, it's effect significantly differed for sad and angry intensity ratings. Angry intensity ratings were fairly consistent across individuals who reported more or less childhood trauma experience. Whereas, for sad expressions, there was a clear positive relationship – as reported experience increased as did ratings for sad expressions. This interaction was somewhat surprising as even though childhood trauma had been associated with better accuracy and more attention allocated to negative expressions (Dodge et al., 1995), we would expect the negative expression to be a threat cue (e.g., angry expressions) rather than sadness.

However, in support of this interaction, Saarinen et al.'s (2021) meta-analysis reported that early adversity was associated with greater activation in the bilateral amygdala, and faster reaction times, for sad expressions (but normal accuracy as found in the current emotion recognition accuracy findings). The authors suggested this could be due to an evolutionary perspective as sadness promotes recognition of what has been lost to prevent further loss (Saarinen et al., 2021). They also suggested it was due to less experience of sad expressions, so sadness is viewed as a 'forbidden expression', leading to a heightened vigilance due to lack of experience and exposure (Saarinen et al., 2021). Also, Pollak et al. (2000) reported that neglected children perceived less distinction between angry, sad, and fearful expressions. This may suggest that sad expressions may also be perceived as threat cues similar to angry and fear expressions and explain the heightened perceived intensity of sadness.

When exploring sensitivity to intensity, childhood trauma's effect across emotion expressed was explored. There were higher sensitivity scores for angry expressions compared to happy, disgust, and surprise expressions. This follows the intensity rating findings and the previous research (Biele & Grabowska, 2006; Tsantani et al., 2022). There was no significant effect of childhood trauma, alexithymia or psychopathy, or any significant interactions. This suggests that the effect of childhood trauma, or lack of, on sensitivity is consistent across emotion expressed. Again, similar to the intensity rating findings, this is surprising as previously there has been an association between childhood trauma and negative expressions specifically. The lack of exploration in this area makes it difficult to compare the current findings to previous findings.

However, Figure 19 shows the visualisation of childhood trauma's effect across emotion expressed and it seems that as childhood trauma experience increases, the sensitivity for sadness decreases. This is interesting as the intensity rating findings reported that more experience of childhood trauma led to higher intensity ratings of sadness. When exploring sensitivity, it is directly exploring lower intensity sad expressions compared to higher intensity sad expressions. Thus, the fact sensitivity decreases suggests there is somewhat similar intensity ratings across normal and strong intensity sad expressions. Based on the intensity findings, it seems that individuals with childhood trauma experience rate both normal and strong intensity expressions similarly, specifically both intensity levels are rated highly. Reasonings for this relationship follow the intensity ratings interpretation of a hypervigilance for sad expressions due to evolutionary reasons or lack of experience of sad expressions in their environment (Saarinen et al., 2021).

Similar to the modality findings, the difference between the accuracy and intensity ratings findings suggest a differing effect of childhood trauma. Childhood trauma's effect was consistent across negative, positive, and neutral expressions. However, childhood trauma experience did significantly influence how intense expressions were perceived, specifically for sad compared to angry expressions.

2.4.5. Intensity

When considering childhood trauma and emotion recognition across intensity, there was similar accuracy across both normal and strong intensities. This differs from previous research which reported significantly better accuracy for higher intensity expressions compared to low intensity expressions (Montirosso et al., 2010). There was also no significant interaction between childhood trauma and intensity which differed from expectations, and the previously reported heightened sensitivities (Dodge et al., 1995). The surprising findings may be due to the inclusion of movement (e.g., dynamic and audio-visual expressions). The movements may have attenuated the advantage previously reported for strong intensity expressions, as well as attenuated the associated heightened sensitivities. Maybe, once extra cues (e.g., movement and increased duration) are added, the effect of intensity is weakened. So, accuracy for normal intensity stimuli are improved to the same accuracy as strong intensity stimuli.

Another possible reason for the lack of interaction between childhood trauma and intensity of stimuli when exploring emotion recognition accuracy could be that these sensitivities are specific to negative expressions (Dodge et al., 1995). However, emotion expressed was not added into the childhood trauma and intensity analysis, meaning the interaction between childhood trauma and intensity was explored across all expressions, not specifically the typically reported negative expressions. Although, this was not appropriate for the current data as mixed models require a considerable amount of power per analysis so any interactions between stimulus-based factors themselves (e.g., an interaction between intensity and emotion expressed) or any three-way interactions (e.g., an interaction between childhood trauma, intensity, and emotion expressed) were not conducted. Beside the possible power issue, it also was not relevant to explore these interactions as the specific research question regarding stimulus-based factors focused on whether the relationship between childhood trauma and emotion recognition differed across various conditions; the three specific conditions being either modality, emotion expressed, or intensity. So, the additional analyses would not add any necessary information to better answer the research question. However, as research has reported specific negative sensitivities associated with childhood trauma, future research with the relevant research questions may benefit from exploring three-way interactions between childhood trauma, intensity, and emotion expressed to see whether these sensitivities are only evident for negative expressions as reported in the social information processing mechanism (Dodge et al., 1995).

When exploring childhood trauma and intensity ratings across intensity of stimuli, there were significantly higher intensity ratings for strong intensity stimuli compared to normal intensity stimuli. The higher intensity ratings for stronger intensity stimuli is expected as stronger expressions present more salient cues than normal intensity (e.g., for a happy face the smile would be wider and bigger for strong intensity than a normal intensity expression). Therefore, they are more likely to be perceived as more intense. However, the effect of childhood trauma, or lack of, is consistent across normal and strong intensity stimuli.

There were a lack of significant interactions between childhood trauma and intensity when exploring accuracy and intensity ratings. This suggests that childhood trauma's consistent effect across intensity of stimuli is similar across various aspects of emotion performance (e.g., emotion labelling and perception of intensity). Hence, individuals with more childhood trauma experience are not further hindered in their performance depending on whether an expression is more exaggerated or subtle.

The findings overall may suggest that measures which tap into alterative measures of emotion recognition, like intensity ratings and sensitivity, are not influenced by the same factors as emotion identification. It seems that emotion recognition accuracy may be influenced by both personal factors (individual differences) and stimulus-based factors (modality, emotion expressed, and intensity) whereas intensity ratings and sensitivity may be more strongly influenced by stimulus-based factors. Going beyond accuracy of expressions can determine whether certain individuals or groups are more or less susceptible to emotional cues expressed a certain way (e.g., if they specifically struggle with more subtle expressions or more intense expressions).

2.5. Conclusion

To conclude, this study extended previous research exploring the association between childhood trauma and emotion recognition. It included multiple dynamic modalities, varying intensities of emotional stimuli, and controlled for related individual differences (alexithymia and psychopathy traits). Childhood trauma alone had a significant association with poorer emotion recognition accuracy when exploring modality, emotion expressed, and intensity of stimuli. Notably, when controlling for alexithymia and psychopathy traits, childhood trauma no longer had a significant association with poorer accuracy when considering the modality and intensity of stimuli. However, there was an association between alexithymia and poorer emotion recognition accuracy when exploring intensity. This may suggest that, in the original analyses of childhood trauma alone, actually alexithymia's effect on accuracy was being reported. The accuracy findings illustrate the importance of including and controlling for interrelated individual differences when exploring childhood trauma. It may suggest that present theories, involving childhood trauma and emotion deficits, may need to account for factors such as higher levels of alexithymia and psychopathy traits in the groups being studied. Regarding intensity ratings and sensitivity, there were no significant associations found for childhood trauma or the related traits across any of the analyses. Only the stimulus-based factors were significant.

Even though this study has improved and extended on previous research, there are still unanswered questions regarding why individuals differ in their accuracy and where do the differences in accuracy lie. To start to answer this, the next chapter investigates childhood trauma and emotion recognition using an eye tracker. This will reveal whether differences in gaze patterns associated with childhood trauma, and the related traits, affect emotion recognition performance. This could potentially provide clues as to why some individuals may have poorer accuracy.

The thesis overall focuses on emotion recognition performance and there are various ways to examine this. The current chapter explores recognition using categorisation of stimuli (through accuracy) as well as perception of intensity (through intensity ratings and sensitivity) and the following chapters will use other various methods. The next chapter will investigate the processing of emotional expressions using an eye tracker (using accuracy, number of fixations, and dwell time), Chapter 4 explores the integration of facial and audio cues to recognise audio-visual expressions (using accuracy and intensity ratings), and Chapter 5 explores performance in suboptimal conditions (partial occlusions through face coverings, using accuracy).

3. The effect of childhood trauma on emotion recognition: an eye tracker study.

3.1. Introduction

The previous chapter reported that childhood trauma was significantly associated with poorer emotion recognition accuracy. However, after controlling for alexithymia and psychopathy traits, the relationship between childhood trauma and emotion recognition accuracy was reduced or non-significant. While considering the relationship across intensity of stimuli, alexithymia emerged as significantly associated with poorer accuracy. The findings also reported the relationship between childhood trauma and emotion recognition accuracy was fairly consistent across modality, emotion expressed, and intensity of stimuli. This provided information regarding the unique contribution childhood trauma makes to emotion recognition performance, without the influence of co-morbid traits. It also provided information regarding the universality of the relationship by exploring across different conditions. Although this advanced our knowledge by exploring the relationship between childhood trauma and emotion recognition more widely, we are still unsure whether childhood trauma impacts other aspects of emotion recognition such as how we process emotional expressions before categorising them.

Although the exploration of eye movements and emotion recognition is well researched, similar to previous chapters, there are still methodological improvements to be made, such as using more realistic stimuli. There is currently a distinct lack of research employing eye tracking using dynamic, let alone audio-visual, expressions. By including static expressions as well as moving stimuli (dynamic and audio-visual), we can explore whether previous research, which typically used static expressions, can be generalised to moving stimuli which closer represent real-world interactions. Although for emotion recognition research in general, as well as eye tracking research, there seems to be conflicting conclusions regarding whether our performance differs between static and dynamic expressions.

There has been research which has reported a recognition advantage of dynamic expressions compared to static expressions (Ambadar et al., 2005; Bould & Morris, 2008; Alvez, 2013). Research has suggested an evolutionary advantage for dynamic expressions compared to static expressions. Dynamic expressions encourage early attention and motivation in the perceiver, as well as supporting emotion understanding including helping detect and predict emotional expressions by inducing emotional contagion (viewing the perceiver's emotion can induce similar emotions in the observer; Roark et al., 2003).

However, there is also research which refutes the dynamic advantage over static images (Fiorentini & Vivani, 2011). There is also reason to believe that static expressions would be recognised as well as dynamic expressions. The single static image presented includes the expression's peak frame (e.g., the most salient example of the expression), suggesting quick and accurate recognition (Dobs et al., 2018). Therefore, whether performance, and in turn the application of findings, would be similar across static and moving stimuli is unclear.

It is only fairly recently that eye gaze patterns across static versus dynamic expressions have been explored. Roy et al. (2010) reported that eye gaze can differ depending on how the emotional stimuli are presented (static picture or dynamic video). They tracked participants' eye movements when viewing either static or dynamic emotional expressions of fear, happiness, sadness, disgust, anger, surprise, and neutral. Overall, accuracy was higher for the dynamic expressions compared to the static stimuli and eye movements clearly differed between the two. For dynamic faces, eye gaze stayed in the centre of the face, however, for static faces the gaze quickly spread outward. This pattern was consistent across all emotions. Similarly, Blais et al. (2017) explored eye movements when viewing static versus dynamic expressions using eye tracking and the Bubbles technique (obscuring certain areas of a face to reveal only some features). They reported different gaze patterns depending on how the expression was presented (static or dynamic). There were fewer fixations to the eye and mouth regions when viewing dynamic stimuli compared to static stimuli.

Movement has shown an advantage in other areas of recognition, such as faces (Bennetts et al., 2015). A recent review by Roark et al. (2003) reported the psychological and neural perspectives on movement for face recognition. They presented three hypotheses for why movement improves recognition: the supplemental information hypothesis, representation enhancement hypothesis, and motion as a social signal hypothesis. In particular, the representation enhancement and the motion as a social signal hypotheses can be discussed in relation to emotion recognition. The representation enhancement hypothesis suggests that movement improves recognition by enhancing the quality of the information available from the face, this suggests the advantage is due to perceptual information. This could extend to emotional expressions too as we would get better quality information from dynamic facial expressions than static facial expressions, which would in turn improve recognition accuracy. The motion as a social signal hypothesis, suggests that social communication information from a dynamic face can help attract and maintain attention. This would increase the likelihood of remembering a face but it could also translate to emotion recognition as increased attention is linked to better accuracy of expressions (Barros et al., 2017).

There is also research with infants which found different processing of static and dynamic expressions. Prunty et al. (2021) found that dynamic expressions held infant's attention longer and they were scanned differently, with more fixation towards lower facial regions. These findings suggest that individuals' eye gaze patterns differ depending on whether the stimuli are static or dynamic. As the majority of previous eye tracking research uses static stimuli it may suggest that we cannot generalise these findings to dynamic expressions, and in-turn, real-life interactions (Alves, 2013). To enhance the ecological validity, it would be beneficial for future research to investigate emotional expressions in more realistic ways, such as dynamic or audio-visual expressions.

Eye movements can also differ as a result of individual differences. A key individual difference linked to emotion recognition performance in general is childhood trauma, as well as the co-morbid traits of alexithymia and psychopathy (Blair, 2001; Parker et al., 2005; Bérubé et al., 2023). We want to explore whether individuals with experience of childhood trauma show particular eye gaze patterns when processing emotional expressions and whether this differs across conditions. This can provide insight into whether childhood trauma experience affects emotion recognition accuracy due to where individuals look on the face when recognising emotional expressions. Therefore, this study will explore the effect of childhood trauma on emotion recognition accuracy and eye movements (number of fixations and dwell time) across certain facial features (eyes, nose, mouth), modality (static, dynamic, audio-visual), emotion expressed (basic six and neutral), and intensity of stimuli (normal, strong).

3.1.1. Eye movements and emotion recognition

To better understand how individuals process facial expressions when recognising an emotion, research has explored individuals' eye movements. Research exploring emotion recognition has identified eye gaze, specifically towards the eyes and mouth, as a particularly important aspect for more accurate performance (Jack & Schyns, 2015; Zhang et al., 2022). Previously, it has been found that eye gaze patterns differ, not only across individuals (Fujiwara, 2018; Gillespie et al., 2015), but across emotions (Wegrzyn et al., 2017). Across different methods, the research tends to agree on which facial features are important when recognising certain emotional expressions. Smith et al. (2005) explored where individuals looked on the face when processing emotional expressions using the Bubble technique. Participants were asked to make judgements about static facial expressions overlaid with gaussian filter “bubbles” (e.g., a facial expression presented with grey noise around the face except for one area, such as the eyes). Using this method, they reported that for the accurate recognition of fear, anger, and sadness, individuals relied on the “windows” (e.g., the area unaffected by noise) in the upper facial regions; happy and disgust expressions involved “windows” in the lower regions.

This was supported by Wegrzyn et al. (2017) who used the tile method. Static facial expressions were hidden behind 48 tiles which were uncovered sequentially until participants recognised the expression and stopped the sequence. The findings reported that overall, the eye and mouth regions were most useful for accurate recognition. Specifically, the eye region was important for sad and fear expressions and the mouth was important for happy and disgust expressions. These methods and their findings were further supported using eye tracking methods. Schurgin et al. (2014) showed participants static facial expressions and recorded their eye movements. They reported that participants showed more attention to the eye region for angry, fearful, and sad expressions but looked longer at the mouth for disgust and happy expressions. These findings suggest that across a range of methods the findings are consistent regarding which areas of the face individuals rely on when processing these expressions: the eyes for sad, angry, and fear expressions, and the mouth for happy and disgust expressions. Research has also reported that the accuracy of our emotion recognition abilities is strongly associated with the information-rich facial features (e.g., eyes for sadness) we focus on when processing the expression (Yitzhak et al., 2021). This suggests that certain individuals who deviate from the information-rich areas may show poorer accuracy as a result of their eye movements.

3.1.2. Childhood trauma and eye movements

Childhood trauma and emotion recognition in general has reported an association with better recognition of negative expressions and poorer recognition of positive and neutral expressions, as they are misinterpreted as negative (Dodge et al., 1995). The literature exploring individuals with experience of childhood trauma and eye movements for emotional expressions is scarce. The majority of the literature tends to explore childhood trauma and attention biases to certain emotional expressions rather than facial features. However, research exploring childhood trauma and direct eye contact has suggested that eye contact is avoided, as it can antagonise and provoke an abuser, and is often perceived as threatening by the individual who has been abused (Krill & McKinnon, 2010; Steuwe et al., 2014). Therefore, this may suggest an avoidance of the eye region for individuals with experience of childhood trauma, which may in-turn impact accuracy of recognising expressions, especially for expressions which rely on interpreting the eyes (e.g., sad, anger, and fear).

Bodenschatz and colleagues (2019) explored attentional bias and childhood trauma in individuals with major depressive disorder using an eye tracker. Participants (n=31 with depression, n=31 controls) viewed static facial expressions depicting either happiness, sadness, anger, or neutral expressions. They used dwell time as a measure of attention allocation and found that individuals with depression with childhood trauma experience showed reduced attention to angry and sad facial expressions. This may suggest that these individuals were avoiding the processing of negative expressions as this pattern was not found for happy or neutral expressions. It may also suggest that eye contact was avoided as anger and sadness rely on the eyes for accurate emotion recognition. However, only a small sample of individuals who reported moderate childhood trauma experience were studied.

Nonetheless, research from Hoepfel and colleagues (2022) supports their findings. Hoepfel et al. (2022) also explored the relationship between childhood trauma and attention to facial expressions of emotion. Women completed a dot-probe task where faces depicting either happiness, sadness, or disgust were paired with neutral faces. Alongside childhood trauma experience, the level of alexithymia traits in individuals was controlled for. Initial gaze and dwell time were used as a measure of attention allocation. The findings reported an association between childhood trauma and shorter initial gaze to emotional expressions compared to neutral expressions, and shorter dwell time on disgust expressions compared to neutral expressions. The authors suggested that childhood trauma was associated with heightened early vigilance to emotional social signals overall (positive and negative expressions) compared to neutral expressions. They also suggested that childhood trauma was associated with attention avoidance of hostile (negative) expressions at later stages of attention allocation. This may suggest that initial vigilance to threat cues assesses the dangers of a situation and then avoidance of the threat cues later on are to avoid possible conflicts. The attention to all expressions, positive as well as negative, could be due to positive emotions being misinterpreted as more malicious (happy being misinterpreted as something more negative such as being mocked or laughed at; Pollak et al., 2000), leading to a similar effect across all.

However, there is also evidence to refute an association between childhood trauma and eye movements towards certain emotional expressions. Seitz et al. (2021) explored eye movements in individuals with Borderline Personality Disorder (BPD) with childhood trauma experience. A female sample with and without borderline personality disorder completed a childhood trauma questionnaire and an emotion recognition task. The task included anger, fear, happy, and neutral static facial expressions. The behavioural data reported an anger bias (participants misclassified expressions more often as angry than as happy or as neutral) but there was no significant association between childhood trauma and eye movements towards certain facial expressions. However, the difference in findings could be because the sample included participants with borderline personality disorder who also had childhood trauma experience. Although, Bodenschatz et al. (2019) also used a clinical sample of individuals with major depressive disorder. These findings should be interpreted cautiously as we do not know the unique contribution childhood trauma was making on eye movements and how much variance was due to the clinical features of borderline personality disorder or major depressive disorder. This suggests that future research would benefit from a direct exploration of childhood trauma and eye movements to address the conflicting findings and highlights the importance of the current research.

Mohr (2016) explored childhood trauma and fixation patterns for specific features on facial expressions and did not report an association between childhood trauma and eye movements. A general abuse group (emotional, physical, sexual abuse, and emotional neglect), physical neglect group, and a comparison group viewed static facial expressions displaying happy, angry, sad, or neutral expressions. The areas of interest when recording eye gaze were the eyes, mouth, brow region, and overall face. The findings reported that participants initially gazed to the eye region more often than the other regions for all expressions except happiness. For happiness, participants gazed towards the eyes and mouth the same amount. However, the different facets of childhood trauma (emotional abuse, physical abuse, sexual abuse, emotional neglect, and physical neglect) did not affect where individuals directed their gaze on the face or their ability to identify emotional expressions correctly. This differs from Bodenschatz et al. (2019) and Hoepfel et al. (2022) who reported a significant association between childhood trauma and eye movements across emotional expressions, but it is in line with Seitz et al. (2021) who did not report an association either. The differences may be due to Bodenschatz et al. (2019) and Hoepfel et al. (2022) using a total score of childhood trauma experience whereas Mohr (2016) used subscales of childhood trauma.

The discussed findings of attentional biases towards negative expressions compared to positive expressions could be explained by the social information processing mechanism (Dodge et al., 1995), as described in Chapter 1. Briefly, the model states childhood trauma is associated with better accuracy (and needing less perceptual information) of negative expressions and poorer recognition of positive or neutral expressions, as they are wrongly perceived as negative expressions. Therefore, individuals who experience childhood trauma, and are therefore more sensitive to negative cues, may be more inclined to divert attention to negative expressions compared to positive or neutral expressions.

3.1.3. Interrelated traits and eye movements

As discussed throughout the thesis so far, childhood trauma has strong reported associations with alexithymia and psychopathy. Childhood trauma is associated with the development of these traits (Zlotnick et al., 2001; Craparo et al., 2013), so individuals with childhood trauma experience are more likely to present higher levels of alexithymia and psychopathy traits. These traits are also associated with poorer emotion recognition accuracy (Blair, 2001; Parker et al., 2005). Thus, it becomes difficult to distinguish whether childhood trauma itself, or the co-morbid traits of alexithymia and psychopathy, are responsible for the associated emotion deficits. They are typically explored separately despite the strong associations. Atypical eye gaze patterns have been demonstrated by individuals with experience of childhood trauma, as described above, as well as with the co-morbid alexithymia and psychopathy traits. The atypical eye gaze may provide an explanation for the emotion deficits associated with them.

3.1.3.1. Alexithymia

Alexithymia has been associated with atypical eye gaze for emotional facial expressions. Research has reported that atypical gaze is a core feature of alexithymia (Zhang et al., 2022). The atypical gaze patterns include avoiding the eye region (Fujiwara, 2018), and may explain the emotion deficits associated with alexithymia. For example, if those high in alexithymia have different eye gaze patterns from those low in alexithymia then this might account for the accuracy variation. As described in Chapter 1, alexithymia is associated with poorer emotion recognition overall and specifically for negative expressions (Parker et al., 2005). It is characterised by difficulties identifying and describing your own feelings as well as an external style of thinking (Preece et al., 2017). These difficulties in recognising your own feelings may be reflected in difficulties recognising others' emotions, as suggested by shared circuits model (Keysers & Gazzola, 2006).

Research exploring alexithymia and eye gaze patterns typically reports an avoidance of the eye region when processing and recognising emotional expressions. Fujiwara (2018) investigated the role of attention in identifying facial expressions in those high and low in alexithymia traits. Participants viewed blended emotions (e.g., two emotional expressions blended into one facial expression). They found that individuals with high levels of alexithymia traits showed less attention to the eye region of the facial expressions compared to individuals with low levels of traits. The findings show that alexithymia is associated with attentional avoidance of the eye region. The authors concluded that eye contact may be difficult for those with alexithymia, which may disrupt the processing of facial expressions. This would assume that those with higher levels of alexithymia traits may avoid the eye region when recognising expressions, which may in turn affect accuracy, especially for expressions relying on the eyes (e.g., sad, anger, and fear).

Bird and colleagues (2011) explored alexithymia and autism's relationship with eye gaze for facial expressions of emotion. Participants viewed four video clips (two of an emotional TV drama interaction and two of a newsreader). The areas of interest when recording eye gaze were the eyes and mouth. They reported that attention towards the eye and mouth regions were predicted by alexithymia traits, not autism severity. Therefore, this suggests that atypical gaze patterns for the eyes and mouth may be determined by degree of alexithymia traits rather than previously reported autism. There is further support for atypical gaze patterns being attributed to alexithymia, not autism, by Cuve et al. (2018). The systematic review explored emotion recognition and eye tracking in young adults with autism and concluded that arousal and gaze mechanisms may be modulated by alexithymia. The authors suggested that the atypical gaze patterns associated with alexithymia may shift attention away from essential areas for emotion processing and recognition and may explain the association with poorer accuracy.

A possible reason for why atypical gaze patterns are associated with alexithymia could be because it is associated with an external oriented style of thinking. This facet of alexithymia is associated with a focus on external events or cues rather than inner feelings (Taylor et al., 1985). This could suggest that individual with alexithymia traits, and therefore a preference for external factors compared to internal factors, would focus on external cues such as the environment (e.g., situational cues) during a social interaction instead of the facial expression depicting an emotional expression. This could in-turn explain the avoidance to the eye area. The discussed studies largely agree that alexithymia is associated with atypical eye gaze and suggests that this could influence emotion recognition accuracy. This highlights the importance of exploring alexithymia and eye gaze fixations when viewing emotional stimuli as it could provide insight into a possible reason why these emotion deficits occur.

3.1.3.2. Psychopathy

Psychopathy is also associated with poorer emotion recognition overall as well as specific deficits in recognising sadness and fear (Blair et al., 2001). Psychopathy is characterised by emotion deficits, lack of empathy, and poor behavioural control (Anderson et al., 2015). There is evidence from both children and adults that psychopathy is associated with atypical eye gaze patterns when recognising facial expressions. Similar to alexithymia, psychopathy has been associated with avoidance of the eye region.

Dadds et al. (2008) examined whether psychopathic traits (callous-unemotional traits and antisocial behaviour) were associated with reduced attention to the eye region for emotional facial expressions. A sample of 100 male adolescents viewed 36 child, teen, and adult faces expressing happiness, sadness, anger, disgust, fear, and neutral expressions. They found that individuals reporting a high level of psychopathy traits showed poorer recognition accuracy of fear and a lower number and duration of fixations to the eye region. They also found that gaze to the eye region correlated positively with accurate fear recognition in the high psychopathy group. This suggests that attention to the eye region is reduced in young people with high psychopathy traits which could explain the poorer fear accuracy. Another study by Dadds et al. (2006) also measured attention to the eye region and fear deficits in children presenting psychopathy traits. The authors reported that the deficit could be temporarily corrected by asking participants to look at the eye region. This suggests that the atypical eye gaze to the eye region may be the reason for the typically reported poorer accuracy when exploring psychopathy.

The avoidance of the eye region in individuals with high psychopathy traits is also found in adult samples. Gillespie et al. (2015) examined this relationship between psychopathy traits (primary and secondary) and attention to the eye region. Primary traits include being selfish and uncaring and secondary traits include being impulsive and antisocial. They explored a sample of adult male non-offenders and presented them with facial expressions depicting anger, disgust, fear, happy, sad, and surprise expressions. They reported an association between primary psychopathy traits and reduced fixations to the eye region compared to the mouth region across the emotional expressions. This suggests the findings from a younger sample are reflected in adults. Further support from an adult sample comes from Gehrer et al. (2019). The sample included male incarcerated psychopathic and non-psychopathic offenders. There were two tasks: a gender discrimination task and an emotion recognition task (emotions expressed were anger, disgust, happy, fear, sad, and surprise). They reported that non-psychopathic offenders focused on the eye region during emotion recognition whereas psychopathic offenders showed significantly less attention towards the eye region across all emotional expressions. Psychopathy was also associated with significantly shorter dwell time in the eye region as well as less initial fixations. The studies discussed have shown that the association between psychopathy and reduced eye gaze to the eye region for facial expressions may be consistent across different age groups and across incarcerated and non-incarcerated psychopaths.

A possible explanation for the fear deficit associated with psychopathy could be explained by the Violence Inhibition Mechanism model (VIM), as discussed in Chapter 1. The VIM (Blair et al., 2001) states that the emotion deficit for both fear and sadness is due to a disruption in the VIM (atypical activation of distress) which can lead to violent behaviour (Sun et al., 2023). Fear and sadness are not seen as distressing or negative, so behaviours to avoid causing these expressions in others are not learned. This then leads to psychopathy traits of lack of empathy, poor behavioural control, and the emotion deficits. Another possibility is that sad and fear expressions rely on the eye region for accurate emotion recognition (Wegrzyn et al., 2017), and psychopathy is associated with atypical eye gaze of avoiding the eye region, this may explain these deficits.

3.1.4. The current study

The aim of this chapter is to investigate whether childhood trauma affects accuracy and eye movements across various modalities, emotions, and intensities. Previous research has typically used static facial expressions when exploring emotion recognition. However, it is unclear whether we process these similar to moving stimuli, which more closely resemble everyday interactions. If performance differed then it could suggest that previous findings cannot easily be generalised to real-world interactions. To explore this, the effect of childhood trauma, and the related traits of alexithymia and psychopathy, on emotion recognition accuracy and eye movements (measured by number of fixations and dwell time) will be measured. This will be explored across stimulus presentation (modality: static, dynamic, audio-visual), emotion expressed (basic six and neutral), and intensity of stimuli (normal and strong). This will extend on previous research by exploring childhood trauma's effect on eye movements to specific facial features when recognising emotional expressions rather than eye movements to emotional versus neutral expressions.

The hypotheses regarding accuracy are similar to those of Chapter 2. For emotion recognition accuracy overall, in line with key previous research described in Chapters 1 and 2 (namely, Pollak et al., 2000; Bérubé et al., 2023), it is expected that childhood trauma will be associated with poorer emotion recognition accuracy.

This association will be explored across modality, emotion expressed, and intensity of stimuli. Due to a lack of research investigating the effects of childhood trauma on emotion recognition in dynamic stimuli, it is unclear whether there will be a significant interaction between childhood trauma and modality when exploring accuracy. Regarding emotion expressed, it is hypothesised that childhood trauma will significantly interact with emotion expressed, with better recognition of negative expressions and poorer recognition of positive or neutral expressions. This is in line with the social information processing mechanism (Dodge et al., 1995). A significant interaction between childhood trauma and intensity is hypothesised as childhood trauma has been associated with needing less perceptual information to identify expressions (McLaughlin et al., 2020), which may in-turn improve accuracy. Therefore, individuals without trauma (who may require more perceptual information) may show poorer accuracy for normal intensity expressions as typical populations usually report (Montirosso et al., 2010). Due to a lack of research exploring childhood trauma and the co-morbid traits of alexithymia and psychopathy together, it is unclear whether the relationship between childhood trauma and emotion recognition across the stimulus-based factors will be influenced by these traits.

There are no specific hypotheses regarding the overall effect of childhood trauma on eye movements (fixation count and dwell time) as previous research is sparse and contradictory. This association will be explored across modality, emotion expressed, intensity of stimuli, and interest area. Due to the limitations of previous stimuli used, it is unclear whether childhood trauma will show interactions with modality or intensity. However, a significant interaction between childhood trauma and emotion expressed may be revealed as previous research has reported reduced attention for angry and sad expressions (Bodenschatz et al., 2019), and shorter dwell time for disgust (Hoepfel et al., 2022). There may not be a significant interaction between childhood trauma and interest area for eye movements as Mohr (2016) reported no significant interaction when exploring across specific facial features. Also, whether the association between childhood trauma and eye movements will be influenced by alexithymia and psychopathy traits is unclear. This study will contribute to the literature by enhancing our understanding of whether childhood trauma influences eye movements during emotion processing and the role the co-morbid traits play, as well as exploring whether previous research using static stimuli can be generalised to moving stimuli, and therefore real-world social interactions.

3.2. Methods

3.2.1. Participants

The sample consisted of 73 participants (53 female; 20 male, M_{age} = 22 years, *SD* = 5.42). In the sample, 38 participants identified their ethnicity as Asian / Pacific Islander (52.1%), 20 identified as White (27.4%), 10 identified as Other (13.7%), 4 identified as Black (5.5%), and 1 identified as Native American or American Indian (1.4%). Participants were recruited from the undergraduate psychology cohort at Brunel University London in exchange for 3 course credits or through opportunity sampling in exchange for a £7.50 voucher. The inclusion criteria were: aged between 18 and 50 years, normal or corrected-to-normal vision, no significant hearing loss that would render daily tasks and conversations difficult, and fluent in English (due to the verbal IQ test including unusually spelt English words). Ethical approval was granted by the Research Ethics Committee for the College of Health, Medicine, and Life Sciences at Brunel University London.

3.2.2. Design

The factors when exploring emotion recognition accuracy were modality (static facial expressions, dynamic facial expressions, audio-visual expressions), emotion expressed (basic six emotions and neutral), and intensity level (normal, strong). The factors when exploring number of fixations and dwell time were modality, emotion expressed, intensity, and interest area (eyes, nose, mouth). The individual differences being explored were childhood trauma, alexithymia and psychopathy.

3.2.3. Materials

3.2.3.1. Questionnaires

Participants completed self-report questionnaires to assess childhood trauma, alexithymia, psychopathy, and personality. The questionnaires are the same as Chapter 2 as we wanted to explore the same individual differences.

Childhood trauma: Childhood Trauma Questionnaire Short Form (CTQ-SF)

Reliability of the CTQ-SF in the current sample was analysed, Guttman's $\lambda_2 = .755$.

Alexithymia: Toronto Alexithymia Questionnaire (TAS-20)

Reliability of the TAS-20 in the current sample was analysed, Guttman's $\lambda_2 = .772$.

Psychopathy: Self Report Psychopathy Scale – Short Form (SRP-SF)

Reliability of the SRP-SF in the current sample was analysed, Guttman's $\lambda_2 = .862$.

Personality: The Mini Personality Questionnaire (Mini-IPIP)

The data concerning personality was collected but not analysed in this study as it was not related to any of our main hypotheses. This is in line with the analytical approach adopted in Experiment 1 (Chapter 2).

Similar to previous chapters, the total scores from each questionnaire (as opposed to separate subscales) were standardised and used in the analyses due to needing considerable power for the analyses chosen and our interest being in the overall effect of the individual differences on emotion performance. Also, the questionnaires included attention checker questions and participants were excluded if they failed more than 2 throughout all the questionnaires. In this study, no participants had to be excluded for lack of attention.

3.2.3.2. Intelligent Quotient Verbal task

Wechsler Test of Adult Reading (WTAR)

The procedure and scoring details for the WTAR are as described in Chapter 2. IQ was included to ensure all participants had an IQ score of 80 and above. Participants would have been excluded if their IQ score was categorised as "borderline" or "extremely low". No participants were excluded on this basis.

3.2.3.3. Emotion stimuli

The stimuli were a subset of those used in Chapter 2. These stimuli were selected from the Ryerson Audio-Visual Database of Emotional Speech and Song (RAVDESS; Livingstone & Russo, 2018). This database includes the basic six emotions and a neutral condition, two emotional intensity levels (normal, strong), across three modalities (visual, audio, and audio-visual expressions). The stimuli used in the current study included static facial expressions, dynamic facial expressions, and audio-visual expressions. As this database did not include static expressions, we created our own. We used the visual condition and when the face was showing a prototypical example of the emotion being expressed (e.g., a large smile for happiness or high eyebrows for surprise) a single frame from the video was captured to create the static stimuli. This allowed us to have the same actors across conditions to ensure this did not affect findings. The dynamic facial expressions and the audio-visual expressions were taken exactly as they were from the RAVDESS. A total of 3 identities (2 male, 2 female: actors 2, 7, 12) were used in the main task. The fourth previously used actor in Chapter 2 (actor 15) was excluded from this study as, for the static condition, there was not a clear emotional peak or frame that captured the standard prototype of that emotional expression. Three different identities (2 male, 1 female: actors 8, 17, 23) were used for the practice trials.

The stimuli showed the actor's face and the top of their shoulders with black t-shirts on a white background (same as Figure 3 in Chapter 2). For the audio-visual stimuli the actors said the semantically neutral sentence of "dogs are sitting by the door", the videos were approximately 3 to 4 seconds in duration. The dynamic faces videos were the same as the audio-visual videos but without the audio. To keep timings consistent the static expressions were also presented for 4 seconds. There was a total of 117 trials (13 stimuli (basic six emotions x 2 intensities, and neutral) x 3 actors x 3 modalities; 39 trials per modality).

3.2.3.4. Eye tracker

To collect eye movement data the EyeLink 1000 system was used, a pupil/corneal reflect tracking device sampled at 1000 Hz. Head movements were minimised by asking participants to place their head within a chin rest during the experiment. The eye movements were monitored non-invasively by using a small infra-red camera under the monitor. The distance from the headrest to monitor was 75.5 cm and from the headrest to the camera was 60.5 cm. There were no photographs or identifying images taken of participants. Before starting the task, and between each condition, participants' eye movements were calibrated and validated. During calibration, a dot appeared in different locations on the screen and participants were asked to fixate on the dot and follow it with their eyes as it moved. If the calibration was successful (indicated by a neat square of 9 crosses) then eye movements were validated using the same 9-point array. In between every trial there was a drift correct (a cross fixation in the centre of the screen) to ensure participants were looking in the centre of the screen before every trial and to check the calibration was still valid. If required, participants completed calibration and validation again during the experiment to ensure the tracking was as accurate as possible. In the main task the stimuli were 10 cm horizontal and 13 cm vertical.

This equipment allowed the tracking of participants' eye gaze patterns to specific facial features (e.g., the areas of interest). The areas of interest created were the left eye, right eye, nose, mouth, and the whole face (example in Figure 20). These areas were consistent across modality. The interest areas for the dynamic and audio-visual conditions were adjusted as the head and features moved during the emotional expression. For the analysis, the interest areas included were the eyes (left eye and right eye combined), the nose, and the mouth. The eye movement data showed how many times individuals looked at certain facial features (number of fixations) and for how long (dwell time). Each condition took approximately 6 minutes to complete.

Figure 20

Examples of the interest areas for actor 7's expressions of neutral (left) and surprise (right).

3.2.4. Procedure

Participants completed questionnaires on the researcher's laptop via Qualtrics and completed the emotion tasks on the eye tracker. Included in the questionnaires were 'attention checker' questions. These included the phrasing "This is to check you are paying attention, please select ___" and included one of the questionnaire response options. To minimise eye strain and maximise attention to the emotion tasks, a questionnaire was completed in between each eye tracker task. There were three tasks: the first task presented the static facial expressions, the second task presented the dynamic facial expressions, and the third task presented the audio-visual expressions. The tasks were not counterbalanced as the static images provided the least amount of information cues for emotional expressions and audio-visual expressions provided the most cues. If the modalities were counterbalanced and participants saw conditions with more cues first, it could mean that some participants would show better performance on the static condition due to the experimental procedure, as opposed to individual differences. For example, if participants saw an audio-visual expression first, as the visual element of the audio-visual expression is identical to the dynamic facial expression condition, participants would be more likely to recognise the expression as they were presented additional cues beforehand (e.g., vocal expression), and this would inflate the accuracy score. Participants wore headphones so the audio in the audio-visual expressions could be controlled (maximum volume on the speaker and computer volume at 25). To ensure consistency across all tasks, headphones were worn for every task.

All the emotion tasks had the same procedure, response options, and screens. During the emotion tasks, either an image or video was presented in the middle of the screen. Once participants had viewed the image or video, the next screen asked them which emotion was being expressed with the response options of Happy, Sad, Anger, Fear, Disgust, Surprise, None/Neutral, I don't know, and Other. Participants responded with the keyboard number assigned to that particular emotion. Each submitted response initiated the next trial. A break was offered after every emotion task. There were no intensity ratings recorded for this experiment. Practice trials using stimuli not included in the main task were presented before calibration and validation so participants could ask questions on the procedure before the task. Participants were asked to refrain from moving or talking as this could affect the eye movements being recorded and the calibration, and to try to not look down before the response options were presented.

3.2.5. Data analysis

Similar to Chapter 2, reaction times were not included in the main analyses as the dynamic expressions varied in duration and onset making it difficult to accurately analyse reaction times, and the hypotheses were focused on accuracy. Although, the stimuli did include static stimuli which is typically used when exploring reaction times, however, participants viewed the static stimuli for 4 seconds and they were not able to select a response option (shown on the next page) before the clip was over. Therefore, any reaction time data would be exploring how quickly participants clicked their response option rather than how quickly they actually recognised the expression. When exploring eye movements, namely fixation count and dwell time, only eye movements from the period the emotion stimuli were being displayed were considered (approximately 4 seconds per trial) to ensure we only analysed participants' eye movements during stimulus presentation and not any time they averted their gaze to the keyboard to select a response option.

Generalised mixed models were performed to examine the role of childhood trauma alone, and whilst controlling for alexithymia and psychopathy traits, on emotion recognition accuracy, and whether the effect varied across modality, emotion expressed, or intensity of stimuli. The stimulus-based variables had a reference group: for modality it was audio-visual, for emotion expressed it was neutral, and for intensity it was normal intensity. The emotion recognition accuracy was calculated per trial. Linear mixed models were employed to explore the role of childhood trauma alone, and whilst controlling for alexithymia and psychopathy traits, on fixation count and dwell time, across modality, emotion expressed, intensity of stimuli, and interest area. The reference groups were the same as above and for interest area it was eyes.

3.3. Results

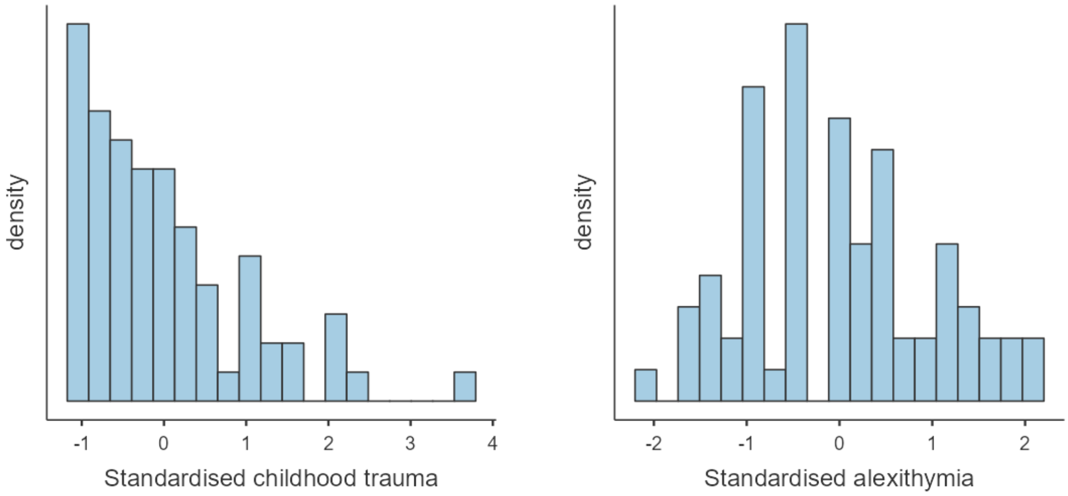
3.3.1 Emotion recognition accuracy

The distribution of different questionnaires are presented in Figure 21 and the average emotion recognition accuracy across the stimulus-based factors of modality, intensity, and emotion expressed are presented in Figure 22.

Figure 21

The distribution of (a) childhood trauma, (b) alexithymia, and (c) psychopathy in the sample.

a) b)



c)

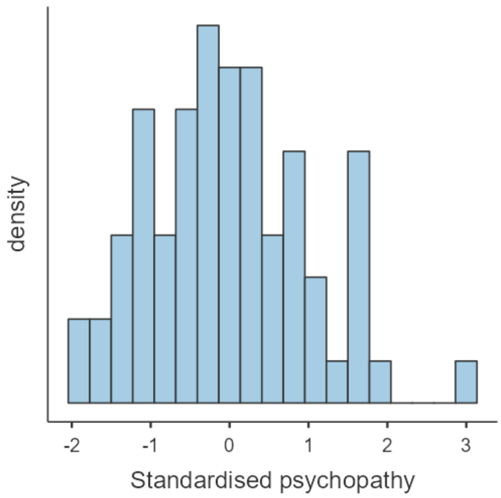
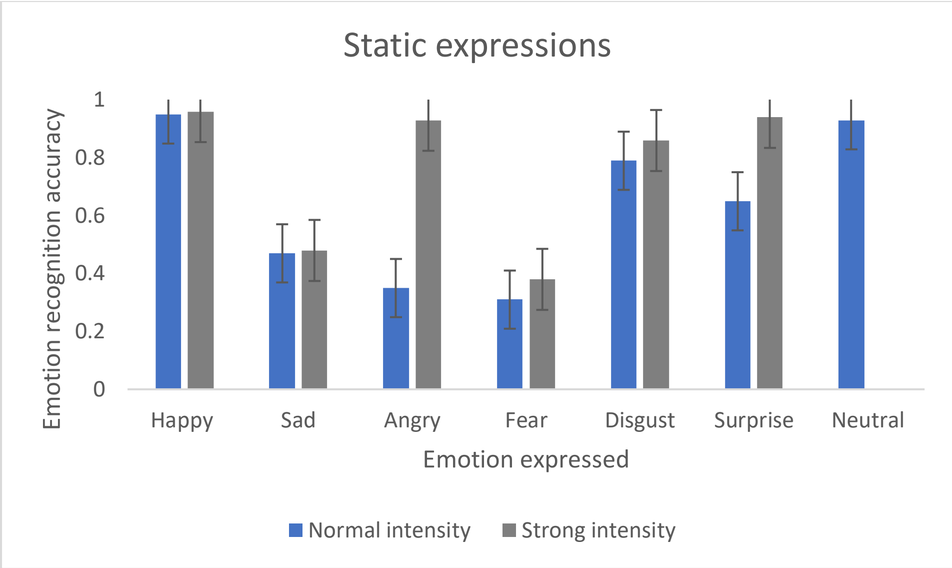


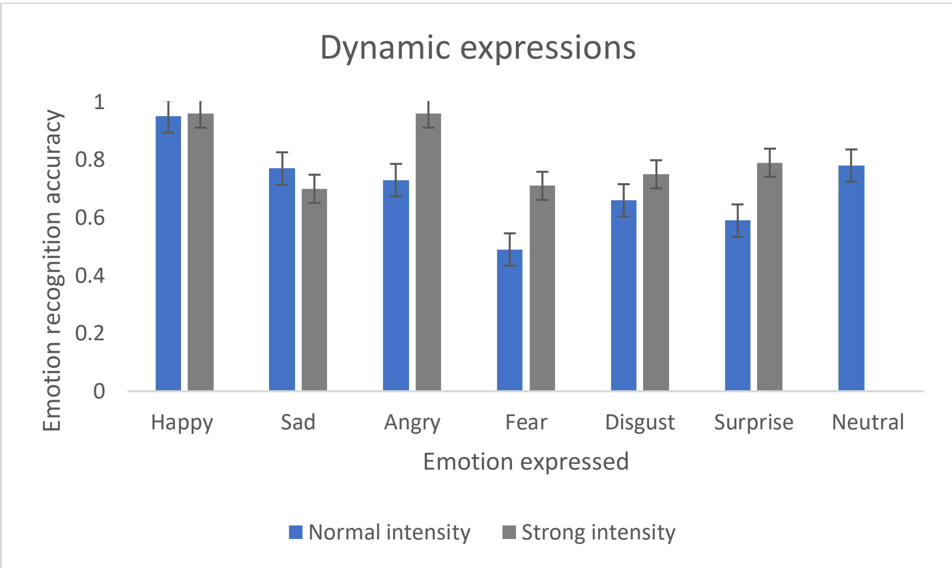
Figure 22

The average emotion recognition accuracy (proportion correct) across intensity and emotion expressed for (a) facial expressions, (b) vocal expressions, and (c) audio-visual expressions.

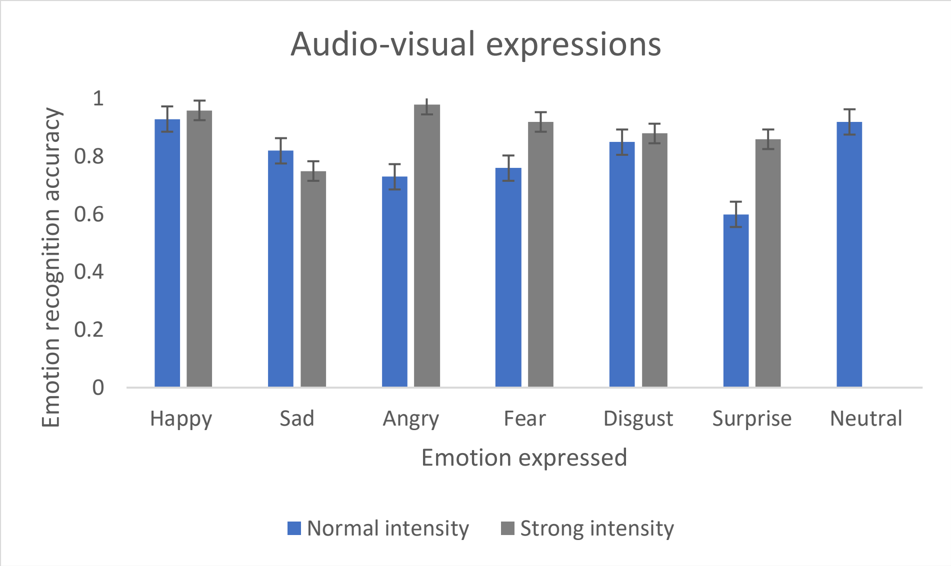
a)


Static expressions
Emotion recognition accuracy
1
0.8
0.6
0.4
0.2
0
Happy
Sad
Angry
Fear
Disgust
Surprise
Neutral
Emotion expressed
Normal intensity
Strong intensity

b)


Dynamic expressions
Emotion recognition accuracy
1
0.8
0.6
0.4
0.2
0
Happy
Sad
Angry
Fear
Disgust
Surprise
Neutral
Emotion expressed
Normal intensity
Strong intensity

c)



The descriptives for the experimental task variables and the individual differences variables are presented in Table 12.

Table 12

Descriptives table for childhood trauma, alexithymia, and psychopathy displaying the mean score, standard deviation, and range of the raw total questionnaire scores. Descriptives for modality (faces, voices, audio-visual), emotion expressed (happy, sad, anger, fear, disgust, surprise, neutral), and intensity (normal, strong) displaying the mean score, standard deviation, and range of emotion recognition accuracy (proprotion correct).

Variables	Mean score	Standard deviation	Range
Childhood trauma	45.19	14.87	70 (28 - 98)
Alexithymia	47.01	11.02	46 (25 – 71)
Psychopathy	54.18	12.43	61 (30 - 91)
Emotion Tasks (Response Accuracy)			
Modality:			
Static	0.69	0.46	0.46 (0.46 – 0.92)
Dynamic	0.76	0.43	0.44 (0.51 – 0.95)
Audio-visual	0.84	0.36	0.36 (0.62 – 0.97)
Emotion:			

Happy	0.95	0.21	0.44 (0.56 – 1.00)
Sad	0.67	0.47	0.67 (0.28 – 0.94)
Anger	0.78	0.41	0.44 (0.50 – 0.94)
Fear	0.60	0.49	0.72 (0.17 – 0.89)
Disgust	0.80	0.40	0.78 (0.22 – 1.00)
Surprise	0.74	0.44	0.71 (0.21 – 0.92)
Neutral	0.87	0.33	0.78 (0.22 – 1.00)
Intensity:			
Normal	0.71	0.45	0.46 (0.46 – 0.92)
Strong	0.82	0.38	0.29 (0.65 – 0.94)

3.3.1.1. Is childhood trauma alone associated with emotion recognition accuracy?

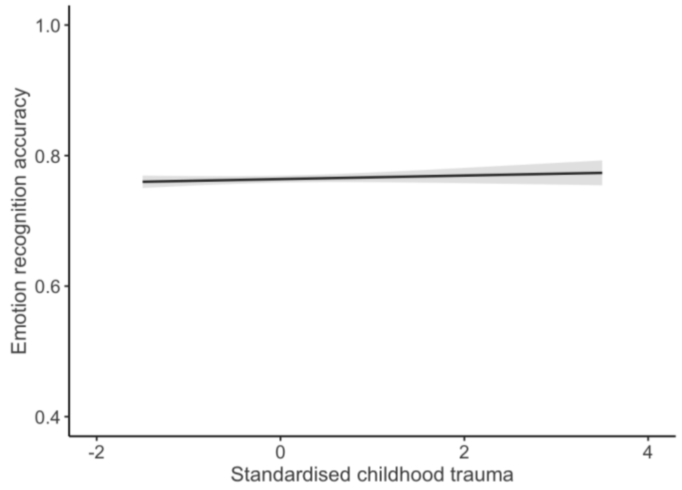
For all models, the random effects were participant and actor.

Does the relationship vary across modality?

A generalised mixed model was employed to explore the effect of childhood trauma on emotion recognition accuracy. The fixed factors were childhood trauma and modality. There was no significant effect of childhood trauma, X^2 (1) = 0.02, p = .891, β = 0.01, exp(B) = 1.01 (Figure 23). However, there was a significant main effect of modality, X^2 (2) = 537.23, p < .001, with β = −0.89 and exp(B) = 0.41 for static and β = −0.55 and exp(B) = 0.58, for dynamic compared to audio-visual. Accuracy was significantly better for audio-visual expressions compared to static expressions, z = - 23.18, p < .001, and dynamic expressions, z = -13.18, p < .001. There was also a significant interaction between childhood trauma and modality, X^2 (2) = 6.96, p = .0.31, with β = -0.01 and exp(B) = 0.99 for childhood trauma * static – audio-visual, and β = -0.09 and exp(B) = 0.91 for childhood trauma * dynamic – audio-visual. The effect of childhood trauma signficantly differed for audio-visual expressions compared to dynamic expressions, with more childhood trauma experience resulting in better accuracy for audio-visual expressions but poorer accuracy for dynamic expressions, z = -2.25, p = .024. There was not a significant interaction between childhood trauma and static expressions compared to audio-visual expressions.

Figure 23

The average emotion recognition accuracy (proportion correct) for the standardised total score of childhood trauma (derived from the CTQ-SF). The shaded area represents the 95% confidence interval.



Does the relationship vary across emotion expressed?

A generalised mixed model was employed to explore the effect of childhood trauma on emotion recognition accuracy. The fixed factors were childhood trauma and emotion expressed. There was no significant main effect of childhood trauma, X^2 (1) = 0.08, p = .784, $\beta = -0.02$, exp(B) = 0.98. There was a significant effect of emotion expressed, X^2 (6) = 1519.73, p < .001. Every emotion was significant, with better accuracy for neutral expressions compared to sad, anger, fear, disgust, and surprise, β ranging from – 0.59 to -1.61 and exp(B) ranging from 0.20 to 0.55, and better accuracy for happy expressions compared to neutral expressions, β = 1.08 and exp(B) = 2.96. There was also a significant interaction between childhood trauma and emotion expressed overall, X^2 (6) = 28.62, p < .001. The effect of childhood trauma signficantly differed for sad (z = 3.64, p < .001), anger (z = 1.37, p = .027), disgust (z = 2.51, p = .012), and surprise (z = 2.18, p = .029) compared to neutral expressions. As childhood trauma experience increased the accuracy of neutral expressions decreased, yet the accuracy of sad, anger, disgust, and surprise increased. There were not any significant interactions reported for childhood trauma and happy and fear expressions compared to neutral.

Does the relationship vary across intensity?

A generalised mixed model was employed to explore the effect of childhood trauma on emotion recognition accuracy. The fixed factors were childhood trauma and intensity of stimuli. The was not a significant main effect of childhood trauma, X^2 (1) = 0.00, p = .974. β = -0.00, exp(B) = 1.00. There was a significant main effect of intensity, X^2 (1) = 405.97, p < .001, β = 0.62, exp(B) = 1.87. There was significantly better accuracy for strong expressions compared to normal expressions, z = 20.15, p < .001. There was not a significant interaction between childhood trauma and intensity, X^2 (1) = 3.32, p = .069, β = −0.06, exp(B) = 0.95. This suggests the effect of childhood trauma did not vary significantly depending on whether the stimuli were normal or strong intensity.

3.3.1.2. Is childhood trauma associated with emotion recognition accuracy when controlling for alexithymia and psychopathy traits?

For all models, the random effects were participant and actor.

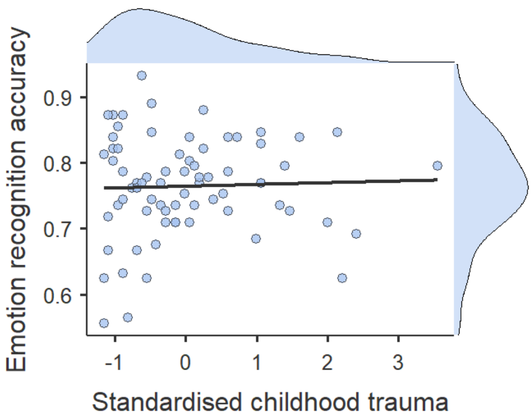
Does the relationship vary across modality?

A generalised mixed model was employed to explore the effect of childhood trauma on emotion recognition accuracy. The fixed factors were childhood trauma and modality and the covariates were alexithymia and psychopathy. There was not a significant effect of childhood trauma, X^2 (1) = 0.21, p = .644, alexithymia, X^2 (1) = 1.30, p = .255, or psychopathy, X^2 (1) = 0.09, p = .770 (Figure 24). However, modality was significant, X^2 (2) = 537.27, p < .001, with significantly higher accuracy for audio-visual expressions compared to static and dynamic expressions. There was still a significant interaction between childhood trauma and modality, X^2 (2) = 6.96, p = .031. The effect of childhood truama experience significantly differed across audio-visual and dynamic expressions. As childhood trauma experience increased there was better accuracy for audio-visual expressions but poorer accuracy for dynamic expressions, z = -0.09, p = .024 (Figure 25). There was not a significant interaction between childhood trauma and static expressions compared to audio-visual expressions. Fixed effects parameter estimates are presented in Table 13.

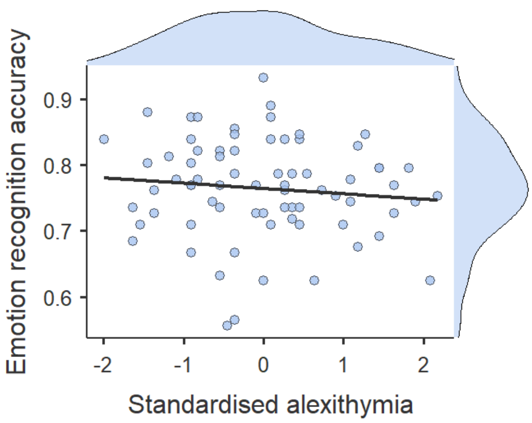
Figure 24

Plots showing the average emotion recognition accuracy for the standardised total scores of (a) childhood trauma (derived from the CTQ-SF), (b) alexithymia (derived from the TAS-20), and (c) psychopathy (derived from the SRP-SF): higher scores indicating more experience of childhood and a higher level of traits of alexithymia and psychopathy.

a)



b)



c)

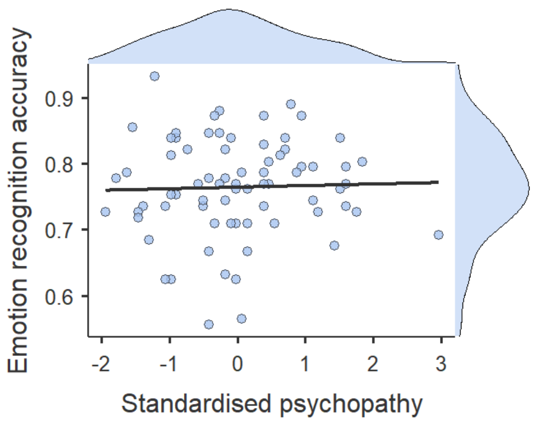


Table 13

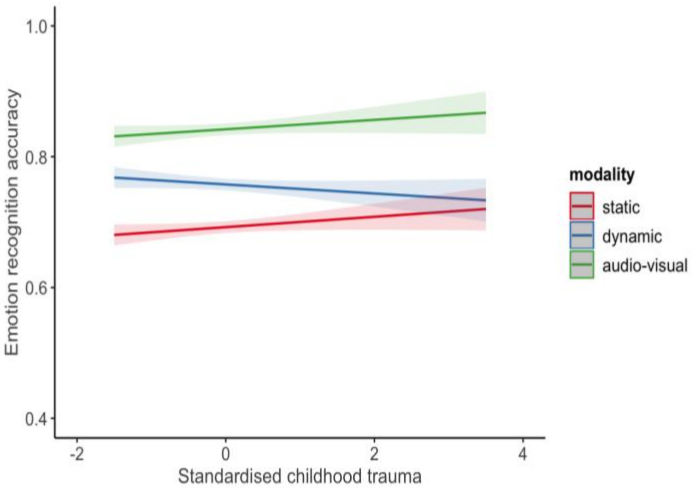
The Fixed Effects Parameter Estimates table for emotion recognition accuracy for childhood trauma, modality, alexithymia, and psychopathy.

Fixed effects	**Estimate**	**Standard Error**	**exp(B)**	**95% CI (lower, upper)**		**z**	***p***
Intercept	1.26	0.10	3.51	2.91	4.24	13.15	< **.001***
Childhood trauma	0.03	0.05	1.03	0.92	1.14	0.46	.644
Static (Static – Audio-visual)	-0.89	0.05	0.41	0.38	0.44	-23.18	< **.001***
Dynamic (Dynamic – Audio-visual)	-0.55	0.04	0.58	0.53	0.62	-13.89	< **.001***
Alexithymia	-0.06	0.05	0.94	0.84	1.05	-1.14	.255
Psychopathy	0.02	0.05	1.02	0.92	1.12	0.29	.770
Childhood trauma * Static	-0.01	0.04	0.99	0.92	1.07	-0.25	.799
Childhood trauma * Dynamic	-0.09	0.04	0.91	0.85	0.99	-2.25	**.024***

*** represents significant values (*p* < .05)**

Figure 25

Average emotion recognition accuracy of the standardised total score for childhood trauma (derived from the CTQ-SF), when controlling for alexithymia and psychopathy traits, across modalities. The shaded area represents the 95% confidence interval.



Does the relationship vary across emotion expressed?

A generalised mixed model was employed to explore the effect of childhood trauma on emotion recognition accuracy. The fixed factors were childhood trauma and emotion expressed and the covariates were alexithymia and psychopathy. There was not a significant effect of childhood trauma, X^2 (1) = 0.00, p = .948, alexithymia, X^2 (1) = 1.29, p = .256, or psychopathy, X^2 (1) = 0.09, p = .765. There was a significant main effect of emotion expressed, X^2 (6) = 1519.97, $p < .001$. There was also a significant interaction between childhood trauma and emotion expressed, X^2 (6) = 28.63, $p < .001$. This suggests the effect of childhood trauma significantly varied across emotion expressed (Figure 26). As childhood trauma experience increased the accuracy of neutral expressions decreased and the accuracy of sad, anger, disgust, and surprise increased. There were not any significant interactions reported for childhood trauma and happy and fear expressions compared to neutral. Fixed effects parameter estimates are presented in Table 14.

Figure 26

Average emotion recognition accuracy of a standardised total score for childhood trauma (derived from the CTQ-SF), when controlling for alexithymia and psychopathy traits, across emotion expressed.

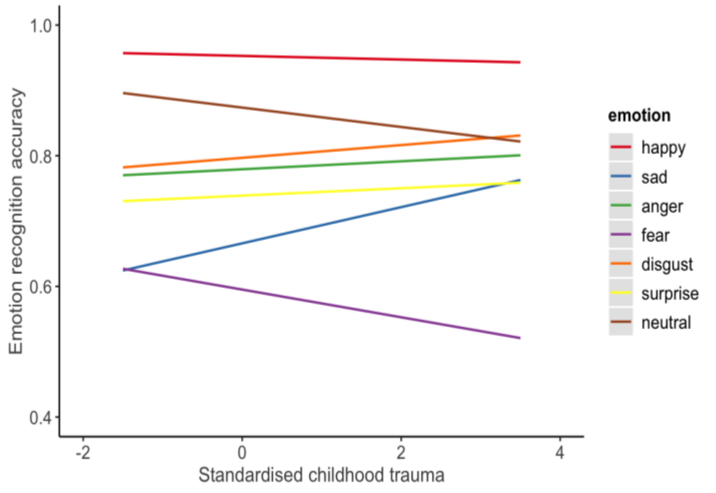


Table 14

The Fixed Effects Parameter Estimates table for emotion recognition accuracy for childhood trauma, emotion expressed, alexithymia, and psychopathy.

Fixed effects	Estimate	Standard Error	exp(B)	95% CI (lower, upper)		z	*p*
Intercept	1.44	0.10	4.23	3.46	5.16	14.15	**< .001***
Childhood trauma	0.00	0.06	1.00	0.90	1.12	0.06	.948
Happy (Happy – Neutral)	1.08	0.10	2.96	2.42	3.61	10.62	**< .001***
Sad (Sad – Neutral)	-1.29	0.08	0.27	0.24	0.32	-16.79	**< .001***
Angry (Angry – Neutral)	-0.7	0.08	0.50	0.43	0.58	-8.84	**< .001***
Fear (Fear – Neutral)	-1.61	0.08	0.20	0.17	0.23	-21.08	**< .001***
Disgust (Disgust – Neutral)	-0.59	0.08	0.55	0.47	0.65	-7.4	**< .001***
Surprise (Surprise – Neutral)	-0.93	0.08	0.40	0.34	0.46	-11.89	**< .001***
Alexithymia	-0.07	0.06	0.94	0.84	1.05	-1.14	.256
Psychopathy	0.02	0.06	1.02	0.91	1.13	0.3	.765
Childhood trauma * Happy	0.06	0.10	1.07	0.88	1.29	0.66	.507
Childhood trauma * Sad	0.27	0.07	1.31	1.13	1.51	3.64	**< .001***
Childhood trauma * Angry	0.17	0.08	1.18	1.02	1.37	2.21	**.027***
Childhood trauma * Fear	0.05	0.07	1.05	0.91	1.21	0.65	.513
Childhood trauma * Disgust	0.19	0.08	1.21	1.04	1.41	2.51	**.012***
Childhood trauma * Surprise	0.16	0.07	1.18	1.02	1.36	2.18	**.029***

*** represents significant values (*p* < .05)**

Does the relationship vary across intensity?

A generalised mixed model was employed to explore the effect of childhood trauma on emotion recognition accuracy. The fixed factors were childhood trauma and intensity and the covariates were alexithymia and psychopathy. There was not a significant effect of childhood trauma, X^2 (1) = 0.09, *p* = .764, alexithymia, X^2 (1) = 1.30, *p* = .255, or psychopathy, X^2 (1)

= 0.08, *p* = .771. There was a significant effect of intensity, X^2 (1) = 405.95, *p* < .001. There was not a significant interaction between childhood trauma and intensity, X^2 (1) = 3.31, *p* = .069. This suggests the effect of childhood trauma did not vary significantly depending on whether the stimuli were normal or strong intensity (Figure 27). Fixed effects parameter estimates are presented in Table 15.

Figure 27

Average emotion recognition accuracy of a standardised total score for childhood trauma (derived from the CTQ-SF), when controlling for alexithymia and psychopathy traits, across intensity. The shaded area represents the 95% confidence interval.

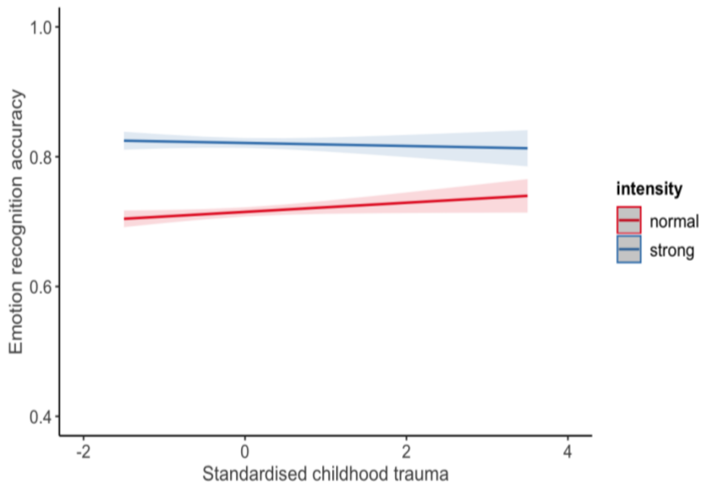


Table 15

The Fixed Effects Parameter Estimates table for emotion recognition accuracy for childhood trauma, intensity, alexithymia, and psychopathy.

Fixed effects	Estimate	Standard Error	exp(B)	95% CI (lower, upper)		z	*p*
Intercept	1.27	0.10	3.56	2.96	4.29	13.36	**<.001***
Childhood trauma	0.02	0.05	1.02	0.91	1.13	0.30	.764
Intensity (Strong – Normal)	0.62	0.03	1.87	1.76	1.98	20.15	**<.001***
Alexithymia	-0.06	0.05	0.94	0.84	1.05	-1.14	.255
Psychopathy	0.02	0.05	1.02	0.92	1.12	0.29	.771
Childhood trauma * Intensity	-0.06	0.03	0.95	0.89	1.00	-1.82	.069

*** represents significant values (*p* < .05)**

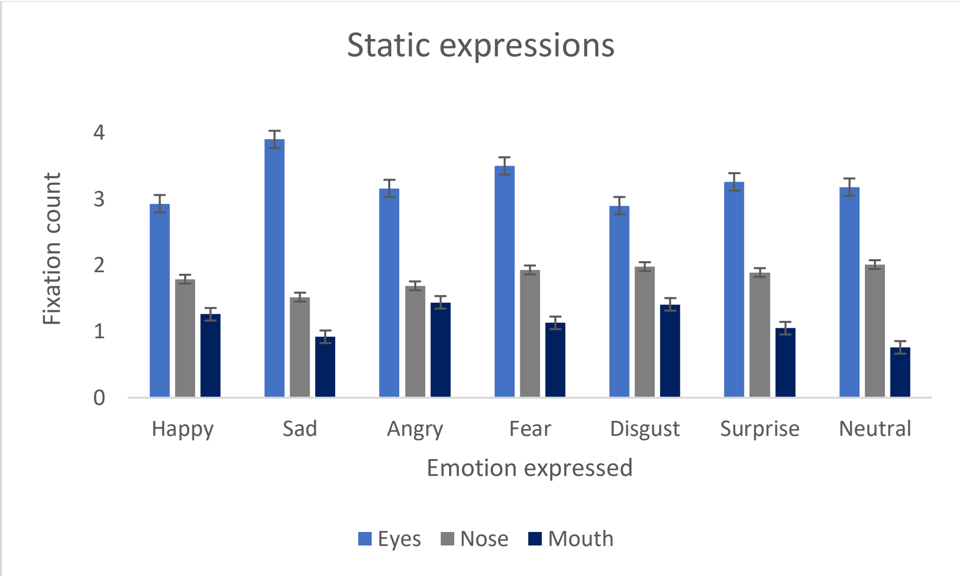
3.3.2. Fixation count

The average number of fixations across modality (static, dynamic, audio-visual), emotion expressed (basic six and neutral), and interest areas (eyes, nose, mouth) are presented in Figure 28.

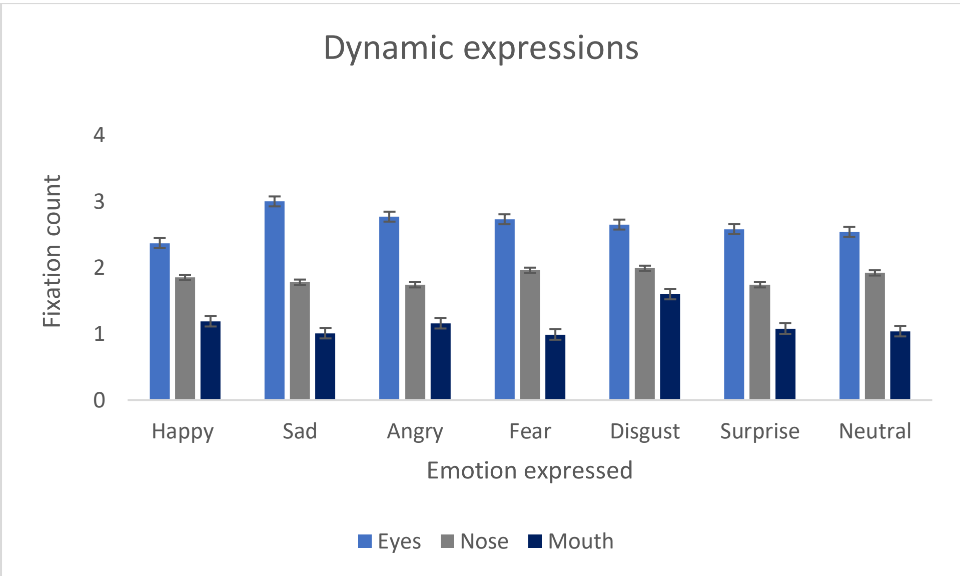
Figure 28

The average number of fixations (fixation count) across interest areas and emotion expressed for (a) static expressions, (b) dynamic expressions, and (c) audio-visual expressions.

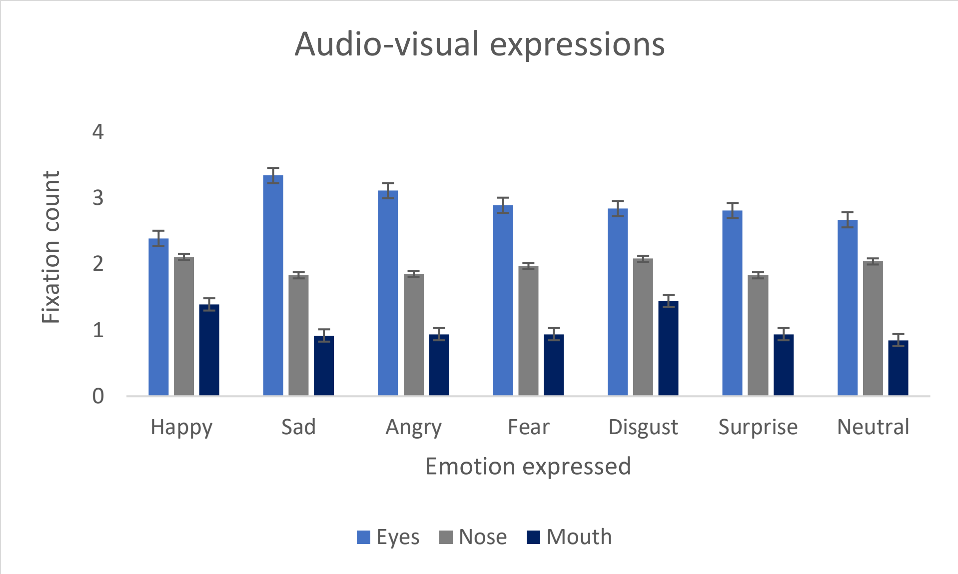
a)



b)



c)



The descriptives for the experimental task variables and the individual differences variables are presented in Table 16.

Table 16

Descriptives table for modality (faces, voices, audio-visual) and emotion expressed (happy, sad, anger, fear, disgust, surprise) displaying the mean, standard deviation, and range of fixation count.

Variables	Mean score	Standard deviation	Range
Emotion Tasks (Fixation count)			
Modality:			
Static	2.09	1.99	14 (0 – 14)
Dynamic	1.90	2.08	22 (0 – 22)
Audio-visual	1.97	2.19	22 (0 - 22)
Emotion:			
Happy	1.92	1.93	16 (0 – 16)
Sad	2.03	2.23	15 (0 – 15)
Anger	1.99	1.08	18 (0 – 18)
Fear	2.00	2.10	13 (0 – 13)
Disgust	2.11	2.14	22 (0 – 22)
Surprise	1.91	2.09	22 (0 – 22)

Neutral	1.89	1.98	13 (0 – 13)
Intensity:			
Normal	1.94	2.07	22 (0 – 22)
Strong	2.03	2.11	22 (0 – 22)
Interest areas:			
Eyes	2.94	2.43	16 (0 – 16)
Nose	1.87	1.64	18 (0 – 18)
Mouth	1.14	1.68	22 (0 – 22)

3.3.2.1. Is childhood trauma alone associated with fixation count?

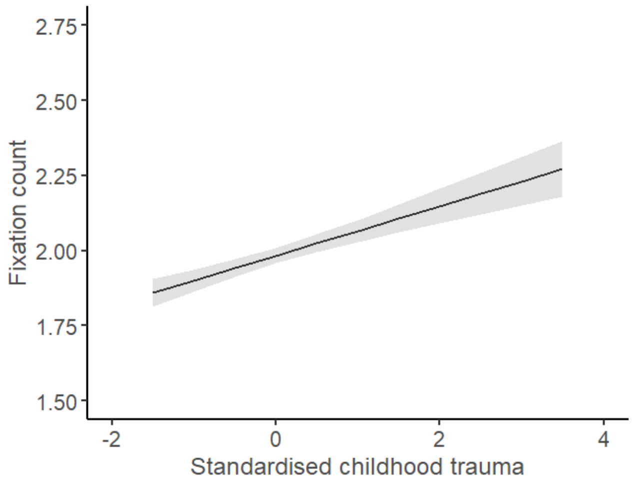
For all models, the random effects were participant and actor.

Does the relationship vary across modality?

A mixed model was employed to explore the effect of childhood trauma on fixation count. The fixed factors were childhood trauma and modality. There was not a significant main effect of childhood trauma, F (1) = 2.41, p = .125, with β = 0.08 and exp(B) = 1.08 (Figure 29). There was a significant main effect of modality, F (2) = 19.21, p < .001, with β = 0.12 and exp(B) = 1.13 for static and β = -0.07 and exp(B) = 0.93 for dynamic compared to audio-visual. Number of fixations were significantly higher for static expressions compared to audio-visual expressions, t = 3.79, p < .001, and significantly higher for audio-visual expressions compared to dynamic, t = -2.35, p = .019. There was not an overall significant interaction between childhood trauma and modality, F (2) = 2.58, p = .076, with β = 0.06 and exp(B) = 1.06 for childhood trauma * static – audio-visual and β = -0.01 and exp(B) = 0.99 for childhood trauma * dynamic – audio-visual. This suggests the effect of childhood trauma on fixation count did not vary significantly across modalities.

Figure 29

The average fixation count for the standardised total score of childhood trauma (derived from the CTQ-SF). The shaded area represents the 95% confidence interval.



Does the relationship vary across emotion expressed?

A mixed model was employed to explore the effect of childhood trauma on fixation count. The fixed factors were childhood trauma and emotion expressed. There was not a significant main effect of childhood trauma, F (1) = 2.52, p = .117, with β = 0.08 and exp(B) = 1.08. There was a significant main effect of emotion, F (6) = 4.95, p < .001, there were significant differences between sad, fear, and disgust expressions compared to neutral expressions, with β ranging from 0.11 to 0.22 and exp(B) ranging from 1.12 to 1.25. Fixations were significantly higher for sad, fear, and disgust expressions compared to neutral expressions. There was not a significant interaction between childhood trauma and emotion expressed, F (6) = 0.12, p = .994. This suggests the effect of childhood trauma on number of fixations did not vary significantly across emotion expressed.

Does the relationship vary across intensity?

A mixed model was employed to explore the effect of childhood trauma on emotion recognition accuracy. The fixed factors were childhood trauma and intensity. There was not a significant effect of childhood trauma, F (1) = 2.39, p = .126, with β = 0.08 and exp(B) = 1.08. There was a significant effect of intensity, F (1) = 11.96, p < .001, with β = 0.09 and exp(B) = 1.09, with more fixations for strong intensity stimuli compared to normal intensity stimuli. There was not a significant interaction between childhood trauma and intensity, F (1) = 0.11, p = .741, with β = −0.01 and exp(B) = 0.99. This suggests the effect of childhood trauma on number of fixations did not vary depending on whether the stimuli were normal or strong intensity.

Does the relationship vary across interest area?

A mixed model was employed to explore the effect of childhood trauma on dwell time. The fixed factors were childhood trauma and interest areas. There was not a significant effect of childhood trauma, F (1) = 2.41, p = .125, with β = 0.08 and exp(B) = 1.08. There was a significant effect of interest area, F (2) = 1985.28, p < .001, with β = -1.07 and exp(B) = 0.34 for nose and β = -1.81 and exp(B) = 0.16 for mouth compared to eyes. There was also a significant interaction between childhood trauma and interest area, F (2) = 233.53, p < .001. The effect of childhood trauma significantly differed for nose compared to eyes, t = -37.11, p < .001, and for mouth compared to eyes, t = -62.66, p < .001. As childhood trauma experience increased the number of fixations for the eyes increased significantly more than for the nose and for the mouth fixations decreased.

3.3.2.2. Is childhood trauma associated with fixation count when controlling for alexithymia and psychopathy traits?

For all models, the random effects were participant and actor.

Does the relationship vary across modality?

A mixed model was employed to explore the effect of childhood trauma on fixation count. The fixed factors were childhood trauma and modality and the covariates were alexithymia and psychopathy. There was not a significant main effect of childhood trauma, F (1) = 2.26, p = .137, alexithymia, F (1) = 0.09, p = .767, or psychopathy, F (1) = 1.15, p = .286. However, modality was still significant, F (2) = 19.21, p < .001, with significantly higher fixation count for static expressions compared to audio-visual expressions and signficantly higher fixation for audio-visual compared to dynamic expressions. There was not a significant interaction between childhood trauma and modality, F (2) = 2.58, p = .076. This may suggest that childhood trauma influences number of fixations similarly regardless of what modality the emotion is expressed (Figure 30). Fixed effects parameter estimates are presented in Table 17.

Figure 30

Fixation count of the standardised total score for childhood trauma (derived from the CTQ-SF), when controlling for alexithymia and psychopathy traits, across modalities. The shaded area represents the 95% confidence interval.

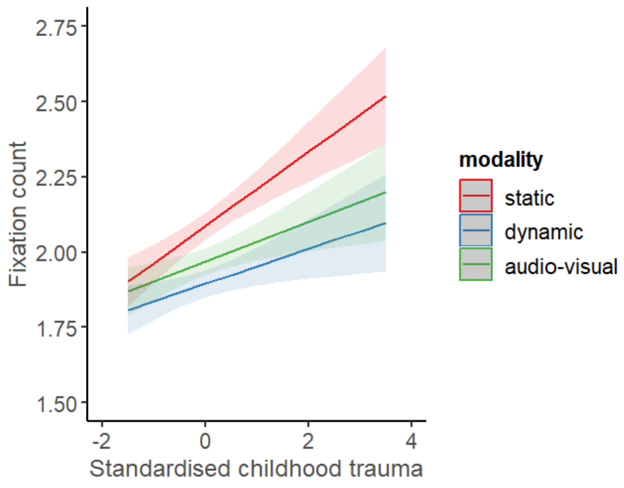


Table 17

The Fixed Effects Parameter Estimates table for fixation count for childhood trauma, modality, alexithymia, and psychopathy.

Fixed effects	**Estimate**	**Standard Error**	**exp(B)**	**95% CI (lower,**	**upper)**	***t***	***p***
Intercept	1.98	0.05	7.24	1.88	2.09	36.74	**< .001***
Childhood trauma	0.09	0.06	1.09	-0.03	0.20	1.5	.137
Static (Static – Audio-visual)	0.12	0.03	1.13	0.06	0.18	3.79	**< .001***
Dynamic (Dynamic – Audio-visual)	-0.07	0.03	0.93	-0.13	-0.01	-2.35	**.019***
Alexithymia	0.02	0.06	1.02	-0.10	0.13	0.3	.767
Psychopathy	-0.06	0.05	0.94	-0.17	0.05	-1.07	.286
Childhood trauma * Static	0.06	0.03	1.06	0.00	0.12	1.83	.067
Childhood trauma * Dynamic	-0.01	0.03	0.99	-0.07	0.05	-0.25	.805

*** represents significant values (*p* < .05)**

Does the relationship vary across emotion expressed?

A mixed model was employed to explore the effect of childhood trauma on fixation count. The fixed factors were childhood trauma and emotion expressed and the covariates were alexithymia and psychopathy. There was no significant main effect of childhood trauma, *F* (1) = 2.36, *p* = .129, alexithymia, *F* (1) = 0.09, *p* = .767, or psychopathy, *F* (1) = 1.15, *p* =

.286. However, emotion expresed was significant, F (6) = 4.95, p < .001, with significantly more fixations for sad, fear, and disgust expressions compared to neutral expressions. There was no significant interaction between childhood trauma and emotion expressed, F (6) = 0.12, p = .994 (Figure 31). Fixed effects parameter estimates are presented in Table 18.

Figure 31

Average fixation count of a standardised total score for childhood trauma (derived from the CTQ-SF), when controlling for alexithymia and psychopathy traits, across emotion expressed.

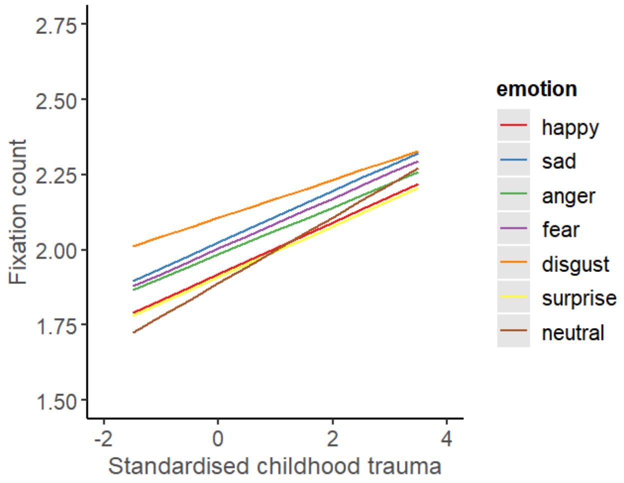


Table 18

The Fixed Effects Parameter Estimates table for fixation count for childhood trauma, emotion expressed, alexithymia, and psychopathy.

Fixed effects	**Estimate**	**Standard Error**	**exp(B)**	**95% CI (lower, upper)**		***t***	***p***
Intercept	1.98	0.05	7.24	1.87	2.08	36.55	**< .001***
Childhood trauma	0.09	0.06	1.09	-0.02	0.20	1.54	.129
Happy (Happy – Neutral)	0.03	0.06	1.03	-0.08	0.14	0.56	.577
Sad (Sad – Neutral)	0.14	0.06	1.15	0.03	0.25	2.42	**.016***
Angry (Angry – Neutral)	0.10	0.06	1.11	-0.01	0.21	1.7	.090
Fear (Fear – Neutral)	0.11	0.06	1.11	0.00	0.23	2.04	**.041***
Disgust (Disgust – Neutral)	0.22	0.06	1.25	0.11	0.33	3.86	**< .001***
Surprise (Surprise – Neutral)	0.02	0.06	1.02	-0.09	0.13	0.34	.732
Alexithymia	0.02	0.06	1.02	-0.10	0.13	0.30	.767
Psychopathy	-0.06	0.05	0.94	-0.17	0.05	-1.07	.286
Childhood trauma * Happy	-0.02	0.06	0.98	-0.14	0.09	-0.43	.669
Childhood trauma * Sad	-0.02	0.06	0.98	-0.14	0.09	-0.43	.665
Childhood trauma * Angry	-0.03	0.06	0.97	-0.14	0.08	-0.55	.583
Childhood trauma * Fear	-0.03	0.06	0.97	-0.14	0.09	-0.46	.648
Childhood trauma * Disgust	-0.05	0.06	0.85	-0.16	0.06	-0.82	.413
Childhood trauma * Surprise	-0.02	0.06	0.98	-0.14	0.09	-0.43	.671

*** represents significant values (*p* < .05)**

Does the relationship vary across intensity?

A mixed model was employed to explore the effect of childhood trauma on fixation count. The fixed factors were childhood trauma and intensity and the covariates were alexithymia and psychopathy. There was not a significant main effect of childhood trauma, F (1) = 2.24, p = .139, alexithymia, F (1) = 0.09, p = .767, or psychopathy, F (1) = 1.15, p = .286. There was a significant effect of intensity, F (1) = 11.96, p < .001, with a higher number of fixations for strong expressions compared to normal expressions. There was not a significant interaction between childhood trauma and intensity, X^2 (1) = 0.11, p = .741. This suggests the effect of childhood trauma on fixation count did not vary significantly depending on whether the stimuli were normal or strong intensity (Figure 32). Fixed effects parameter estimates are presented in Table 19.

Figure 32

Average emotion recognition accuracy of a standardised total score for childhood trauma (derived from the CTQ-SF), when controlling for alexithymia and psychopathy traits, across intensity. The shaded area represents the 95% confidence interval.

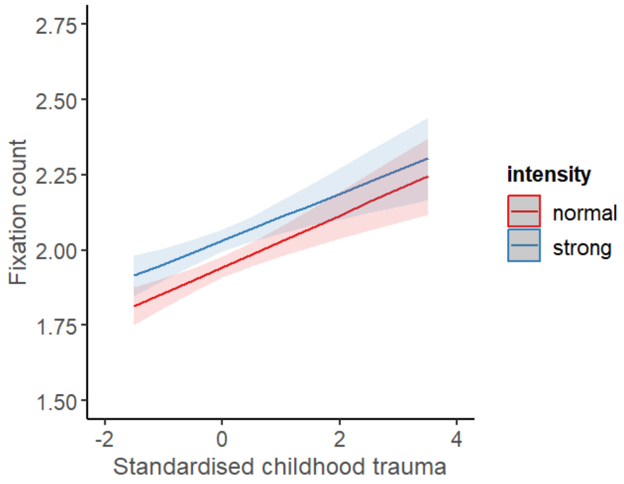


Table 19

The Fixed Effects Parameter Estimates table for emotion recognition accuracy for childhood trauma, intensity, alexithymia, and psychopathy.

Fixed effects	Estimate	Standard Error	exp(B)	95% CI (lower, upper)		z	*p*
Intercept	1.99	0.05	7.32	1.88	2.09	36.8	**< .001***
Childhood trauma	0.08	0.06	1.08	-0.03	0.20	1.50	.139
Intensity (Strong – Normal)	0.09	0.03	1.09	0.04	0.14	3.46	**< .001***
Alexithymia	0.02	0.06	1.02	-0.10	0.13	0.30	.767
Psychopathy	-0.06	0.05	0.94	-0.17	0.05	-1.07	.286
Childhood trauma * Intensity	-0.01	0.03	0.99	-0.06	0.04	-0.33	.741

*** represents significant values (*p* < .05)**

Does the relationship vary across interest area?

A mixed model was employed to explore the effect of childhood trauma on fixation count. The fixed factors were childhood trauma and interest area and the covariates were alexithymia and psychopathy. There was not a significant main effect of childhood trauma, *F* (1) = 2.26, *p* = .137, alexithymia, *F* (1) = 0.09, *p* = .767, or psychopathy, *F* (1) = 1.15, *p* = .286. There was a significant effect of interest area, *F* (2) = 1985.28, *p* < .001, with significantly higher fixations for eyes compared to the nose and mouth. There was also a significant interaction between childhood trauma and interest area, F (2) = 233.53, $p < .001$. As childhood trauma increased the fixations to the eyes increased significantly compared to the nose yet fixations to the mouth decreased as experience of childhood trauma increased. This suggests the effect of childhood trauma on the number of fixations differs across facial features: eyes, nose, mouth (Figure 33). Fixed effects parameter estimates are presented in Table 20.

Figure 33

Average fixation count of a standardised total score for childhood trauma (derived from the CTQ-SF), when controlling for alexithymia and psychopathy traits, across interest area. The shaded area represents the 95% confidence interval. The Y axis is different for this graph compared to previous dwell time graphs (previous graph groups were indistinguishable when the axis was 0 –5 as in the current graph but the current graph was incomplete with the axis was 1.5 – 2.75 as in previous graphs).

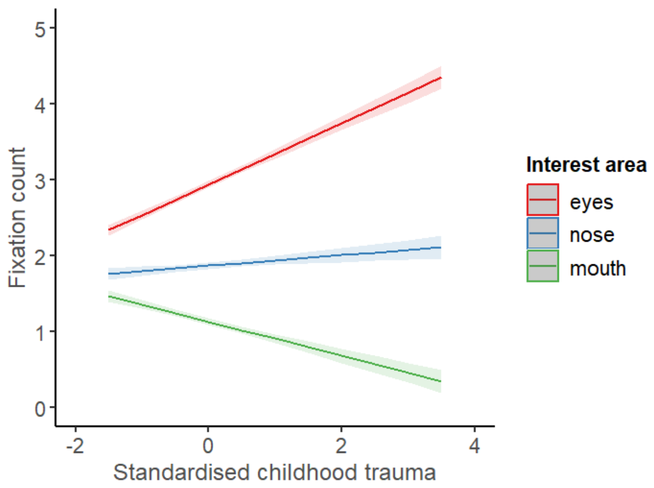


Table 20

The Fixed Effects Parameter Estimates table for fixation count for childhood trauma, interest areas, alexithymia, and psychopathy.

Fixed effects	**Estimate**	**Standard Error**	**exp(B)**	**95% CI (lower, upper)**		***t***	***p***
Intercept	1.98	0.05	7.24	1.88	2.09	36.59	**< .001***
Childhood trauma	0.09	0.06	1.09	-0.03	0.20	1.50	.137
Nose (Nose – Eyes)	-1.81	0.03	0.16	-1.86	-1.75	-62.66	**< .001***
Mouth (Mouth – Eyes)	-1.07	0.03	0.34	-1.13	-1.01	-37.11	**< .001***
Alexithymia	0.02	0.06	1.02	-0.10	0.13	0.30	.767
Psychopathy	-0.06	0.05	0.94	-0.17	0.05	-1.07	.286
Childhood trauma * Nose	-0.63	0.03	0.53	-0.68	-0.57	-21.60	**< .001***
Childhood trauma * Mouth	-0.33	0.03	0.72	-0.39	-0.28	-11.45	**< .001***

*** represents significant values (p < .05)**

3.3.3. Dwell time

Dwell time was also analysed when exploring childhood trauma alone and childhood trauma when controlling for alexithymia and psychopathy traits across modality, emotion expressed, intensity, and interest area. There were similar findings to number of fixations of a significant effect of modality and interest area, as well as a significant interaction between childhood trauma and interest area. There was significantly more dwell time for the static expressions compared to audio-visual expressions and for the eyes compared to the nose and mouth. Also, there were similar findings to number of fixations of a lack of significant effects of childhood trauma, alexithymia, and psychopathy and no significant interactions between childhood trauma and modality or intensity. There were different findings reported for the two eye movement measures as fixation count reported a significant effect of emotion and intensity, yet dwell time did not report this. The full analyses for dwell time are reported in Appendix 1.

3.3.4. Summary

The emotion recognition accuracy analyses revealed a significant effect of modality, emotion expressed, and intensity of stimuli. There was significantly better accuracy for audio-visual expressions compared to static and dynamic expressions, for neutral expressions compared to all expressions except happy, which had significantly better accuracy than neutral expressions, and for strong intensity stimuli compared to normal intensity stimuli. There was not a significant effect of childhood trauma, alexithymia, or psychopathy. There was, however, a significant interaction between childhood trauma and modality and emotion expressed. More childhood trauma experience led to better accuracy for audio-visual expressions but poorer accuracy for dynamic expressions, as well as better accuracy for sad, anger, disgust, and surprise but poorer accuracy for fear and neutral expressions.

For eye movements, number of fixations and dwell time were explored. Regarding number of fixations, there was a significant effect of modality, emotion expressed, intensity, and interest area. There were significantly more fixations for static faces compared to audio-visual expressions and for audio-visual compared to dynamic expressions, for sad, fear, and disgust expressions compared to neutral expressions, for strong expressions compared to normal expressions, and for the eyes compared to the nose and mouth. For dwell time, only modality and interest area were significant with more dwell time for static compared to audio-visual expressions and for the eye region compared to the nose and mouth. However, there were no significant effects of childhood trauma, alexithymia, and psychopathy reported for either fixations or dwell time. Although, there was a significant interaction between childhood trauma and interest area reported for both number of fixations and dwell time, with more childhood trauma experience leading to significantly more gaze to the eye region compared to the nose and mouth.

3.4. Discussion

It was unclear whether childhood trauma experience influenced eye movements when recognising emotional expressions, and if atypical gaze (avoidance of the eye region) could explain the emotion deficits associated with childhood trauma. Chapter 2 reported that emotion recognition was affected by experience of childhood trauma, and this was shown through accuracy measures. The current chapter sought to explore this more by examining where individuals looked on the face to process the expression before categorising it. This can explore whether emotion recognition performance is poor due to more perceptual factors or whether it is due to higher level factors.

Therefore, the main aim of the study was to investigate whether childhood trauma, when controlling for alexithymia and psychopathy traits, was associated with emotion recognition accuracy and eye movements (fixation count and dwell time). We explored whether these effects varied across modality, emotion expressed, and intensity of stimuli, as well as interest area for eye movements. By exploring across various conditions, we can explore whether internal factors (e.g., individual differences) and/or external factors (e.g., stimulus-based factors) influence how we process and recognise emotional expressions. The current emotion recognition literature has typically used static facial expressions when exploring emotion recognition performance, even more so when using eye tracking. However, whether findings which used static facial expressions can be generalised to real-world conversations, due to the lack of ecological validity, is unclear.

3.4.1. Childhood trauma and eye movements

The current study adds to the limited literature exploring the effect of childhood trauma experience on eye movements when processing emotional expressions. The previous research exploring childhood trauma and eye movements has focused heavily on comparing eye gaze between emotional expressions versus neutral expressions (Bodenschatz et al., 2019; Seitz et al., 2021; Hoepfel et al., 2022) as opposed to specific facial features, like the current study. This means our understanding of the specific facial features used for accurate emotion recognition in individuals with experience of childhood trauma was limited. However, the current study did explore this and reported there was no significant effect of childhood trauma experience on eye movements to specific facial features when processing emotional expressions. This suggests that individuals with experience of childhood trauma show similar eye gaze patterns as individuals without experience of childhood trauma. This is supported by previous research, Mohr (2016), which reported that the facets of childhood trauma did not influence where individuals looked on the face when processing emotional expressions. As atypical eye gaze patterns have been associated with a variety of cognitive processes, it can allow us to better understand how individuals perceive and process information which could impact social behaviour (Keles et al., 2022). Further, number of fixations when exploring eye movements can provide insight into what we remember, how we read, how we solve problems, and how we learn (Eckstein et al., 2017). The lack of a main significant effect of childhood trauma on number of fixations may suggest that individuals with more reported childhood trauma experience are no more impacted in these cognitions than individuals reporting less childhood trauma experience. Also, as reported childhood trauma experience increased as did fixations towards the eye region, which is a key region for accurate emotion recognition (Schurgin et al., 2014; Mohr, 2016), suggesting typical eye gaze and fixation patterns for individuals with childhood trauma experience.

There is a plethora of research explaining the neural differences between individuals with childhood trauma experience and individuals without (Dannlowski et al., 2012; Marusak et al., 2015; McLaughlin et al., 2015; Cassiers et al., 2018; Demers et al., 2018). They have suggested differences in activation during emotion tasks in the prefrontal cortex (Marusak et al., 2015; Demers et al., 2018), amygdala (Marusak et al., 2015; McLaughlin et al., 2015; Demers et al., 2018), and the insula (McLaughlin et al., 2015) for individuals with and without experience of childhood trauma. This may suggest differences in the processing of emotional expressions depending on childhood trauma experience. However, similar processing patterns, when exploring eye gaze in the current study, were found regardless of the amount of childhood trauma experience. This suggests typical processing patterns when scanning faces to recognise expressions. Additionally, the current study reported differences in processing patterns for static and dynamic facial expressions. This suggests difficulties comparing the current research, which employed realistic stimuli, to previous research, which employed static facial expressions. In order to address the differences in the eye tracking findings in the current study with the previous neural work, it may be beneficial to explore childhood trauma's influence on emotion processing using both an eye tracker and neuroimaging (e.g., EEG) together to address this.

Another difficulty when interpreting the current childhood trauma and eye movements literature is that the majority employs clinical samples (Bodenschatz et al., 2019; Seitz et al., 2021). Therefore, it is difficult to distinguish which factor is responsible for the atypical eye gaze patterns. Research had also excluded key co-morbid traits to childhood trauma, such as alexithymia and psychopathy, which were also associated with eye gaze patterns. The current study included these traits but, as there was no significant effect of childhood trauma, the alexithymia and psychopathy traits did not significantly influence the relationship between childhood trauma and eye movements.

However, there was also no significant effect of alexithymia or psychopathy themselves which differs from previous research. Multiple studies have reported that both alexithymia and psychopathy traits were associated with atypical eye movements, including avoiding the eye region (Gillespie et al., 2015; Fujiwara, 2018). Research had suggested, specifically for alexithymia, that eye contact may be difficult hence the avoidance of that area (Fujiwara, 2018). It has also been suggested that atypical eye gaze patterns may explain the emotion recognition difficulties associated with alexithymia and psychopathy traits (Dadds et al., 2008; Fujiwara, 2018). However, the co-morbid traits showed typical gaze patterns. A possible reason for the differences in findings could be due to including more realistic stimuli alongside static stimuli of dynamic faces and audio-visual expressions, which previous research had not included. However, similar to childhood trauma, higher levels of these traits did not hinder eye movements which suggests similar, and typical, processing for individuals with lower levels of traits.

3.4.2. Childhood trauma and accuracy

The emotion recognition accuracy analyses reported similar findings when exploring childhood trauma alone and when controlling for alexithymia and psychopathy traits. There was a significant effect of the stimulus-based factors, as well as significant interactions between childhood trauma and modality and childhood trauma and emotion expressed. This suggests that, when comparing across static, dynamic, and multimodal expressions, the effect of childhood trauma experience on emotion recognition accuracy does differ depending on how the emotion is being presented and which specific emotion is expressed. When exploring childhood trauma overall, there was not a significant effect on emotion recognition accuracy. This differs from the previous research discussed which reported a significant association between childhood trauma and poorer emotion recognition accuracy overall (Pollak et al., 2000; Bérubé et al., 2023). This differs from Chapter 2, which reported childhood trauma influenced performance on an emotion recognition task. It may suggest that childhood trauma experience itself does not influence accuracy for emotion processing tasks but does interact with other factors to influence performance. Chapter 2 had also reported a significant effect of alexithymia whereas the current study did not report that alexithymia or psychopathy traits influenced the relationship between childhood trauma and emotion recognition accuracy or had a significant effect themselves. This could suggest that some of those effects were driven by the use of auditory stimuli used in Chapter 2 or the use of static stimuli in the current chapter, which are more difficult to recognise than moving stimuli (Scherer, 2003; Alvez, 2013).

Another possible difference between the current chapter and Chapter 2 could be the methods employed. In particular, the way participants were tested. The current chapter used in-person lab testing as the eye tracker was involved, however, Chapter 2 used online testing through Testable. This evident difference in testing could explain the differences in findings. It also adds uncertainty for whether the findings from the two chapters can be reliably and directly compared, which poses possible issues for ensuring validity and generalisability of the study's conclusions. However, Schidelko et al. (2021) explored the comparison between online testing and lab testing for the false belief task (typically used to explore Theory of Mind) and reported that the performance seen in lab-based studies was replicated in online studies. This may suggest that there can be reliable comparisons between different testing procedures. However, this was for the false belief task and not an emotion recognition task as used in the current chapter, so the direct comparisons between chapters should be cautious.

Interestingly, it seems Figure 24 panel (a) (visualising the relationship between childhood trauma and emotion recognition accuracy) shows a non-linear relationship. It seems to show that some individuals reporting less childhood trauma experience struggle with emotion recognition accuracy and some individuals reporting more experience of childhood trauma also struggle with emotion recognition accuracy. Although, the individuals in the mid-range of reported childhood trauma experience seem to have better emotion recognition accuracy. The current data cannot answer why this relationship may be non-linear, but this would be an interesting avenue for future research exploring childhood trauma and emotion performance to explore these non-linear effects and delve deeper into this relationship and all the possible influences.

3.4.3. Childhood trauma and stimulus-based factors

3.4.3.1. Interest areas

When exploring eye movements, performance was explored across specific facial features: eyes, nose, and mouth. The findings for fixations and dwell time were consistent regarding the effect of interest area, with more fixations and dwell time for the eye region compared to the nose and mouth. This suggests that individuals focused more on the eye region when processing emotional expressions. This was supported by previous research using various methods, research using eye tracking (Schurgin et al., 2014; Mohr, 2016), the Bubble technique (Smith et al., 2005), and the tile method (Wegrzyn et al., 2017), which suggested individuals pay attention to the eye region for the majority of emotional expressions. This is also in line with research which used the Reading the Mind in the Eyes Test (RMET). This presents only the eye region of an emotional expression and suggests that the eye region alone is sufficient for accurate emotion recognition (Baron-Cohen et al., 2001; Schmidtmann et al., 2020). This could suggest that recognition in situations where the lower half of the face is occluded but the eye region is available, such as a face mask as seen during the COVID-19 pandemic, may not be as impaired as expected as the eye region may be sufficient for accurate recognition.

The findings suggest that the effect of childhood trauma on number of fixations differed across specific facial features. When comparing the eyes and nose, as childhood trauma increased as did the fixations towards the eye region compared to the nose. Whereas when comparing the eyes to the mouth, as childhood trauma increased the fixation to the eyes increased but fixations to the mouth decreased. This suggests that individuals with childhood trauma experience directed more fixations towards to the eye region when processing expressions. This is somewhat surprising as when discussing childhood trauma in general, research suggested that individuals with experience of childhood abuse avoid eye contact as this can be perceived as threatening to individuals who were abused and may provoke their abuser (Krill & McKinnon, 2010; Steuwe et al., 2014). However, our opposing findings may suggest this pattern may not generalise to individuals who are not their abuser or in a controlled environment, i.e., a lab.

Though, there is support for childhood trauma, and co-morbid disorders, paying more attention to the eye region as the current study found. Childhood trauma experience has been reported as mediating the relationship between BPD and sensitivity to interpersonal threat cues (Seitz et al., 2021), and BPD has been associated with prolonged fixations to the eye region as a result of key information regarding threat-related facial expressions (Kaiser et al., 2019). Therefore, attending more to the eye region may suggest a hypervigilance to threat cues in individuals with BPD as well as individuals with experience of childhood trauma. Research has reported an increase in attention to the eyes for individuals with BPD and co-morbid PTSD, which suggests a significant role of traumatic experiences (Kaiser et al., 2019). This supports the current finding of individuals with childhood trauma attending more to the eye region. The fact dwell time did not report a significant interaction with childhood trauma may suggest that childhood trauma interacts with specific facial features for how many times we look at features (number of fixations) but now how long for (dwell time). Although, dwell time may differ as stimuli were presented for a fixed duration of time (4 seconds) instead of self-paced (e.g., stimuli finishing once the participant selected a response).

3.4.3.2. Modality (Stimulus presentation)

The current study employed updated and more realistic stimuli by including dynamic and audio-visual expressions. Previous eye tracking research typically used static facial expressions and there is little to no research exploring the effect of individual differences on eye gaze patterns across static and moving stimuli (dynamic and audio-visual). By including both static and moving stimuli we can determine whether they are processed differently. If they are processed differently then previous research using static stimuli may not be the best option to generalise findings to real-world interactions from.

When exploring childhood trauma and modality for eye movements, there was a significant effect of modality. There were significantly more fixations for static expressions compared to audio-visual expressions as well as for audio-visual expressions compared to dynamic expressions. There was also significantly more dwell time for static expressions compared to audio-visual expressions. Static faces receiving more fixations, and time spent, may be because there are fewer cues in static expressions which might have resulted in individuals spending longer scanning the face and employing featural processing (using separate facial features) to recognise the expression. Whereas the audio-visual expressions have more cues (e.g., facial and vocal cues) so individuals may be able to process the expression more holistically. Similarly, the fact dynamic expressions had the least fixations may suggest that you can get more information from a single fixation in dynamic stimuli, as non-fixated areas will still be processed to some extent, and movement may aid this. This follows Roy et al. (2010) who reported gaze for static faces quickly spread outward whereas gaze for dynamic faces stayed more central.

When exploring emotion recognition accuracy and modality, the results show better accuracy for audio-visual expressions compared to dynamic and static expressions. This follows Chapter 2's findings of accuracy increasing as the amount of emotion cues increased. This also follows previous research which reported higher accuracy when viewing moving compared to static stimuli (Ambadar et al., 2005; Bould & Morris, 2008; Alvez, 2013). There was also a significant interaction between childhood trauma and modality, with more reported experience of childhood trauma improving the recognition of audio-visual expressions but hindering the recognition of dynamic expressions. This was unexpected as childhood trauma has been associated with hypervigilance of social cues to help predict the next onset of abuse (Seitz et al., 2021), which would suggest more attention and better accuracy.

A possible reason for the poorer performance could be explained by Hoepfel et al. (2022) who suggested individuals initially attend to negative cues to assess the danger of a situation and then later avoid these cues to evade possible conflict. Therefore, participants may have avoided attention towards dynamic emotional expressions, leading to the poorer accuracy. However, this was not possible in the audio-visual condition due to the vocal expression also present, possibly leading to better accuracy. Future research should explore other eye tracking measures such as order of fixations or first fixations to better explore avoidance type patterns. Future research may also benefit from using a wider and more diverse sample, or screen participants to create low and high childhood trauma groups, to see if the findings are replicated.

Both the accuracy and eye movement findings agree that performance differs for static expressions compared to moving expressions. This may suggest that previous emotion research, which typically used static expressions, may be useful in exploring how we process and recognise static expressions. However, it may struggle to generalise and apply the findings to real-world interactions. The childhood trauma literature reporting emotion recognition accuracy has also typically used static expressions. It may be that childhood trauma's previously reported emotion recognition deficit with static facial expressions may not generalise to real conversations/situations. The result that individuals process static and moving stimuli differently highlights the need to use realistic stimuli when investigating emotion recognition performance.

3.4.3.3. Emotion expressed

When exploring eye movements and emotion expressed, there were significantly more fixations for sad, fear, and disgust expressions compared to neutral expressions. This is somewhat expected as research has reported a negativity bias (e.g., more attention to negative expressions compared to positive or neutral expressions) as these expressions have evolutionary adaptive functions of avoiding potentially harmful situations (Vaish et al., 2008). Therefore, more attention is paid to negative expressions compared to neutral expressions as they serve a purpose.

The findings also show the effect of childhood trauma on eye movements was similar across the emotions expressed. Previous research has reported that childhood trauma's effect differs across emotions expressed, with reduced attention to angry and sad expressions (Bodenschatz et al., 2019) and shorter dwell time on disgust (Hoepfel et al., 2022). It would be expected that the negative expressions are impacted in line with the social processing mechanism (Dodge et al., 1995). This states that childhood trauma is associated with better recognition of negative expressions, due to heightened sensitivity to threat or negative cues (McLaughlin et al., 2020). However, this was not found. This difference could also be due to the employed stimuli, as previously only static stimuli were used. This is supported by the current findings as significant differences in eye movements when processed moving stimuli compared to static stimuli were found.

When exploring emotion recognition accuracy and emotion expressed, there was significantly better accuracy for happy expressions compared to neutral expressions, and for neutral expressions compared to sad, anger, fear, disgust, and surprise. This somewhat differs from Chapter 2's findings as the only significant expression reported was fear, with significantly poorer accuracy compared to neutral. The findings also reported that individuals who reported more childhood trauma reported better accuracy for sad, anger, disgust, and surprise expressions compared to neutral expressions. The finding of increased accuracy for negative expressions is also in line with the social processing mechanism (Dodge et al., 1995), similar to the eye movement findings. There is additional support from imaging studies, e.g., McLaughlin et al. (2015), who reported increased activation in the amygdala, putamen, and anterior insula for negative stimuli compared to neutral stimuli in adolescents with experience of childhood trauma compared to controls. They also reported no significant association between childhood trauma and neural responses for positive stimuli. The areas highlighted (amygdala, putamen, and anterior insula) are nodes of the salience network (involved in determining the importance of stimuli) so the authors concluded that childhood trauma heightens the salience of negative emotional stimuli.

A possible reason for the sensitivity to negative expressions, suggested by previous research, is that children in abusive environments become hypervigilant to negative cues to predict the next occurrence of abuse (Pollak et al., 2005; Pearce & Pezzot-Pearce, 2013). Masten et al. (2008) extended on this and suggested that children may be better at recognising anger expressions in their abuser as well as fear expressions in people around them as both cues help identify threat quickly and potentially avoid additional abuse. However, the current findings reported better accuracy for anger, but not fear. A possible reason for this could be that fear expressions are often confused and mislabelled as surprise. The current findings reported a recognition advantage for surprise compared to neutral, but this could have been misinterpreted as fear. Previous research has omitted surprise due to its similarity with fear (Bombari et al., 2013). Therefore, the current findings may have included confusions between fear and surprise. It could also be that previous research which omitted surprise had not flagged the relationship between childhood trauma and surprise expressions before. As childhood trauma has been associated with poorer performance of positive expressions, but typically the only positive emotion explored is happy, it may suggest that the happy condition itself is impacted by childhood trauma rather than positive emotions overall, if surprise is not impacted. Future research should hence include all six basic emotions, instead of typically focusing on negative expressions, to explore this further.

Interestingly, Figure 26 seems to visualise that as childhood trauma experience increased, the emotion recognition accuracy of fear decreased. As discussed in Chapter 2, previous research had used and supported the idea of neutral expressions being the reference category when exploring emotion recognition (Sonia et al., 2023). However, the current data may suggest using the emotion which stays consistent across experience of childhood trauma as the reference category, as seen with happy expressions, to ensure important information is not missed. For example, the evident decrease of fear expressions shown in Figure 26 was not highlighted in the statistics. This could be because neutral also follows this trend (e.g., as childhood trauma experience increases, the accuracy of neutral expressions decreases), and because neutral is the category, we are exploring childhood trauma's effect on fear expressions compared to neutral expressions. Thus, future research may benefit from using happy expressions as the reference category when exploring emotion recognition instead of the previously supported neutral expressions.

The eye movement findings differed from the accuracy findings. Childhood trauma's effect on eye movements was fairly consistent across all expressions but it varied across expressions for accuracy. This may suggest that childhood trauma's interaction with emotion expressed varied across different aspects of the emotion recognition process. For example, childhood trauma significantly interacts with emotion expressed to influence how we label an expression (e.g., accuracy) but not where we look when processing the expression (e.g., eye movements). Also, previous research has suggested an issue with interpretation. Pollak et al. (2000) suggested that individuals with childhood trauma experience misinterpret positive expressions as more malicious than intended (e.g., a smile is interpreted as mocking). This may suggest that childhood trauma is associated with typical processing abilities but difficulties with accurate interpretation of expressions. For example, individuals with childhood trauma can process that the expression is a positive expression but they misinterpret and mislabel it as having negative intentions behind it. Future research should explore this theory as it could inform us where the difficulties lie and possible ways to improve performance.

3.4.3.4. Intensity

When exploring eye movements and intensity of stimuli, there were significantly more fixations for strong intensity stimuli compared to normal intensity stimuli. Consequently, the accuracy findings reported better accuracy for stronger intensity stimuli too. Previous research is scarce regarding whether eye movements differ across intensity of expressions. However, Schurgin et al. (2014) reported eye gaze differed across intensities depending on which emotion was expressed: fixations to the eye region increased as the intensity of the anger expression increased, and fixations to the eyes decreased as the intensity of disgust, fear, joy, and shame expressions increased. Although this does not follow the pattern observed in the current study of fixations increasing as the intensity increased, it does support that fixations differ across intensity levels. There is evidence of attention increasing as saliency increases (Treue, 2003). As strong intensity expressions are more salient than normal intensity expressions this may explain the increased attention to strong intensity expressions.

When exploring emotion recognition accuracy and intensity of stimuli, there was significantly better accuracy for strong intensity stimuli compared to normal intensity stimuli. This differs from Chapter 2’s findings which did not report a recognition advantage for strong intensity stimuli. However, it does follow previous findings (Montirosso et al., 2010) which also reported better accuracy for stronger intensity expressions. A stronger intensity expression would display a more exaggerated or obvious expression compared to normal or subtle expressions, which would make recognition easier and more accurate. However, the findings suggest that childhood trauma’s effect on accuracy was similar across normal and strong intensity stimuli. It could be that the heightened sensitivities improve accuracy for more subtle expressions but for more exaggerated or obvious expressions they plateau, hence the similar accuracy between normal and strong intensity stimuli. This may suggest that individuals with experience of childhood trauma would not be further hindered in situations, or with certain people, which typically display one intensity expression (e.g., subtle expressions) as they have the ability to recognise these expressions with similar accuracy as individuals without experience of childhood trauma. Previous research tended to use one emotional intensity but in everyday conversations individuals express a mixture of more subtle and exaggerated expressions so emotion recognition should be explored this way too to increase the ecological validity.

The accuracy and fixation findings indicate that emotion recognition performance overall does differ across intensity of stimuli, with better accuracy and more fixations for strong intensity compared to normal intensity stimuli. This suggests the importance of using various intensities when exploring emotion recognition. However, they also agree that childhood trauma's effect is consistent across different intensity levels, suggesting individuals are not further helped or hindered depending on how exaggerated or subtle an expression is.

The overall childhood trauma findings differ from Chapter 2's findings. The current chapter reported no significant effect of childhood trauma on performance whereas Chapter 2 reported an initial significance of childhood trauma experience. Therefore, it may be that childhood trauma influences 'later stages', such as accurate categorisation of certain expressions, but not so much 'earlier stages', such as viewing and processing certain expressions. There is research exploring a typical sample (individuals without experience of childhood trauma) who reported differing activation patterns for matching tasks versus labelling tasks. For an emotion matching task there was increased activation in the left and right amygdala whereas for an emotion labelling task there was decreased activation in the amygdala (Hariri et al., 2003). This would suggest it is possible, if not likely, for performance to differ for various aspects of the recognition process. By exploring which stages of the emotion recognition process are impacted the most, it can inform possible interventions to focus on these aspects to improve performance.

3.5. Conclusion

In conclusion, to our knowledge this study is the first to explore childhood trauma's effect on eye movements across static and moving stimuli (dynamic and audio-visual). The analyses reported significant effects of stimulus-based factors for accuracy and number of fixations, but no significant effects of the individual differences. However, childhood trauma experience interacted with modality and emotion expressed to influence accuracy, as well as interacting with interest area to influence the number of fixations. The lack of significant effect of childhood trauma differed from Chapter 2. The difference in findings may suggest that childhood trauma influences various aspects of emotion recognition. It seems childhood trauma may influence later stages of categorisation or labelling (as seen in Chapter 2) but not so much for the processing of expressions (as explored in the current chapter). However, as these different aspects were not explored in the same experiment, it is possible that study differences were at play. Therefore, to better understand this, future research should explore childhood trauma's effect on different aspects of the emotion recognition process.

The current chapter has extended the eye tracking literature in general by including and exploring static and dynamic expressions to explore whether differences exist in processing these stimulus types. There were significant differences found which suggests that previous research using static expressions are useful for exploring our recognition of pictures of emotional expressions, but it is unlikely they will generalise well to real-world interactions. This highlights the importance of including moving stimuli when exploring emotion performance. The current study has also contributed to the childhood trauma literature by exploring, not only accuracy across various conditions, but also eye movements. This is currently an under researched topic and future research should include eye movements to better explore how individuals with childhood trauma differ in aspects beyond simple accuracy data.

Another method to explore beyond accuracy, whilst using more realistic stimuli, is the integration of facial and vocal cues displaying consistent or conflicting information (e.g., a facial expression paired with the same or different vocal expression). This would extend upon the previous chapters, which have focused on emotion recognition and processing, to explore how different sources of information available from emotional expressions are integrated. Thus, the next chapter explores childhood trauma (alone and when controlling for alexithymia and psychopathy traits) and the integration of consistent or conflicting facial and vocal emotion cues across modality (focusing on the facial expression or focusing on the vocal expression), emotion expressed (basic six and neutral), and congruence (congruent/consistent or incongruent/conflicting cues). The aim is to reveal whether childhood trauma influences the integration of audio-visual cues, an ability required in daily interactions.

4. The effect of childhood trauma on the integration of congruent and incongruent facial and vocal emotion cues.

4.1. Introduction

The previous chapter reported that emotion recognition accuracy and eye movements (specifically, number of fixations) were influenced by modality, emotion expressed, and intensity of stimuli. There was better accuracy for audio-visual expressions compared to static and dynamic expressions, for neutral expressions compared to all expressions except happy, and strong intensity compared to normal intensity stimuli. Also, there were more fixations for static compared to audio-visual expressions and for audio-visual compared to dynamic expressions, for sad, fear, and disgust expressions compared to neutral expressions, strong intensity compared to normal intensity, and for the eyes compared to the nose and mouth. Even though there was not a significant main effect of childhood trauma, the effect of childhood trauma varied across modality and emotion expressed for accuracy and across interest areas for fixations. More reported childhood trauma led to better accuracy for audio-visual expressions and poorer accuracy for dynamic expressions, and better accuracy for sad, anger, disgust, and surprise expressions but poorer accuracy for fear and neutral expressions, as well as more fixations for the eyes compared to the mouth. This provided information regarding whether certain individuals (in this case those with experience of childhood trauma) show atypical eye movements when recognising a range of expressions presented in different ways (static, dynamic, audio-visual) and whether these atypical patterns could explain the previously reported emotion deficits. Although this has advanced the previous literature by including a range of modalities, namely audio-visual emotional expressions which were not previously explored, there are still unanswered questions which need further exploration. Specifically, whether the emotion recognition difficulties reported are reflected in difficulties integrating facial and vocal emotion cues. The current chapter focuses on whether individuals with childhood trauma are also impacted at the integration stage of audio-visual emotion recognition.

Emotions in everyday life are expressed and experienced through multiple modalities - visual and auditory channels. The visual and auditory emotional information is integrated to give a complete overview of what emotion is being expressed, with one modality possibly altering processing in another modality (Gerdes et al., 2014). For example, viewing an emotional facial expression may alter the emotion processing of a vocal expression and vice versa. This was seen in Chapters 2 and 3 which concluded that there is better recognition for multimodal conditions compared to unimodal conditions. Also, previous research has shown that even when tasking participants to ignore a modality (e.g., focus on the face and ignore the voice) there is still a measurable influence (de Gelder & Vroomen, 2000). The current experiment aims to understand how information is integrated when cues are matched (e.g., a smiling face with a happy tone) or mismatched (e.g., a smiling face with a sad tone). This can provide insight into how individuals process and recognise emotional expressions. Also, as facial expressions and certain emotions show a recognition advantage (as discussed in Chapter 2; facial expressions show a quicker and more detailed portrayal of emotion than vocal expressions and negative emotions have quicker recognition due to evolutionary advantages) it may highlight any perceptual biases towards a specific modality or emotion.

There are various ways to explore the integration of emotion cues but by exploring audio-visual elements we can continue the pattern from previous chapters of enhancing the literature by employing more realistic stimuli. As social interactions are experienced audio-visually, by employing an audio-visual stimulus, we can more confidently generalise to everyday conversations. Emotion recognition performance is important as it influences social relationships, and in-turn, well-being (Helliwell & Putnam, 2004; Grundmann et al., 2021). Emotion performance may be particularly influenced by certain individual differences which affect social cognition, such as childhood trauma and the interrelated alexithymia and psychopathy traits. Therefore, this chapter aims to explore how the integration of audio-visual information is affected by the experience of childhood trauma, whilst controlling for alexithymia and psychopathy traits, across congruence (congruent or incongruent expressions), modality focus (focusing on the facial expression or the vocal expression), and emotion expressed (basic six and neutral).

4.1.1. Congruence and emotion recognition

Previous research exploring congruent emotions reported that recognition is quicker and more accurate in emotionally congruent situations (e.g., matching information) than in emotionally incongruent situations (e.g., mismatching information). Studies typically explored congruent emotions using a static facial expression paired with an emotional word overlayed (e.g., a happy face paired with “Fear” written over it for an incongruent trial; Caldwell et al., 2014; Marusak et al., 2015; Powers et al., 2015). However, there is limited research on congruent and incongruent emotional facial and vocal expressions. The conclusions from these previous studies may have poorer generalisability to everyday social interactions as they do not resemble everyday dynamic interactions (Alves, 2013). Ultimately, emotions are audio-visual in daily life so the multisensory nature of emotion processing should be explored by using similar stimuli (Collignon et al., 2008; Wang et al., 2021).

There has been some exploration of facial expressions of emotion paired with vocal expressions instead of words/contexts. For example, de Gelder and Vroomen (2000) conducted experiments using bimodal trials of a black and white static morphed facial expression presented with matching or mismatching audio. For one of the experiments, a happy-sad continuum was used and participants had to identify the facial expression as happy or sad whilst ignoring the simultaneously presented vocal expression. The findings reported that the selected response for the facial expression shifted in the direction of the emotion expressed vocally. So, participants were still influenced by the vocal expression even though they were asked to ignore it. They also reported slower reaction times for incongruent trials (e.g., happy face, sad voice) compared to congruent trials (e.g., happy face, happy voice). de Gelder and Vroomen (2000) conducted another experiment which used bimodal trials with a happy-fear continuum. This time participants were asked to identify the vocal expression as happy or fearful whilst ignoring the simultaneously presented facial expression. Similar to the other experiment, the recognition of vocal expressions was influenced by the facial expression even when they were asked to ignore it. Overall, the findings support that the visual and auditory modalities can influence the processing and recognition of each other. This may support the multimodal model, described in Chapter 1, suggesting a shared area for both modalities and explain the overlap/interference reported.

There is also research suggesting that we automatically integrate visual and auditory facial cues, as described by the McGurk effect (McGurk & MacDonald, 1976). This is an auditory-visual illusion regarding how we merge information across faces and voices; looking at the face influences what we believe we are hearing. However, even though de Gelder and Vroomen's (2000) study used more ecologically valid methods of faces paired with voices instead of faces paired with emotion words/abstracts, there is still the issue of static facial expressions. As described in previous chapters, static stimuli are not representative of everyday interactions (Alves, 2013; Johnston et al., 2013). So, we may not be able to generalise the findings to real-world social situations (Alves, 2013). The stimuli could be further improved by using dynamic facial expressions presented with a vocal expression of emotion.

Collignon et al. (2008) used this suggested method across two experiments. The first experiment asked participants to view fear and disgust expressions across three modalities: (1) dynamic facial expressions, (2) emotional non-linguistic vocal clips ("ah"), and (3) both combined (congruent or incongruent audio-visual stimuli). They reported that participants were faster and more accurate for congruent audio-visual stimuli compared to incongruent audio-visual stimuli and for single modalities. When viewing incongruent audio-visual expressions, participants showed a preference for the facial expression of emotion, suggesting a visual dominance when processing incongruent emotional expressions. However, if the visual stimuli were unreliable (e.g., adding white Gaussian noise to alter the signal-to-noise ratio to lower accuracy) then participants showed a preference for the auditory modality. This suggests that dominance is fairly flexible depending on how reliable we deem a modality. For the second experiment, the same stimuli were used but participants were instructed to focus on only one modality at a time (e.g., either only the facial expression or only the vocal expression). They found that, even when asked to ignore one modality, the irrelevant modality still significantly influenced the processing of the emotion. This was especially true for stimuli which were less reliable (e.g., altered signal-to-noise ratio). This supports the idea that one modality can influence the other, even when asked to ignore it. It also highlights the advantage of having multisensory processing of emotions in everyday interactions as we can adapt our approach to ensure accurate emotion recognition when the reliability of one modality is reduced (e.g., a dark or noisy environment).

There is also neuroimaging support for the relationship between congruence and emotion recognition abilities. Müller et al. (2011) asked participants to view happy, fearful, or neutral 3-dimensional static facial expressions accompanied by an emotional sound (e.g., laughter or screams) or a neutral sound (e.g., yawn). They found that fearful and neutral faces were recognised as more fearful when presented with screams compared to neutral sounds. This suggests, similar to previously discussed behavioural studies, that one modality (e.g., faces or voices) can influence the processing of the other. Also, imaging data showed that incongruent stimuli (e.g., neutral face paired with screams) led to increased activation in conflict monitoring regions.

Even though the studies described (de Gelder & Vroomen, 2000; Collignon et al., 2008; Müller et al., 2011) have started to improve upon previous stimuli (e.g., static faces paired with an emotion word), the stimuli can still be improved further. Static facial expressions were still used (de Gelder & Vroomen, 2000; Müller et al., 2011). As described in Chapter 1, static stimuli lack ecological validity as they do not engage 'authentic' mechanisms used to recognise facial expressions in everyday interactions (Alves, 2013; Johnston et al., 2013). Collignon et al. (2008) used dynamic facial expressions, which was an improvement, but also used non-linguistic sounds (e.g., "ah"), which do not represent real-world conversations. Therefore, the current literature could be further improved by using dynamic facial expressions presented with a linguistic vocal expression (e.g., a neutral sentence spoken in an emotional way) to better represent everyday interactions. Further, relatively little is known about how the relationship between congruence and emotion recognition varies between individuals. As such, the main focus of the current chapter is to explore how childhood trauma is associated with the integration of facial and vocal emotion cues when processing congruent and incongruent expressions.

4.1.2. Childhood trauma and (in)congruent emotions

As previously discussed in Chapters 1, 2, and 3, individuals vary in their abilities to recognise and process emotional expressions. Similar to previous chapters, the key individual difference explored is childhood trauma. Alexithymia and psychopathy traits will be included and controlled for to ensure any deficits found are definitely from childhood trauma experience. The majority of previous research exploring childhood trauma and emotion recognition or processing has explored facial or vocal expressions of emotion separately and has rarely employed audio-visual stimuli integrating both facial and vocal expressions. Integration of audio-visual stimuli is important to explore as this is how emotions are processed in real life. Therefore, this is the most appropriate way to better understand how it influences real-world behaviour. As a result of previous methods, we do not know how individual differences affect the integration of visual (facial expressions) and auditory (vocal expressions) cues during emotion processing. We know that visual and auditory emotional information influence the processing of each other (de Gelder & Vroomen, 2000; Collignon et al., 2008; Müller et al., 2012) but we are unsure how much this varies between individuals.

As previously described throughout the thesis, childhood trauma is exposure to adverse experiences including neglect and abuse (De Bellis & Zisk, 2014). There is a relationship between childhood trauma and heightened emotional reactivity to negative expressions (McLaughlin et al., 2020). In support of this, the social information processing mechanism (Dodge et al., 1995) suggests childhood trauma is associated with better accuracy for negative expressions but poorer accuracy for positive or neutral expressions. The processing of incongruent audio-visual emotional expressions may be affected by childhood trauma due to the associated heightened sensitivities to negative expressions. For example, if an individual was asked to identify the facial expression, whilst ignoring the vocal expression, of an audio-visual incongruent expression, including a happy face with an angry voice, then the negative emotion may override the modality instruction (e.g., ignore the voice). Thus, the expression would be deemed negative even though the facial expression was happy. There is evidence of individuals with childhood trauma interpreting positive expressions (e.g., happy facial expression – smiling) as a more malevolent expression (e.g., being mocked or laughed at; Pollak et al., 2000). This may become even more prevalent for incongruent expressions when a negative expression is also present. The report of a processing bias towards negative stimuli overall would provide support for the claims of the social information processing mechanism (Dodge et al., 1995).

Previous research has found an association between childhood trauma and the processing of congruent and incongruent stimuli. All studies being described used the same method of a facial expression paired with an emotion word (e.g., happy) overlaying the face. An example of a congruent trial would be a happy facial expression paired with the word "happy" and an incongruent trial would be a happy facial expression paired with the word "sad". Marusak et al. (2015) asked participants to perform this task whilst undergoing fMRI. Behavioural (accuracy and reaction times) and neural (dorsolateral prefrontal cortex and amygdalae) measures were used to explore automatic regulation of emotional conflict. They found that those with childhood trauma were unable to regulate emotional conflict. For repeated incongruent trials, those with childhood trauma showed a lack of improvement in accuracy and reaction time. Individuals with childhood trauma also displayed a simultaneous heightened sensitivity to conflicting/incongruent expressions. This was shown by greater amygdalae response, and a lack of regulatory control over processing emotions, shown by a lack of engagement of amygdala-pregenual cingulate cortex circuit and dorsolateral prefrontal cortex. Ultimately, it suggests that childhood trauma exposure alters the way emotional information is processed and prioritised.

In support of this, Caldwell et al. (2014), used the same method but included non-emotional trials (e.g., male or female neutral face overlayed with the word “male” or “female”). They found that overall women with more experience of childhood trauma showed comparable performance to women with less/no experience of childhood trauma for non-emotional trials. However, for emotional trials, those with more experience of childhood trauma were significantly poorer at adapting, especially when the incongruent stimuli included a fearful face. The authors suggested when individuals with childhood trauma view fearful stimuli they may struggle to regulate their emotions whilst also avoiding distractions. Similar to this, research has suggested that, instead of simple inaccuracy, those with experience of childhood trauma may have learned that conflicting signs can indicate fear or anger in a situation so they may favour those emotions over the others simultaneously presented (Assed et al., 2020).

Further support using the same method was Powers et al. (2015). They found that moderate to severe childhood trauma was significantly related to poorer emotional conflict regulation, independent of PTSD, depression, and adult trauma. Those with high levels of childhood trauma had less accurate emotion recognition when the facial expression was shown with an incongruent word. These deficits in processing incongruent stimuli cannot be attributed to emotion conflict regulation, PTSD, depression, or adult trauma. The fact that specifically childhood trauma was related to incongruent emotion recognition shows the importance of exploring this individual difference for congruent and incongruent emotional expressions. Also, the methods employed, of a static facial expression paired with an emotion word, do not represent real-world interactions and therefore may affect the generalisability of the findings (Alves, 2013). The methodology would closer resemble everyday interactions by using dynamic facial expressions presented with a vocal expression of emotion.

Childhood trauma may also be associated with alternative measures of emotion recognition, such as intensity ratings. As discussed in Chapter 1 and Chapter 2, there is reason to believe childhood trauma would be associated with intensity ratings as a result of the associated heightened sensitivity (Dodge et al., 1995). This may lead to expressions being interpreted as more intense. However, Neil et al. (2022) found no association between childhood trauma and intensity ratings. Similarly, in Chapter 2 the findings did not report a significant interaction between childhood trauma and intensity ratings. However, as the stimuli in this study differ (congruent and incongruent) and this chapter explores the integration of emotion cues, we wanted to explore intensity ratings to see whether they are impacted during integration. Regarding emotion performance in general, previous research reported that congruent trials were associated with higher intensity ratings compared to incongruent trials (Föcker et al., 2011). However, how childhood trauma may influence this association is unclear.

4.1.3. Interrelated traits and (in)congruent emotions

As discussed throughout the thesis, childhood trauma is associated with the development of alexithymia and psychopathy traits (Zlotnick et al., 2001; Craparo et al., 2013). As well as links to childhood trauma, alexithymia and psychopathy are also associated with emotion recognition difficulties (Blair, 2001; Parker et al., 2005). Therefore, it becomes difficult to distinguish whether childhood trauma itself is responsible for any reported emotion deficits or if it is the related traits. Previous research has reported an association between psychopathy and alexithymia with congruent and incongruent trials, just not directly linked to emotional expressions.

For psychopathy, White et al. (2012) explored youths with psychopathy traits and a control group to see whether congruent or incongruent stimuli affected eye gaze. A static neutral expression was presented and after 300 milliseconds the expression stayed neutral or changed to an angry or fearful expression, with eye gaze either to the left or right. Concurrently, an “x” probe appeared to the left or right of the stimuli either towards (congruent trial) or away from the probe (incongruent trial). They found that all groups (youths with psychopathy traits and controls) were significantly faster in the congruent trials compared to incongruent trials. Also, in certain brain regions (right middle temporal cortex and right thalamus), healthy controls showed higher activation to incongruent trials compared to youths with psychopathy traits. This may suggest atypical processing of incongruent trials for individuals reporting psychopathy traits. It is unclear whether this pattern of atypical processing would be seen for emotional expressions as the literature is scarce.

Alexithymia has also reported atypical processing of congruent and incongruent trials. Goerlich et al. (2011) explored congruent and incongruent processing of music and speech prosody using ERPs. The stimuli included happy or sad music or prosody either matched (congruent) or mismatched (incongruent) with a positive or negative word. The electrophysiological findings reported that alexithymia was associated with significantly smaller amplitudes to incongruent music and speech stimuli. Although this methodology differs to the current study (using music and prosody instead of faces and voices) it still confirms that alexithymia is associated with atypical processing of incongruent stimuli. This suggests that alexithymia and psychopathy traits, alongside childhood trauma, have associations with congruent and incongruent processing in general. However, it is unclear whether this extends to congruent and incongruent emotional expressions. Therefore, research directly exploring the effect of these individual differences on the integration of facial and vocal expressions of emotion is needed to better understand this relationship.

4.1.4. The current study

The aim of this chapter is to explore how childhood trauma may affect the integration of visual and auditory information during audio-visual emotion processing. Updated and more realistic depictions of congruent and incongruent expressions will be employed by using dynamic facial expressions paired with vocal expressions (semantically neutral sentence expressed in an emotional way). To explore this, the effect of childhood trauma, and the related alexithymia and psychopathy traits, on audio-visual emotion integration across congruence (congruent or incongruent trials), modality focus (focusing on the facial or vocal expression), and emotion expressed (basic six and neutral) will be examined. Emotion integration will be assessed in two ways: accuracy of identification and intensity ratings.

For emotion recognition accuracy overall, in line with previous findings it is hypothesised that childhood trauma will be associated with atypical emotion processing and show poorer accuracy (Caldwell et al., 2014; Marusak et al., 2015; Powers et al., 2015). This relationship will be explored across stimulus-based factors of congruence, modality focus, and emotion expressed. It is hypothesised that there will be an interaction between childhood trauma and congruence with poorer accuracy for incongruent trials as individuals may not be able to ignore the negative expression even when instructed to (e.g., if an angry facial expression is presented but you are asked to identify the mismatched vocal expression). It is also hypothesised that the effect of childhood trauma may stay consistent across modality focus. Regardless of whether participants are asked to focus on the facial or vocal expression, similar to the point above, they may struggle to ignore the threatening expression presented in one of the modalities. In line with the social information processing mechanism (Dodge et al., 1995), an interaction with emotion expressed is hypothesised, with better recognition of negative expressions and poorer recognition of positive or neutral expressions. As it has not been explored before it is unclear whether the relationship between childhood trauma and accuracy across the stimulus-based factors will be affected by the related alexithymia or psychopathy traits.

Intensity ratings will be measured due to childhood trauma's association with heightened sensitivity to negative expressions. Therefore, this may affect how intense individuals perceive and rate emotional stimuli. There has been a lack of research exploring childhood trauma and intensity ratings for general emotion recognition, let alone incongruent emotion recognition, so there is limited research to base hypotheses on. However, due to the heightened sensitivities, it may suggest that more experience of childhood trauma will result in a more intense perception and higher rating of stimuli. Whether this effect will vary across congruence and modality focus is unclear. However, as the heightened sensitivity is to negative expressions specifically, it is hypothesised that individuals with childhood trauma experience will report higher intensity ratings for negative expressions compared to individuals without. Although, whether this relationship between childhood trauma and intensity ratings is affected by alexithymia and psychopathy traits is unclear.

The hypotheses are fairly cautious due to the limited research surrounding individual differences and congruent and incongruent emotion processing. In particular, the lack of research using similar stimuli. The current study uses dynamic audio-visual stimuli whereas previous research used static facial expressions paired with emotion words or paired with non-linguistic vocal expressions (e.g., sounds rather than sentences). This highlights the gap in the literature for exploring the emotion processing of facial and vocal emotion cues similar to real-world interactions.

4.2 Methods

4.2.1. Participants

The final sample consisted of 142 participants (70 female; 70 male; 1 nonbinary; 1 selected "prefer not to say", M_{age} = 33 years (18 - 50), SD = 9.55). Data for 149 participants was originally collected but 7 participants were excluded after; 1 due to repeated/tactical answering (responded with "Neutral" for every item on all three questionnaires) and 6 due to a diagnosis of autism (which has also been associated with emotion deficits and could have influenced emotion performance). There were 93 participants who identified as White (65%), 26 who identified as Asian / Pacific Islander (18%), 15 who identified as Black (11%), 6 who identified as “Other” (4%), and 2 who identified as Hispanic or Latino (1%). Participants were recruited from an online participation site (Testable Minds) in exchange for 7.50 USD, and from the undergraduate psychology cohort at Brunel University London in exchange for 3 course credits. The inclusion criteria were aged between 18 and 50 years old, normal or corrected-to-normal vision, no significant hearing loss that would render daily tasks and conversations difficult, and fluent in English to a native standard (for the verbal IQ test). Ethical approval was granted by the Research Ethics Committee for the College of Health, Medicine, and Life Sciences at Brunel University London.

4.2.2. Design

The experimental task variables were congruence (congruent, incongruent), modality (facial focus, vocal focus), and emotion expressed (basic six and neutral). The individual differences were childhood trauma, alexithymia, and psychopathy. The outcome variables were emotion recognition accuracy and intensity ratings.

4.2.3. Materials

4.2.3.1. Questionnaires

Participants completed self-report questionnaires to assess childhood trauma, alexithymia, psychopathy, and personality. The questionnaires are the same as throughout the thesis as we wanted to explore the same individual differences.

Childhood trauma: Childhood Trauma Questionnaire Short Form (CTQ-SF)

Reliability of the CTQ-SF in the current sample was analysed, Guttman’s λ_2 = .730.

Alexithymia: Toronto Alexithymia Questionnaire (TAS-20)

Reliability of the TAS-20 in the current sample was analysed, Guttman’s λ_2 = .802.

Psychopathy: Self Report Psychopathy Scale – Short Form (SRP-SF)

Reliability of the SRP-SF in the current sample was analysed, Guttman’s λ_2 = .915.

Personality: The Mini Personality Questionnaire (Mini-IPIP)

Personality was not explored in this chapter either, the reasoning follows the one described in Chapter 2.

Similar to previous chapters, the total scores from each questionnaire were standardised and used in the analyses due to needing considerable power for the analyses chosen and the interest being in the overall effect of the individual differences on emotion performance.

4.2.3.2. Intelligent Quotient Verbal task

Wechsler Test of Adult Reading (WTAR)

The procedure and scoring details for the WTAR are as described in Chapter 2. Similar to the previous chapters, IQ was included to ensure all participants had an IQ score of 80 and above. Participants would have been excluded if their IQ score was categorised as "borderline" or "extremely low".

4.2.3.3. Stimuli creation

The same stimuli database and actors were used in this study as in Chapter 2 (actors 2, 7, 12, and 15 from the RAVDESS database). The stimuli were edited to resemble congruent and incongruent emotional expressions, using the Lightworks app. Using the visual only (facial expressions) and the audio only (vocial expressions) stimuli from the RAVDESS database we were able to edit and create our own version of audio-visual expressions. This created congruent (e.g., happy face paired with a happy voice) or incongruent (e.g., happy face paired with a sad voice) stimuli. Both the congruent and incongruent stimuli were edited to ensure consistency. For the congruent videos, a facial expression of one emotion was paired with the same vocal expression from a different actor (using the same gender). For example, actor 2's (female) facial expression of happy would be paired with actor 12's (female) vocal expression of happy. For the incongruent videos, they were edited so that the actor's facial expression did not match the vocal expression (using the same gender). For example, actor 2's facial expression of happy would be paired with actor 12's vocal expression of disgust. Only normal intensity expressions were used to create the audio-visual stimuli. The full stimuli set created are available on Open Science Framework (https://osf.io/cmqay/?view_only=c67ac524ade644149396e04a52e90270).

There were originally 28 videos created for the congruent audio-visual condition and 28 videos created for the incongruent audio-visual condition (4 actors x 7 expressions; 4 videos of each expression -one from each actor). For the incongruent videos, the pairing of the emotions ensured there were equal numbers of emotions in the facial focus and vocal focus condition similar to the congruent condition (e.g., 4 happy facial expressions and 4 happy vocal expressions). Each of the actor's facial expression would be paired with a different vocal expression (e.g., actor 2's facial expression of happy would be paired with a different vocal expression). The pairings were originally randomised but then amendments were made to ensure equal numbers of paired vocal expressions.

After creating the stimuli an independent sample (*N* = 11) was asked to view the congruent and incongruent stimuli. They rated how well the audio synced with the visual aspects of the video on a scale from 0 (not synced at all) to 10 (very well synced). From the ratings, there was a significant difference between the congruent and incongruent stimuli in how well the videos were edited. To rectrify this we removed the two lowest rated videos (the most out of sync) from the incongruent condition: (1) angry face paired with a fearful voice, and (2) angry face paired with a disgust voice. To counteract this, we took out the two highest rated (most in sync) angry stimuli from the congruent facial focus condition and the highest rated fear and disgust stimuli from the congruent vocal focus condition. This resulted in no significant differences between how in sync the stimuli were edited. This should mean that the editing will not significantly impact the findings. This resulted in 52 facial focus trials (26 incongruent, 26 congruent) and 52 vocal focus trials (26 incongruent, 26 congruent).

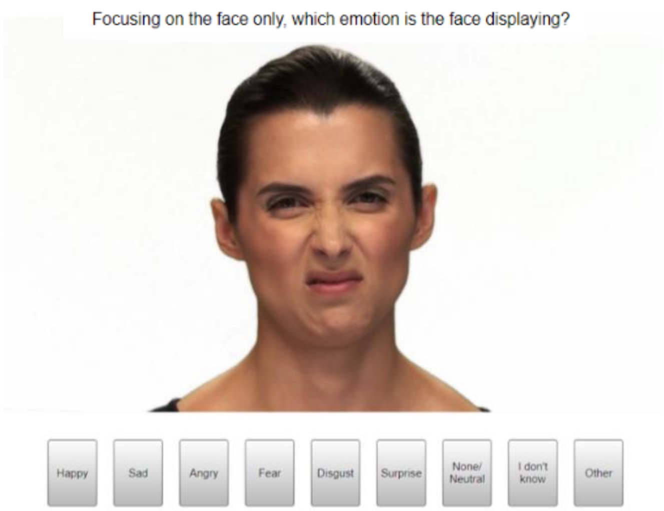
4.2.4. Procedure

The whole task was completed online via Qualtrics (for demographics) and Testable (main task, questionnaires, and IQ test). For programming purposes each questionnaire was paired with one condition of the emotion recognition task. The emotion tasks (and their associated questionnaires) were counterbalanced. Both emotion tasks included six practice trials (3 facial focus, 3 vocal focus) with feedback (e.g., whether participants were correct or incorrect in their choice and which emotion was displayed in the face and the voice). The response options displayed under the stimuli and the consequences were the same for all tasks. The options were Happy, Sad, Fear, Anger, Disgust, Surprise, None/Neutral, I don't know, and Other. If participants chose a non-emotional answer (None/Neutral or I don't know) then it skipped to the next trial. If one of the basic six emotions was chosen, the next screen repeated the video and asked how intense they would rate the emotion expressed. Participants answered on a 1-10 Likert scale (with 1 being a low intensity and 10 being a high intensity expression). If 'Other' was chosen they were given the option to free label the emotion and then the intensity screen was shown. Breaks were offered after each emotion task. For the facial focus trials, participants were asked to focus on the face only and decide which emotion was being expressed. The instructions were "Focusing on the face only, which emotion is the face displaying?" displayed above the video (example in Figure 34). The vocal focus trial instructions were "Focusing on the voice only, which emotion is the voice displaying?".

The trials were split into two tasks to give participants a break in between, each emotion task included a mix of facial and vocal focus trials to minimise the risk of participants either muting the sound for the facial focus trials or looking away for the vocal focus trials. The attention checker questions displayed a black screen with the added option of "There is no video playing" to check if participants were paying attention. Both the main task and practice trials were randomised.

Figure 34

Example of actor 12 in the facial focus trial displaying disgust and showing the instructions and response options. The vocal focus would be presented the same except for the instructions which would ask them to focus on the voice instead.



4.2.5. Data analysis

Similar to previous chapters, reaction times were not included in the main analyses as the dynamic emotional expressions varied in duration and onset making it difficult to accurately analyse reaction times. Also, our hypotheses were focused on emotion recognition accuracy, thus making it an inappropriate outcome variable. When calculating accuracy scores in the emotion recognition task, free labelled responses and responses of "I don't know" were classified as incorrect to ensure consistency with how the database labelled the emotions. Less than 1% of responses were free labelled responses and roughly 1% of all responses were "I don't know".

Similar to previous chapters, generalised mixed models and cumulative link mixed models were the most appropriate for the data and were employed. Generalised mixed models were performed to examine the role of childhood trauma alone, and whilst controlling for alexithymia and psychopathy traits, on emotion recognition accuracy, and whether the effect varied across congruence, modality focus, or emotion expressed. Cumulative link mixed models were performed to examine the same as above but for intensity ratings.

The stimulus-based variables had to have a reference group. When exploring emotion recognition, they were congruent for congruence, facial focus for modality, and neutral for emotion expressed. For intensity ratings, the reference categories were the same for modality and congruence but the reference group for emotion expressed was anger. This was because neutral was not included as it is a non-emotional answer, so the intensity screen was skipped if it was chosen. In Chapter 2 the emotion with the highest average intensity rating became the reference category, which was anger. In the current study the highest average intensity rating was for fear but anger was close second (with 0.02 difference). Therefore, to keep some continuity between the reported results and interpretation throughout the thesis the current reference category is also anger.

4.3. Results

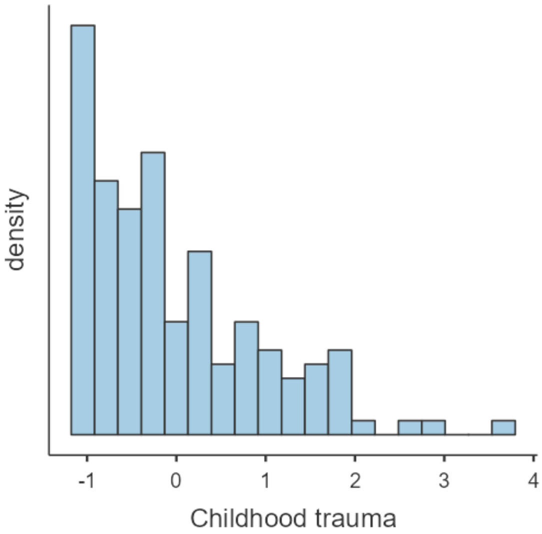
4.3.1. Emotion recognition accuracy

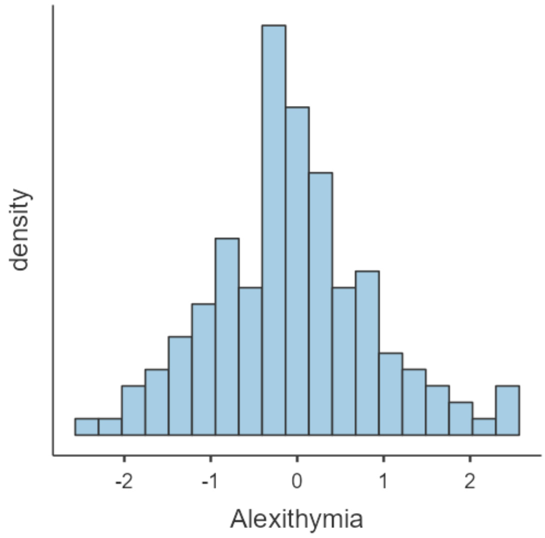
The distribution of different questionnaires are presented in Figure 35 and the average emotion recognition accuracy across the stimulus-based factors of congruence, modality focus, and emotion expressed are presented in Figure 36.

Figure 35

The distribution of (a) childhood trauma, (b) alexithymia, and (c) psychopathy in the sample.

a) b)





c)

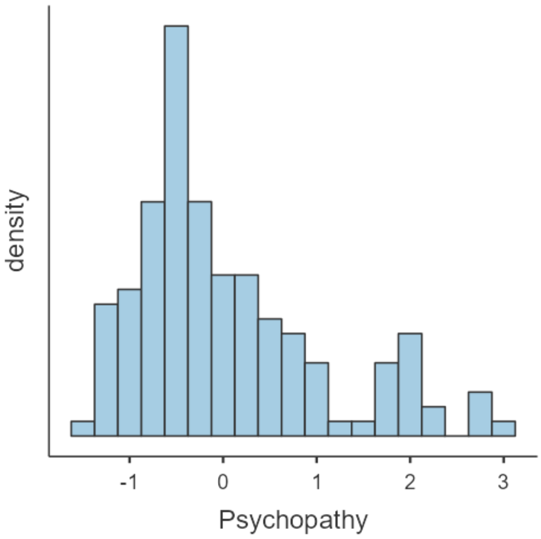
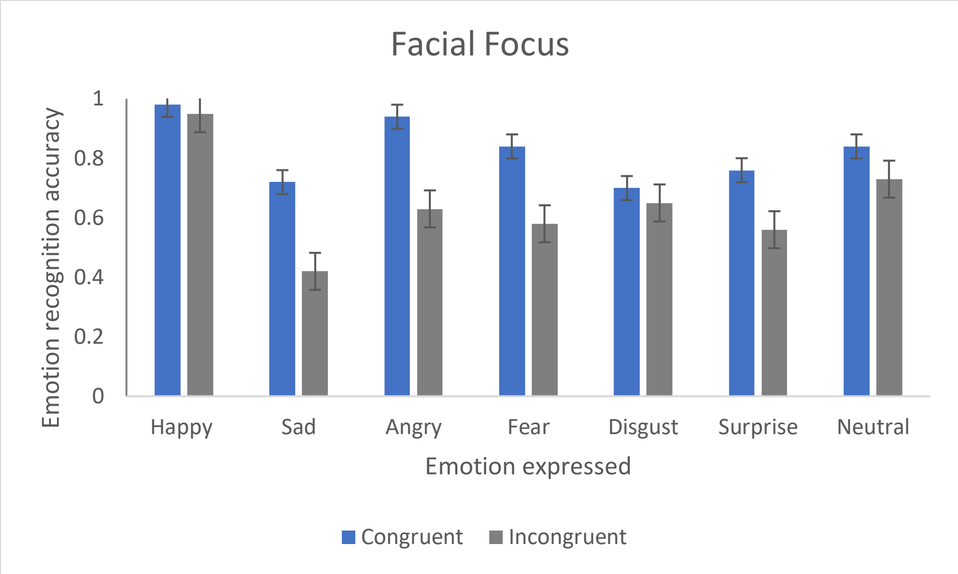


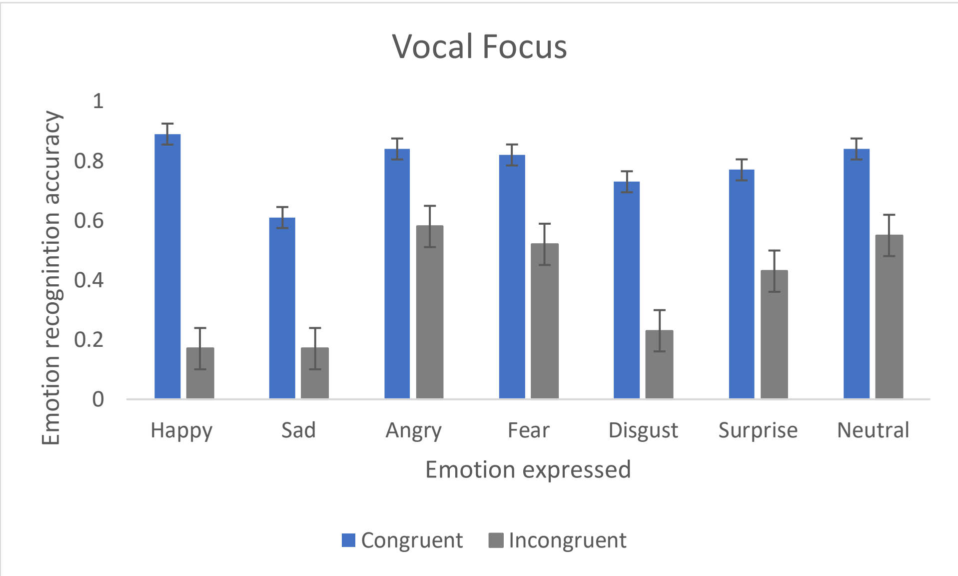
Figure 36

The average emotion recognition accuracy (proportion correct) across congruence and emotion expressed for (a) facial focus and (b) vocal focus.

a)



b)



The descriptives for the experimental task variables and the individual differences are presented in Table 21.

Table 21

Descriptives table for childhood trauma, alexithymia, and psychopathy displaying the mean score, standard deviation, and range of the raw total questionnaire scores. Descriptives for congruence (congruent, incongruent), modality (facial focus, vocal focus), and emotion expressed (happy, sad, anger, fear, disgust, surprise, neutral) displaying the mean, standard deviation, and range of emotion recognition accuracy (proprotion correct).

4.3.1.1. Is childhood trauma alone associated with emotion recognition accuracy?

For all models, the random effects were participant and actor.

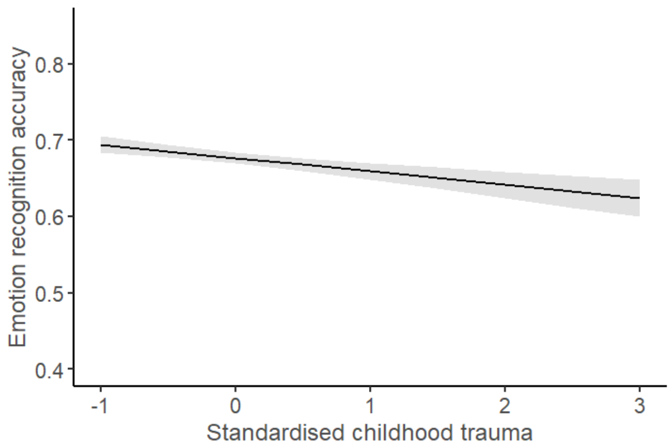
Does the relationship vary across congruence?

Variables	Mean score	Standard deviation	Range
Childhood trauma	40.54	14.30	70 (24 – 94)
Alexithymia	47.76	11.46	60 (19 – 79)
Psychopathy	52.76	16.42	73 (26 – 99)
Emotion Tasks (Response Accuracy)			
Congruence:			
Congruent	0.80	0.09	0.46 (0.50 – 0.96)
Incongruent	0.52	0.13	0.52 (0.21 – 0.73)
Modality:			
Facial focus	0.74	0.10	0.48 (0.42 – 0.90)
Vocal focus	0.58	0.11	0.46 (0.33 – 0.79)
Emotion:			
Happy	0.75	0.09	0.44 (0.50 – 0.94)
Sad	0.48	0.18	0.81 (0.00 – 0.81)
Anger	0.75	0.15	0.85 (0.15 – 1.00)
Fear	0.67	0.17	0.79 (0.14 – 0.93)
Disgust	0.60	0.15	0.79 (0.14 – 0.93)
Surprise	0.64	0.14	0.73 (0.27 – 1.00)
Neutral	0.74	0.19	1.00 (0.00 – 1.00)

A generalised mixed model was employed to explore the effect of childhood trauma on emotion recognition accuracy. The fixed factors were childhood trauma and congruence. The fixed factors had a significant main effect of childhood trauma, X^2 (1) = 4.87, p = .027. β = −0.09, exp(B) = 0.91, and congruence, X^2 (1) = 30.54, p < .001, β = - 1.50, exp(B) = 0.22. The higher score of childhood trauma, indicating more childhood trauma experience, was associated with poorer emotion recognition accuracy, z = - 2.21, p = .027 (Figure 37). Congruent trials (the same emotion presented facially and vocally) were associated with better emotion recognition accuracy compared to incongruent trials, z = -5.53, $p < .001$. There was not a significant interaction between childhood trauma and congruence, X^2 (1) = 0.00, $p = .994$, β = −0.00, exp(B) = 1.00. This suggests the effect of childhood trauma (e.g., childhood trauma's association with poorer accuracy) stayed consistent when participants viewed both congruent and incongruent trials.

Figure 37

The average emotion recognition accuracy (proportion correct) for the standardised total score of childhood trauma (derived from the CTQ-SF). The shaded area represents the 95% confidence interval.



Does the relationship vary across modality?

A generalised mixed model was employed to explore the effect of childhood trauma on emotion recognition accuracy. The fixed factors were childhood trauma and modality. The fixed factors had a significant main effect of childhood trauma, X^2 (1) = 4.87, $p = .027$, β = −0.09, exp(B) = 0.92, and modality, X^2 (1) = 23.10, $p < .001$, β = −0.76 and exp(B) = 0.47. More experience of childhood trauma was associated with poorer accuracy, z = - 2.21, p = .027. Accuracy was significantly better for facial focus trials compared to vocal focus trials, z = - 4.81, $p < .001$. There was not a significant interaction between childhood trauma and modality, X^2 (1) =0.02, $p = .875$, with β = 0.01 and exp(B) = 1.01 This suggests childhood trauma showed the same pattern (poorer accuracy) across both facial focus and vocal focus trials.

Does the relationship vary across emotion expressed?

A generalised mixed model was employed to explore the effect of childhood trauma on emotion recognition accuracy. The fixed factors were childhood trauma and emotion expressed. The fixed factors had a significant main effect of childhood trauma, X^2 (1) = 4.84, *p* = .028, β = −0.10, exp(B) = 0.90, and emotion expressed, X^2 (6) = 325.97, *p* < .001. More experience of childhood trauma was associated with poorer emotion recognition accuracy overall, z = -2.20, *p* = .028. There was a significant effect of Sad (Sad – Neutral), β = −1.32 and exp(B) = 0.27, and Disgust (Disgust – Neutral), β = −0.89 and exp(B) = 0.41. Accuracy was significantly poorer for sad expressions, z = -3.57, *p* < .001, and disgust expressions, z = -2.98, *p* = .003, compared to neutral expressions. There was not a significant interaction between childhood trauma and emotion expressed overall, X^2 (6) = 4.05, *p* = .670, or between any of the specific emotions. This suggests the effect of childhood trauma did not vary significantly across emotion expressed.

4.3.1.2. Is childhood trauma associated with emotion recognition accuracy when controlling for alexithymia and psychopathy traits?

For all models, the random effects were participant and actor.

Does the relationship vary across congruence?

A generalised mixed model was employed to explore the effect of childhood trauma on emotion recognition accuracy. The fixed factors were childhood trauma and congruence and the covariates were alexithymia and psychopathy. After controlling for alexithymia and psychopathy, childhood trauma was no longer significant, X^2 (1) = 3.41, *p* = .065 (Figure 38). Psychopathy, X^2 (1) = 0.77, *p* = .381, and alexithymia, X^2 (1) = 1.88, *p* = .171, were also not significant (Figure 38). Congruence remained significant, X^2 (1) = 30.50, *p* < .001. There was not a significant interaction between childhood trauma and congruence, X^2 (1) = 0.00, *p* = .992. This suggests the effect of childhood trauma did not vary significantly depending on whether the stimuli were congruent or incongruent (Figure 39). Fixed effects parameter estimates are presented in Table 22.

Table 22

The Fixed Effects Parameter Estimates table for emotion recognition accuracy for childhood trauma, congruence, alexithymia, and psychopathy.

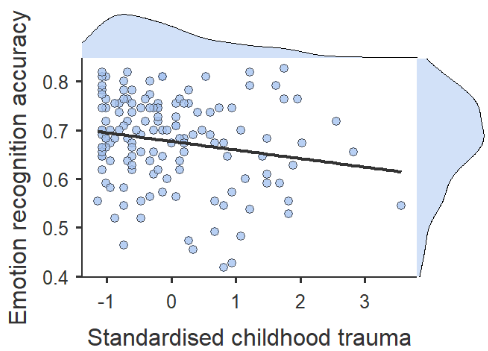
Fixed effects	Estimate	Standard Error	exp(B)	95% CI (lower, upper)	z	*p*
Intercept	0.81	0.19	2.25	1.55, 3.27	4.27	**<.001***
Childhood trauma	-0.08	0.04	0.92	0.85, 1.00	-1.82	.065
Congruence (Incongruent – Congruent)	-1.50	0.27	0.22	0.13, 0.38	-5.52	**<.001***
Alexithymia	-0.06	0.05	0.94	0.86, 1.03	-1.37	.171
Psychopathy	-0.04	0.04	0.96	0.89, 1.05	-0.88	.381
Childhood trauma * Congruence	0.00	0.05	1.00	0.91, 1.10	0.01	.992

*** represents significant values (*p* < .05)**

Figure 38

Plots showing the average emotion recognition accuracy for the standardised total scores of (a) childhood trauma (derived from the CTQ-SF), (b) alexithymia (derived from the TAS-20), and (c) psychopathy (derived from the SRP-SF): higher scores indicating more experience of childhood and a higher level of traits of alexithymia and psychopathy.

a)



b) c)

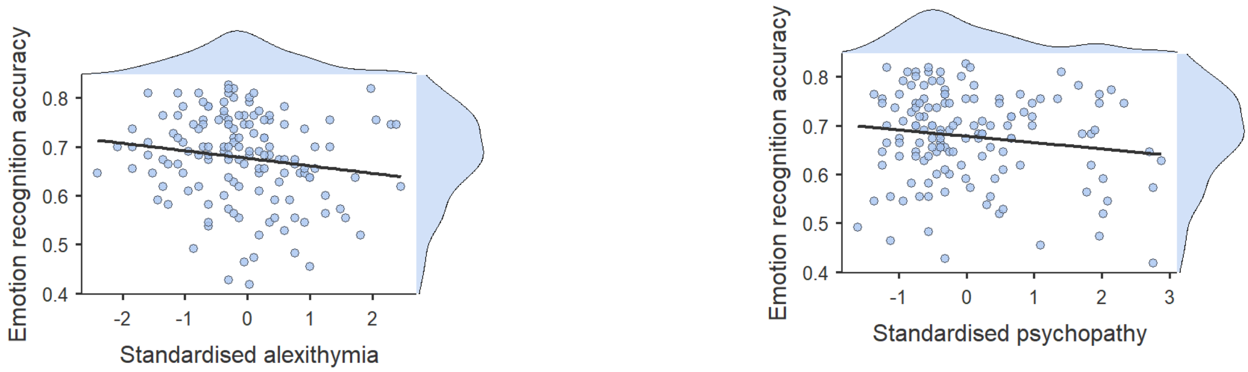
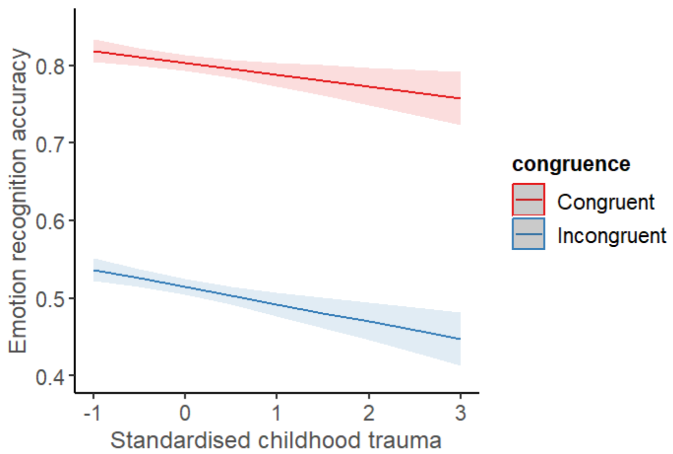


Figure 39

Average emotion recognition accuracy of a standardised total score for childhood trauma (derived from the CTQ-SF) across congruence when controlling for alexithymia and psychopathy traits. The shaded area represents the 95% confidence interval.



Does the relationship vary across modality?

A generalised mixed model was employed to explore the effect of childhood trauma on emotion recognition accuracy. The fixed factors were childhood trauma and modality and the covariates were alexithymia and psychopathy. After controlling for alexithymia and psychopathy, childhood trauma was no longer significant, X^2 (1) = 3.52, p = .060. Also not significant were alexithymia, X^2 (1) = 2.05, p = .152, and psychopathy, X^2 (1) = 0.49, p = .482. However, modality was still significant, X^2 (1) = 23.11, p < .001, with significantly better accuracy for facial focus trials compared to vocal focus trials. There was not a significant interaction between childhood trauma and modality. This suggests the effect of childhood trauma did not vary significantly across the two modalities (Figure 40). Fixed effects parameter estimates are presented in Table 23.

Table 23

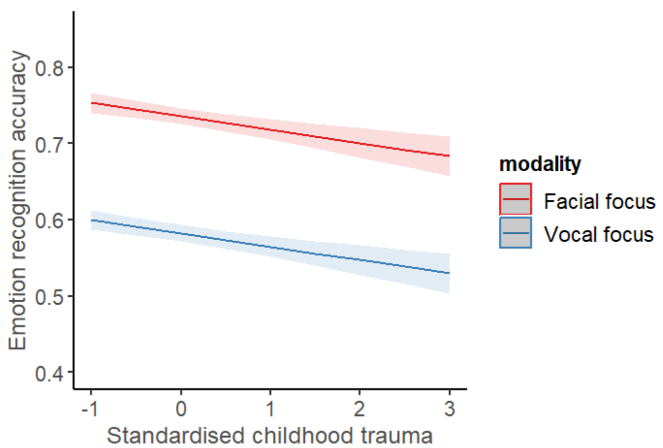
The Fixed Effects Parameter Estimates table for emotion recognition accuracy for childhood trauma, modality, alexithymia, and psychopathy.

Fixed effects	Estimate	Standard Error	exp(B)	95% CI (lower, upper)	z	*p*
Intercept	0.73	0.16	2.07	1.52, 2.82	4.59	< **.001***
Childhood trauma	-0.07	0.04	0.93	0.86, 1.00	-1.88	.060
Modality (Vocal focus – Facial focus)	-0.76	0.16	0.47	0.34, 0.64	-4.81	< **.001***
Alexithymia	-0.06	0.04	0.94	0.87, 1.02	-1.43	.152
Psychopathy	-0.03	0.04	0.97	0.90, 1.05	-0.70	.482
Childhood trauma * Modality	0.01	0.04	1.01	0.93, 1.09	0.16	.871

*** represents significant values (*p* < .05)**

Figure 40

Average emotion recognition accuracy of the standardised total score for childhood trauma (derived from the CTQ-SF) across modality focus when controlling for alexithymia and psychopathy traits. The shaded area represents the 95% confidence interval.



Does the relationship vary across emotion expressed?

A generalised mixed model was employed to explore the effect of childhood trauma on emotion recognition accuracy. The fixed factors were childhood trauma and emotion expressed and the covariates were alexithymia and psychopathy. After controlling for alexithymia and psychopathy, childhood trauma was no longer significant, X^2 (1) = 3.49, *p* = .062. There was not a significant effect of alexithymia, X^2 (1) = 1.77, *p* = .184, or psychopathy, X^2 (1) = 1.01, *p* = .315. Although, there was a significant main effect of emotion expressed, X^2 (6) = 325.39, *p* < .001. There was not a significant interaction between childhood trauma and emotion expressed, X^2 (6) = 4.02, *p* = .675. This suggests the effect of childhood trauma did not vary significantly across which emotion was expressed (Figure 41). Fixed effects parameter estimates are presented in Table 24.

Figure 41

Average emotion recognition accuracy of a standardised total score for childhood trauma (derived from the CTQ-SF) across emotion expressed when controlling for alexithymia and psychopathy traits.

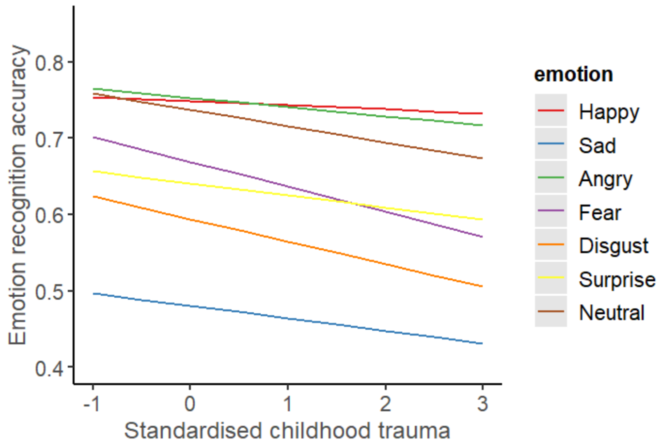


Table 24

The Fixed Effects Parameter Estimates table for emotion recognition accuracy for childhood trauma, emotion expressed, alexithymia, and psychopathy.

Fixed effects	Estimate	Standard Error	exp(B)	95% CI (lower, upper)	z	*p*
Intercept	0.84	0.15	2.31	1.72, 3.11	5.54	**<.001***
Childhood trauma	-0.09	0.05	0.92	0.84, 1.00	-1.87	.062
Happy (Happy – Neutral)	-0.10	0.34	0.90	0.46, 1.76	-0.30	.763
Sad (Sad – Neutral)	-1.32	0.37	0.27	0.13, 0.55	-3.57	**<.001***
Angry (Angry – Neutral)	0.21	0.60	1.23	0.38, 3.97	0.35	.728
Fear (Fear – Neutral)	-0.25	0.58	0.78	0.25, 2.41	-0.44	.663
Disgust (Disgust – Neutral)	-0.89	0.30	0.41	0.23, 0.74	-2.98	**.003***
Surprise (Surprise – Neutral)	-0.36	0.54	0.70	0.24, 2.03	-0.65	.513
Alexithymia	-0.06	0.04	0.94	0.87, 1.03	-1.33	.184
Psychopathy	-0.04	0.04	0.96	0.89, 1.04	-1.01	.315
Childhood trauma * Happy	0.08	0.10	1.08	0.88, 1.33	0.77	.440
Childhood trauma * Sad	0.03	0.11	1.03	0.83, 1.28	0.24	.812
Childhood trauma * Angry	0.04	0.11	1.04	0.84, 1.29	0.37	.712
Childhood trauma * Fear	-0.08	0.10	0.92	0.76, 1.12	-0.82	.413
Childhood trauma * Disgust	-0.04	0.10	0.96	0.79, 1.18	-0.36	.717
Childhood trauma * Surprise	0.01	0.09	1.01	0.84, 1.22	0.14	.892

*** represents significant values (*p* < .05)**

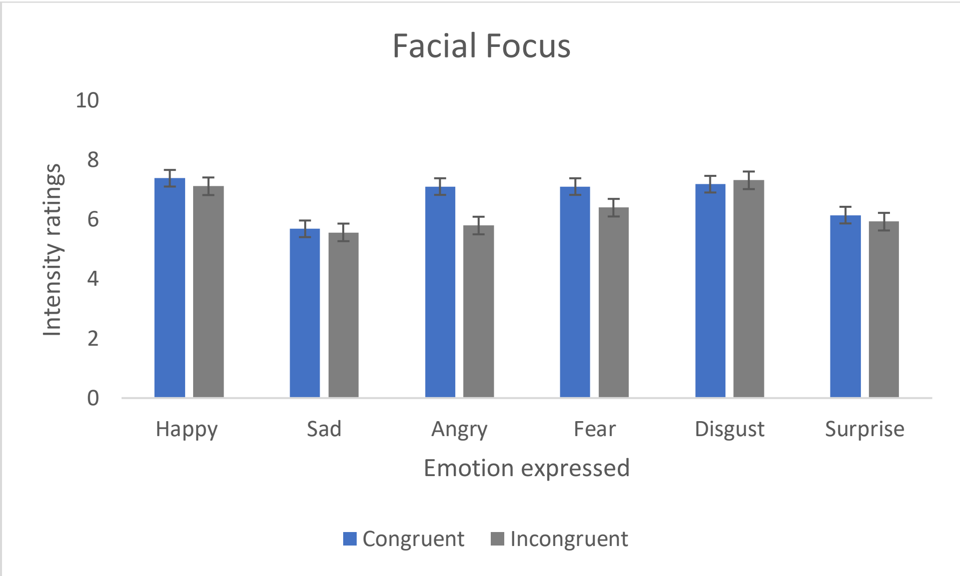
4.3.2. *Intensity ratings*

The average intensity ratings across the stimulus-based factors of congruence, modality focus, and emotion expressed are presented in Figure 42.

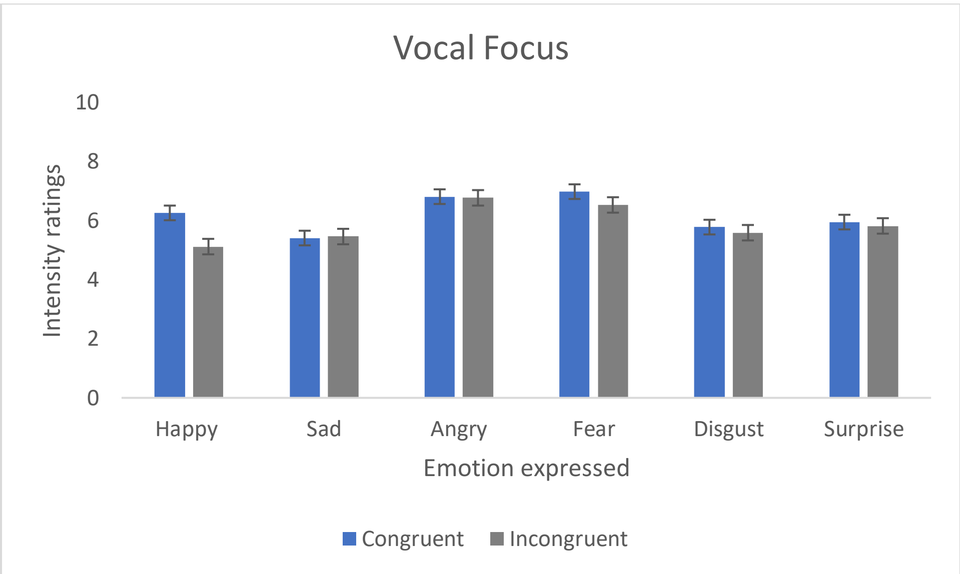
Figure 42

The average intensity ratings across congruence and emotion expressed for (a) facial focus and (b) vocal focus.

a)



b)



The descriptives for the experimental task variables and the individual differences are presented in Table 25.

Table 25

Descriptives table for congruence (congruent, incongruent), modality focus (facial focus, vocal focus), and emotion expressed (happy, sad, anger, fear, disgust, surprise), displaying *the mean and standard deviation of intensity ratings. All emotion task ranges were 10 (0 – 10).*

Variables	Mean score	Standard deviation
Congruence:		
Congruent	6.47	2.18
Incongruent	6.22	2.22
Modality:		
Facial focus	6.61	2.13
Vocal focus	6.06	2.24
Emotion:		
Happy	6.62	2.22
Sad	5.54	2.24
Anger	6.72	2.14
Fear	6.74	1.99
Disgust	6.54	2.16
Surprise	5.97	2.17

4.3.2.1. Is childhood trauma alone associated with intensity ratings?

For all models, the random effects were participant and actor.

Does the relationship vary across intensity?

A cumulative link mixed model was employed to explore the effect of childhood trauma on intensity ratings, across congruence. There was not a significant effect of childhood trauma on intensity ratings (Figure 43), but there was a significant effect of congruence (Table 26). Intensity ratings were significantly higher for congruent trials compared to incongruent trials. There was not a significant interaction between childhood trauma and congruence. This suggests the effect of childhood trauma stayed consistent regardless of whether the stimuli were congruent or incongruent.

Table 26

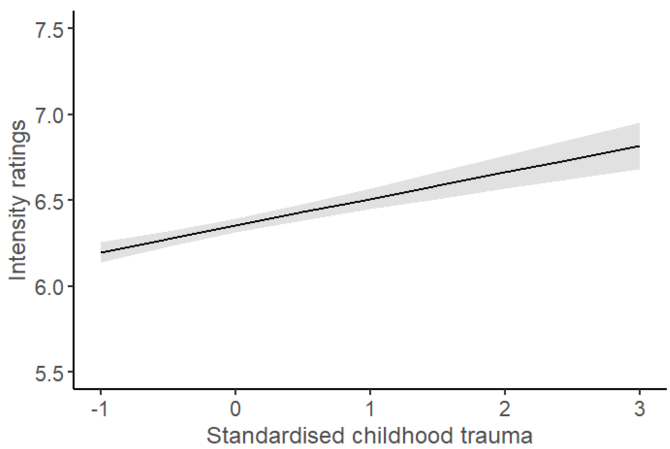
The fixed effects and threshold coefficients are presented for intensity ratings for childhood trauma and congruence.

	B	Standard Error	exp(B)	z	*p*
Childhood trauma	0.12	0.11	1.13	1.07	.286
Congruence (Incongruent – Congruent)	-0.25	0.03	0.78	-7.40	**< .001***
Childhood trauma * Congruence	-0.00	0.03	1.00	-0.08	.939
Threshold coefficients:					
1|2	-5.26	0.22	0.01	-23.63	
2|3	-3.71	0.21	0.02	-17.84	
3|4	-2.76	0.21	0.06	-13.47	
4|5	-2.00	0.20	0.14	-9.79	
5|6	-1.25	0.20	0.29	-6.12	
6|7	-0.31	0.20	0.73	-1.54	
7|8	0.74	0.20	2.10	3.62	
8|9	2.04	0.20	7.69	10.01	
9|10	3.39	0.21	29.67	16.36	

*** represents significant values (p < .05)**

Figure 43

The average intensity ratings for the standardised total score of childhood trauma (derived from the CTQ-SF).



Does the relationship vary across modality?

A cumulative link mixed model was employed to explore the effect of childhood trauma on intensity ratings, across modality. There was not a significant effect of childhood trauma on intensity ratings, but there was a significant effect of modality (Table 27). Intensity ratings were significantly higher for facial focus trials compared to vocal focus trials. There was not a significant interaction between childhood trauma and modality. This suggests the effect of childhood trauma on intensity ratings stayed consisent across modalities.

Table 27

The fixed effects and threshold coefficients are presented for intensity ratings for childhood trauma and modality.

	B	**Standard Error**	**exp(B)**	**z**	***p***
Childhood trauma	0.12	0.11	1.13	1.09	.278
Modality (Vocal focus – Facial focus)	-0.60	0.09	0.55	-6.58	**< .001***
Childhood trauma * Modality	0.00	0.06	1.00	-0.01	.995
Threshold coefficients:					
1|2	-5.56	0.24	0.00	-23.33	
2|3	-3.96	0.22	0.02	-17.72	
3|4	-2.99	0.22	0.05	-13.54	
4|5	-2.29	0.22	0.10	-10.02	
5|6	-1.43	0.22	0.24	-6.51	
6|7	-0.47	0.22	0.63	-2.15	
7|8	0.60	0.22	1.82	2.76	
8|9	1.94	0.22	6.96	8.81	
9|10	3.31	0.22	27.39	14.84	

*** represents significant values (*p* < .05)**

Does the relationship vary across emotion expressed?

A cumulative link mixed model was employed to explore the effect of childhood trauma on intensity ratings, across emotion expressed. There was not a significant effect of childhood trauma on intensity ratings, but there was a significant result for the emotion of sad (Sad – Anger) (Table 28). Intensity ratings were significantly lower for sad expressions compared to angry expressions. There was not a significant interaction between childhood trauma and any of the emotions. This suggests the effect of childhood trauma on intensity ratings stayed consisent regardless of emotion expressed.

Table 28

The fixed effects and threshold coefficients are presented for intensity ratings for childhood trauma and emotion expressed.

	B	**Standard Error**	**exp(B)**	**z**	***p***
Childhood trauma	0.10	0.14	1.11	0.74	.459
Happy (Happy – Anger)	0.06	0.41	1.06	0.14	.886
Sad (Sad – Anger)	-1.27	0.37	0.28	-3.43	**<.001***
Fear (Fear – Anger)	0.13	0.45	1.14	0.30	.768
Disgust (Disgust – Anger)	0.01	0.51	1.01	0.03	.977
Surprise (Surprise – Anger)	-0.77	0.59	0.46	-1.31	.190
Childhood trauma * Happy	0.06	0.11	1.06	0.55	.584
Childhood trauma * Sad	0.02	0.08	1.02	0.21	.833
Childhood trauma * Fear	0.02	0.08	1.02	0.28	.777
Childhood trauma * Disgust	-0.00	0.09	1.00	-0.01	.992
Childhood trauma * Surprise	0.02	0.08	1.02	0.26	.792
Threshold coefficients:					
1|2	-5.90	0.41	0.00	-14.28	
2|3	-4.28	0.41	0.01	-10.56	
3|4	-3.26	0.40	0.04	-8.07	
4|5	-2.41	0.40	0.09	-5.98	
5|6	-1.57	0.40	0.21	-3.91	
6|7	-0.53	0.40	0.59	-1.32	
7|8	0.64	0.40	1.90	1.59	
8|9	2.08	0.40	8.00	5.17	
9|10	3.54	0.40	34.47	8.76	

*** represents significant values (p < .05)**

4.3.2.2. Is childhood trauma associated with intensity ratings when controlling for alexithymia and psychopathy traits?

For all models, the random effects were participant and actor.

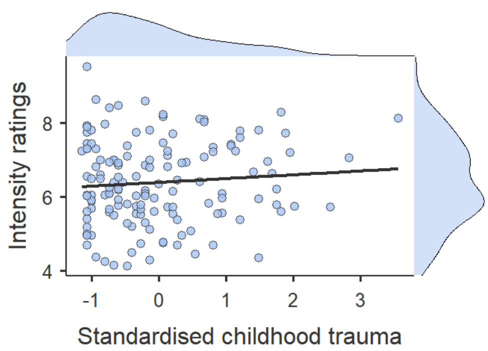
Does the relationship vary across congruence?

A cumulative link mixed model was employed to explore the effect of childhood trauma on intensity ratings, across congruence, with the covariates of alexithymia and psychopathy traits. When controlling for alexithymia and psychopathy traits, childhood trauma was not significant (Figure 44). There was also not a significant effect of alexithymia or psychopathy (Figure 44). However, there was a significant effect of congruence (Table 29). Intensity ratings were significantly higher for facial focus trials compared to vocal focus trials. There was not a significant interaction between childhood trauma and congruence (Figure 45). This suggests the effect of childhood trauma stayed consistent regardless of whether the stimuli were congruent or incongruent.

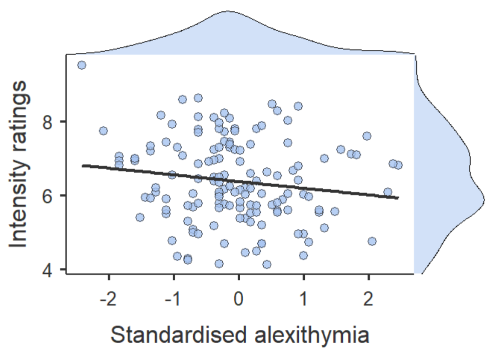
Figure 44

Plots showing the average intensity ratings for the standardised total scores of (a) childhood trauma (derived from the CTQ-SF), (b) alexithymia (derived from the TAS-20), and (c) psychopathy (derived from the SRP-SF): higher scores indicating more experience of childhood and a higher level of traits of alexithymia and psychopathy.

a)



b)



c)

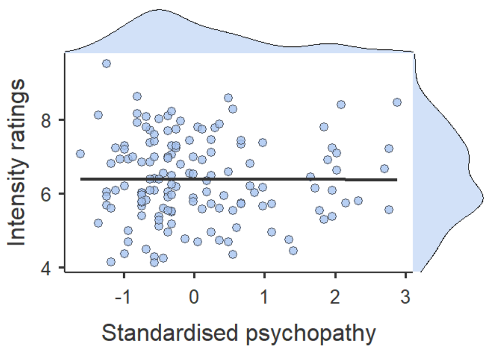


Table 29

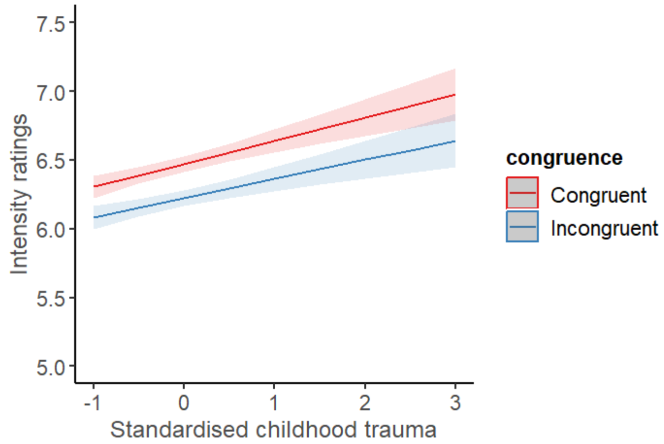
The fixed effects and threshold coefficients are presented for intensity ratings for childhood trauma, congruence, alexithymia, and psychopathy.

	B	**Standard Error**	**exp(B)**	**z**	***p***
Childhood trauma	0.12	0.11	1.13	1.09	.274
Congruence (Incongruent – Congruent)	-0.25	0.03	0.78	-7.40	**<.001***
Alexithymia	-0.23	0.12	0.79	-1.94	.052
Psychopathy	0.06	0.11	1.06	0.52	.601
Childhood trauma * Congruence	-0.00	0.03	1.00	-0.08	.940
Threshold coefficients:					
1|2	-5.25	0.22	0.01	-23.60	
2|3	-3.69	0.21	0.02	-17.79	
3|4	-2.74	0.20	0.06	-13.42	
4|5	-1.98	0.20	00.14	-9.72	
5|6	-1.23	0.20	0.29	-6.05	
6|7	-0.29	0.20	0.75	-1.45	
7|8	0.75	0.20	2.11	3.72	
8|9	2.06	0.20	7.85	10.12	
9|10	3.41	0.21	30.27	16.48	

*** represents significant values (*p* < .05)**

Figure 45

Average intensity ratings of a standardised total score for childhood trauma (derived from the CTQ-SF) across congruence when controlling for alexithymia and psychopathy traits.



Does the relationship vary across modality?

A cumulative link mixed model was employed to explore the effect of childhood trauma on intensity ratings, across modality, with the covariates of alexithymia and psychopathy traits. When controlling for alexithymia and psychopathy traits, childhood trauma and psychopathy were not significant. However, there was a significant effect of alexithymia (Figure 46). Higher scores of alexithymia (more reported traits) were associated with significantly lower intensity ratings of stimuli. There was also a significant effect of modality, with higher intensity ratings for facial focus trials (Table 30). There was not a significant interaction between childhood trauma and modality (Figure 47). This suggested that the effect of childhood trauma on intensity ratings stayed consistent across facial and vocal focus trials.

Figure 46

Average intensity ratings of the standardised total score for alexithymia (derived from the TAS-20) across modalities.

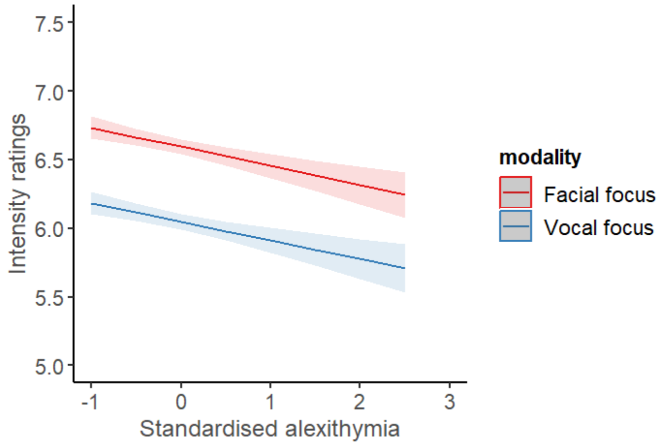


Table 30

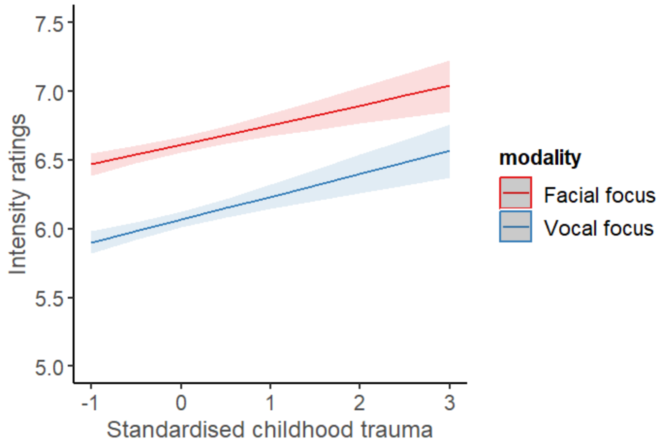
The fixed effects and threshold coefficients are presented for intensity ratings for childhood trauma, modality, alexithymia, and psychopathy.

	B	**Standard Error**	**exp(B)**	**z**	***p***
Childhood trauma	0.12	0.11	1.13	1.12	.262
Modality (Vocal focus – Facial focus)	-0.60	0.06	0.55	-10.24	**<.001***
Alexithymia	-0.25	0.12	0.78	-2.07	**.004***
Psychopathy	0.06	0.11	1.06	0.56	.576
Childhood trauma * Modality	-0.00	0.06	1.00	-0.02	.985
Threshold coefficients:					
1|2	-5.53	0.23	0.00	-24.52	
2|3	-3.94	0.21	0.02	-18.74	
3|4	-2.97	0.21	0.05	-14.32	
4|5	-2.18	0.21	0.11	-10.57	
5|6	-1.41	0.21	0.24	-6.84	
6|7	-0.45	0.21	0.64	-2.20	
7|8	0.62	0.21	1.86	3.03	
8|9	1.96	0.21	7.10	9.47	
9|10	3.32	0.21	27.66	15.86	

*** represents significant values (p < .05)**

Figure 47

Average intensity ratings of the standardised total score for childhood trauma (derived from the CTQ-SF) across modalities when controlling for alexithymia and psychopathy traits.



Does the relationship vary across emotion expressed?

A cumulative link mixed model was employed to explore the effect of childhood trauma on intensity ratings, across emotion expressed, with the covariates of alexithymia and psychopathy traits. When controlling for alexithymia and psychopathy traits, childhood trauma and psychopathy were not significant. However, there was a significant effect of alexithymia, with more reported alexithymia traits being associated with lower intensity ratings (Figure 48). There was also a significant effect of the emotion Sad (Sad – Anger), with significantly lower intensity ratings compared to angry expressions (Table 31). There was not a significant interaction between childhood trauma and emotion expressed (Figure 49). This suggests the effect of childhood trauma on intensity ratings stayed consisent regardless of emotion expressed.

Figure 48

Average intensity ratings of a standardised total score for alexithymia (derived from the TAS-20) across emotion expressed.

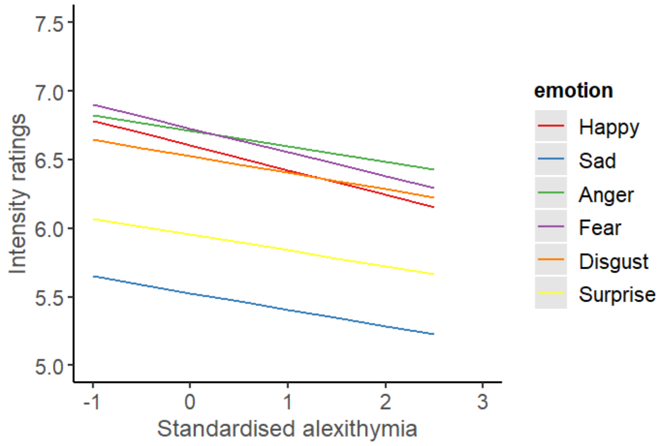


Table 31

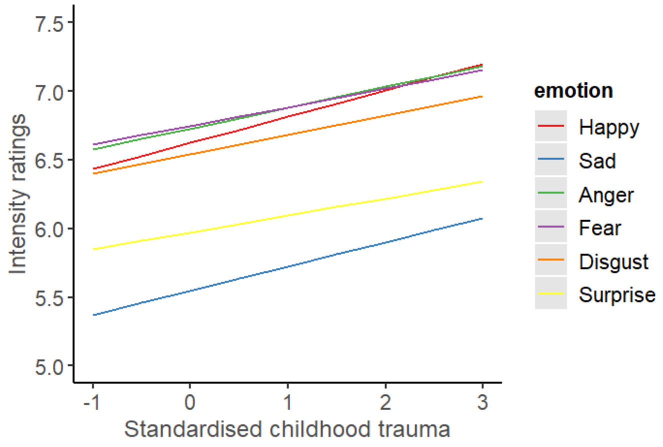
The fixed effects and threshold coefficients are presented for intensity ratings for childhood trauma, emotion expressed, alexithymia, and psychopathy.

	B	**Standard Error**	**exp(B)**	**z**	***p***
Childhood trauma	0.11	0.14	1.12	0.75	.452
Happy (Happy – Anger)	0.03	0.39	1.03	0.07	.941
Sad (Sad – Anger)	-1.30	0.35	0.27	-3.77	**<.001***
Fear (Fear – Anger)	0.17	0.41	1.19	0.41	.685
Disgust (Disgust – Anger)	0.02	0.46	1.02	0.05	.961
Surprise (Surprise – Anger)	-0.84	0.57	0.43	-1.48	.140
Alexithymia	-0.28	0.13	0.76	-2.25	**.025***
Psychopathy	0.08	0.12	1.08	0.68	.498
Childhood trauma * Happy	0.06	0.11	1.06	0.55	.586
Childhood trauma * Sad	0.02	0.09	1.02	0.21	.837
Childhood trauma * Fear	0.23	0.08	1.26	0.29	.775
Childhood trauma * Disgust	-0.00	0.09	1.00	-0.01	.995
Childhood trauma * Surprise	0.02	0.08	1.02	0.27	.788
Threshold coefficients:					
1|2	-5.81	0.40	0.00	-14.56	
2|3	-4.18	0.39	0.02	-10.71	
3|4	-3.16	0.39	0.04	-8.13	
4|5	-2.31	0.39	0.10	-5.96	
5|6	-1.47	0.39	0.23	-3.81	
6|7	-0.43	0.39	0.65	-1.12	
7|8	0.74	0.39	2.10	1.90	
8|9	2.18	0.39	8.85	5.62	
9|10	3.64	0.39	38.10	9.34	

*** represents significant values (p < .05)**

Figure 49

Average intensity ratings of a standardised total score for childhood trauma (derived from the CTQ-SF) across emotion expressed when controlling for alexithymia and psychopathy traits.



4.3.3. Summary

The findings show that when considering childhood trauma in isolation there was a significant relationship with poorer emotion recognition accuracy. However, when controlling for alexithymia and psychopathy traits childhood trauma was no longer significantly associated with emotion recognition accuracy. There was a significant effect of congruence, modality focus, and emotion expressed with better accuracy for congruent compared to incongruent trials, facial focus compared to vocal focus trials, and neutral expressions compared to sad and disgust expressions. There were no significant interactions. For intensity ratings, there was no significant association between childhood trauma and intensity ratings. However, there was a significant association between higher levels of alexithymia traits and lower intensity ratings. Also, there was a significant effect of the stimulus-based factors with higher intensity ratings for congruent trials, facial focus trials, and anger expressions compared to sad expressions. There were no significant interactions.

4.4 Discussion

The current emotion recognition literature has focussed almost exclusively on stimuli that express a single emotion (e.g., unimodal trials or congruent bimodal trials). When employing this approach, it was found that accuracy and intensity ratings were higher for bimodal trials (audio-visual) than unimodal trials (facial or vocal expressions) (Chapter 2) as well as eye gaze patterns differ depending on whether stimuli are static, dynamic, or audio-visual

(Chapter 3). However, by examining audio-visual stimuli which present conflicting or incongruent cues, as in the current chapter, it is possible to explore how individuals process and integrate facial and vocal emotions when recognising expressions. This provides insight into whether modalities influence each other and recognition performance, as well as highlight any perceptual biases towards certain modalities or emotions. Therefore, the main aim of the current study was to investigate whether childhood trauma, when controlling for alexithymia and psychopathy traits, was associated with emotion integration performance (accuracy and intensity ratings) of congruent and incongruent expressions. Furthermore, it was of interest as to how performance varies across congruence, modality focus, and emotion expressed.

The emotion recognition accuracy analyses explored the effects of childhood trauma alone (across congruence, modality focus, and emotion expressed) as well as the effects of childhood trauma whilst controlling for alexithymia and psychopathy traits (across congruence, modality focus, and emotion expressed). All analyses, childhood trauma alone and when controlling for related traits, reported a significant effect of stimulus-based factors (congruence, modality focus, and emotion expressed). There were no significant interactions between childhood trauma and the stimulus-based factors. The three analyses exploring childhood trauma alone revealed that childhood trauma was significantly associated with poorer emotion recognition accuracy. This association is generally supported by previous literature which reports similar patterns of childhood trauma leading to emotion deficits which persist into adulthood (Pollak et al., 2000; Bérubé et al., 2023). As emotion recognition is key for behaving appropriately and maintaining relationships, this may pose issues for individuals with childhood trauma (Grundmann et al., 2021; Pfaltz et al., 2022). However, after controlling for alexithymia and psychopathy traits, the association between childhood trauma and emotion recognition accuracy was no longer significant in any analysis. This may suggest that another factor is influencing the relationship between childhood trauma and poorer accuracy.

For intensity ratings, we explored childhood trauma alone (across congruence, modality focus, and emotion expressed) and childhood trauma when controlling for alexithymia and psychopathy traits (across congruence, modality focus, and emotion expressed). All analyses reported a significant effect of congruence, modality focus, and emotion expressed. Also, across all analyses, there was no significant association between childhood trauma and intensity ratings. However, previous research had suggested that childhood trauma is associated with heightened sensitivities (McLaughlin et al., 2020). Hence, it was expected that individuals with childhood trauma would rate stimuli as more intense than individuals without childhood trauma. Although Neil et al. (2022), as well as our findings in Chapter 2, support the current findings of a lack of association between childhood trauma and intensity ratings. Furthermore, the analyses including alexithymia and psychopathy traits revealed a significant association between alexithymia and intensity ratings in the modality and emotion expressed analyses. Individuals who reported a higher level of alexithymia traits showed significantly lower intensity ratings of stimuli.

4.4.1 Congruence

The current study extended and improved upon previous methodologies as we used more realistic and comprehensive stimuli which more closely resemble real-world social interactions. When exploring emotion recognition accuracy and congruence, individuals showed poorer accuracy for incongruent trials which is in line with previous research (de Gelder & Vroomen, 2000; Collignon et al., 2008). This may suggest that, even when asked to avoid one of the modalities (e.g., ignore the face and focus only on the voice), individuals struggled to disengage from the other channel when the information is conflicting. Also, the congruence analyses reported no significant interaction between childhood trauma and congruence. An interaction was expected based on previous research reporting childhood trauma being associated with poorer accuracy for incongruent stimuli (Caldwell et al., 2014; Marusak et al., 2015; Powers et al., 2015). Hence it was predicted that individuals may not be able to ignore the negative expression when instructed to. Instead, the current findings suggest that childhood trauma's effect on the integration of audio-visual information was fairly consistent regardless of whether the stimuli were congruent or incongruent.

Previous methods which explored congruent and incongruent stimuli (Caldwell et al., 2014; Marusak et al., 2015; Powers et al., 2015) used a static facial expression with an emotional word overlaying it (either matching the facial expression or mismatching it). However, the current study used audio-visual expressions. The current study's use of more realistic methods might mean that we have more experience and practice of these stimuli in everyday life, and therefore some deficits may be attenuated. This may explain why there was no interaction found. The current chapter explored the impact of situations where emotion recognition is difficult or not typical (e.g., conflicting cues). Another way to explore situations with difficult emotion recognition would be to explore partial occlusions (e.g., face masks which obscure the lower half of the face).

Regarding intensity ratings, congruent trials were rated as more intense compared to incongruent trials. This pattern is in line with previous research (Föcker et al., 2011). This suggests that we perceive expressions as more intense when the two emotion channels present matching information. The data indicates that accuracy and intensity ratings are impacted when the audio-visual information being integrated is conflicting. The findings reported no significant association between childhood trauma and intensity ratings and there was no interaction with congruence. This suggests experience of childhood trauma does not affect our perception of how intense expressions are across congruent and incongruent expressions. There is currently no previous research to compare findings to, so more research is needed before drawing conclusions concerning childhood trauma and intensity ratings of congruent and incongruent expressions.

4.4.2. Modality

In the modality focus analyses, there was significantly higher accuracy for facial focus trials compared to vocal focus trials. This is in line with previous research, Pell (2002), which also reported better accuracy for facial expressions compared to vocal expressions. This may suggest that when viewing audio-visual expressions in ideal conditions (e.g., the ability to hear and see the expression) that more weight is given to the face when trying to categorise expressions into one of the basic six expressions. The advantage for facial focus trials over vocal focus trials may provide support for the unimodal explanation of emotion (explained in Chapter 1), suggesting two distinct brain areas responsible for emotion processing – one for faces and one for voices. However, neuroimaging methods, not employed in the current study, would better provide evidence for the unimodal explanation of emotion.

Also, the same pattern of no significant interaction with childhood trauma was observed. A lack of interaction was predicted as if participants with childhood trauma experience were asked to focus on the facial or vocal expression they may struggle to ignore the negative expression presented in one of the modalities. As expected, childhood trauma was associated with poorer accuracy across both facial and vocal focus trials. To our knowledge there was no previous research which had explored childhood trauma and modality focus when exploring emotion processing of facial and vocal cues. The current findings may suggest that childhood trauma's effect on emotion processing of cues is consistent across a range of environments and situations.

There were significantly higher intensity ratings for facial focus trials compared to vocal focus trials. This is in line with previous findings which also reported higher intensity ratings for facial expressions compared to vocal expressions (Kuhn, 2015). A potential issue here is that in situations where vocal expressions are the primary source of emotional information (e.g., dark environments), this may lead to difficulties when accurately perceiving subtle variability in expression intensity. Similar to the congruence analyses, we found there was no significant interaction between childhood trauma and modality focus. However, there was a significant association between alexithymia and intensity ratings when exploring modality. A higher level of alexithymia traits was associated with lower intensity ratings of stimuli. This is in line with previous research by Prkachin et al. (2009) who also reported that a higher level of alexithymia traits was associated with rating emotional expressions as less intense. This association is somewhat expected as neuroimaging research has reported that alexithymia is associated with blunted emotional responses (Grynberg et al., 2012; Deng et al., 2013; Goerlich-Dobre et al., 2014). As a result of this, individuals with more reported alexithymia traits may perceive expressions as less intense, leading to lower intensity ratings.

4.4.3 Emotion expressed

When exploring emotion recognition accuracy across emotion expressed, there was significantly better accuracy for neutral expressions compared to sad expressions and disgust expressions. This is surprising as sadness and fear have evolutionary advantages for our survival. As described in Chapter 2, sadness recognition promotes recognition of what has been lost to prevent further loss (Saarinen et al., 2021) and disgust promotes avoidance of toxic or harmful substances being ingested (Rottman, 2014). Therefore, we would expect better recognition of these expressions. It may be possible that the editing and incongruence of the stimuli disrupted the typical processing of sad and disgust expressions. However, the independent sample ratings, of how in sync elements of the stimuli were, ensured there were no significant differences between conditions. So, it is unlikely that the editing of the stimuli effected results. Another explanation could be the difference in stimuli (e.g., previous research not employing audio-visual expressions) causing the unexpected findings.

Also, there was no significant interaction between childhood trauma and emotion expressed. An interaction was expected, in line with the social information processing mechanism (Dodge et al., 1995), of better accuracy for negative expressions and poorer accuracy for positive and neutral expressions. However, it suggests that childhood trauma's effect on accuracy was consistent across emotion expressed rather than attending more to negative expressions. This was similar to what was found in Chapters 2 and 3. In support of this, eye tracking research reported that individuals with experience of childhood trauma avoided the processing of negative emotional expressions (Bodenschatz et al., 2019; Hoepfel et al., 2022). This may explain why negative expressions also showed poorer processing and recognition, similar to positive and neutral expressions. Future reviews should consider compiling recent findings to discuss whether the negative expression advantage, proposed by the social information processing mechanism (Dodge et al. 1995), is supported.

When exploring intensity ratings across emotion expressed, there was a significant effect of sad expressions (Sad – Anger), with significantly lower intensity ratings for sad expressions compared to angry expressions. This is in line with Matsumoto and Ekman (1989) who reported that both American and Japanese participants rated sadness as the lowest intensity expression. There has been reports of sad expressions being confused as neutral (Busso et al., 2004), if this is the case then it would be likely that they would be rated as low intensity compared to other emotional expressions. It was predicted, as a result of the associated heightened sensitivities to negative expressions, that individuals with childhood trauma experience would rate negative expressions as more intense than individuals without childhood trauma experience. However, there was no significant interaction between childhood trauma and emotion expressed for intensity ratings found. A possible reason could be that audio-visual expressions provide more cues than previously used static facial expressions. Therefore, the extra information for positive and neutral expressions may lead to similar processing as negative cues, and lead to a comparable effect of childhood trauma across emotions. With the current stimuli, as all expressions were audio-visual, performance cannot be compared to static faces with less cues. However, Chapter 3 included static expressions as well as dynamic and audio-visual expressions and did not report a significant interaction between childhood trauma and emotion expressed.

Even though childhood trauma was not significant, alexithymia was. Similar to the modality focus discussion, this association is most likely due to the associated blunted responses. The fact that alexithymia was associated with two analyses of the intensity ratings, but none of the accuracy analyses, may suggest that under the study's conditions alexithymia is associated with alternative measures of emotion recognition – intensity ratings – rather than accuracy itself. There is currently limited exploration of alexithymia and intensity ratings so it is unclear why this occurred. Further research into this topic, and replication of the current study, may shed light on this relationship.

When comparing the current chapters findings overall to Chapter 2's findings there are similar results. Both report that childhood trauma alone is significantly associated with poorer emotion recognition accuracy, but after controlling for the related traits, the relationship is reduced or non-significant. However, in Chapter 3, whether childhood trauma was examined in isolation or with alexithymia and psychopathy, there was no significant association with emotion performance. Chapter 3's findings explored emotion processing whereas Chapter 2 and the current findings explored more recognition performance. By comparing the findings, we can explore whether a specific aspect of emotion recognition is impacted by childhood trauma. For example, is the emotion processing stage fairly typical but then is the recognition stage particularly hindered which leads to poorer recognition? The difference in childhood trauma's effect on emotion processing (Chapter 3) and emotion recognition (Chapter 2 and the current chapter) may suggest that the effect of childhood trauma differs across various stages of emotion recognition. This may suggest that experience of childhood trauma may not have a significant effect on early processes (emotion processing) but becomes more salient at later stages such as integration of emotional cues and labelling.

As discussed above, Chapter 2's results were similar to the current study and therefore, similar implications are relevant here. The findings still suggest that individuals with childhood trauma struggle with emotion recognition but that the deficits may be a result of a co-morbid factor or trait as a result of childhood trauma experience rather than childhood trauma itself. This co-morbid factor or trait would be related to childhood trauma as well as emotion deficits, similar to alexithymia and psychopathy. Similar to this theory, Bird and Cook (2014) suggested that the emotion deficits associated with autism are the result of the co-morbid alexithymia rather than autism itself. A similar concept could be applied to the relationship between childhood trauma and emotion performance. This may suggest that our understanding of the relationship between childhood trauma and emotion recognition may need to be revised and updated to include related factors which may be influencing this relationship. An update of the models may inform interventions to incorporate other factors. For example, an intervention may need to include aspects to target co-morbid traits (e.g., alexithymia and psychopathy) as well as childhood trauma itself. Other research has reported strong associations between childhood trauma, emotion performance, and psychopathology

(Flechsenhar et al., 2022) which may also be a co-morbid factor to consider. Although alexithymia and psychopathy were not significant themselves, they still significantly influenced the relationship between childhood trauma and emotion performance. However, the findings also suggest that an additional co-morbid factor, not included in the analysis, may also influence the relationship between childhood trauma and emotion recognition accuracy. Therefore, future research may benefit from exploring other co-morbid factors linked to childhood trauma and emotion recognition.

4.5. Conclusion

In conclusion, to our knowledge this is the first study to explore individual differences in congruent and incongruent audio-visual stimuli (e.g., dynamic facial expressions paired with linguistic vocal expressions) when exploring the integration of facial and vocal cues. The analyses exploring childhood trauma alone reported that individuals with experience of childhood trauma showed poorer accuracy. After we controlled for alexithymia and psychopathy traits, childhood trauma was no longer significant, and neither were alexithymia or psychopathy. This may suggest that the original analyses (childhood trauma alone) were reporting a related factor or trait rather than childhood trauma's unique effect. This suggests that individuals with childhood trauma experience do present difficulties with emotion recognition, but this may be due to co-morbid traits or factors as a result of the experience rather than childhood trauma itself. This suggests an update or revision of the models, and our understanding of childhood trauma and emotion recognition, to better understand which factors are influencing the relationship. If an understanding of this relationship, and all factors at play, is achieved this could guide the development of interventions to address the deficits and possibly improve emotion performance.

For intensity ratings, there was no significant association with childhood trauma in any of the analyses. However, in the modality focus and emotion expressed analyses there was a significant effect of alexithymia, with a higher level of alexithymia traits being associated with lower intensity ratings. As alexithymia was not significant in the accuracy analyses, but was for intensity ratings, it may suggest that, when exploring the integration of cues, alexithymia is associated with perception of expressions rather than accuracy.

Although Chapters 2, 3, and the current chapter have used improved and more realistic stimuli which closer resemblance everyday interactions, it has not been examined how performance was impacted during real-world situations. A specific, recent example would be the COVID-19 pandemic and the introduction of face coverings which omit certain, and important, facial information (e.g., the lower half of the face) when recognising emotional expressions. To start to answer this, the next chapter explores childhood trauma (alone and when controlling for alexithymia and psychopathy traits) and emotion recognition accuracy of masked (stimuli wearing a face covering) or unmasked (stimuli expression is unobscured) facial expressions. This will allow the exploration of how this particular real-world event impacted our social interactions, and whether certain individuals or groups were further affected.

5. The effects of individual differences on emotion recognition of masked and unmasked faces.

Experiment 4b in this chapter has been published in *Cognitive Research: Principles and Implications*. The content has been adapted to be more thesis appropriate.

Cooper, H., Brar, A., Beyaztas, H., Jennings, B. J., & Bennetts, R. J. (2022). The effects of face coverings, own-ethnicity biases, and attitudes on emotion recognition. *Cognitive Research: Principles and Implications*, 7(1), 1-22. https:// doi.org/10.1186/s41235-022-00400-x

5.1. Introduction

The previous chapter explored the effect of childhood trauma on the integration of audio and visual cues when processing emotional expressions, and whether this varied across modality focus, emotion expressed, and congruence. The findings reported a significant effect of childhood trauma on emotion recognition accuracy when exploring childhood trauma alone. However, after controlling for alexithymia and psychopathy traits, childhood trauma's effect was no longer significant. The findings suggested that a co-morbid factor or trait of childhood trauma may be influencing the relationship with emotion integration, rather than childhood trauma experience itself. This is in line with the findings from Chapter 2, which also showed the relationship between childhood trauma and emotion recognition was reduced or non-significant after controlling for alexithymia and psychopathy traits. When exploring intensity ratings, alexithymia was associated with lower intensity ratings. This chapter provided information regarding whether certain individual differences were associated with atypical emotion integration across various conditions (congruence, modality focus, emotion expressed).

Throughout the thesis, various aspects of emotion recognition (e.g., recognition accuracy, processing, and integration of cues) have been explored. However, the impact of specific recent events on our emotion performance is still unclear. Therefore, this chapter explores the novel and unexpected COVID-19 pandemic, which introduced a mask mandate, to see how this impacted our interactions and whether certain individuals or groups were further hindered due to face coverings. Previous chapters have explored childhood trauma's effect on emotion recognition accuracy whilst increasing the emotion cues available (e.g., the inclusion of movement and bimodal cues). However, this chapter explores a different method of the underpinnings and characteristics of childhood trauma's effect on emotion recognition by limiting the emotion cues available.

The rise of research exploring face masks has tended to overlook whether any particular individuals or groups were further impacted when recognising emotional expressions. As such, the current study will extend on the individual differences previously explored throughout the thesis across two experiments. Chapter 2 details Experiment 1, Chapter 3 details Experiment 2, Chapter 4 details Experiment 3, and this chapter will detail Experiment 4a and Experiment 4b. Experiment 4a, similar to Chapters 2, 3, and 4, will explore childhood trauma whilst controlling for alexithymia and psychopathy traits. Experiment 4b will explore different individual differences to Experiment 4a, and previous chapters, of a match or mismatch of participant and actor ethnicity as well as our attitudes towards masks. Research has suggested ethnicity can influence emotion recognition performance. This experiment will explore whether any in-group effects are at play with face coverings. This is the first study of the thesis to include ethnicity as it explores a real-world event so the exploration of various factors, including one which impacts everyone (e.g., in-groups and out-groups for ethnicity) gives us a broader understanding of how COVID-19 may have impacted our interactions.

In July 2020, as a result of the COVID-19 pandemic, the UK government mandated face coverings in indoor environments (e.g., shops, transport, restaurants, etc) (Department of Health and Social Care, 2021). By August 2020, over one hundred countries had also introduced mandatory mask-wearing (Felter & Bussemaker, 2020). There has been a surge of research into how wearing face masks may affect our daily lives. One major area negatively affected is social interactions (Mheidly et al., 2020). Face coverings can cause difficulties interpreting and responding to conversations (Mheidly et al., 2020) as they obscure the lower part of a face which can hinder the extraction of important information (Biermann et al., 2021). One aspect of social interactions particularly hindered is emotion recognition abilities. Accuracy is poorer for masked facial expressions, and more misclassifications are made, compared to unmasked facial expressions (Carbon, 2020; Cooper et al., 2022; Grundmann et al., 2021; Noyes et al. 2021). Emotion recognition accuracy is essential in creating and maintaining relationships with others (Grossmann, 2017) as well as ensuring our response to others is appropriate for the situation (Grundmann et al., 2021). For example, if we are conversing with someone and they start to express a negative expression, we know to adapt our behaviour in order to rectify this. By exploring whether, and how, face masks impact our emotion recognition, we can start to understand how our social interactions were impacted as a result of the pandemic.

5.1.1. Masks and emotion recognition

There are various reasons to predict that emotion recognition abilities would be hindered by masks. For example, partial occlusions work reported that individuals rely on different parts of the face when recognising certain emotional expressions. As described in detail in Chapter 1 and 3, a variety of methods (e.g., point light displays, tile method, and eye tracking) have reported that sadness, fear, and anger rely on the eyes for accurate recognition and disgust and happiness rely on the mouth for accurate recognition (Bassilli, 1979; Eisenbarth & Alpers, 2011; Wegrzyn et al., 2017). Therefore, it may be more likely for disgust and happiness (needing information from lower half of the face) to be most affected when wearing face masks.

On the contrary, there is also research showing how important the eye region is for accurate emotion recognition. This may suggest that the partial occlusion of the lower region may not hinder recognition as much as expected. A key method involved in exploring this is the Reading the Mind in the Eyes Test (Baron-Cohen et al., 2001). This method asks participants to view photographs of the eye region only and determine what emotional expression is depicted (Baron-Cohen et al., 2001). A study by Schmidtmann et al. (2020) asked 30 participants to complete this task including 36 expressions (e.g., playful, upset, worried, interested) for various durations (ranging from 12.5 to 100 milliseconds). They reported that individuals could recognise facial expressions of complex emotional expressions (e.g., beyond the basic six emotions) within a fraction of a second based on the eye region only. This suggests the eye region alone can display an appropriate amount of information needed for accurate emotion recognition. This could suggest that the recognition of masked facial expressions, with unobscured eye regions, may still be possible. In further support, Grossmann (2017) conducted a review and concluded that recognition of emotional expressions is collated from the eye region and is crucial for initiating, maintaining, and regulating social interactions. As the upper half of the face is not obscured by face masks, it may be unlikely that limiting information to this region would completely abolish emotion recognition abilities.

There has been an increase in research exploring face coverings and emotion recognition since the pandemic introduced a mask mandate. Noyes et al. (2021) examined face and emotion recognition using either face coverings, sunglasses, or no occlusions. The sample included typical recognisers and super recognisers (individuals highly skilled at recognising faces). They reported that any occlusion to the face (masks or sunglasses) led to poorer accuracy for face recognition and emotion recognition but, out of the three conditions, the mask condition showed the highest number of errors. However, this study used images of actual individuals wearing masks and sunglasses rather than editing the images. This means the stimuli were more naturalistic but the images from the non-occluded condition did not perfectly match the occluded ones. This disparity may have affected accuracy differences between conditions. Though, in support of these findings, Kim et al. (2022) explored emotion recognition performance with masks or sunglasses in a South Korean sample. They reported that emotion recognition performance was poorest in the mask condition, followed by the sunglasses condition, then unobscured faces. This may suggest that masks, and occlusions of the lower half of the face, may hinder recognition more than occlusions of the upper half of the face. Further support of the overall negative effect of masks on emotion recognition is Grundmann et al. (2021). They explored the effect of face masks on emotion recognition accuracy and social judgements and reported significantly poorer accuracy for masked facial expressions (48.9% accuracy) compared to unmasked facial expressions (69.9% accuracy).

This research field has neglected to explore individual differences more broadly. It is important to explore this so we can identify whether certain groups or individuals are more susceptible to issues with face masks and start to rectify this. For example, informing policies on whether certain people should be exempt if they are significantly more impaired than others. Also, it can provide an insight regarding the underpinning processes that might be causing emotion recognition deficits for these individuals more generally. Therefore, the current research aims to investigate whether individual differences modulate the effects of masks on emotion recognition accuracy. Experiment 4a will explore the effect of childhood trauma, when controlling for alexithymia and psychopathy traits, on emotion recognition across masks and emotion expressed. Experiment 4b will explore the effect of the individual differences of ethnicity and attitudes towards masks on emotion recognition accuracy across masks and emotion expressed.

5.2. Experiment 4a

5.2.1. Introduction

The individual differences being explored in this experiment are childhood trauma and the related traits of alexithymia and psychopathy. The direct exploration of whether mask deficits are more prevalent across certain individual differences is lacking. Therefore, the majority of evidence discussed throughout will focus on partial occlusions or eye tracking work. These findings can explore emotion recognition across certain facial features (e.g., the eyes only) and, as face masks only leave the eye region unobscured, the findings may generalise to masked faces. This highlights the need for the current study.

5.2.1.1. Childhood trauma

The lack of face covering or partial occlusion work exploring childhood trauma makes any predictions for whether individuals with childhood trauma experience were impacted by face coverings difficult. Research has reported an association between childhood trauma and significantly poorer emotion recognition accuracy of positive expressions (Koizumi & Takagishi, 2014) and better accuracy for negative expressions (Weinstein et al., 2016). This follows the social information processing mechanism (Dodge et al., 1995). This states that the better recognition for negative expressions is due to heightened sensitivities or a hypervigilance to threat cues. This leads to poorer recognition of positive expressions as they are misinterpreted and mislabelled as negative expressions.

Research employing eye tracking suggests similar difficulties for individuals with childhood trauma experience. Mohr (2016) asked participants with experience of childhood trauma to complete an emotion recognition task including happy, angry, sad, or neutral expressions whilst their eye movements were tracked. They reported that childhood trauma was associated with initial eye gaze towards the eye region more than other facial features for all expressions except happiness, where initial gaze was toward the mouth region as often as the eyes. These findings support Chapter 3's findings which also reported that more childhood trauma experience led to increase gaze to the eye region. Therefore, it may suggest that emotion recognition accuracy for individuals with experience of childhood trauma may not be abolished completely, as gaze is focused on the upper region which is unobscured by masks. However, the studies discussed did not use actual face coverings. Thus, we cannot conclude for certain whether individuals with childhood trauma experience were further impacted by the introduction of face coverings.

5.2.1.2. Interrelated traits

Similar to throughout the thesis, alexithymia and psychopathy traits are being explored as they have strong reported links to childhood trauma (Zlotnick et al., 2001; Craparo et al., 2013) as well as emotion recognition difficulties (Blair, 2001; Parker et al., 2005). They will be included and controlled for in this chapter to ensure we are exploring childhood trauma's unique effect on masked emotion recognition.

Research has directly explored alexithymia and face coverings. Gehdu et al. (2023) explored emotion recognition performance of individuals with autism (with and without high levels of alexithymia traits) and individuals without autism on masked and unmasked faces. They reported that individuals with autism with a high level of alexithymia traits showed poorer emotion recognition accuracy compared to individuals with autism with a low level of traits or individuals without autism. Though, the deficits associated with alexithymia were found across both masked and unmasked faces. This may suggest that alexithymia was associated with emotion deficits in general, but these deficits were not exacerbated by face coverings. Nonetheless, eye tracking research has reported an association between alexithymia traits and atypical eye gaze towards the eye region, in particular an avoidance of the eye region, when recognising emotional expressions (Fujiwara, 2018; Cuve et al., 2021). If this avoidance of the eye region is reflected for masked faces – where only the eye region is unobscured – it may suggest that individuals exhibiting a higher level of alexithymia traits will show poorer accuracy for masked faces. However, Gehdu et al.'s (2023) findings suggest that alexithymia traits do not influence the emotion recognition of masked faces specifically. The different methods employed (e.g., masks versus eye tracking) may explain the conflicting findings.

Psychopathy and psychopathic traits are also associated with reduced attention to the eye region when recognising emotional expressions (Dadds et al., 2006; Gillespie et al., 2015; Gehrer et al., 2019). Research exploring psychopathy whilst employing eye tracking has reported an association between psychopathy and less dwell time overall and less fixations to the eye region (Gillespie et al., 2015; Gehrer et al., 2019). There is no current research directly exploring psychopathy and the emotion recognition of masked and unmasked faces, but the eye track literature may suggest an avoidance of the eye region. Consequently, we might expect that interventions which reduce information from the lower regions, such as face masks, could have a disproportionate effect on individuals with high psychopathy traits.

5.2.1.3. The current study

The current study explores the effect of childhood trauma on emotion recognition accuracy across masks and emotion expressed and whether this association is influenced by alexithymia and psychopathy traits.

For the overall effect of masks, it is hypothesised, in line with previous partial occlusion research (Fischer et al., 2012; Kret & De Gelder, 2012) and mask studies (Grundmann et al., 2021; Noyes et al. 2021), that masked faces will have poorer emotion recognition than unmasked faces. It is also hypothesised, in line with previous findings (Grahlow et al., 2022), that masks will interact with emotion expressed. All unobscured expressions will show better accuracy than obscured expressions, and expressions relying on the lower region of the face for accurate recognition (happiness and disgust; Bassili, 1979; Wegrzyn et al., 2017) will be most affected.

In line with key previous research described in Chapters 1 and 2 (namely, Pollak et al., 2000; Bérubé et al., 2023), it is expected that childhood trauma will be associated with poorer emotion recognition accuracy overall. Even though childhood trauma has been associated with increased eye gaze to the eye region (Mohr, 2016), and with sensitivities to negative expressions, the distinct lack of research exploring childhood trauma's effect across masked faces makes any interactions between childhood trauma and masks or emotion expressed unclear. It is also unclear how the relationship between childhood trauma and masks and emotion expressed will be influenced by alexithymia and psychopathy traits. Therefore, the current study aims to address these gaps.

5.2.2. Methods

5.2.2.1. Participants

A final sample of 126 participants were analysed (53 female; 72 male; 1 nonbinary, M_{age} = 30 years (19 - 50), SD = 7.84). Data for 134 participants was originally collected but 8 participants were excluded: 7 due to incomplete data and 1 due to reaction times (< 300 milliseconds over 10% of trials). There were 46 participants who identified as White (37%), 38 who identified as Black (30%), 20 who identified as Asian / Pacific Islander (16%), 16 who identified as South Asian (13%), and 6 who identified as "Other" (5%). Participants were recruited from an online participation site (Testable Minds) in exchange for 5 USD. The inclusion criteria were aged between 18 and 50 years old, normal or corrected-to-normal vision, and fluent in English to a native standard (due to the verbal IQ test). Ethical approval was granted by the Research Ethics Committee for the College of Health, Medicine, and Life Sciences at Brunel University London.

5.2.2.2. Design

The experimental task variables included face masks (masked and unmasked) and emotion expressed (basic six emotions and neutral). The individual differences variables were childhood trauma, alexithymia, and psychopathy. The outcome variable measured was emotion recognition accuracy.

5.2.2.3. Materials

5.2.2.3.1. Questionnaires

Participants completed self-report questionnaires to assess childhood trauma, alexithymia, psychopathy, and personality. The questionnaires are the same as throughout the thesis as we wanted to explore the same individual differences.

Childhood trauma: Childhood Trauma Questionnaire Short Form (CTQ-SF)

Reliability of the CTQ-SF in the current sample was analysed, Guttman's λ_2 = .720.

Alexithymia: Toronto Alexithymia Questionnaire (TAS-20)

Reliability of the TAS-20 in the current sample was analysed, Guttman's λ_2 = .852.

Psychopathy: Self Report Psychopathy Scale – Short Form (SRP-SF)

Reliability of the SRP-SF in the current sample was analysed, Guttman's λ_2 = .905.

Personality: The Mini Personality Questionnaire (Mini-IPIP)

Data regarding personality was collected but not analysed in this study, as it was not related to any of our main hypotheses. This is in line with the analytical approach adopted in Experiment 1 (Chapter 2).

Similar to previous chapters, the total scores from each questionnaire were standardised and used in the analyses due to needing considerable power for the analyses chosen and the interest being in the overall effect of the individual differences on emotion performance.

5.2.2.3.2. Intelligent Quotient Verbal task

Wechsler Test of Adult Reading (WTAR)

The procedure and scoring details for the WTAR are as described in Chapter 2. Similar to the previous chapters, IQ was included to ensure all participants had an IQ score of 80 and above. Participants would have been excluded if their IQ score was categorised as "borderline" or "extremely low".

5.2.2.3.3. Emotion stimuli

The stimuli were from the RADIATE database (Conley et al., 2018), a validated emotion database which includes a large, ethnically diverse set of facial expressions and presents good reliability and validity. The stimuli chosen included 24 identities and 3 ethnicities. There were 4 females and 4 males chosen for each ethnicity – Asian, Black, and White. The emotional expressions chosen were the basic six emotions and neutral.

The stimuli showed the actor's face and the top of their shoulders with grey clothing on a white background. The original stimuli were duplicated and edited to wear face masks using the website Photopea (example in Figure 50). Four different face coverings were used from Google image searches. The masks shared the same basic shape and covered the same areas of the face but had different colours (blue, black, green, and pink). This was to make the stimuli somewhat more realistic as we do interact with people with various styles and colours of masks. There were a total of 336 trials (4 identities x 3 ethnicities x 2 genders x 7 emotions x 2 images (masked/unmasked)). All the material used in the experiment are openly available (https://osf.io/57nfe/).

Figure 50

Examples of unmasked (left) and masked (right) stimuli displaying a happy expression.

5.2.2.4. Procedure

Participants completed the three questionnaires and an emotion recognition task. The emotion recognition task was split into two sections to ensure participants had a break in between. Participants completed the questionnaires in between the emotion tasks. Both emotion recognition tasks had the same instructions and procedure and included a mix of masked and unmasked faces. Participants were asked to identify the emotional expression depicted on each face. They were told the stimuli would be displayed for 1 second and they would have 6 seconds to select an answer until it skipped to the next trial. They were asked to try and answer as quickly and accurately as possible. There were seven practice trials for participants (none of the faces were used in the main task) before moving on to the main task. Both the practice trials and main task trials were randomised.

The stimuli were presented in the middle of the screen with the seven response options presented underneath: Happy, Angry, Disgusted, Fearful, Sad, Surprised, and Neutral. The effects of face masks are primarily visual so we did not include an audio or audio-visual condition. We considered it important to match the masked and unmasked stimuli as closely as possible, and in the absence of video databases that meant static facial expressions could be used and be edited more consistently for face masks. Also, as a result of all previous chapters reporting participants selected the response options of 'Other' or 'I don't know' approximately 1% or less, and these options were not providing additional information, they were not included in the current study. To respond, participants selected the expression they believe was expressed.

5.2.2.5. Data analysis

Previous chapters did not explore reaction time due to the use of dynamic expressions, which vary in onset and duration, making reaction time an inappropriate measure. However, this chapter included static stimuli which would make exploration of reaction times possible. Although, the stimuli were presented for 500 milliseconds rather than free view until the participant selects an answer, as how typically reaction time is explored. Although, the main reasoning behind not including reaction time is that the hypotheses are focused on emotion recognition accuracy instead. Therefore, the methods employed, and hypotheses focus, make exploration of reaction time inappropriate and it was not explored in the analyses.

Generalised mixed models were used to explore the role of childhood trauma, when controlling for alexithymia and psychopathy traits, on the emotion recognition accuracy of masked and unmasked faces across emotions expressed. The reference category for masks was unmasked faces and for emotion expressed was neutral expressions.

5.2.3. Results

The distribution of different questionnaires are presented in Figure 51 and the average emotion recognition accuracy across the stimulus-based factors of masks and emotion expressed are presented in Figure 52.

Figure 51

The distribution of (a) childhood trauma, (b) alexithymia, and (c) psychopathy in the sample.

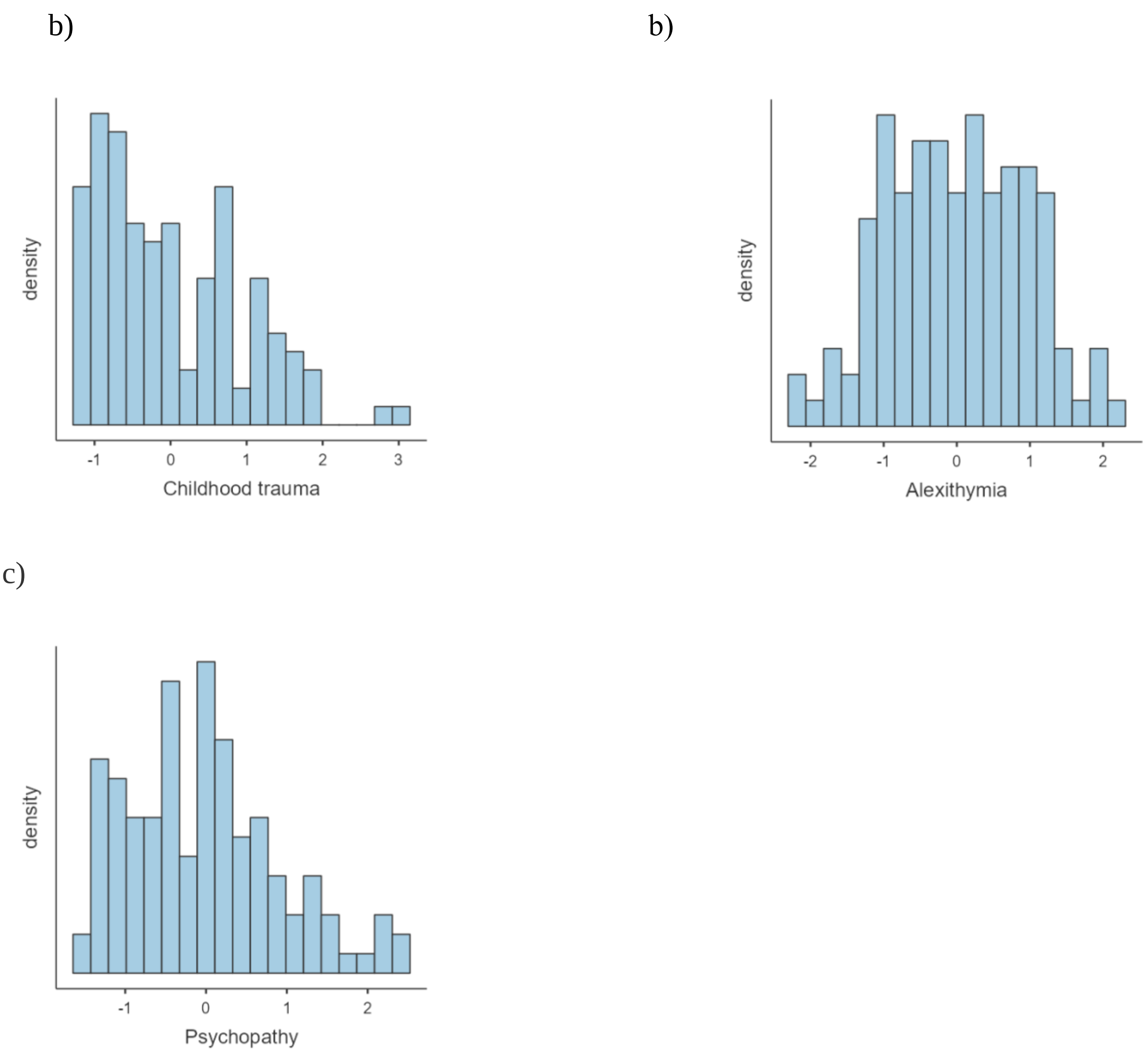
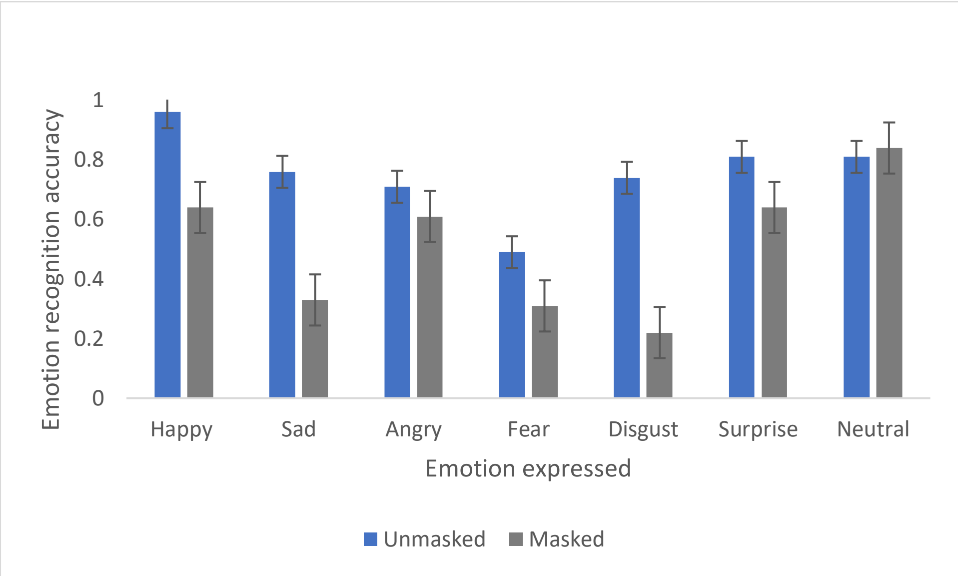


Figure 52

The average emotion recognition accuracy (proportion correct) across masks and emotion expressed.



The descriptives for the experimental task variables and the individual differences variables are presented in Table 32.

Table 32

Descriptives table for childhood trauma, alexithymia, and psychopathy displaying the mean score, standard deviation, and range of the raw total questionnaire scores. Descriptives for masks (unmasked, masked) and emotion expressed (happy, sad, anger, fear, disgust, surprise, neutral) displaying the mean score, standard deviation, and range of emotion recognition accuracy (proprotion correct).

Variables	Mean score	Standard deviation	Range
Childhood trauma	42.53	14.07	63 (25 – 88)
Alexithymia	50.63	13.14	60 (21 – 81)
Psychopathy	54.49	16.06	69 (30 – 99)
Emotion Tasks (Response Accuracy)			
Masks:			

Unmasked	0.75	0.43	0.57 (0.37 – 0.94)
Masked	0.51	0.50	0.45 (0.23 – 0.68)
Emotion:			
Happy	0.80	0.40	0.50 (0.50 – 1.00)
Sad	0.55	0.50	0.80 (0.08 – 0.88)
Anger	0.66	0.47	0.92 (0.08 – 1.00)
Fear	0.40	049	0.88 (0.00 – 0.88)
Disgust	0.48	0.50	0.88 (0.00 – 1.00)
Surprise	0.72	0.45	0.78 (0.17 – 0.96)
Neutral	0.82	0.38	0.96 (0.04 – 1.00)

5.2.3.1. Is childhood trauma alone associated with emotion recognition accuracy?

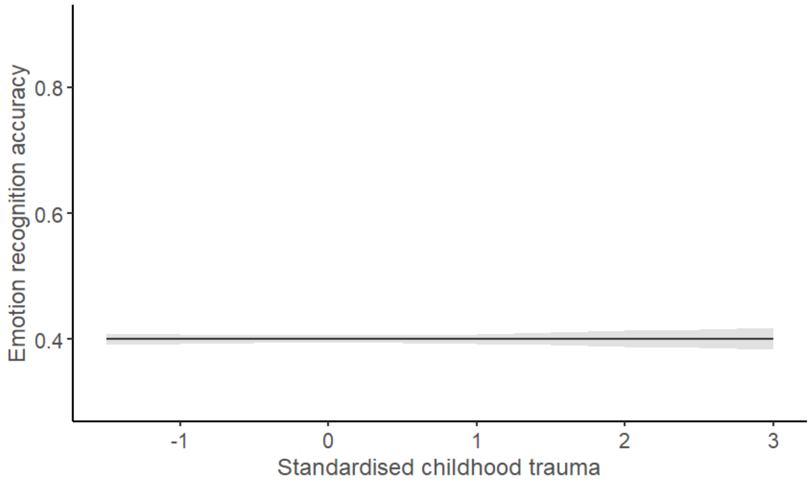
For all models, the random effects were participant and actor.

Does the relationship vary across masks?

A generalised mixed model was employed to explore the effect of childhood trauma on emotion recognition accuracy. The fixed factors were childhood trauma and masks. There was not a significant main effect of childhood trauma, X^2 (1) = 0.00, p = .973, β = −0.00, exp(B) = 1.00 (Figure 53). There was a significant effect of masks, X^2 (1) = 210.58, p < .001, with β = −1.14 and exp(B) = 0.32. There was significantly better accuracy for unmasked faces compared to masked faces, z = -14.51, p < .001. There was not a significant interaction between childhood trauma and masks, X^2 (1) = 0.23, p = .633, with β = 0.02 and exp(B) = 1.02. This suggests that regardless of whether individuals reported more or less experience of childhood trauma, performance for masked and unmasked faces was comparable.

Figure 53

The average emotion recognition accuracy (proportion correct) for the standardised total score of childhood trauma (derived from the CTQ-SF). The shaded area represents the 95% confidence interval.



Does the relationship vary across emotion expressed?

A generalised mixed model was employed to explore the effect of childhood trauma on emotion recognition accuracy. The fixed factors were childhood trauma and emotion expressed. There was not a significant effect of chilhdood trauma, X^2 (1) = 0.07, p = .790, β = 0.01, exp(B) = 1.01. There was a signficant effect of emotion expressed, X^2 (6) = 277.59, p < .001. There were significant differences reported for all expressions, except happy, compared to neutral, β ranging from -0.79 to -2.45 and exp(B) ranging from 0.09 to 0.46. There was poorer accuracy for sad, z = -7.87, p < .001, anger, z = -4.77, p < .001, fear, z = -11.17, p < .001, disgust, z = -11.07, p < .001, and surprise, z = -3.72, p < .001, compared to neutral. There was not a significant difference between happy and neutral expressions, z = -0.66, p = .509. There was not a significant interaction between childhood trauma and emotion expressed overall, X^2 (6) = 6.73, p = .347. This suggests that individuals who reported more or less childhood trauma experience showed comparable accuracy regardless of which emotion was expressed.

5.2.3.2. Is childhood trauma associated with emotion recognition accuracy when controlling for alexithymia and psychopathy traits?

For all models, the random effects were participant and actor.

Does the relationship vary across masks?

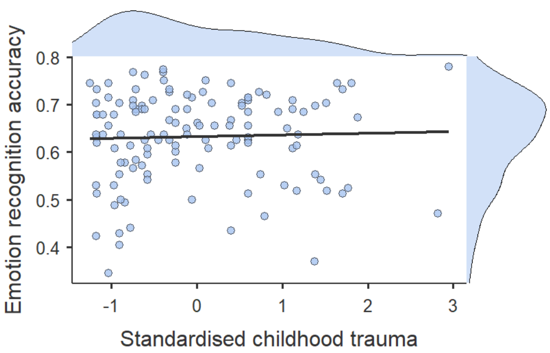
A generalised mixed model was employed to explore the effect of childhood trauma on emotion recognition accuracy. The fixed factors were childhood trauma and masks and the covariates were alexithymia and psychopathy. There was no significant effect of childhood trauma, X^2 (1) = 0.66, p = .415, or psychopathy, X^2 (1) = 0.80, p = .370 (Figure 54).

However, there was a significant effect of alexithymia, X^2 (1) = 4.98, p = .026, with alexithymia being associated with poorer accuracy (Figure 55). There was also a significant effect of masks, X^2 (1) = 210.67, p < .001, with significantly better accuracy for unmasked faces compared to masked faces. There was not a significant interaction between childhood trauma and masks. This suggests the effect of childhood trauma experience on accuracy was comparable across masked and unmasked faces (Figure 56). Fixed effects parameter estimates are presented in Table 33.

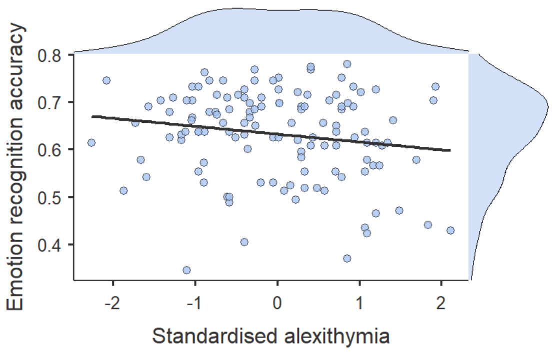
Figure 54

Plots showing the average emotion recognition accuracy for the standardised total scores of (a) childhood trauma (derived from the CTQ-SF), (b) alexithymia (derived from the TAS-20), and (c) psychopathy (derived from the SRP-SF): higher scores indicate more experience of childhood and a higher level of traits of alexithymia and psychopathy.

a)



b)



c)

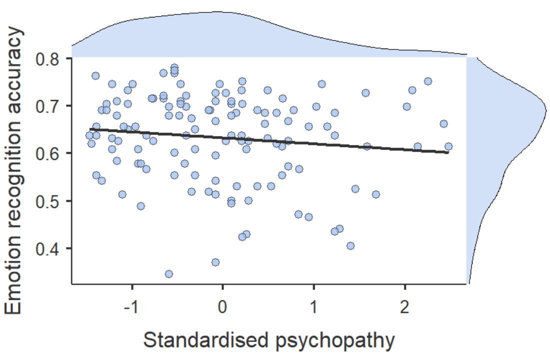


Table 33

The Fixed Effects Parameter Estimates table for emotion recognition accuracy for childhood trauma, masks, alexithymia, and psychopathy.

Fixed effects	**Estimate**	**Standard Error**	**exp(B)**	**95% CI (lower,**	**upper)**	**z**	***p***
Intercept	0.60	0.07	1.82	1.59	2.07	9.01	**<.001***
Childhood trauma	0.03	0.04	1.04	0.95	1.13	0.82	.415
Masks (Masked – Unmasked)	-1.14	0.32	0.32	0.27	0.37	-14.51	**<.001***
Alexithymia	-0.09	0.04	0.91	0.84	0.99	-2.23	**.026***
Psychopathy	-0.04	0.04	0.96	0.89	1.04	-0.90	.370
Childhood trauma * Masks	0.02	0.04	1.02	0.94	1.10	0.48	.633

*** represents significant values (*p* < .05)**

Figure 55

Average emotion recognition accuracy of the standardised total score for alexithymia (derived from the TAS-20) across masks. The shaded area represents the 95% confidence interval.

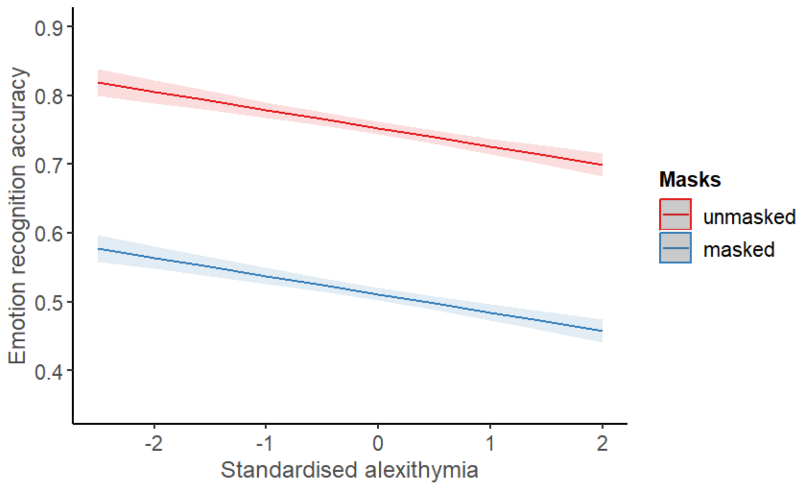
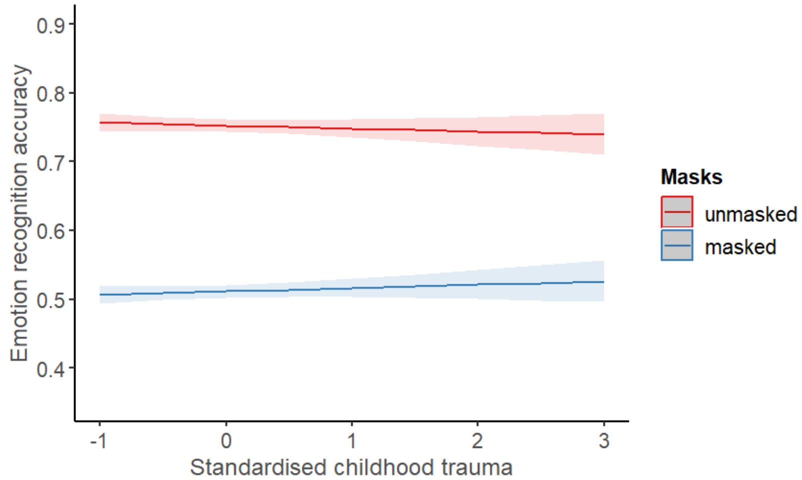


Figure 56

Average emotion recognition accuracy of the standardised total score for childhood trauma (derived from the CTQ-SF), when controlling for alexithymia and psychopathy traits, across masks. The shaded area represents the 95% confidence interval.



Does the relationship vary across emotion expressed?

A generalised mixed model was employed to explore the effect of childhood trauma on emotion recognition accuracy. The fixed factors were childhood trauma and emotion expressed and the covariates were alexithymia and psychopathy. There was not a significant effect of childhood trauma, X^2 (1) = 1.70, p = .192, or psychopathy, X^2 (1) = 1.33, p = .248. However, there was a significant effect of alexithymia, X^2 (1) = 7.70, p = .006, with alexithymia being associated with poorer accuracy (Figure 57). There was also a significant effect of emotion expressed, X^2 (1) = 277.51, p < .001, with significantly poorer accuracy for sad, anger, fear, disgust, and surprise expressions compared to neutral expressions. There was not a significant interaction between childhood trauma and emotion expressed, X^2 (6) = 6.70, p = .350. This suggests the effect of childhood trauma experience on accuracy was comparable across emotion expressed (Figure 58). Fixed effects parameter estimates are presented in Table 34.

Figure 57

Average emotion recognition accuracy of a standardised total score for alexithymia (derived from the TAS-20) across emotion expressed.

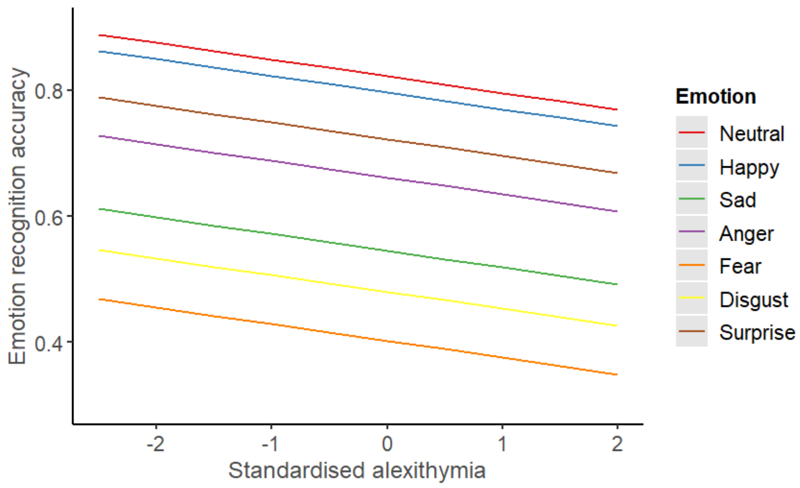


Figure 58

Average emotion recognition accuracy of a standardised total score for childhood trauma (derived from the CTQ-SF), when controlling for alexithymia and psychopathy traits, across emotion expressed.

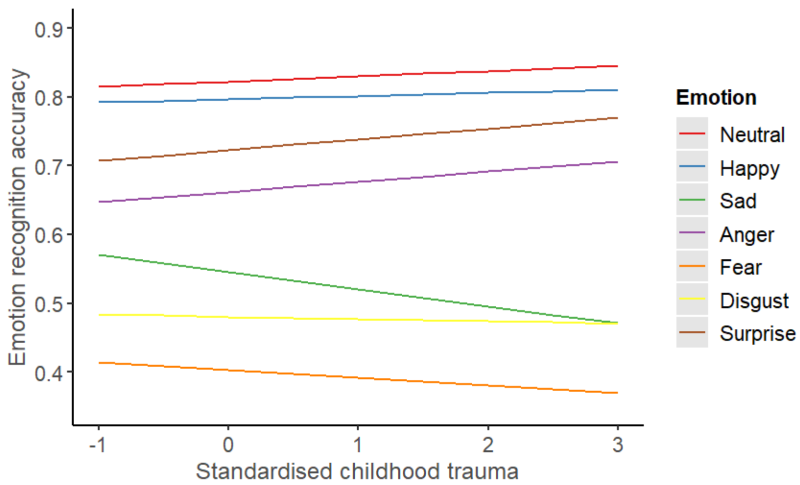


Table 34

The Fixed Effects Parameter Estimates table for emotion recognition accuracy for childhood trauma, emotion expressed, alexithymia, and psychopathy.

Fixed effects	Estimate	Standard Error	exp(B)	95% CI (lower, upper)		z	*p*
Intercept	0.70	0.08	2.02	1.73	2.36	8.82	**<.001***
Childhood trauma	0.06	0.05	1.07	0.97	1.17	1.31	.192
Happy (Happy – Neutral)	-0.19	0.31	0.82	0.45	1.50	-0.63	.526
Sad (Sad – Neutral)	-1.63	0.21	0.20	0.13	0.29	-7.88	**<.001***
Angry (Angry – Neutral)	-1.14	0.24	0.32	0.20	0.51	-4.76	**<.001***
Fear (Fear – Neutral)	-2.45	0.22	0.09	0.06	0.13	-11.17	**<.001***
Disgust (Disgust – Neutral)	-2.00	0.18	0.14	0.10	0.19	-11.07	**<.001***
Surprise (Surprise – Neutral)	-0.78	0.21	0.46	0.30	0.69	-3.69	**<.001***
Alexithymia	-0.13	0.05	0.88	0.81	0.96	-2.78	**.006***
Psychopathy	-0.05	0.05	0.95	0.87	1.04	-1.15	.248
Childhood trauma * Happy	-0.02	0.13	0.98	0.76	1.25	-0.19	.851
Childhood trauma * Sad	-0.17	0.13	0.84	0.66	1.08	-1.35	.176
Childhood trauma * Angry	0.02	0.13	1.02	0.79	1.32	0.14	.885
Childhood trauma * Fear	-0.13	0.13	0.88	0.69	1.13	-0.99	.324
Childhood trauma * Disgust	-0.07	0.12	0.93	0.74	1.16	-0.64	.522
Childhood trauma * Surprise	0.04	0.12	1.04	0.83	1.31	0.34	.737

*** represents significant values (p < .05)**

5.2.3.3. Summary

There was a significant effect of masks and emotion expressed, with better accuracy for unmasked faces compared to masked faces and for neutral expressions compared to sad, anger, fear, disgust, and surprise expressions. There was not a significant effect of childhood trauma in any of the analyses (when exploring childhood trauma alone and when controlling for alexithymia and psychopathy traits) or of psychopathy. There was a significant effect of alexithymia, with poorer accuracy for individuals reporting more alexithymia traits (indicated by a higher score on the TAS-20). There were also no significant interactions reported between childhood trauma and masks or emotion expressed. This suggests that, regardless of whether individuals reported more or less experience of childhood trauma, accuracy was comparable across masks and emotion expressed.

5.2.4. Discussion

Previous chapters had increased the perceptual information of faces by including movement and/or bi-modal conditions. However, the use of face masks reduced the perceptual information available from a face. This may help us understand whether the relationship between childhood trauma and emotion recognition is influenced by face masks, or whether the emotion recognition deficits observed in Chapters 2, 3, and 4 can be attributed to more perceptual underpinnings. The findings reported no significant effect or interactions for childhood trauma. Yet, there was a significant association between alexithymia and poorer accuracy reported in both the mask and emotion expressed analyses.

A possible reason why childhood trauma was not significantly associated with emotion recognition across face masks and emotion expressed may be explained by Chapter 3's eye tracking findings. Chapter 3 reported that individuals with more reported childhood trauma had increased eye gaze to the eye region. As face masks only obscure the lower half the face, this may suggest that individuals with childhood trauma experience, who focus on the upper unobscured regions, are not further hindered compared to individuals without experience. However, the lack of significant interaction between childhood trauma and masks suggests a similar effect across masked and unmasked facial expressions. This may suggest that the emotion recognition deficits associated with childhood trauma experience are more likely to be due to high-level perception rather than low-level perception. Research has explained low-level perceptions as physical characteristics (e.g., visual or audio properties) whereas high-level perceptions combine low-level representations and understand them at a conceptual level (Nahum et al., 2008). In this case, low-level perceptions would be image properties, such as stimuli characteristics, and high-level perceptions would be combining the information available to categorise/label the expression.

If the effect of childhood trauma was due to low-level perceptions, then a difference across masked and unmasked faces would be expected, due to differences in visual appearance. This was not the case. This could suggest that early processes of emotion recognition, such as cataloguing stimuli properties or where we look on a face to recognise the expression, is not significantly influenced by childhood trauma experience. Supporting this, Chapter 3 employed eye tracking to see where individuals looked on the face to recognise the expression and reported no significant effect of childhood trauma. However, Chapter 2 and 4, which explored simple emotion recognition accuracy through labelling and integration of cues, did report a significant effect of childhood trauma. This may suggest that childhood trauma impacts later stages of the emotion recognition process, such as categorising and labelling expressions. This follows the findings reported throughout the thesis. Although, the current study used a similar paradigm to Chapter 2 and did not report a significant effect of childhood trauma. However, this may be due to the different stimuli used as the current chapter used static facial expressions. It may be beneficial for future research to use more realistic stimuli, as seen in previous chapters, including dynamic and audio-visual expressions, as the use of moving stimuli would increase the ecological validity and generalisability of the findings.

A key finding from Experiment 4a was the significant association reported between alexithymia and poorer emotion recognition accuracy. This is in line with general emotion recognition findings which reported emotion deficits associated with alexithymia (Parker et al., 2005) as well as mask findings. Gehdu et al. (2023) explored masked emotion recognition and reported that individuals with autism, and a high level of alexithymia traits, showed poorer emotion recognition accuracy compared to individuals with autism and a low level of alexithymia traits or individuals without autism. A possible reason for the poorer performance associated with alexithymia could be the avoidance of the eye region as indicated by eye tracking research (Fujiwara, 2018; Cuve et al., 2021). As masks only leave the eye region unobscured, if this area is avoided there is a lack of information from the face available to recognise the expression which may hinder recognition. However, Chapter 3 explored eye movements and did not report a significant association between alexithymia and an avoidance of the eye region. Although, there was the inclusion of moving stimuli, differing from previous findings, which may explain the differences.

The findings suggest that individuals who exhibit higher levels of alexithymia traits are further hindered in their abilities to recognise expressions. As recognition abilities have been linked to establishing and maintaining relationships (Grossmann, 2017) as well as behaving appropriately (Grundmann et al., 2021), it may suggest that individuals with a higher level of alexithymia traits were also hindered in other areas of their social interactions too during this time. Interactions between alexithymia and masks were not explored, as it was a control variable, so it is unclear whether mask policies concerning exemptions are needed for individuals with alexithymia. Chapter 3 also reported differences in processing patterns for static versus moving stimuli. This may suggest that the findings of alexithymia's difficulties presented in this chapter may be for static facial expressions and may not generalise to moving expressions or real-world interactions.

5.3. Experiment 4b

5.3.1. Introduction

As this chapter explores whether emotion recognition performance was impacted during the COVID-19 pandemic, this experiment considered other individual differences that might be important, particularly in the context of the pandemic. A key individual difference highlighted by research was ethnicity. Whether attitudes towards masks and mask-wearers impacted performance were also explored. Previous emotion recognition research has reported that own-ethnicity or in-group identity is an important factor for accuracy (Elfenbein & Ambady, 2002). When discussing in-group identity, it means individuals who share similar characteristics or ideas (e.g., ethnicity, religion, attitudes, etc.). A meta-analysis reported that emotion recognition accuracy was higher when emotions were expressed and recognised by individuals of the same ethnicity, nationality, or religion (Elfenbein & Ambady, 2002), suggesting an in-group advantage. However, there was a smaller effect when individuals had greater exposure to other groups. This may suggest that individuals living in multi-cultural areas will show less of an advantage. Studies by Yan et al. (2016) and Soto and Levenson (2009) support that exposure attenuates the in-group advantage. Yan et al. (2016) reported a considerable amount of cross-cultural agreement and Soto and Levenson (2009) reported no difference between in-group and out-group performance. Both samples were student samples and students tend to have more exposure to diverse populations which may explain why there was no in-group advantage shown.

The majority of the face mask and emotion recognition research has focused on the presence/absence of masks but it is also important to explore whether mask-related deficits could be due to social biases. For example, if you do not wear masks yourself then are you are less likely to allocate attention to recognising other people's emotional expressions if they are mask-wearers, and therefore your out-group? This concept is similar to the social motivation theory (Young & Hugenberg, 2010) which suggests that less attention is allocated to our out-groups (e.g., mask-wearers) compared to in-groups (e.g., non-mask-wearers) and this influences our processing abilities. Grahlow et al. (2022) explored the impact of face masks on emotion recognition and perception of threat. A sample of 790 participants completed an emotion recognition task including masked and unmasked facial expressions. Two additional samples performed another emotion recognition task using other occlusions of the face: half stimuli (original stimuli cut off beneath the eyes) and "bubble" stimuli (a skin-toned bubble obscuring the mouth). All occlusions (masks, half stimuli, and bubble stimuli) showed the same face areas: an unobscured upper region and obscured lower region. The findings reported that emotion recognition was poorer for masked compared to unmasked faces for all expressions (happy, sad, anger, fear, disgust, and neutral). Also, for most expressions, especially disgust, the poorer accuracy was a result of face masks specifically rather than other occlusions. This may suggest some deficits may go beyond perceptual aspects (occluded areas) and maybe be due to social biases (e.g., disliking masks so allocating less attention to masked faces).

To support the influence of social biases, Kret and De Gelder (2012) presented facial expressions either obscured by a religious face covering (a niqab) or other face coverings (cap and scarf). Even though the niqab condition and the cap and scarf condition covered the same regions of the face, the faces in the niqab condition were attributed negative expressions more frequently than in the cap and scarf condition. In further support, Fischer et al. (2012) agreed that religious face coverings can negatively impact emotion recognition beyond simple perceptual effects of a face being obscured. It is possible that face masks would follow the same pattern. So, individuals who wear masks themselves would attend more to masked faces. This could in turn create an in-group advantage for mask wearers recognising expressions from masked faces. The findings may suggest that face coverings and emotion recognition may be more complex than simple perceptual occlusion (e.g., obscured areas), and it is important to examine how different personal factors (individual differences) can influence the relationship.

There is research directly exploring face masks and ethnicity by Li et al. (2023). The study explored whether emotion recognition performance was impacted by the ethnicity of the actor or use of medical masks. They reported poorer accuracy for masked stimuli compared to unmasked stimuli overall and that medical masks exacerbated actor-ethnicity emotion recognition differences for anger and surprise expressions. There was better accuracy for White angry stimuli compared to Black angry stimuli in masked conditions, and better accuracy for Black surprise stimuli compared to White surprise stimuli in masked conditions. This suggests a relationship between masked faces and ethnicity of the individual expressing the emotion. For example, there may be an advantage in recognising expressions from masked individuals similar to our ethnicity (e.g., Black individuals may have better accuracy when recognising Black mask-wearers emotional expressions compared to White mask-wearers). In order to understand how we recognise emotional expressions in masked faces in a diverse population, actors of various ethnicities should be explored. Research should explore the ethnicity of actor but also ethnicity of the perceiver, as it is the combination of the two that is important.

Attitudes have been associated with emotion recognition in general. For example, Hutchings and Haddock (2008) asked White participants to view racially ambiguous Black and White faces depicting anger, neutral, or happy expressions. Participants were asked to identify the race, emotion expressed, and intensity of the stimuli. They found that White participants high in implicit prejudice, according to an implicit association test, reported a higher intensity anger expression if the stimulus was categorised as Black compared to White. This suggests that attitudes and prejudice influenced emotion perception. In support of this, Van Hiel et al. (2019) explored the relationship between right-wing and prejudiced attitudes and emotional abilities. They reported that participants holding right-wing attitudes were associated with lower emotional abilities, whereas participants holding left-wing attitudes were associated with higher emotional abilities. This suggests that our attitudes towards ‘out-groups’ influences emotion recognition. Currently, it is unclear whether similar effects may be observed for other attitudes and biases, such as attitudes towards masks.

Our attitudes towards masks in the UK varied considerably. Some people accepted face masks and the safety that came with them, while others deemed them ‘oppressive’, as voiced in the anti-mask riots (Taylor & Asmundson, 2021). These attitudes have been shown to affect behaviour and health outcomes. For example, attitudes towards mask-wearing were associated with face mask purchase intentions in Pakistan (Shah et al., 2021), conformity to masculine norms (Mahalik et al., 2021), as well as reductions in COVID-19 cases (Adjodah et al., 2021). Furthermore, Biermann et al. (2021) conducted a study in Germany and reported that participants holding more negative attitudes towards masks rated masked faces as less trustworthy compared to faces without masks. This research suggests that attitudes towards masks can influence social processes. However, currently it is unclear whether mask attitudes would exacerbate or ameliorate the effect of masks on emotion recognition accuracy.

5.3.1.1. The current study

The current study explores the effect of ethnicity, as well as attitudes towards masks, on emotion recognition accuracy across masks and emotion expressed. As Experiment 4a and 4b both explore the effect of masks and emotion expressed, the hypotheses are the same as previously stated; masked faces will show poorer emotion recognition than unmasked faces and masks will interact with emotion expressed, with all unobscured expressions having better accuracy than obscured expressions and happiness and disgust being most affected.

We are exploring ethnicity as an in-group by exploring accuracy when the participant and stimulus ethnicity matched (e.g., White participant and White stimuli) or mismatched (e.g., White participant and Asian stimuli). Based on previous research (Elfenbein & Ambady, 2002), it is hypothesised that a mismatch of perceiver and expresser ethnicity (e.g., an out-group effect) will show poorer emotion recognition. However, as a result of conflicting findings (Soto & Levenson, 2009; Li et al., 2023), it is unclear whether these effects will be exacerbated by face masks (e.g., whether in-group effects will be more evident in masked than unmasked faces).

The influence of attitudes towards masks on emotion recognition accuracy was also explored. Research on general attitudes and emotion abilities (Hutchings & Haddock, 2008; Van Hiel et al., 2019) suggests that attitudes and biases can influence emotion recognition. Further, research concerning attitudes towards masks on trustworthiness (Biermann et al., 2021), as well as the religious face coverings research (Fischer et al., 2012; Kret & De Gelder, 2012), suggests effects can go beyond simple perceptual occlusions. Therefore, it is hypothesised that individuals with strong negative attitudes towards face masks will show poorer accuracy for masked facial expressions. These analyses extend upon previous research by exploring how individual differences in the mask-wearer and the perceiver can modulate the effect of masks on emotion recognition accuracy.

5.3.2. Methods

5.3.2.1. Participants

A final sample of 131 participants were analysed (103 female, 27 male, 1 non-binary; M_{age} = 20 years (18 - 34), *SD* = 2.01). Data for 137 participants was originally collected but 6 participants were excluded: 3 did not consent to all sections of the consent form, 2 due to reaction times (< 300 milliseconds or were timed out on over 10% of trials), and 1 had incomplete data. There were 38 participants who identified as White (29.0%), 37 who identified as Asian / Pacific Islander (28.2%), 35 who selected 'Other' (26.7%), and 21 who identified as Black (16.0%). Participants were recruited from the undergraduate psychology cohort at Brunel University in exchange for 2 course credits. Informed consent was taken from all participants before completing the study and ethical approval was granted by the Research Ethics Committee at Brunel University London.

5.3.2.2. Design

The variables included face masks (masked and unmasked), emotion expressed (happy, sad, anger, fear, disgust, surprise, and neutral), stimuli ethnicity and participant ethnicity (Asian, Black, White), and attitudes towards masks. Emotion recognition accuracy was measured.

5.3.2.3. Materials

5.3.2.3.1. Emotion stimuli

The creation of stimuli and the stimuli used in the study were identical to Experiment 4a, with 336 trials (4 identities x 3 ethnicities x 2 genders x 7 emotions x 2 images (masked/unmasked)). All the material used in the experiment are openly available (https://osf.io/57nfe/).

5.3.2.3.2. Attitudes Towards Masks

After the emotion task, participants completed a 13-item questionnaire. This explored mask-wearing behaviour and attitudes towards mask-wearing. Participants rated how likely they were to wear masks in different environments on a 7-point Likert scale (1 = Never; 7 = Always). Then, participants rated their attitude towards someone if they were wearing a mask, or not wearing a mask, in different environments on a 7-point Likert scale (1 =

Extremely negative; 4 = Neutral; 7 = Extremely positive). For both ratings (of themselves and someone else), ratings were collected for four different environments: a) on public transport; b) in shops/businesses (when not eating); c) in other enclosed/inside environments with multiple people inside (e.g., lecture halls); and d) outside (e.g., walking down the street). Participants also chose the most common reason for not wearing a face mask from a drop-down list. This included reasons such as “I find it hard to breathe”, “I find it hard to communicate”, “I have an exemption”, “I forget to bring/wear a face covering”, “I just don’t want to”, and “I always wear a face covering”.

5.3.2.4. Procedure

For this experiment, only the emotion recognition task and attitudes towards masks questionnaire were completed. Participants completed an identical emotion recognition task to Experiment 4a. Thus, the procedure follows the one explained in Experiment 4a, which was split into two different tasks to ensure participants could take a break. Once this was completed participants completed the attitudes towards masks questionnaire.

5.3.2.5. Data analysis

Similar to the explanation in Experiment 4a, reaction time was not explored due to the methods employed (all stimuli presented for 500 milliseconds) and the hypotheses focusing on emotion recognition accuracy, thus making reaction time inappropriate to explore in this context.

Generalised mixed models were performed to examine the role of masks on emotion recognition accuracy across emotion expressed. The reference categories were unmasked for masks and neutral expressions for emotion expressed.

Further generalised mixed models were performed to examine whether there was an in-group effect (own-ethnicity effect, e.g., Asian observers having better accuracy for Asian stimuli) on emotion recognition accuracy and whether ethnicity interacted with masked faces (e.g., are the effects of mask-wearing on emotion recognition modulated by ethnicity match or mismatch of mask-wearer and the perceiver of the emotion). To do this, the stimuli were split into the three ethnicities: (1) Asian, (2) Black, and (3) White. Within these groups, using Asian stimuli as an example, participants were categorised as either Asian observers or non-Asian observers (e.g., all participants who did not identify as Asian). The same procedure was taken for the Black and White stimuli – with individuals classified similarly. The reference category for the Asian analysis was non-Asian, for the Black analysis was non-Black, and for the White analysis was non-White.

Finally, a Principal Components Analysis (PCA) was performed on the attitudes towards masks data. From the two components identified (mask-wearing inside and mask-wearing outside) a Spearman's rho was employed to explore the correlation between attitudes towards mask-wearing inside and outside and the emotion recognition of masked and unmasked faces.

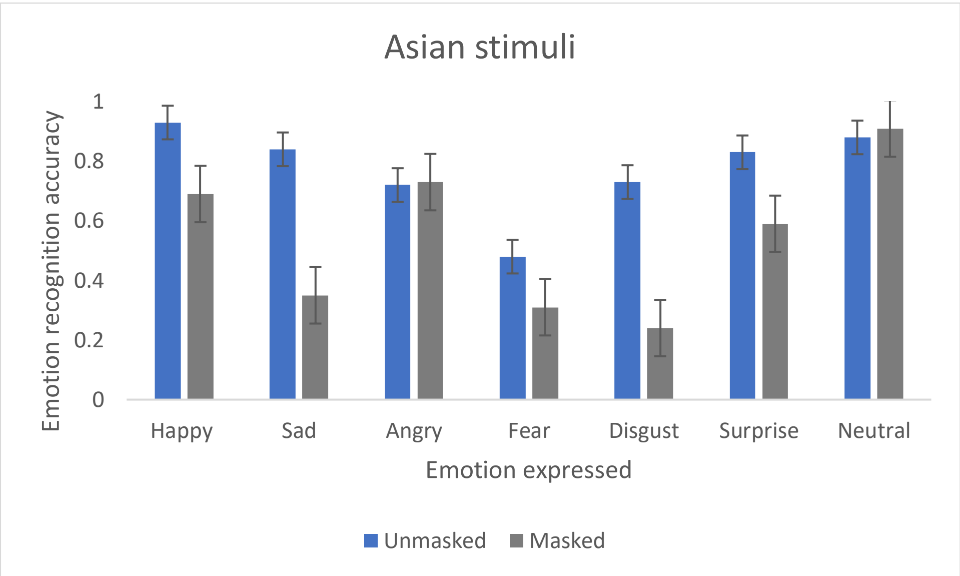
5.3.3. Results

The distribution of the average emotion recognition accuracy across the factors of masks, emotion expressed, and ethnicity are presented in Figure 59.

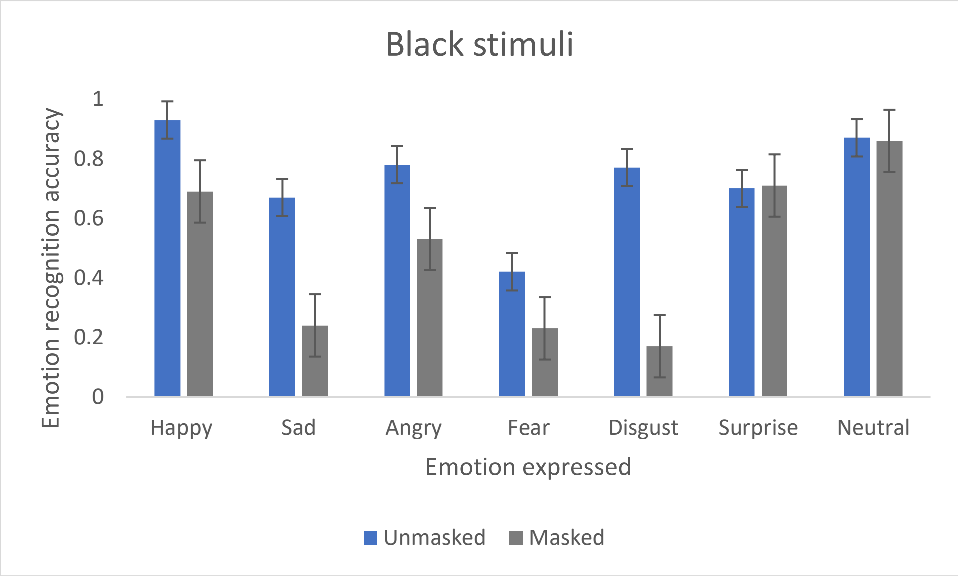
Figure 59

The average emotion recognition accuracy (proportion correct) across masks (masked, unmasked) and emotion expressed (Happy, Sad, Angry, Fear, Disgust, Surprise, and Neutral) for (a) Asian, (b) Black, and (c) White stimuli.

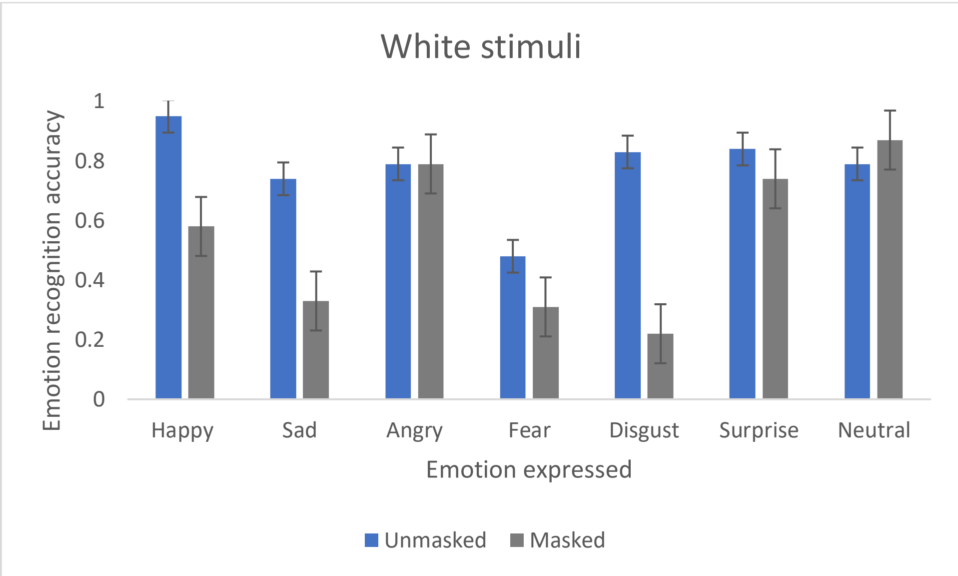
a)



b)



c)



The results are divided into three subsections. The first section examines the overall impact of masks, the second examines the impact of own-ethnicity effects on masked and unmasked emotion recognition, and the third examines whether attitudes towards masks influenced emotion recognition.

The descriptives for the experimental task variables are presented in Table 35.

Table 35

Descriptives table for masks (unmasked, masked) and emotion expressed (happy, sad, anger, fear, disgust, surprise, neutral) displaying the mean score, standard deviation, and range of emotion recognition accuracy (proprotion correct).

Variables	Mean score	Standard deviation	Range
Emotion Tasks			
(Response Accuracy)			
Masks:			
Unmasked	0.76	0.13	0.77 (0.17 – 0.94)
Masked	0.53	0.10	0.60 (0.12 – 0.71)
Emotion:			
Happy	0.79	0.14	0.88 (0.13 – 1.00)
Sad	0.53	0.15	0.80 (0.12 – 0.92)
Anger	0.72	0.20	0.96 (0.04 – 1.00)
Fear	0.37	0.18	0.88 (0.00 – 0.88)
Disgust	0.49	0.14	0.67 (0.08 – 0.75)
Surprise	0.73	0.16	0.87 (0.09 – 0.96)
Neutral	0.86	0.16	1.00 (0.00 – 1.00)

5.3.3.1. Is emotion recognition accuracy influenced by masks?

A generalised mixed model was employed to explore the effect of masks on emotion recognition accuracy. The fixed factors were masks and emotion expressed and the random factors were participant and actor. There was a significant effect of masks, X^2 (1) = 236.33, $p < .001$, and emotion expressed, X^2 (6) = 2514.44, $p < .001$, with better accuracy for unmasked faces compared to masked faces and for neutral expressions compared to all emotional expressions. There was also a significant interaction between masks and emotion expressed, X^2 (6) = 835.57, $p < .001$, with a variation in performance for emotional versus neutral expressions in masked and unmasked conditions. There was better accuracy for emotional expressions (the basic six emotions) in unmasked conditions compared to masked conditions, but there was better accuracy for neutral expressions in masked conditions compared to unmasked conditions. Fixed effects parameter estimates are presented in Table 36.

Table 36

Fixed effects parameter estimates for the mask condition and emotions expressed.

Fixed Effects	Estimate	Standard Error	exp(B)	95% CI	*z*	*p*

Intercept	0.80	0.10	2.22	1.83, 2.69	8.11	< .001*
Masks (masked – unmasked)	-1.28	0.08	0.28	0.24, 0.33	-15.37	< .001*
Happy (Happy – Neutral)	-0.17	0.08	0.84	0.72, 0.99	-2.12	.034*
Sad (Sad – Neutral)	-1.87	0.07	0.15	0.13, 0.18	-27.23	< .001*
Anger (Anger – Neutral)	-0.96	0.07	0.38	0.34, 0.44	-13.89	< .001*
Fear (Fear – Neutral)	-2.64	0.07	0.07	0.06, 0.08	-38.82	< .001*
Disgust (Disgust – Neutral)	-2.04	0.07	0.13	0.11, 0.15	-28.67	< .001*
Surprise (Surprise – Neutral)	-0.86	0.07	0.42	0.37, 0.48	-12.29	< .001*
Masks * Happy	-2.56	0.16	0.08	0.06, 0.11	-15.71	< .001*
Masks * Sad	-2.37	0.14	0.09	0.07, 0.12	-17.29	< .001*
Masks * Anger	-0.70	0.14	0.50	0.38, 0.65	-5.06	< .001*
Masks * Fear	-1.07	0.14	0.34	0.26, 0.45	-7.86	< .001*
Masks * Disgust	-3.09	0.14	0.05	0.03, 0.06	-21.65	< .001*
Masks * Surprise	-0.90	0.14	0.41	0.31, 0.54	-6.42	< .001*

*** represents significant values (*p* < .05)**

5.3.3.2. Is emotion recognition accuracy influenced by ethnicity?

For all models, the fixed factors were masks, stimuli ethnicity (e.g., Asian or non-Asian), and participant ethnicity (e.g., Asian or non-Asian) and the random factors were participant and actor.

Does the relationship vary across Asian stimuli?

There was a significant effect of masks, X^2 (1) = 244.44, $p < .001$, with better accuracy for unmasked faces compared to masked faces. There was not a significant effect of participant ethnicity, X^2 (1) = 0.05, $p = .822$, or stimuli ethnicity, X^2 (1) = 0.47 $p = .495$, suggesting accuracy was similar regardless of whether there was a match or mismatch of ethnicity. There was no significant interaction between mask-wearing and participant ethnicity, X^2 (1) = 0.05, $p = .831$, or mask-wearing and stimuli ethnicity found, X^2 (1) = 0.04, $p = .849$, suggesting accuracy was comparable for masked and unmasked faces for Asian and non-Asian stimuli and participants. Fixed effects parameter estimates are presented in Table 37.

Table 37

Fixed effects parameter estimates for masks, participant ethnicity (Asian – non-Asian), and stimuli ethnicity (Asian – non-Asian).

Fixed Effects	Estimate	Standard Error	exp(B)	95% CI	*z*	*p*
Intercept	0.69	0.10	1.99	1.65, 2.40	7.16	**<.001***
Masks (masked – unmasked)	-1.14	0.07	0.32	0.28, 0.37	-15.63	**< .001***
Stimuli Ethnicity (Asian – non-Asian)	0.12	0.17	1.12	0.80, 1.57	0.68	0.495
Participant Ethnicity (Asian – non-Asian)	-0.02	0.09	0.98	0.82, 1.17	- 0.23	0.822
Masks * Stimuli Ethnicity	0.03	0.13	1.03	0.79, 1.33	0.19	0.849
Masks * Participant Ethnicity	0.02	0.09	1.02	0.86, 1.21	0.21	0.831

*** represents significant values (p < .05)**

Does the relationship vary across Black stimuli?

There was a significant effect of masks, X^2 (1) = 212.86, p < .001, with better accuracy for unmasked faces compared to masked faces. There was not a significant effect of participant ethnicity, X^2 (1) = 1.17, p = .278, or stimuli ethnicity, X^2 (1) = 2.80, p = .094, suggesting accuracy was similar regardless of whether there was a match or mismatch of ethnicity. There was not a significant interaction between mask-wearing and participant ethnicity, X^2 (1) = 2.35, p = .125, or mask-wearing and stimuli ethnicity found, X^2 (1) = 0.22, p = .643, suggesting accuracy was comparable for masked and unmasked faces for Black and non-Black stimuli and participants. Fixed effects parameter estimates are presented in Table 38.

Table 38

Fixed effects parameter estimates for masks, participant ethnicity (Black – non-Black), and stimuli ethnicity (Black – non-Black).

Fixed Effects	Estimate	Standard Error	exp(B)	95% CI	*z*	*p*

Intercept	0.59	0.09	1.81	1.51, 2.16	6.45	**< .001***
Masks (masked – unmasked)	-1.11	0.08	0.33	0.29, 0.38	-14.59	**< .001***
Stimuli Ethnicity (Black – non-Black)	-0.22	0.13	0.80	0.62, 1.04	-1.67	0.094
Participant Ethnicity (Black – non-Black)	-0.15	0.14	0.86	0.66, 1.13	-1.08	0.278
Masks * Stimuli Ethnicity	-0.06	0.13	0.94	0.73, 1.21	-0.46	0.643
Masks * Participant Ethnicity	0.16	0.10	1.17	0.96, 1.44	1.53	0.125

*** represents significant values (*p* < .05)**

Does the relationship vary across White stimuli?

There was a significant effect of masks, X^2 (1) = 262.38, *p* < .001, with better accuracy for unmasked faces compared to masked faces. There was not a significant effect of participant ethnicity, X^2 (1) = 0.16, *p* = .688, or stimuli ethnicity, X^2 (1) = 0.64, *p* = .425, suggesting accuracy was similar regardless of whether there was a match or mismatch of ethnicity. There was no significant interaction between mask-wearing and participant ethnicity, X^2 (1) = 0.24, *p* = .624, or mask-wearing and stimuli ethnicity found, X^2 (1) = 0.05, *p* = .822, suggesting accuracy was comparable for masked and unmasked faces for White and non-White stimuli and participants (Figure 60). Fixed effects parameter estimates are presented in Table 39.

Table 39

Fixed effects parameter estimates for masks, participant ethnicity (White – non-White), and stimuli ethnicity (White – non-White).

Fixed Effects	**Estimate**	**Standard Error**	**exp(B)**	**95% CI**	***z***	***p***
Intercept	0.70	0.08	2.02	1.72, 2.37	8.59	**< .001***

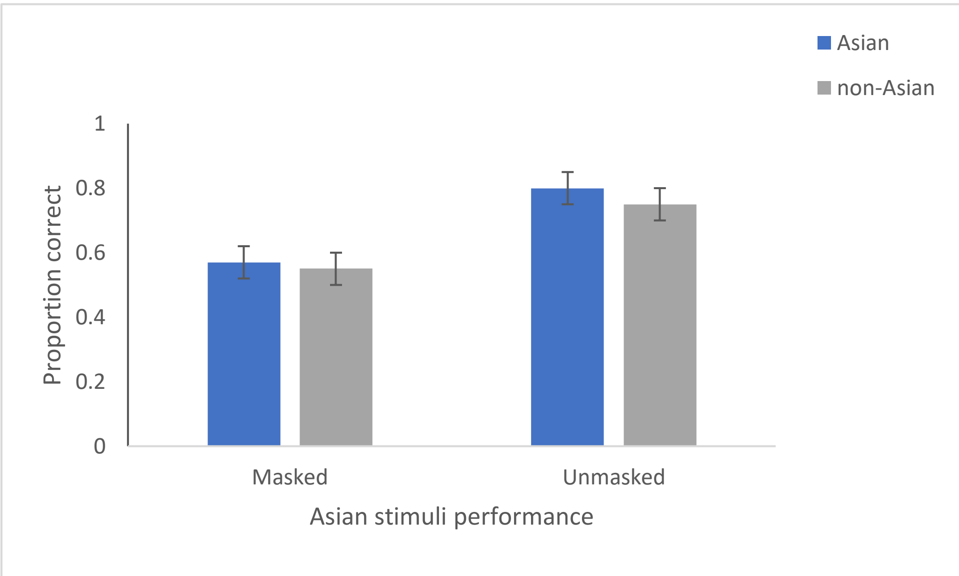
Masks (masked – unmasked)	-1.15	0.07	0.32	0.27, 0.36	-16.20	**< .001***
Stimuli Ethnicity (White – non-White)	0.10	0.12	1.10	0.87, 1.39	0.80	0.425
Participant Ethnicity (White – non-White)	0.05	0.12	1.05	0.83, 1.32	0.40	0.688
Masks * Stimuli Ethnicity	0.03	0.13	1.03	0.80, 1.32	0.23	0.819
Masks * Participant Ethnicity	-0.04	0.09	0.96	0.81, 1.14	-0.49	0.624

*** represents significant values (*p* < .05)**

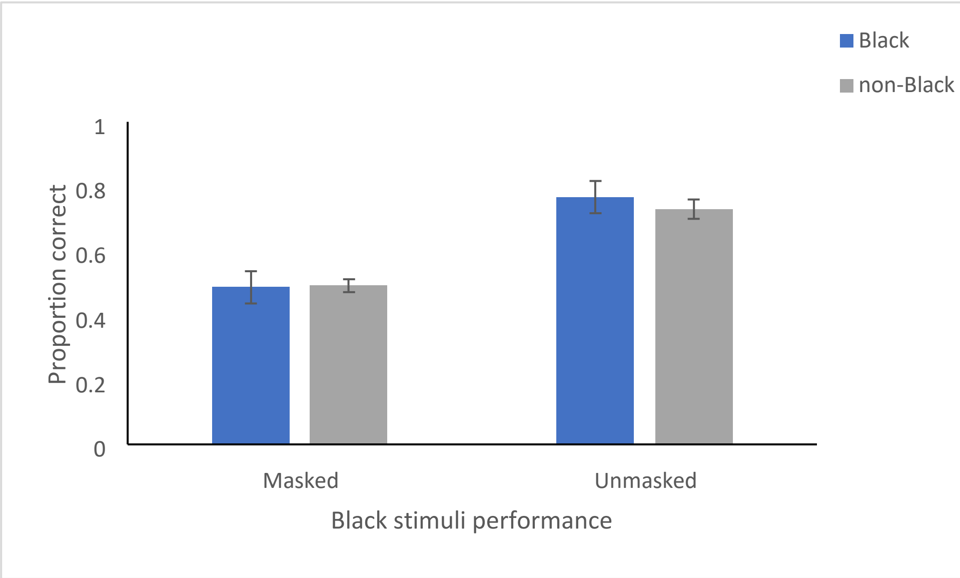
Figure 60

Bar graphs showing the proportion correct for masked and unmasked Asian, Black, and White stimuli: a) Asian faces, split by Asian vs non-Asian observers. b) Black faces, split by Black vs non-Black observers. c) White faces, split by White vs non-White observers. Error bars represent 95% confidence intervals.

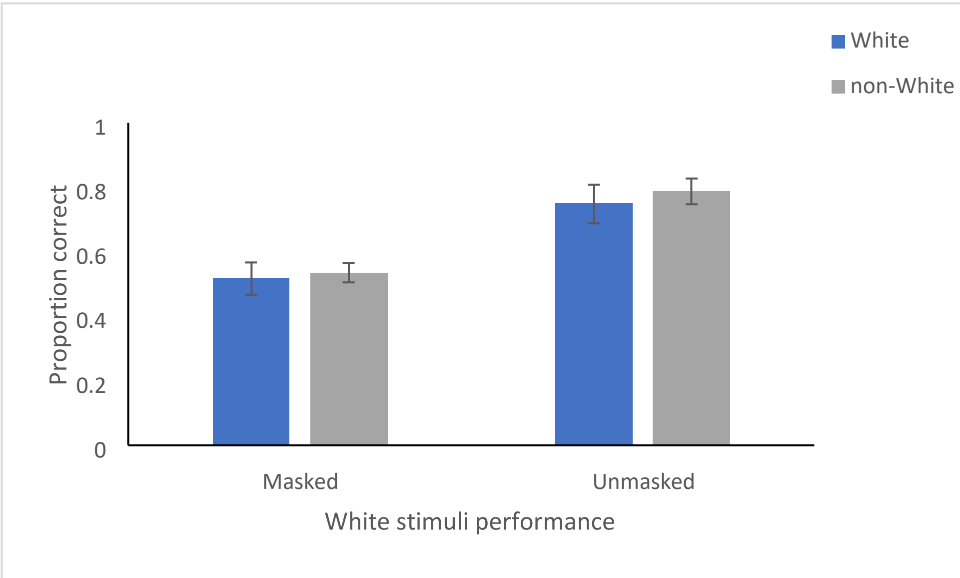
a)



b)



c)



5.3.3.3. Attitudes towards masks

The responses from the mask-wearing attitudes questionnaire were entered into a PCA to examine the effect of attitudes towards masks on masked and unmasked emotion recognition accuracy. There were high correlations (*r*'s > .8) between items 1a and 1b, 2a and 2b, and 3a and 3b (mask-wearing and attitudes towards individuals who do/do not wear masks on public transport and in shops) so the responses were averaged across these items. This resulted in three new items: mask-wearing on public transport AND in shops, subsequently 1e; attitudes towards people who wear masks on public transport AND in shops, subsequently 2e; and attitudes towards people who do not wear masks in public transport AND in shops, subsequently 3e. An initial PCA revealed very low communality for the item relating to reasons for not wearing masks ($h^2 = .19$), so this item was excluded from the final PCA.

A PCA with oblique rotation (direct oblimin) was carried out on the remaining 9 items. Bartlett's test of sphericity was significant (χ^2 (36) = 756, $p < .05$); the Kaiser-Meyer-Olkin measure of sampling adequacy was acceptable (KMO = .79); and all KMO values for individual variables were above 0.76 (above the acceptable limit of 0.5; Field, 2018). This confirms the data was suitable for PCA. An inspection of the scree plot and components with eigenvalues greater than 1 confirmed that a 2-component solution was appropriate for the data. Table 40 shows the pattern matrix following rotation for the final component solution (component loadings lower than 0.3 are omitted). The items that load onto each factor suggest that a high score on the first component (Inside) represents a tendency to wear masks more frequently inside (transport/shops and other indoor situations). Higher scores on the first factor also reflects a tendency to rate individuals who wear masks inside (and to a lesser extent, outside) more positively, and those who do not wear masks inside more negatively.

At the time of data collection (Jan - Feb 2021), face coverings were a legal requirement in most inside environments in the UK (but generally not outside). Therefore, this component may reflect a higher tendency to follow rules around face masks and to view individuals who also follow the rules more positively (and view individuals who do not more negatively). The second component primarily reflects responses to questions about outside mask-wearing. Higher scores on the second component reflects more positive attitudes towards those who wear masks outside, negative attitudes towards those who do not wear masks outside, and a higher likelihood of outside mask-wearing yourself. Higher scores on this item also reflect a slightly more negative rating of individuals who do not wear masks in indoor environments. This component is interpreted broadly as reflecting negative attitudes towards the use of face masks in environments where they are not required.

Table 40

Rotated component loadings for each item in the attitude towards masks questionnaire.

	Rotated component loadings	
Item	Component 1 (Inside)	Component 2 (Outside)

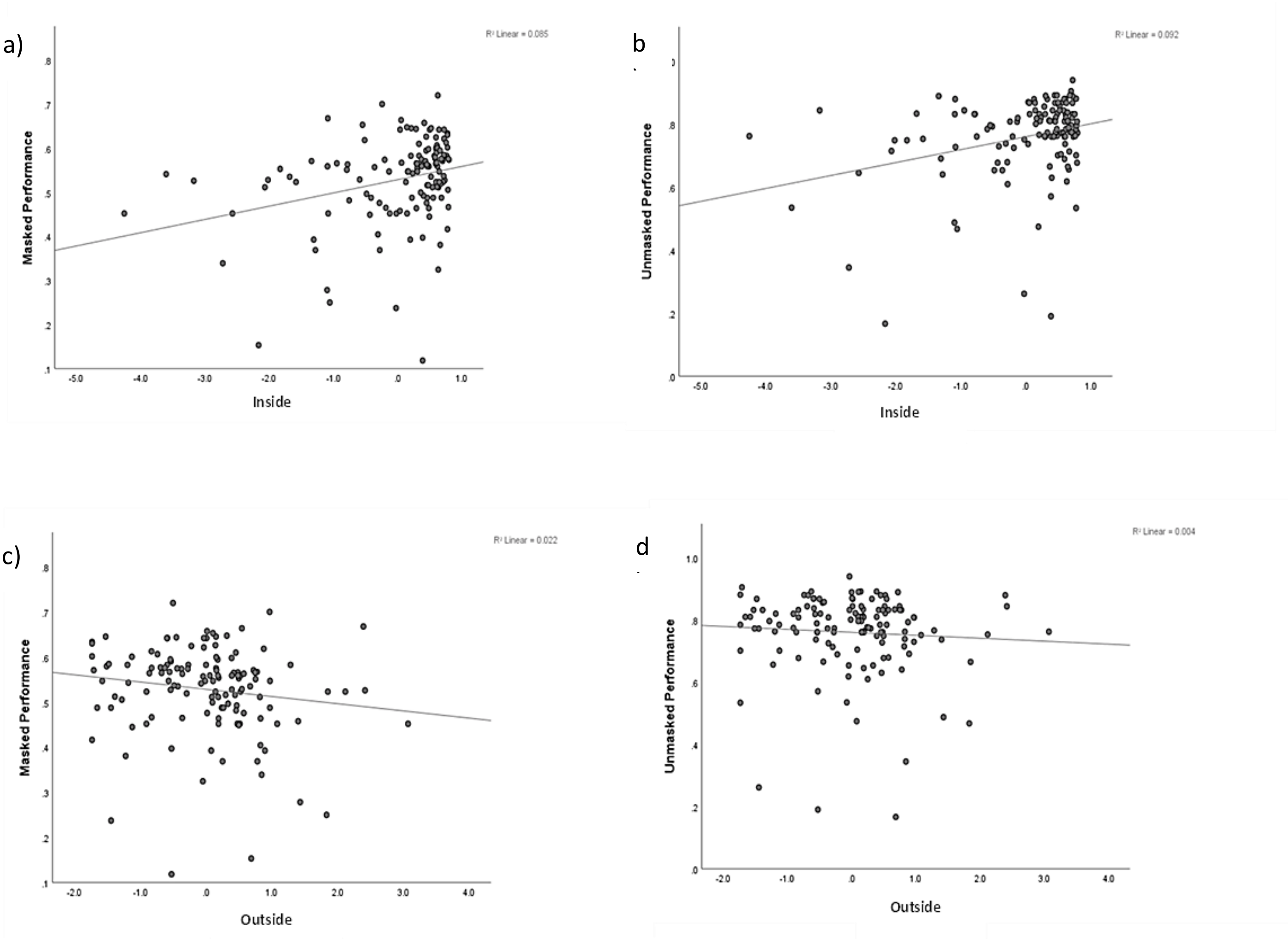
2c: Rating of someone wearing a face covering inside	0.92	
2e: Rating of someone wearing a face covering on public transport AND in shops/businesses	0.87	
1e: Likelihood of wearing a face covering on public transport AND in shops/businesses	0.76	
1c: Likelihood of wearing a face covering inside	0.62	
3e: Rating of someone NOT wearing a face covering on public transport AND in shops/businesses	-0.59	
3c: Rating of someone NOT wearing a face covering inside	-0.56	-0.35
3d: Rating of someone NOT wearing a face covering outside		-0.91
1d: Likelihood of wearing a face covering outside		0.57
2d: Rating of someone wearing a face covering outside	0.36	0.45

A Spearman's rho analysis was also employed to assess the correlation between attitudes towards mask-wearing Inside and Outside and the emotion recognition accuracy of masked and unmasked faces. There was a significant correlation between Inside and masked performance, $r_s(131) = .33$, $p < .001$, 95% CI [0.16, 0.48], Inside and unmasked performance, $r_s(131) = .26$, $p = .003$, 95% CI [0.09, 0.42], and Outside and masked performance, $r_s(131) = .24$, $p = .005$, 95% CI [- 0.07, 0.40] (Figure 61). There was not a significant correlation between Outside and unmasked performance, $r_s(131) = .16$, $p = .072$, 95% CI [- 0.01, 0.32]. So, attitudes towards masks Inside were associated with emotion recognition overall for masked and unmasked faces. Whereas attitudes towards masks Outside were only associated with emotion recognition for masked faces. This may suggest that negative attitudes towards

Outside mask-wearing predicts poorer performance with masked faces but does not predict emotion recognition more generally.

Figure 61

Scatter graphs showing the correlation between the components and masked or unmasked emotion recognition performance: a) Inside and masked performance, b) Inside and unmasked performance, c) Outside and masked performance, d) Outside and unmasked performance.



5.3.3.4. Summary

The findings reported a significant effect of masks, with better accuracy for unmasked faces compared to masked faces, and emotion expressed, with better accuracy for neutral expressions compared to all emotional expressions. There was also a significant interaction between masks and emotion expressed, with masks influencing neutral expressions differently to emotional expressions. For the emotional expressions (the basic six emotions), accuracy was significantly poorer for masked faces compared to unmasked faces, yet, for neutral expressions accuracy was higher for masked faces compared to the unmasked faces. There was also a significant association between attitudes towards masks Inside and emotion recognition performance for masked and unmasked faces as well as between attitudes towards masks Outside and emotion recognition for masked faces. However, there was not a significant effect of stimulus ethnicity, participant ethnicity, or any significant interactions reported. This suggests that the effect of masks on emotion recognition is not influenced by the match (or mismatch) between perceiver and mask-wearer ethnicity. In sum, the findings did not report an own-ethnicity, or in-group, effect on emotion recognition overall.

5.3.4. Discussion

The study explored whether performance for recognising expressions from masked and unmasked faces is further influenced by a match or mismatch of participant and stimulus ethnicity as well as individual's attitudes towards masks. The findings reported that attitudes towards masks for Inside environments impacted masked and unmasked emotion recognition, whereas attitudes towards masks for Outside environments impacted masked emotion recognition specifically. This was in line with the hypothesis as strong negative attitudes towards face masks influenced performance for masked faces. Also, there was no significant influence of own-ethnicity effect on emotion recognition accuracy. This suggests that emotion recognition accuracy of masked and unmasked faces was comparable regardless of whether the participant had the same ethnicity as the stimulus shown or a different ethnicity. This differed from the hypothesis as a difference in performance depending on a match or mismatch of perceiver and observer ethnicity was predicted.

Regarding the lack of own-ethnicity bias, this is somewhat unexpected as it differs from the social motivation theory (Young & Hugenberg, 2010). This suggests that we allocate more attention to our in-group (e.g., stimuli ethnicity which matches participant ethnicity) which leads to more accurate face processing than our out-group (e.g., stimuli ethnicity which mismatches participant ethnicity). It was also unexpected as a meta-analysis exploring cross-cultural emotion recognition found that accuracy was higher when viewing members of your own-ethnicity (Elfenbein & Ambady, 2002). However, the meta-analysis (Elfenbein & Ambady, 2002) also mentioned that own-ethnicity effects were weakened when exploring more culturally diverse populations. This may explain the current findings as the sample was recruited from a student population in London, this means participants are more likely to have exposure to various ethnicities and may explain why an own-ethnicity effect was not found. It is unclear whether this explains the findings definitely as demographics about participants' experience and exposure to other ethnicities were not collected. This information would have been useful to collect as research suggests that early experiences play a key role in processing other-ethnicity faces (McKone et al., 2019).

When exploring attitudes towards masks, the majority of participants reported frequent mask-wearing in indoor environments: 80.2% selected 7 (always) in response to "How likely are you to wear a face covering on public transport"; and 72.5% and 60.3% reported always wearing a mask inside shops/businesses and other indoor environments, respectively. Previous research has reported similar distributions (Taylor & Asmundson, 2021). The present findings reported that attitudes towards masks Inside were associated with emotion recognition accuracy in masked and unmasked faces. This seems to reflect broader emotion recognition abilities. On the other hand, attitudes towards masks Outside were associated with masked emotion recognition only.

It is possible that the relationship between positive attitudes towards masks and better masked emotion recognition may be driven by the mere exposure effect (Fang et al., 2007). The mere exposure effect suggests an increased liking after repeated exposure. For example, if individuals spend more time around people who wear masks then they might be more likely to develop a positive attitude towards masks. Although increased exposure to masked faces may also improve performance by increasing perceptual expertise. Previous research reported that perceptual learning can shape emotion perception (Pollak et al., 2009). Therefore, it is possible that individuals could develop a perceptual expertise for masked faces and this may be associated with improved emotion recognition accuracy. Perceptual expertise might also explain the own-ethnicity effect results. Exposure to other ethnicities would increase perceptual expertise which could explain the improved accuracy for other ethnicities and therefore the lack of own-ethnicity effect found.

There is research reporting an association between attitudes towards masks and trustworthiness judgements (Biermann et al., 2021) but, to date, mask attitudes have not been explored in the context of emotion recognition. Research exploring attitudes towards different ethnicities and political attitudes (Fischer et al., 2012; Van Hiel et al., 2019) reported that attitudes can influence emotion recognition. This supports the current findings as it was also reported that attitudes had a significant effect on emotion recognition performance. This suggests that attitudes towards different groups/characteristics, or attitudes more generally, can impact emotion recognition abilities. This may provide difficulties for social interactions with ‘out-groups’. However, there was not a significant own-ethnicity bias, which suggests that under similar conditions used in the current study (e.g., maybe the London-based student sample), ethnicity is not one of the factors which would hinder social cognition.

5.4. General discussion

The current study conducted two experiments to explore the effect of individual differences (Experiment 4a: childhood trauma, alexithymia, and psychopathy; Experiment 4b: ethnicity and attitudes towards masks) on masked and unmasked faces across a range of expressions. Both Experiment 4a and 4b reported similar findings of a significant effect of masks, with better accuracy for unmasked than masked faces, and for emotion expressed, with better accuracy for neutral expressions compared to all emotional expressions (except happy in Experiment 4a). This suggests that face masks impacted our everyday social interactions. The current study explored emotion recognition specifically but previous research has explored other aspects of social interactions which may have also been impaired by the introduction of mask-wearing. Saunders et al. (2021) reported that face masks led to difficulties in hearing, understanding, and engagement, as well as connecting with the speaker. Also, they found that the use of face masks increased levels of anxiety and stress and made communicating tiring and frustrating. This shows the negative impact that face masks have had not only on processing facial features obscured during emotion recognition, but the wider impact too of making communication a negative and stressful experience.

As research has supported the idea of masks keeping us safer and preventing the spread of viruses (Asadi et al., 2020), it suggests that extra adjustments being made to face masks (e.g., transparent masks; Marini et al., 2021) may be effective at minimising the issue of face masks impacting social interactions, particularly emotion recognition. There is also the question of whether emotion recognition is as negatively affected in real-life conversations – as static faces were used but our daily interactions are dynamic in nature (Alves, 2013). As described previously, Chapter 3 reported that individuals process static and moving stimuli differently, which may pose potential generalisability issues for everyday interactions. Future research should employ moving stimuli when exploring masked emotion recognition to address this uncertainty.

Both Experiment 4a and 4b also reported no significant effect of the main individual differences being explored of childhood trauma (Experiment 4a) and ethnicity (Experiment 4b) or any significant interactions with masks or emotion expressed. As the groups explored in this study are not more negatively affected by the use of face masks compared to the general population, it may inform policies regarding mask exemptions. Specifically, it may not be necessary for these groups to have an exemption for the benefit of emotion recognition if they do not struggle significantly more than others with masks. A possible reason for the lack of ethnicity effect could be the sample used (student sample). For the lack of childhood trauma effect, the reason could be the sample was too restricted in range of more or less reported childhood trauma experience. Chapter 3 also used an entirely student-based sample and also did not report a significant effect of childhood trauma. However, across all chapters including the current one, the mean total score of childhood trauma was very similar (ranging from 40.54 to 45.19), suggesting this is not the reason for the lack of effect. Instead, it could be that childhood trauma's effect is more apparent when using more naturalistic stimuli as both the current chapter and Chapter 3 both included static stimuli and neither reported a significant effect of childhood trauma experience. Although, previous research including static stimuli reported significant effects of childhood trauma experience so it could be a combination of the samples and stimuli causing the differences.

Notably, Experiment 4a did report a significant effect of one of the individual differences – alexithymia. Individuals who reported a higher level of alexithymia traits reported poorer emotion recognition accuracy. This is in line with previous research by Gehdu et al. (2023) which explored alexithymia and masked facial expressions and reported a significant association between alexithymia traits and poorer emotion recognition overall. Experiment 4b also reported a significant effect of attitudes towards masks, with attitudes to Inside environments influencing emotion recognition in general and attitudes to Outside environments influencing masked recognition only. This somewhat follows other attitude research which has reported a significant association between individuals' attitudes with social judgements (Biermann et al., 2021) and emotion recognition accuracy (Fischer et al., 2012; Van Hiel et al., 2019). However, these studies explored attitudes or prejudices to religion and politics rather than face masks as in the current study. Overall, the majority of the findings were similar across Experiment 4a and 4b.

5.4.1. Masks and emotion expressed

Across both experiments there was a significant association between face masks and poorer emotion recognition accuracy. This was in line with hypotheses and supported by previous research which reported that face masks hindered emotion recognition accuracy (Noyes et al., 2021; Marini et al., 2021). Across both experiments there was a significant effect of emotion expressed, with better accuracy for neutral expressions compared to sad, anger, fear, disgust, and surprise, and better accuracy of neutral compared to happy expressions only in Experiment 4b.

Emotion recognition accuracy was lowest for disgust, sad, and fear expressions in the masked conditions across both studies. For neutral expressions, there was an inverse effect: masked expressions were more accurately recognised than unmasked expressions. This suggests that recognition accuracy of masked expressions differed depending on the emotion expressed. It was expected that disgust and happy expressions would be most impacted by face coverings because these expressions rely on the lower half of the face for recognition (Bassili, 1979; Wegrzyn et al., 2017), and this area was covered by the mask. This seems to be the case for disgust expressions. However, the recognition of happy expressions in the masked condition did not seem to be as affected as sad and fear expressions, which rely on the upper regions of the face for accurate recognition (Wegrzyn et al., 2017). Although, this follows previous findings. Grahlow et al. (2021) explored face masks and specific expressions and reported that anger, sadness, and disgust were most affected by masks, but fear, happy and neutral expressions were not. This supports the current findings as disgust was one of the expressions most affected by masks, and happiness was not. This also provides support for sad being another expression most affected by masks and for neutral expressions not being affected.

However, Grahlow et al. (2021) also reported anger expressions were most impacted by masks, but the current findings did not. A possible explanation for the difference in findings could be due to the different emotional stimuli selected. The current study used a database which did not provide intensity ratings of the stimuli. Therefore, it is possible that the current study used more intense expressions and, as observed by Montirosso et al. (2010), more intense expressions have better accuracy than more subtle expressions. In the future, databases should include intensity ratings for expressions so research can compare the different expressions and say with certainty whether the difference in stimuli caused the difference in results. Future research into this area would also benefit from using expressions of varying intensity levels to explore whether the effect of masks varies across intensity of stimuli.

A rather surprising finding was that, across Experiment 4a and 4b, fear expressions had relatively low accuracy across both masked and unmasked faces. Previous research exploring face masks and emotion recognition has reported fear expressions were unaffected by masks (Carbon; 2020; Bani et al., 2021). Also, in line with the evolutionary accounts of emotion (Tracy & Robins, 2008), fear typically has accurate recognition as it is categorised as ‘threat recognition’ and can be rapidly recognised from 39 milliseconds (Bar et al., 2006). This suggests we have accurate and fast fear recognition in order to increase our chances of survival. A possible explanation for why poor accuracy across both conditions for fear expressions was found could be because it was confused with and mislabelled as surprised in both conditions. Carbon (2020) explored masked faces and confusion of expressions but did not include surprise expressions, hence why this confusion pattern was not flagged. A reason why fear and surprise are frequently confused is because they share similar perceptual characteristics, both expressions include wide eyes and raised eyebrows (Sacco & Hugenberg, 2009). The confusion between fear and surprise has been reported across a variety of methods: research using isolated eye regions (Chamberland et al., 2017), unobscured faces presented rapidly (Zhao et al., 2017), and masked faces (face masks or sunglasses) in a younger sample (Ruba and Pollak, 2020). This may suggest that the confusion of fear with surprise may be genuine confusion rather than issues with the stimuli (e.g., not a good representation of a fear expression).

Regarding the neutral expressions, there was no negative effect of masks on emotion recognition accuracy. In support of this, other mask research did also report that neutral expressions were unaffected by masks (Marini et al., 2021; Noyes et al., 2021). However, the current findings reported that not only was recognition unaffected, but that recognition of neutral expressions was more accurate in masked than unmasked faces. A possible explanation for this finding could be that participants were using the neutral response option as a sort of default button for when they were unsure. Although forced-choice formats are easier for participants to grasp and understand (which is essential for online studies), they can exaggerate accuracy scores and include decision strategies, such as process of elimination (Nelson & Russell, 2011). Therefore, previous research has suggested the inclusion of a default option: “I don’t know”, “other”, or “none of the above” (Frank & Stennett, 2001).

Another possibility is that many emotional expressions rely on the lower part of the face to recognise the expression (Bassili, 1979; Wegrzyn et al., 2017), so participants may have perceived these expressions as neutral as they could only see the eye region. Partial occlusion research has typically explored emotional expressions and omitted neutral expressions. However, the findings suggest the importance of exploring neutral expressions in occluded facial expressions and urges future research to include these alongside emotional expressions.

The findings may suggest that ethnicity did not act as a social cue as performance was similar whether the in-group (stimuli matching participant ethnicity) or out-group (stimuli differing from participant ethnicity) stimuli were being recognised. Although, it may be possible that face masks themselves were acting as a social cue to influence emotion recognition performance. Previous research by Kret and De Gelder (2012) reported that face coverings acted as a social grouping cue and influenced accuracy. They found that performance went beyond simple perceptual occlusions and was influenced by out-groups (poorer performance for stimuli differing from your religion). In support of this, research had reported that social grouping cues can override ethnicity effects in face recognition (Van Bavel & Cunningham, 2012). This effect may be present in the current study. For example, the social grouping cue of face masks (e.g., grouped as mask-wearers or not mask-wearers) may have overridden the match or mismatch of ethnicity. This would suggest that individuals who do not wear masks themselves would have reduced the amount of attention allocated to masked faces regardless of whether the stimuli were their ethnicity or not.

However, the majority of participants recorded high levels of face mask use which makes it difficult for mask-wearers to be considered an “out-group” for most participants. Given the very small numbers of individuals who reported low mask usage in the current sample, it is not possible to compare the effects of mask-wearing (and, by extension, “in-groups” and “out-groups” based on mask-wearing) on emotion performance in more depth. Future research may wish to selectively recruit an even sample of mask- and non-mask wearers to examine potential in-group and out-group biases (and their interaction with other social cues such as ethnicity) in more depth.

5.5. Conclusion

In conclusion, this study employed two experiments which explored individual differences (Experiment 4a: childhood trauma, alexithymia, and psychopathy; Experiment 4b: ethnicity and attitudes towards masks) on masked and unmasked emotion recognition accuracy across emotion expressed. Experiment 4a and Experiment 4b both reported there was significantly poorer accuracy for masked facial expressions compared to unmasked facial expressions, for all expressions (except happy in Experiment 4a) compared to neutral expressions, and no significant effect or interactions for the individual differences of childhood trauma and ethnicity. However, Experiment 4a reported a significant association between alexithymia and poorer emotion recognition accuracy and Experiment 4b reported a significant association between attitudes towards masks and emotion recognition performance.

The issues arising from face masks suggest wide-ranging implications for our interpersonal interactions. Although, it seems that whether individuals reported more or less childhood trauma experience, or whether the participant ethnicity matched or mismatched the stimulus ethnicity, performance was not further impacted. These findings suggest there is no reason for concern that the populations in this study might show more severe effects of face masks on social interactions than the general population. The results also give us insight into emotion recognition more broadly and suggests that performance was most likely impacted by low-level perceptions (e.g., lower region occlusions) rather than high-level perceptions (e.g., own-ethnicity effects). Future research would benefit from exploring whether the effect of face masks on emotion recognition is consistent when using more naturalistic stimuli (e.g., moving stimuli) to closer resemble real-world social interactions and allow us to confidently generalise findings to everyday conversations.

6. General discussion

6.1. Chapter aims and overview

This chapter reviews the findings of the experimental chapters included in the thesis. It will summarise the findings of the effect of individual differences (childhood trauma and the related traits of alexithymia and psychopathy) and the stimulus-based factors on emotion recognition, and how this can inform and update our broader understanding of emotion abilities. Future research to continue the work started in this thesis will be identified.

6.2. Summary of thesis findings

The main aim of the thesis was to explore the effect of individual differences on emotion recognition accuracy using more ecologically valid stimuli, e.g., moving stimuli. The research question for Chapter 2 (Experiment 1) was whether the relationship between childhood trauma and emotion recognition accuracy, intensity ratings, and sensitivity to intensity was influenced by alexithymia and psychopathy traits as well as by stimulus-based factors (modality, emotion expressed, and intensity). The research question for Chapter 3 (Experiment 2) was whether the relationship between childhood trauma and emotion recognition accuracy and eye movements was influenced by alexithymia and psychopathy traits as well as by stimulus-based factors (modality, emotion expressed, and intensity). The research question for Chapter 4 (Experiment 3) was whether the relationship between childhood trauma and emotion recognition accuracy and intensity ratings when integrating emotion cues was influenced by alexithymia and psychopathy traits as well as by stimulus-based factors (modality focus, emotion expressed, and congruence). There were two research questions for Chapter 5: Experiment 4a explored whether the relationship between childhood trauma and emotion recognition accuracy of masked and unmasked facial expressions was influenced by alexithymia and psychopathy traits as well as by emotion expressed, and Experiment 4b explored whether the relationship between an ethnicity match or mismatch (between perceiver and actor) and attitudes towards masks and emotion recognition accuracy was influenced by masks and emotion expressed.

The stimuli used throughout the thesis have improved and extended on previous research by using dynamic and audio-visual expressions when the majority of previous research used static facial expressions. However, it was unclear whether the static facial expression findings would be similarly reflected with moving stimuli and therefore more generalisable to real-world social interactions. Another addition to previous methodologies was including the co-morbid traits of alexithymia and psychopathy to ensure the recording of childhood trauma's unique effect on emotion performance rather than the traits' effect. The findings from Chapter 2 indicated that childhood trauma experience was associated with poorer emotion recognition accuracy without considering the traits, but when controlling for the traits, childhood trauma's effect was reduced or non-significant. Chapter 3 reported no significant effect of childhood trauma on emotion processing using eye movements when exploring alone or when controlling for the traits. Chapter 4 reported a significant negative effect of childhood trauma on the integration of facial and vocal emotion cues but after controlling for the traits this effect was no longer significant. Chapter 5 did not report a significant effect of childhood trauma on the recognition of masked and unmasked expressions when exploring childhood trauma alone or when controlling for the traits. Chapter 2 and 4's findings may suggest that previous research not controlling for co-morbid traits may be reporting another factor's effect rather than isolating childhood trauma's effect. It could be possible that, now movement is included, childhood trauma's unique effect on emotion performance may not be as detrimental as previously reported. An overview of the findings across all chapters is provided in Table 41.

Table 41

Overview of thesis findings.

Chapter	Title	Objectives	Methodology	Summary of main findings
Chapter 2 (Experiment 1)	The effect of childhood trauma on emotion recognition and the influence of related traits and stimulus-based factors.	Is the relationship between childhood trauma and emotion recognition, intensity ratings, and sensitivity to intensity influenced by alexithymia and psychopathy traits?	Self-report measures of childhood trauma, alexithymia, and psychopathy. Emotion recognition task including various modalities (faces, voices, audio-visual), emotions expressed (basic six	The relationship between childhood trauma and emotion recognition accuracy was reduced or non-significant after controlling for alexithymia and psychopathy traits. There was no significant effect of childhood trauma for intensity ratings or sensitivity.

		Is the effect of childhood trauma on emotion recognition, intensity ratings, and sensitivity to intensity consistent across modality, emotion expressed, and intensity?	and neutral), and intensity (normal, strong).	Alexithymia was significantly associated with poorer emotion recognition accuracy when exploring across intensity of stimuli. There were no significant interactions reported between childhood trauma and stimulus-based factors for emotion recognition accuracy. There was a significant interaction between childhood trauma and modality and emotion expressed for intensity ratings and sensitivity.
Chapter 3 (Experiment 2)	The effect of childhood trauma on emotion recognition: an eye tracker study.	Is the relationship between childhood trauma and emotion recognition and eye movements influenced by alexithymia and psychopathy traits? Is the effect of childhood trauma on emotion recognition	Self-report measures of childhood trauma, alexithymia, and psychopathy. Emotion recognition task employed on the eye tracker measuring accuracy and eye movements (fixation count and dwell time) across	There was no significant effect of childhood trauma reported for emotion recognition accuracy or eye movements. There was a significant interaction between childhood trauma and modality and emotion expressed for accuracy. There was a significant

		and eye movements consistent across modality, emotion expressed, and intensity?	various modalities (static faces, dynamic faces, audio-visual), emotions expressed (basic six and neutral), intensity (normal, strong), and interest area (eyes, nose, mouth).	interaction between childhood trauma and interest area for eye movements.
Chapter 4 (Experiment 3)	The effect of childhood trauma on the integration of congruent and incongruent facial and vocal emotion cues.	Is the relationship between childhood trauma and emotion recognition and intensity ratings when integrating emotion cues influenced by alexithymia and psychopathy traits? Is the effect of childhood trauma on emotion recognition and intensity ratings when integrating emotion cues consistent across congruence, modality, and emotion expressed?	Self-report measures of childhood trauma, alexithymia, and psychopathy. Emotion recognition task including various modalities (facial focus, vocal focus), emotions expressed (basic six and neutral), and congruence (congruent and incongruent).	The relationship between childhood trauma and emotion recognition accuracy was non-significant after controlling for alexithymia and psychopathy traits. There was no significant effect of childhood trauma for intensity ratings. There was a significant association between higher levels of alexithymia traits and lower intensity ratings. There were no significant interactions reported between childhood trauma and the stimulus-based factors when exploring emotion recognition

				accuracy or intensity ratings.
Chapter 5 (Experiment 4a)	The effects of individual differences on emotion recognition of masked and unmasked faces.	Is the relationship between childhood trauma and emotion recognition influenced by alexithymia and psychopathy traits? Is the effect of childhood trauma on emotion recognition consistent across masks and emotion expressed?	Self-report measures of childhood trauma, alexithymia, and psychopathy. Emotion recognition task including face masks (masked, unmasked) and emotions expressed (basic six and neutral).	There was no significant effect of childhood trauma reported for emotion recognition accuracy. There was a significant association between higher level of alexithymia traits and poorer emotion recognition accuracy. There were no significant interactions reported between childhood trauma and the stimulus-based factors.
Chapter 5 (Experiment 4b)		Is the effect of an ethnicity match or mismatch on emotion recognition consistent across masks and emotion expressed? Is the effect of attitudes towards masks on emotion recognition consistent across	Questions regarding attitudes towards masks. Emotion recognition task including face masks (masked, unmasked), emotions expressed (basic six and neutral), and ethnicity (Asian, Black, White).	There was no significant effect of ethnicity reported for emotion recognition accuracy. Accuracy was poorer for masked compared to unmasked faces and for all expressions compared to neutral. There was a significant effect of attitudes towards masks on masked and

	masks and emotion expressed?	unmasked emotion recognition accuracy.

6.3. Childhood trauma and emotion performance

In Chapters 2 and 4 there was an initial significant association between childhood trauma and poorer emotion recognition accuracy. This follows the previous research exploring childhood trauma experience and emotion performance. There were two key reviews discussed throughout the thesis which explored childhood trauma's effect on emotion recognition performance. Bérubé et al. (2023) reviewed 24 studies exploring adults with experience of childhood maltreatment and reported that more experience of childhood trauma negatively impacted emotion recognition abilities. This supports the current findings that individuals with experience of childhood trauma were impacted for emotion recognition performance. Another review, by Saarinen et al. (2021), explored the effect of early adversity on neurophysiological and behavioural responses in child and adult samples. They reported that only recent adversity, defined as adversity in the last two years, influenced emotion recognition performance, so only child samples were impacted. This differs from the current findings as a significant effect of childhood trauma experience in an adult sample was found. The main difference between Saarinen et al. (2021) and the current research is the outcome variable being explored.

The reviews discussed explored early adversity (Saarinen et al., 2021) and childhood maltreatment (Bérubé et al., 2023). These are more loosely defined than childhood trauma and incorporate a host of other experiences. For example, Saarinen et al. (2021) explored various early adversity measures (e.g., Childhood Trauma Questionnaire, semi-structured interviews, Risky Families Questionnaire, records of child protective services or medical records, and early life stress questionnaires) which covered topics such as homelessness, victimisation to bullying, adverse family environment, maternal maltreatment, and illness/death. Bérubé et al. (2023) explored various childhood maltreatment measures (e.g., Childhood Trauma Questionnaire, records of maltreatment, adult attachment interview, Childhood experience of care and abuse interview, and Risky Families Questionnaire) and the topics covered included experiences of loss and/or abuse, violence between parents, as well as abuse and neglect. The current study only employed one consistent measure of childhood trauma, CTQ-SF, which is more stringent and only explores 5 facets: emotional abuse, physical abuse, sexual abuse, emotional neglect, and physical neglect. Therefore, the reviews discussed included additional experiences (e.g., homelessness and bullying) that were not considered in the current studies.

This is a limitation of the childhood trauma literature as research reports it is exploring childhood trauma but includes various other facets outside of abuse and neglect. The inclusion of extra facets means it is difficult to directly compare the effect of early trauma or adversity across studies. This inconsistency could also explain why there are conflicting findings regarding childhood trauma's effect on emotion performance. Future research would benefit from being specific about what measure is being used when exploring trauma or adversity in childhood. Similarly, there was a major inconsistency in how the reviews measured emotion performance. For example, tasks included emotion discrimination tasks, matching tasks with faces and shapes, dot-probe task, and passive viewing, across adult, child, and infant facial expressions (Saarinen et al., 2021; Bérubé et al., 2023). The difference in methodology as well as age of faces used would influence performance differently but the reviews explored them holistically. Therefore, the emotion recognition literature would also benefit from having a consistent approach.

A limitation of the current study was the lack of details recorded surrounding childhood trauma experience. Saarinen et al. (2021) reported that the recency of abuse was a key factor in influencing emotion performance. Therefore, this additional information may have provided an explanation for any unclear findings. Also, one of the measures used to explore childhood trauma in Bérubé et al.'s (2023) review was the Netherlands Mental Health Survey and Incidence Study (NEMESIS; as seen in De Graaf et al., 2002). This included more comprehensive details regarding participant's childhood trauma. The interview asked individuals whether they had experienced neglect or abuse before the age of 16 years, how often it occurred (e.g., never, sometimes, very often), and what the abuser's relationship was to them. This would have given a more rounded view of the individuals reporting with higher scores on the CTQ-SF, indicating more experience of childhood trauma. However, even though this would have provided additional information which may have proved useful, it was not appropriate to use this measure for the thesis. Firstly, the NEMESIS interview also included extra measures which are not in line with the current research and hypotheses. For example, it includes psychotic experiences, autistic traits, insomnia, and loneliness which are not relevant. Secondly, as this is a comprehensive interview it has previously taken on average 91 minutes (ten Have et al., 2023). Therefore, with the time restrictions included with a PhD it would not have been feasible to pre-screen participants with experience of childhood trauma and invite them back to conduct extensive interviews. Especially as a large sample was needed for each study to ensure there was enough power to perform mixed models due to the limited actors (either 3 or 4 actors) used in the emotion tasks.

Another possible issue with using NEMESIS was the sample used. Across the studies a student sample from the psychology cohort at the same institution, Brunel University London, was explored. It is likely students would not feel comfortable discussing their trauma in detail with a researcher in their department. In sum, more details regarding the trauma would have been useful to have, especially regarding the recency and consistency of abuse, but not appropriate in this case.

The current study has contributed to the literature exploring childhood trauma and emotion recognition by using a consistent measure (CTQ-SF) and methodology (e.g., emotion categorisation using similar response options) across experiments. This helps compare the effect of childhood trauma across various emotion abilities confidently. Therefore, the findings reported that childhood trauma significantly influenced the emotion recognition accuracy of moving stimuli (Chapter 2) and the integration of facial and vocal emotion cues (chapter 4) but did not significantly influence eye movements when processing emotions (Chapter 3) or partially occluded static facial expressions (Chapter 5).

Although childhood trauma was initially significant for Chapters 2 and 4, this differed for Chapters 3 and 5. Chapter 3, exploring childhood trauma's effect on emotion processing and eye movements across various conditions, was not significantly influenced by childhood trauma experience. This was actually in line with Mohr (2016) who explored eye movements across eyes, mouth, overall face, and the brow region and reported that the different facets of childhood trauma did not impact where individuals looked on the face when recognising emotional expressions. As discussed in Chapter 3's discussion, the difference in findings between Chapter 3 and Chapters 2 and 4 could be explained by the different testing methods used (online versus lab-based). However, as Chapter 5 also used online testing, similar to Chapters 2 and 4, and supported Chapter 3's conclusions, it may suggest that the differences are due to other methodological differences rather than the testing procedure. The fact both Chapters 3 and 5 did not report a significant effect of childhood trauma, and that they were the two chapters to incorporate static facial expressions, may tell us how childhood trauma impacts emotion performance more broadly. For example, it may suggest that childhood trauma's effect on emotion performance is significant for moving stimuli, but not for static stimuli. Although, previous research exploring childhood trauma and emotion recognition typically used static facial expressions and did report a significant effect of childhood trauma experience.

Other methodological differences in Chapters 3 and 5 compared to Chapters 2 and 4 should also be noted. Chapter 3 employed eye tracking, this means that the apparatus used during the emotion tasks to record eye movements, such as the chin rest to keep the participant's head and eyes in a fixed position, may have influenced the findings too. Although the chin rest is crucial during eye tracking to minimise head movements, research has reported that chin rests can negatively affect the quality of recorded data (Schneegans et al., 2021). It has been suggested that future eye tracking research instruct participants to keep their head still in a natural position and avoid using chin rests to improve data quality (Zhao et al., 2017; Schneegans et al., 2021). Similarly, it could be that Chapter 5's findings were influenced by the use of masks and their associated threat connotations. For example, face masks used during the COVID-19 pandemic were associated with increased threat as they were associated with the presence of the virus (Saunders et al., 2021). Regarding childhood trauma specifically, a history of childhood trauma was identified as a risk factor for elevated psychological distress during the pandemic (Siegel & Lahav, 2022). As previous chapters did not include masked facial expressions, and therefore the possible increase of threat response in individuals with childhood trauma experience, this may have influenced the findings and explain the different results between chapters.

This difference could be due to the current study using more comprehensive stimuli and also including various modalities and intensities, which are known to influence recognition (e.g., better performance for higher intensity and bimodal conditions compared to lower intensity and unimodal conditions; Montirosso et al., 2010; Collignon et al., 2008). It could suggest that childhood trauma is multifarious and may impact individuals, and separate conditions, differently to impact and shape individual's emotion performance. If experience of childhood trauma does impact individuals differently this may pose problems for interventions as each would have to be tailored to the individual in order to see any beneficial outcomes which may not be feasible on a large scale. It may also support splitting childhood trauma into the subscales (emotional abuse, physical abuse, sexual abuse, emotional neglect, and physical neglect) to explore different experiences. However, for the thesis it would not have been appropriate to split childhood trauma into subscales due to needing considerable power for mixed models and most importantly it was not pertinent to our hypotheses to explore per facet. Although, if this is appropriate and feasible for future research, it may be interesting to explore childhood trauma's overall effect as well as the subscales to see if this does impact findings differently.

It could also be that childhood trauma impacts various aspects of the emotion recognition process differently. Aspects of the emotion recognition process could start with where individuals look on a face to recognise an expression, followed by how they integrate facial and vocal emotion cues, and finally how they categorise and label these expressions. As Chapter 3 explored where individuals look on the face to recognise the expression, this may reflect earlier processes of emotion recognition. Whereas Chapters 2 and 4 explored how individuals integrated emotion cues and categorised them, which may reflect later processes of recognising expressions. Childhood trauma was significant when exploring the integration and labelling of expressions, but it was not for eye movements during emotion recognition. This could suggest that childhood trauma does not impact earlier stages of emotion recognition but may negatively impact later stages of emotion recognition. Although emotion recognition in general has not been explored across various stages, faces have. Face recognition research has explored earlier (e.g., structural encoding) and later processes (e.g., remembering faces) and reported different performance for different aspects (Bentin & Deouell, 2000). Thus, a similar process could be happening during various aspects of emotion recognition. However, as this has not been explored in emotion recognition, it is unclear how childhood trauma's effect fits in. This may also allude to childhood trauma's impact differing across low- and high-level perceptions. For example, the fact childhood trauma was not associated with where individuals look, or with partial occlusions using masks, may suggest that childhood trauma is not significantly associated with low-level perceptions (e.g., image properties).

This idea is further supported by Chapter 3's findings which reported an interaction between childhood trauma and an increased gaze towards the eye region compared to the nose and mouth. As the eye region has been identified as key for accurate emotion recognition in general (Grossman, 2017) it seems that individuals with childhood trauma experience are looking in the typical and necessary areas for accurate emotion recognition, similar to individuals without childhood trauma experience. However, as there are still associated emotion deficits, it may suggest that the difficulties lie in high-level perceptions, as found for integrating cues and labelling expressions. This may be supported by Pollak et al. (2000) who suggested that individuals with childhood trauma experience can understand that an emotion is positive or neutral but the issues lie in the misinterpretation of these expressions having more malevolent connotations. For example, a happy face with a smile being misinterpreted as being mocked or laughed at. This would support the differing effect of childhood trauma on low- and high-level perceptions as they can be viewed as positive or neutral but the interpretation and labelling of the emotion is where the difficulties are.

This information could inform plans for interventions to focus on improving the high-level perceptions which seem to be negatively impacted. The findings of typical performance for emotion recognition concerning low-level perceptions could inform policies regarding mask mandates. Specifically, exemptions may not be necessary for individuals with childhood trauma experience as they are not significantly more hindered in their social cognition due to masks than the general public. Future research should attempt to explore childhood trauma's effect across various different aspects of emotion recognition in one study to explore whether the effect does vary across low- and high-level perceptions. This would provide information regarding where the difficulties lie and how to target these for improvement.

Although one of the major strengths of the study is the inclusion of improved and more realistic moving stimuli, there is a limitation of using these stimuli which may impact some research. For example, the exploration of reaction time is difficult and most likely not appropriate because of the emotional expressions varying onset and peak expression frame (e.g., sad is displayed slower than fear so reaction times would most likely be faster for fear as the expressions hits its peak frame earlier, rather than because it is recognised quicker). This was not an issue for the current thesis as our hypotheses were focused on emotion recognition accuracy and not reaction time. However, exploring childhood trauma and reaction times can provide information regarding the time course of emotional processing, including both early stages (e.g., eye movements when processing emotional expressions) and later stages (e.g., how quickly emotional expressions are recognised and labelled). Also, the literature has identified this relationship as important (Flechsenhar et al., 2022; Bérubé et al., 2023), thus it is likely that research exploring childhood trauma and reaction time may find it more appropriate to use static stimuli than moving stimuli. The generalisability issues associated with static stimuli still apply so it would be beneficial for future research to explore possible methods which incorporate the more realistic moving stimuli whilst being able to appropriately explore reaction times, if necessary for a study's hypotheses.

The interactions reported throughout the chapters suggests that childhood trauma's effect on emotion performance did differ across certain conditions. There are multiple interactions reported between childhood trauma and modality across various outcome variables. For example, across intensity ratings and sensitivity to intensity in Chapter 2 (Experiment 1) and accuracy in Chapter 3 (Experiment 2). Regarding intensity ratings, as more childhood trauma experience was reported there were higher intensity ratings for audio-visual expressions compared to vocal expressions of emotion. Regarding sensitivity to intensity, as more childhood trauma experience was reported there was a lower sensitivity to audio-visual expressions shown. Whereas childhood trauma's effect on sensitivity for facial expressions was similar regardless of how much trauma was reported. A lower sensitivity indicates smaller differences between intensity ratings of normal and strong intensity expressions; both intensities are rated similar regarding how intense they are. This suggests that experience of childhood trauma influenced perceptions of how intense expressions were for audio-visual expressions compared to other modalities.

A possible reason why this may have occurred could be due to the heightened sensitivities associated with childhood trauma experience (McLaughlin, 2020), but it is possible these sensitivities have their limits. For example, it could be that lower intensity stimuli are perceived at a higher intensity, due to heightened sensitivities, but already strong intensity stimuli are not influenced by these sensitivities. There is no research exploring this but future research may benefit from a better understanding of the heightened sensitivities and how they are influenced by various factors. It could also be that audio-visual expressions are perceived as more intense than faces and voices as individuals are more likely to experience traumatic events through bimodal displays of emotion than unimodal displays (Ambadar et al., 2005).

There is also evidence of childhood trauma varying across modality when exploring emotion recognition accuracy in Chapter 3. As more experience of childhood trauma was reported, there was better accuracy for audio-visual expressions and poorer accuracy for dynamic expressions. A possible explanation for this finding may be described by Hoepfel et al. (2022) who suggested individuals initially attend to negative expressions to assess the danger of a situation and then after this they avoid the negative cues to escape possible danger or conflict. If this is applied to dynamic facial expression performance, participants with more experience of childhood trauma may have avoided attention of this stimuli which led to poorer performance. This is in line with the vigilance-avoidance hypothesis (Mogg et al., 1997) which suggested that individuals with anxiety initially direct attention to threat cues in their environment but then avoid additional processing of this cue to reduce their anxiety level. A similar pattern could be seen with individuals with childhood trauma experience. However, this avoidance would not be possible in the audio-visual condition due to the vocal expressions also present, leading to better accuracy due to the extra cues. If future research replicated Experiment 2 (Chapter 3) and included order of fixations or first fixations, it would shed light on any avoidance type patterns associated with childhood trauma.

It is interesting that there was a main effect of childhood trauma on emotion recognition accuracy but not for intensity ratings. This may suggest that childhood trauma's effect on emotion performance differs depending on the measure. So, childhood trauma impacts how individuals categorise expressions, but not our perception of how intense the expression is. It may suggest that childhood trauma impacts emotion-specific information (as used in labelling and categorising expressions) but not more general perceptions such as how intense it may be. To fully understand the relationship between childhood trauma and various measures of emotion recognition it would be useful for research to include additional measures, such as neural measures, to explore if these performance differences between accuracy and perception of intensity are evident in activation patterns too.

The multiple reports of an interaction between childhood trauma and modality across the chapters may suggest broader implications and adjustments needed for individuals with childhood trauma experience. It seems that individuals with childhood trauma experience have better performance for audio-visual expressions compared to unimodal expressions (e.g., facial or vocal expressions of emotion). This may suggest difficulties in social situations where only one modality is available. For example, individuals with childhood trauma may struggle in situations where only the vocal expression is available (e.g., dark environments such as outside evening events) or situations where only the facial expression is available (e.g., noisy environments such as concerts or clubs). It may also suggest difficulties with phone calls as only the vocal expression is available. These findings could suggest that individuals with childhood trauma experience should interact using audio-visual means, such as video calls or face-to-face instead of over the phone, as well as going to environments where both the facial and vocal expressions can be experienced. If individuals are in suboptimal conditions which hinders accurate emotion recognition accuracy, it can impact other factors such as the ability to initiate, maintain, and regulate social interactions and relationships (Grossman, 2017). This emphasises the importance of optimal conditions, in this case access to audio-visual expressions.

There were also significant interactions reported between childhood trauma and other stimulus-based factors in Chapter 3 (Experiment 2), such as emotion expressed. It was reported that more experience of childhood trauma was associated with better accuracy of sad, anger, disgust, and surprise expressions compared to neutral expressions. This is somewhat in line with the social information processing mechanism (Dodge et al., 1995) as it reports better accuracy of negative expressions (in this case sad, anger, and disgust) compared to neutral. Research has suggested that this sensitivity to negative expressions could be due to children in abusive environments becoming hypervigilant in order to predict the next occurrence of abuse (Pollak et al., 2005; Pearce & Pezzot-Pearce, 2013). There is also neural support (blood oxygen level-dependent response, detected in fMRI) for increased activation in certain brain areas (e.g., amygdala, putamen, anterior insula) for negative stimuli compared to neutral stimuli for individuals with experience of childhood trauma versus individuals with no reported childhood trauma experience (McLaughlin et al., 2015).

It is somewhat surprising that childhood trauma experience influenced the recognition of surprise expressions as this relationship had not been reported before. However, typically research omits surprise expressions as they are frequently confused with fear expressions (Bombari et al., 2013). So, typically happy is the only positive expression employed. This could mean the relationship between childhood trauma and surprise expressions was missed in previous research due to its exclusion. In the broader context of childhood trauma and emotion recognition, it may suggest that childhood trauma is associated with poorer performance of happy expressions specifically rather than positive expressions in general (which also encompasses surprise) as reported by previous research and childhood trauma models (Dodge et al., 1995; McLaughlin et al., 2020). This suggests the importance of including and exploring surprise expressions to see if this relationship is replicated and if the models suggesting poorer performance of positive expressions in general need updating to just happy expressions.

There were also a lack of interactions which need to be discussed as they can give us insight into emotion recognition more generally (e.g., are performance differences as a result of childhood trauma diminished in everyday interactions and in certain situations?). In Chapters 2, 4, and 5 there were no interactions reported between childhood trauma and stimulus-based factors when exploring emotion recognition accuracy. This would suggest typical performance regardless of how much childhood trauma experience was reported. For modality, this was somewhat expected as previous research had reported similar brain activation patterns across facial and vocal expressions of emotion (Grynberg et al., 2012; Goerlich-Dobre et al., 2014). It would also be expected that the sensitivities to threat cues, which help predict the next occurrence of abuse, would be modality-general. For example, whether a threat cue was presented facially or vocally it would be expected that individuals with childhood trauma experience would recognise this as a safety behaviour (Shackman et al., 2007).

However, a lack of interaction between childhood trauma and emotion expressed in Chapters 2, 4, and 5 was surprising. It was expected that individuals with experience of childhood trauma would show better accuracy for negative expressions and poorer accuracy for positive and neutral expressions (in line with the social information processing mechanism; Dodge et al., 1995). However, this was not found. Previous research has reported that movement aids our emotion recognition abilities and better resembles our everyday interactions (Alves, 2013). This may suggest a perceptual expertise for dynamic expressions compared to static facial expressions. More specifically, the movement element may have enhanced emotion recognition of positive and neutral expressions comparable to negative expressions. This would lead to a similar effect of childhood trauma across all expressions and explain the lack of interaction.

It was also surprising that there was no interaction reported between childhood trauma and intensity across all chapters. It was predicted that more experience of childhood trauma would result in better accuracy across intensity than individuals without experience of childhood trauma due to less perceptual information needed to identify expressions (McLaughlin et al., 2020). Similar to the above explanation, the additional cues provided by the movement element may have somewhat attenuated the heightened sensitivities (and ability to recognise expressions with less perceptual information) associated with childhood trauma. Thus, leading to a comparable effect of childhood trauma across various intensities and explain the lack of significant interactions reported. Future research would benefit from continuing and extending on the current studies to confirm if movement does attenuate some associated difficulties and sensitivities associated with childhood trauma experience.

6.4. Interrelated alexithymia and psychopathy traits

Another key contribution to the childhood trauma literature was controlling for the co-morbid traits of alexithymia and psychopathy. This can identify which effects are specific to childhood trauma experience and which are the result of the co-morbid traits. Research typically includes and controls for psychopathologies as these can also influence emotion recognition and make it difficult to identify how much variance is due to childhood trauma (Catalana et al., 2020). However, there is little research controlling for other traits when exploring emotion recognition. Experiments 1, 2, 3, and 4a explored the relationship between childhood trauma and emotion recognition accuracy and the influence of alexithymia and psychopathy traits. Experiments 1 and 4a reported that alexithymia was associated with poorer emotion recognition accuracy and Experiment 3 reported that alexithymia was associated with lower intensity ratings of stimuli. Whereas, across all experiments there was not a significant effect of psychopathy reported across any emotion measure.

The fact that alexithymia was associated with poorer emotion recognition accuracy across two experiments suggests it is a key factor which influences emotion recognition. This follows previous research which also reported a significant association between a higher level of alexithymia traits and poorer emotion recognition accuracy (Prkachin et al., 2009; Jongen et al., 2014; Rosenberg et al., 2020). Possible reasons for the emotion deficits are due to difficulties identifying and describing one's own feelings which is then reflected in difficulties recognising other's emotional expressions. This is described in the shared circuits model (Keysers & Gazzola, 2006) and the self to other model of empathy (Bird & Viding, 2014). These findings have broader implications as the current research used moving stimuli and supports previous findings, which employed static stimuli. This suggests the deficits are also present in more realistic stimuli, and most likely real-world interactions. Thus, it seems individuals exhibiting a higher level of alexithymia traits struggle with accurate emotion recognition, which can in turn impact various aspects of social cognition such as relationships and appropriate behaviour (Grundmann et al., 2021). This can lead to negative outcomes of limited and poor quality social networks which can result in poor mental health (Helliwell & Putnam, 2004).

The analyses including the co-morbid traits (specifically in Experiment 1) suggest that in the initial childhood trauma analyses actually alexithymia was responsible for the poorer emotion recognition accuracy. This is similar to the relationship between autism and alexithymia which reports that the co-morbid alexithymia traits are responsible for the emotion deficits associated with autism (Bird & Cook, 2013). Therefore, a similar relationship may be present with childhood trauma and alexithymia traits; the emotion deficits are due to the related alexithymia traits rather than childhood trauma itself. The implications of this finding suggest an update and revision of the model and theories reporting on the relationship between childhood trauma and emotion recognition to acknowledge and highlight alexithymia as a key factor. It may also inform interventions to address the emotion difficulties associated with alexithymia traits as this may in turn improve childhood trauma's difficulties too. Although, there is limited research discussing interventions for improving emotion recognition in individuals with experience of childhood trauma.

There was also a significant association between alexithymia and alternative measures of emotion recognition, specifically lower intensity ratings (Experiment 3). This is in line with previous research (Prkachin et al., 2009) and is expected as alexithymia has been associated with blunted emotional responses to emotional stimuli (Grynberg et al., 2012; Deng et al., 2013; Goerlich-Dobre et al., 2014). Therefore, individuals with higher levels of alexithymia traits would experience and rate emotion stimuli as low intensity, as seen. Surprisingly, there is limited research exploring alexithymia and intensity ratings, especially using behavioural measures. However, there is research which has found that less intense emotional expressions are more difficult to recognise than higher intensity expressions (Montirosso et al., 2010). This may suggest that individuals with a high level of alexithymia traits struggle with recognising emotional expressions because they are perceiving emotional stimuli as less intense which is impacting accuracy. This is somewhat supported by Starita et al.'s (2018) findings of alexithymia being associated with needing more perceptual information to identify fear expressions. The need for more perceptual information suggests that a more intense or exaggerated expression was needed before accurate recognition.

In the broader context of social interactions, it may suggest that individuals with higher levels of alexithymia are incorrectly perceiving expressions as less intense than they are intended. This may be an issue as the intensity of an emotional expression can highlight the urgency or importance of the conversation (Holz et al., 2021) and therefore key information may be misinterpreted or missed which could lead to inappropriate behavioural responses. Thus, accurate interpretation of emotional intensity is important and future research should explore ways to inform and improve this difficulty associated with alexithymia traits.

An unexpected finding was the lack of significant effect of psychopathy on emotion performance across all experiments. Previous research, and the psychopathy models (Patrick, 1994; Blair, 2001), have suggested that a higher level of psychopathy traits is associated with poorer accuracy overall but especially for sadness and fear (Blair, 2001). Other research has suggested that the emotion deficits are more general and go beyond just sadness and fear (Dawel et al., 2012; Bowen et al., 2014). However, in the current research it seems individuals reporting a high level of psychopathy traits and individuals reporting a low level of psychopathy traits showed similar performance. A possible reason for the lack of effect could be the different samples used. One of the main limitations of the psychopathy literature discussed was that the majority of research used a forensic sample, typically male-only (Dawel et al., 2012). The current study used a community sample and included females too. It was unclear whether the previous psychopathy findings would generalise to the sample used by the current research, but it seems it cannot. Research should acknowledge that previous findings may provide insight into incarcerated males but the findings may not appropriately generalise outside of this sample. This significantly limits the outreach of the findings and the implications.

Another key difference was the use of moving stimuli in the current study. There is limited research exploring psychopathy's effect on emotion recognition for dynamic and audio-visual stimuli which may also explain the difference in findings. It could be that previous findings are specific to static facial expressions and cannot generalise to more realistic stimuli and in turn real-world interactions. Future research would benefit from using the more realistic stimuli as in the current research and directly comparing incarcerated males with a community sample to see whether findings can be generalised to the wider population. The broader implications of the psychopathy findings suggest that individuals with psychopathy traits are not further hindered or disadvantaged in their emotion recognition, and in turn social interactions, and that the emotion recognition deficits associated with childhood trauma are not significantly influenced by psychopathy traits.

Another crucial avenue for future research to explore would be the different facets of psychopathy. Previous research has identified that the interpersonal and affective facets of psychopathy may be more associated with emotion deficits than the other facets of antisocial and lifestyle (Brook et al., 2013). Therefore, as we explored the total score of psychopathy, it could be that the facets which did impact emotion performance were somewhat minimised as there were also facets included in the total score which did not seem as linked to emotion performance. This may explain why comparable findings across individuals with lower and higher scores of psychopathy were reported. Although, as considerable power was needed for the mixed models and because the main individual difference was childhood trauma, and alexithymia and psychopathy were the control variables, it was not appropriate for the thesis to split psychopathy into facets. Future research, where appropriate, should examine these facets individually to give a more nuanced understanding of the relationship between childhood trauma and emotional processing within the psychopathy spectrum.

The inclusion of alexithymia and psychopathy traits when exploring childhood trauma has provided a more comprehensive understanding of the relationship between childhood trauma and emotion recognition. The findings have highlighted the importance of controlling for co-morbid traits to explore an individual differences' unique effect on emotion performance. Thus, future research should incorporate other co-morbid individual differences where appropriate. In particular, future research exploring childhood trauma should control for alexithymia traits to ensure childhood trauma's effect is solely responsible for the reported findings.

6.5. Stimulus-based factors and emotion performance

Across all chapters, multiple stimulus-based factors were included to explore how robust/universal the relationship between childhood trauma and emotion recognition was across various conditions. The main recurring stimulus-based factors explored throughout were modality, emotion expressed, and intensity of stimuli. The exploration across modality differed per experiment: Experiment 1 was across facial, vocal, and audio-visual expressions, Experiment 2 was across static faces, dynamic faces, and audio-visual expressions, and Experiment 3 was a facial focus (e.g., what expression is the face showing) or a vocal focus. The use of intensity of stimuli and emotion expressed were consistent across all chapters with normal and strong intensity and the basic six emotions and neutral expressions.

The main overarching finding regarding modality was that as the number of emotion cues increased, as did accuracy. For example, in Experiment 1 and 2 there was better accuracy for audio-visual expressions compared to the unimodal conditions of facial and vocal expressions (Experiment 1) and static and dynamic facial expressions (Experiment 2). As an increase in emotion cues provides us with extra information regarding the expression, it is understandable that it would enhance our emotion recognition performance. This follows previous research which also reported better emotion recognition accuracy for bimodal conditions compared to unimodal conditions (Collignon et al., 2008). Similar to this, Experiment 1 and 3 found higher accuracy for facial expressions compared to vocal expressions of emotion. The data is consistent with the limited literature available; better accuracy for facial expressions compared to vocal expressions (Scherer, 2003; Nelson &

Russell, 2011). This may suggest that facial expressions cannot be generalised to vocal expressions. Thus, previous research, which has typically used facial expressions, cannot be applied to emotion recognition broadly as this also encompasses vocal expressions of emotion. Future research should incorporate both facial and vocal expressions to provide a broader overview of emotion recognition performance in general.

Another key stimulus-based factor explored across the current research was emotion expressed. There did not seem to be a consistent trend of which emotional expressions were significantly better recognised across various methodologies. This suggests that different methodologies can influence the performance of specific expressions. For performance overall, it was consistent that happy and neutral expressions where accurately recognised. It is surprising as these expressions are without evolutionary advantages. For example, the recognition of negative expressions of anger, fear, and disgust are thought to enhance our survival (e.g., avoiding violent situations and the ingestion of harmful substances; Vaish et al., 2008). Whereas the evolutionary advantages of recognising happy or neutral expressions are under studied. Although, happy being accurately recognised compared to negative expressions is in line with previous research by Leppänen and Hietanen (2004). They suggested the happy advantage could be due to a perceptual expertise, as happy facial expressions are encountered more often than other facial expressions in everyday social interactions. They also suggested a higher-level asymmetry in recognising positive and negative expressions from a tendency to show a positive mood and to form positive attitudes or predictions about others and reality.

There is also a saliency-and-distinctiveness hypothesis (Calvo et al., 2014) suggesting the advantage for recognising happy expressions is due to the smiling mouth involving perceptual saliency (e.g., the smile captures more attention than other expressions) and categorical distinctiveness (e.g., the smile is uniquely associated with happy expressions, whereas there is overlap between other expressions). Along similar lines, the uneven split of positive and negative expressions in the basic six emotions (e.g., 2 positive emotions of happy and surprise, and 4 negative expressions of sad, anger, fear, and disgust) could suggest easier categorisation if interpreted as positive. However, as surprise is frequently misclassified as fear (Chamberland et al., 2017; Zhao et al., 2017; Ruba and Pollak, 2020), it may leave only happiness as the positive expression. Thus, the participant would identify happy expressions due to the valence-specific information rather than emotion-specific information (e.g., identifying the expression as positive rather than specifying happiness), which could boost accuracy. However, if they recognised the expression as negative then they would still have to distinguish which specific expression to categorise it from sad, anger, fear, and disgust. Research has shown that it is difficult to distinguish and perceive distinctions between specific negative expressions (Kashdan et al., 2015). Kashdan et al. (2015) suggested that difficulties differentiating between negative expressions can lead to issues with well-being and emotion regulation, suggesting the importance of being able to accurately recognise the distinct expressions. The other issue would be that, due to the survival advantages, we could be putting ourselves in danger if we cannot distinguish sadness from anger or disgust as we could end up in a potentially dangerous situation which anger and disgust typically connote (Vaish et al., 2008).

The other surprising finding was that neutral expressions frequently showed better accuracy than emotional expressions. This is somewhat in line with partial occlusion research using face masks which reported poorer accuracy for masked faces compared to unmasked faces across all emotional expressions, except neutral expressions (Marini et al., 2021; Noyes et al., 2021). Similarly, Experiment 4a and 4b reported that accuracy for neutral expressions actually improved for masked compared to unmasked faces. Previous research proposed that a neutral advantage could suggest participants are using it as a default button (Frank & Stennett, 2001). However, a neutral advantage was also seen in previous chapters and this possibility was reduced, if not eliminated, by incorporating the additional buttons of 'I don't know' and 'Other', suggesting a genuine advantage for neutral expressions. A limitation of the emotion recognition literature is the exclusion of neutral expressions. This leads to gaps in our knowledge and means it is unclear why we found a recognition advantage for neutral expressions. This suggests future research should include neutral expressions alongside the basic six emotions so we can start to research the gaps surrounding neutral expressions and how our performance differs compared to emotional expressions.

Across all studies, sad and disgust expressions were highlighted as having poor accuracy. As these are negative expressions it is key to recognise them accurately in order to ensure appropriate behaviour. For example, if you are speaking to someone and they express a sad or disgust expression they are clearly unhappy with the conversation. So, by not being able to accurately identify this you cannot appropriately adapt the conversation to avoid any further negative feelings. This may lead to individuals being identified as insensitive or inappropriate. The poorer accuracy may be explained by difficulties distinguishing between distinct negative expressions (Kashdan et al., 2015). Future research needs to explore emotion recognition across various emotions expressed to fully understand how certain expressions may be hindered compared to others to devise methods or interventions to counteract any difficulties and ensure appropriate behaviour.

The final frequent stimulus-based factor explored was intensity of stimuli. Previous emotion recognition research tended to explore one intensity level but in reality we use a variety of expression intensities in conversations. As expected, the more intense the emotional expression was, the higher the accuracy. This is in line with Montirosso et al.'s (2010) findings. Research has also reported that the emotion recognition of facial expressions is driven by perceptual factors, so identifying them is easier when visual saliency increases (Calvo & Nummenmaa, 2011). As strong intensity expressions show more visual saliency than normal intensity expressions, they would have better accuracy as seen in the current findings. This could impact individuals who tend to use more subtle or less intense emotional expressions (e.g., introverted or shy individuals) compared to individuals who express more intense and salient expressions (e.g., extroverted or confident individuals). This could lead to issues with accurate recognition and the typical issues of inappropriate behaviour or difficulties establishing and maintaining relationships (Grossman, 2017). Typically, research explores intensity using morphing techniques from 0% intensity to 100% intensity (Biele & Grabowska, 2006; Chronaki et al., 2015; Green & Guo, 2018; Starita et al., 2018). However, this is not realistic of how we experience emotions in real-world situations so the generalisability may be limited. To improve upon this, the use of updated stimuli, similar to the current research, would greatly improve and contribute to the emotion recognition literature. This gives us a broader and more in-depth view of emotion recognition used in everyday interactions.

The exploration of various stimulus-based factors has contributed to the emotion recognition literature by giving a better understanding of how our emotion performance is impacted across various situations. Typically, research has explored emotion recognition using a static facial expression of one intensity so it tells us little of what stimulus-based factors can influence emotion performance. Therefore, the findings show that emotion recognition performance does differ across multiple factors and there are optimal conditions for accurate recognition. The implications of these findings include exploring ways to improve performance in suboptimal conditions (e.g., unimodal or static conditions, negative expressions, and lower intensity expressions) to ensure appropriate responding and relationship maintenance in everyday interactions (Grossman, 2017).

6.6. Implications of the research

There are both theoretical and practical implications of the current research which could improve our understanding of the relationship between childhood trauma and emotion recognition, as well as provide a guide on how to address the emotion deficits. The theoretical implications of the findings include an update and revision of the models discussing childhood trauma and emotion recognition. The findings reported alexithymia as a key influence on the relationship between childhood trauma and emotion recognition so it would make sense for the model to include all the key factors. Not only this, the social information processing mechanism (Dodge et al., 1995) suggested a variation in performance across emotion expressed, with better accuracy for negative expressions and poorer for positive and neutral expressions. However, the current findings suggested a similar performance across all emotional expressions. This could be due to positive expressions being misinterpreted as more malevolent (Pollak et al., 2000), or because of the inclusion of movement. If it is due to the inclusion of movement it could suggest that previous findings may have been specific to static facial expressions rather than everyday interactions which are dynamic in nature (Alves, 2013). Therefore, the inclusion of alexithymia, as well as the consistent effect of childhood trauma across emotional expressions, would have to be revised in the social information processing mechanism (Dodge et al., 1995).

The more practical implications include using the information regarding alexithymia's influence on the relationship between childhood trauma and emotion recognition to inform interventions. By targeting and focusing on alexithymia traits during an intervention it could in-turn improve and reduce the emotion deficits associated with childhood trauma. Research has also reported the importance and effectiveness of targeting alexithymia traits in therapy to improve outcomes for individuals with childhood trauma experience (Zorzella et al., 2020). Therefore, there could be a similar effectiveness of targeting alexithymia traits for emotion recognition difficulties. However, this has not been put into practice regarding emotion recognition accuracy yet. Possible interventions can also be informed by the findings regarding perceptions as it seems high-level perceptions are significantly impacted by childhood trauma rather than low-level perceptions. Thus, interventions should focus on higher-level perceptions such as the integration of emotion cues or the labelling of emotional expressions to alleviate difficulties. This would in turn improve the establishment and maintenance of social relationships (Grossman, 2017), which as social beings is essential for our mental health and well-being (Helliwell & Putnam, 2004). Ultimately, the findings have provided more in-depth theoretical knowledge of the relationship between childhood trauma and emotion recognition and how it is influenced by alexithymia, as well as suggestions for effective interventions in practice to improve emotion performance.

6.7. Future directions

Although this research has contributed greatly to both the childhood trauma and the emotion recognition literature, there are still areas which are unclear and require further exploration. For example, it is still unclear whether childhood trauma's differing effect across the different chapters is definitely the result of low- and high-level perceptions. Therefore, it would be useful for future research to confirm this and explore various tasks which employ both perceptions (such as tracking eye movements and integrating emotion facial and vocal cues) in the same experiment. This could provide vital information regarding which processes childhood trauma impacts specifically and how to counteract any difficulties. Another process which is unclear is whether childhood trauma is associated with avoidance type behaviours. This would provide insight into the processing and recognition of negative expressions, which are reported to show atypical processing for individuals with childhood trauma experience (McLaughlin et al., 2015). As accurate emotion recognition is linked to appropriate behaviour (Grundmann et al., 2021), it may be useful to provide training to adapt this avoidance to ensure any adverse situations are not exacerbated from inaccurate recognition. Eye tracking research using order of fixations or first fixation would be useful to explore the possible avoidance behaviours.

The current research has extended and improved upon previous methodologies and shown the importance of future research using updated stimuli. Therefore, future research should use similar stimuli to the current research (e.g., including movement across various stimulus-based factors) to enhance the ecological validity and generalisability of the findings to real-world interactions. It would be best to use audio-visual expressions as these are closest to everyday interactions. The findings reported that emotion recognition of facial expressions significantly differs from vocal expressions of emotion. So, any research exploring facial expressions cannot be generalised to vocal expressions. Thus, it would be better if using unimodal stimuli to include both faces and voices to gain a wider understanding of emotion recognition overall. The findings also highlight the importance of controlling for co-morbid individual differences to ensure the main individual differences' unique effect is assessed.

A methodological improvement for future research, which was not employed in the current research, would be the use of a more thorough and detailed measure of childhood trauma experience if the time and resources allow. It was not feasible for the current research but future research would be improved by extra information regarding how recent participant's childhood trauma was, as this can influence the associated emotion deficits (Saarinen et al., 2021), as well as the consistency of the abuse (e.g., was it an isolated event or was it repeated over long period of time). This information would give a better understanding of individual's circumstances and may address the question of whether childhood trauma is multifarious and influences individual's emotion recognition differently depending on their experience. It would also be ideal for research to use a consistent measure of childhood trauma as currently a variety of measures are used (e.g., early adversity, childhood maltreatment, or childhood trauma) which may be influencing the significance of relationships and causing the inconsistencies in the literature.

6.8. Conclusion

This thesis has explored how individual differences (mainly childhood trauma, alexithymia, and psychopathy) influence emotion performance across various measures including where we look on a face to recognise an expression, how we integrate facial and vocal emotion cues, as well as how we label and categorise obscured and unobscured emotional expressions. The research has addressed two key gaps in the literature. The first is regarding childhood trauma's unique effect on emotion recognition, by including and controlling for alexithymia and psychopathy traits. The second is the universality of the relationship between childhood trauma and emotion recognition, by exploring across various modalities, emotions expressed, and intensities. The overall thesis findings suggest that the relationship between childhood trauma and emotion recognition is influenced by alexithymia and psychopathy traits when exploring later processes of emotion recognition (or higher-level perceptions) such as integrating emotion cues or categorising emotional expressions. However, this does not seem to be replicated for earlier processes (or lower-level perceptions) such as where we look on a face. It also suggests that certain environments can hinder emotion recognition in general, such as unimodal conditions, negative emotional expressions (especially sadness and disgust), and less intense expressions. The key findings provide important theoretical implications of informing and updating the current models regarding childhood trauma and emotion recognition to include alexithymia. As well as practical implications of possible interventions to improve the associated emotion deficits through targeting alexithymia traits and high-level perceptions.

In order to improve the current individual differences and emotion recognition literature, future research should continue and extend on the current research by using similar realistic (e.g., moving stimuli) and comprehensive stimuli (e.g., exploring across various conditions). This can provide a deeper and broader understanding of how individuals with childhood trauma are impacted in their social cognition, in particular emotion recognition, in real-world social situations. As childhood trauma is a serious public health issue, with 1 in 5 adults experiencing child abuse and 1 in 10 experiencing neglect (Office for National Statistics, 2020; NSPCC, 2021), the research can have a great impact. The current findings provide important clues regarding where the difficulties exist and give a stepping stone for future research to devise methods to alleviate the emotion recognition deficits. This would allow individuals with experience of childhood trauma to recognise emotions accurately, in-turn helping them to navigate social situations appropriately, and ensure their health and well-being is not impacted by poor establishment and maintenance of relationships (Helliwell & Putnam, 2004; Grossman, 2017) as a result of poor emotion abilities.

7. References

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8. Appendices

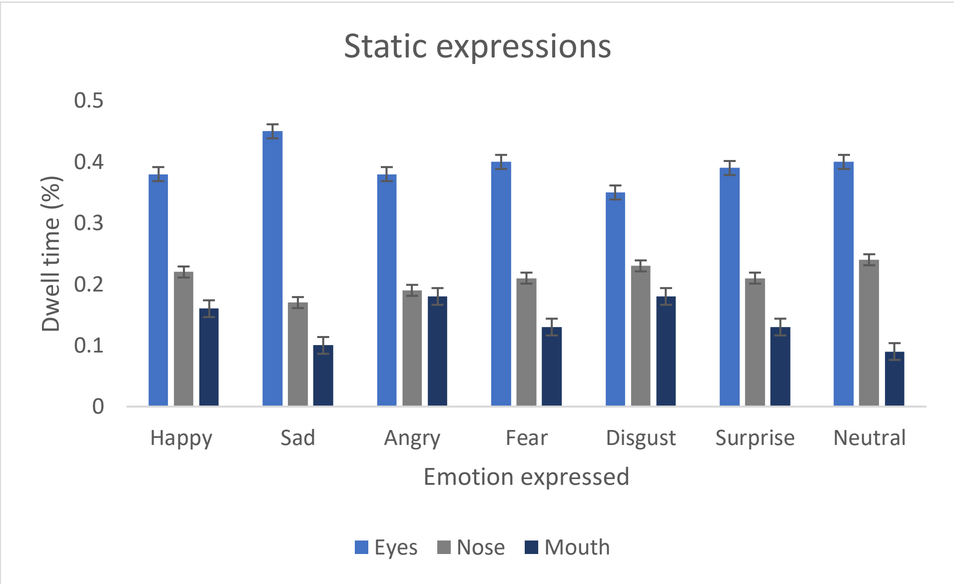
Appendix 1: Dwell time analyses

The average amount of time individuals were looking (dwell time) across modality (static, dynamic, audio-visual), interest areas (eyes, nose, mouth), and emotion expressed (basic six and neutral) are presented in Figure 62.

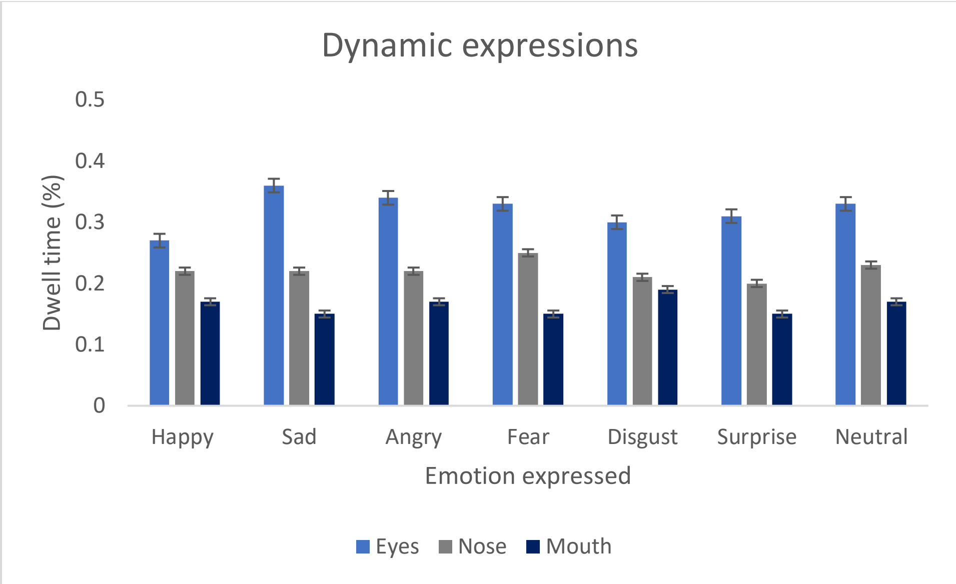
Figure 62

The average dwell time (%) across interest areas and emotion expressed for (a) static expressions, (b) dynamic expressions, and (c) audio-visual expressions.

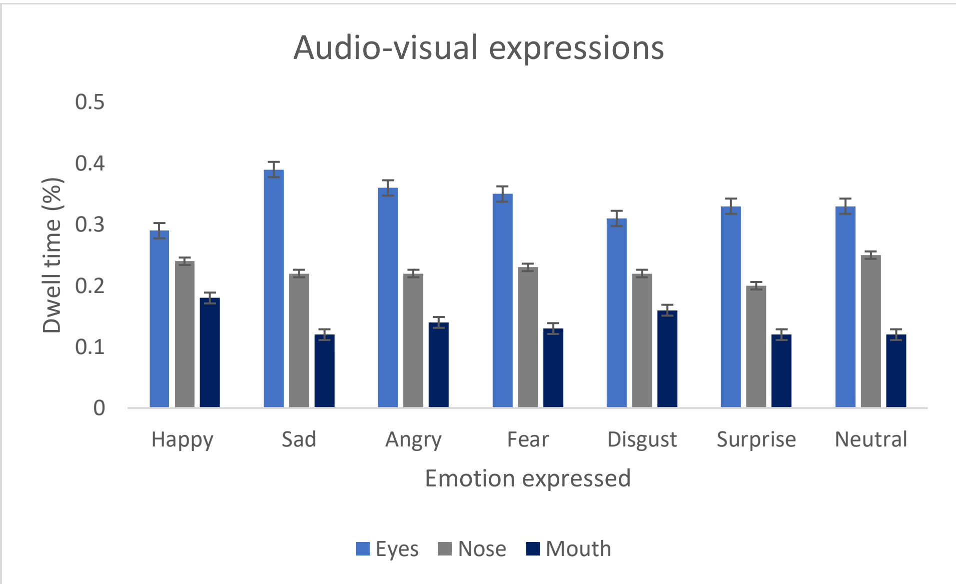
a)



b)



c)



The descriptives for the experimental task variables and the individual differences variables are presented in Table 42.

Table 42

Descriptives table for modality (faces, voices, audio-visual) and emotion expressed (happy, sad, anger, fear, disgust, surprise) displaying the mean and standard deviation of percentage of dwell time. The range of all variables was 1.00 (0.00 – 1.00).

Variables	Mean score	Standard deviation
Emotion Tasks (dwell time)		
Modality:		
Static	0.25	0.24
Dynamic	0.23	0.27
Audio-visual	0.23	0.27
Emotion:		
Happy	0.24	0.25
Sad	0.24	0.27
Anger	0.24	0.26
Fear	0.24	0.26
Disgust	0.24	0.25
Surprise	0.23	0.26
Neutral	0.24	0.27
Intensity:		
Normal	0.24	0.26
Strong	0.24	0.26
Interest areas:		
Eyes	0.35	0.29
Nose	0.22	0.23
Mouth	0.15	0.21

Is childhood trauma alone associated with dwell time?

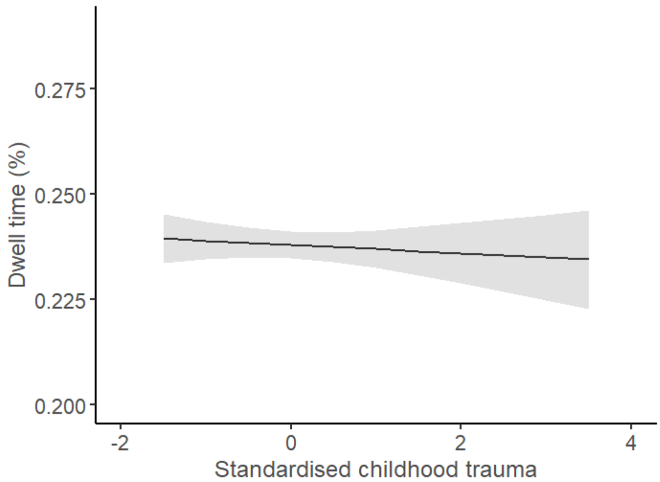
For all models, the random effects were participant and actor.

Does the relationship vary across modality?

A mixed model was employed to explore the effect of childhood trauma on dwell time. The fixed factors were childhood trauma and modality. There was not a significant main effect of childhood trauma, F (1) = 0.11, p = .746, with β = -0.00 and exp(B) = 1.00 (Figure 63). There was a significant main effect of modality, F (2) = 8.06, p < .001, with β = 0.01 and exp(B) = 1.01 for static and β = 0.00 and exp(B) = 1.00 for dynamic expressions compared to audio-visual. Dwell time was significantly higher for static expressions compared to audio-visual expressions, $t = 3.68$, $p < .001$. There was not an overall significant interaction between childhood trauma and modality, F (2) = 2.14, $p = .118$, with β = 0.01 and exp(B) = 1.01 for childhood trauma * static – audio-visual and β = -0.00 and exp(B) = 1.00 for childhood trauma * dynamic – audio-visual. This suggests the effect of childhood trauma on dwell time did not vary significantly across modalities.

Figure 63

The average dwell time (%) for the standardised total score of childhood trauma (derived from the CTQ-SF). The shaded area represents the 95% confidence interval.



Does the relationship vary across emotion expressed?

A mixed model was employed to explore the effect of childhood trauma on dwell time. The fixed factors were childhood trauma and emotion expressed. There was not a significant main effect of childhood trauma, F (1) = 0.07, $p = .789$, with β = −0.00 and exp(B) = 1.00, or emotion, F (6) = 1.69, $p = .120$, with β ranging from -0.01 to 0.00 and exp(B) ranging from 0.99 – 1.00. There was not a significant interaction between childhood trauma and emotion expressed, F (6) = 0.08, $p = .998$, with all interactions having β = -0.00 and exp(B) = 1.00. This suggests the effect of childhood trauma across dwell time did not vary significantly across emotion expressed.

Does the relationship vary across intensity?

A mixed model was employed to explore the effect of childhood trauma on emotion recognition accuracy. The fixed factors were childhood trauma and intensity. There was not a significant effect of childhood trauma, F (1) = 0.11, $p = .746$, with β = −0.00 and exp(B) = 1.00, or intensity, F (1) = 2.35, $p = .125$, with β = 0.00 and exp(B) = 1.00. There was not a significant interaction between childhood trauma and intensity, *F* (1) = 0.00, *p* = .996, with β = −0.00 and exp(B) = 1.00. This suggests the effect of childhood trauma on dwell time did not vary depending on whether the stimuli were normal or strong intensity.

Does the relationship vary across interest area?

A mixed model was employed to explore the effect of childhood trauma on dwell time. The fixed factors were childhood trauma and interest areas. There was not a significant effect of childhood trauma, *F* (1) = 0.11, *p* = .746, with β = −0.00 and exp(B) = 1.00. There was a significant effect of interest area, *F* (2) = 1520.61, *p* < .001, with β = -0.13 and exp(B) = 0.88 for nose and β = -0.20 and exp(B) = 0.82 for mouth compared to eyes. There was also a significant interaction between childhood trauma and interest area, *F* (2) = 162.52, *p* < .001. The effect of childhood trauma significantly differed for nose compared to eyes, *t* = -17.87, *p* < .001, and for mouth compared to eyes, *t* = -10.97, *p* < .001. As childhood trauma experience increased the percentage of dwell time increased for the eyes, where as it decreased for the nose and mouth.

Is childhood trauma associated with dwell time when controlling for alexithymia and psychopathy traits?

For all models, the random effects were participant and actor.

Does the relationship vary across modality?

A mixed model was employed to explore the effect of childhood trauma on dwell time. The fixed factors were childhood trauma and modality and the covariates were alexithymia and psychopathy. There was not a significant main effect of childhood trauma, *F* (1) = 0.53, *p* = .468, alexithymia, *F* (1) = 2.26, *p* = .110, or psychopathy, *F* (1) = 0.65, *p* = .421. However, modality was still significant, *F* (2) =8.06, *p* < .001, with significantly higher dwell time for static expressions compared to audio-visual expressions. There was not a significant interaction between childhood trauma and modality, *F* (2) = 2.14, *p* = .118. This suggests that the effect of childhood trauma on dwell time stays consistent across modality (Figure 64). Fixed effects parameter estimates are presented in Table 43.

Figure 64

Dwell time of the standardised total score for childhood trauma (derived from the CTQ-SF), when controlling for alexithymia and psychopathy traits, across modalities. The shaded area represents the 95% confidence interval.

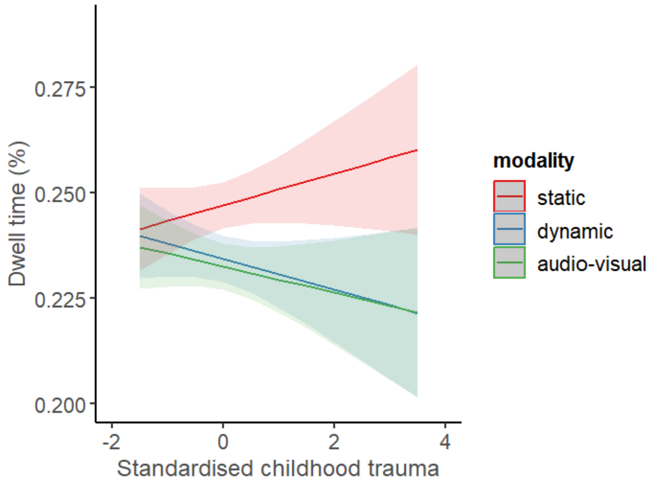


Table 43

The Fixed Effects Parameter Estimates table for dwell time for childhood trauma, modality, alexithymia, and psychopathy.

Fixed effects	**Estimate**	**Standard Error**	**exp(B)**	**95% CI (lower,**	**upper)**	***t***	***p***
Intercept	0.24	0.00	1.27	0.23	0.25	54.81	<**.001***
Childhood trauma	-0.00	0.00	1.00	-0.01	0.00	-0.73	.468
Static (Static – Audio-visual)	0.01	0.00	1.01	0.01	0.00	3.68	<**.001***
Dynamic (Dynamic – Audio-visual)	0.00	0.00	1.00	-0.01	0.02	0.45	.650
Alexithymia	0.01	0.00	1.01	-0.00	0.01	1.62	.110
Psychopathy	-0.00	0.00	1.00	-0.01	0.00	-0.81	.421
Childhood trauma * Static	0.01	0.00	1.01	-0.00	0.01	1.72	.086
Childhood trauma * Dynamic	-0.00	0.00	1.00	-0.01	0.01	-0.14	.886

*** represents significant values (*p* < .05)**

Does the relationship vary across emotion expressed?

A mixed model was employed to explore the effect of childhood trauma on dwell time. The fixed factors were childhood trauma and emotion expressed and the covariates were alexithymia and psychopathy. There was not a significant main effect of childhood trauma, *F* (1) = 0.45, *p* = .504, alexithymia, *F* (1) = 2.62, *p* = .110, or psychopathy, *F* (1) = 0.65, *p* = .421, or emotion expresed, *F* (6) = 1.69, *p* = .120. There was not a significant interaction between childhood trauma and emotion expressed, *F* (6) = 0.08, *p* = .998 (Figure 65). Fixed effects parameter estimates are presented in Table 44.

Figure 65

Average dwell time of a standardised total score for childhood trauma (derived from the CTQ-SF), when controlling for alexithymia and psychopathy traits, across emotion expressed.

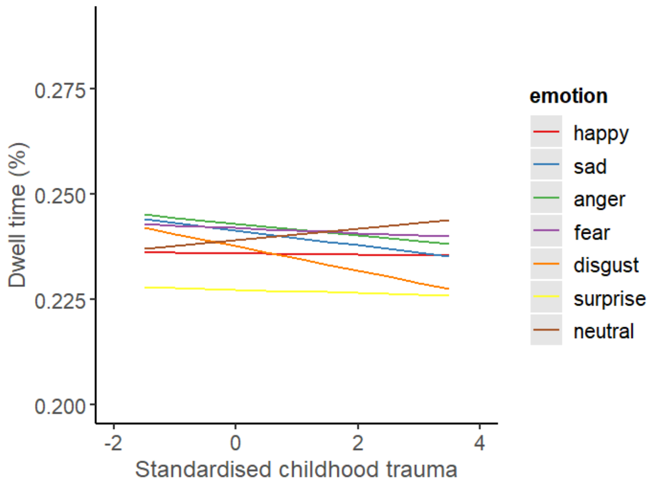


Table 44

The Fixed Effects Parameter Estimates table for dwell time for childhood trauma, emotion expressed, alexithymia, and psychopathy.

Fixed effects	Estimate	Standard Error	exp(B)	95% CI (lower, upper)		*t*	*p*
Intercept	0.24	0.00	1.00	0.23	0.25	54.61	**< .001***
Childhood trauma	-0.00	0.00	1.00	-0.01	0.00	-0.67	0.504
Happy (Happy – Neutral)	-0.00	0.01	1.00	-0.02	0.01	-0.46	0.646
Sad (Sad – Neutral)	0.00	0.01	1.00	-0.01	0.02	0.31	0.757
Angry (Angry – Neutral)	0.00	0.01	1.00	-0.01	0.02	0.54	0.590
Fear (Fear – Neutral)	0.00	0.01	1.00	-0.01	0.02	0.39	0.695
Disgust (Disgust – Neutral)	-0.00	0.01	1.00	-0.02	0.01	-0.21	0.830
Surprise (Surprise – Neutral)	-0.01	0.01	0.99	-0.03	0.00	-1.66	0.097
Alexithymia	0.01	0.00	1.01	0.00	0.01	1.62	0.110
Psychopathy	-0.00	0.00	1.00	-0.01	0.00	-0.81	0.421
Childhood trauma * Happy	-0.00	0.01	1.00	-0.02	0.01	-0.21	0.833
Childhood trauma * Sad	-0.00	0.01	1.00	-0.02	0.01	-0.44	0.662
Childhood trauma * Angry	-0.00	0.01	1.00	-0.02	0.01	-0.39	0.698
Childhood trauma * Fear	-0.00	0.01	1.00	-0.02	0.01	-0.27	0.785
Childhood trauma * Disgust	-0.00	0.01	1.00	-0.02	0.01	-0.59	0.553
Childhood trauma * Surprise	-0.00	0.01	1.00	-0.02	0.01	-0.24	0.807

*** represents significant values (*p* < .05)**

Does the relationship vary across intensity?

A mixed model was employed to explore the effect of childhood trauma on emotion recognition accuracy. The fixed factors were childhood trauma and intensity and the covariates were alexithymia and psychopathy. There was not a significant effect of childhood trauma, F (1) = 0.53, p = .468, alexithymia, F (1) = 2.62, p = .110, psychopathy, F (1) = 0.65, p = .421, or intensity, F (1) = 2.35, p = .125. There was not a significant interaction between childhood trauma and intensity, F (1) = 0.00, p = .996. This suggests the effect of childhood trauma on dwell time did not vary depending on whether the stimuli were normal or strong intensity (Figure 66). Fixed effects parameter estimates are presented in Table 45.

Table 45

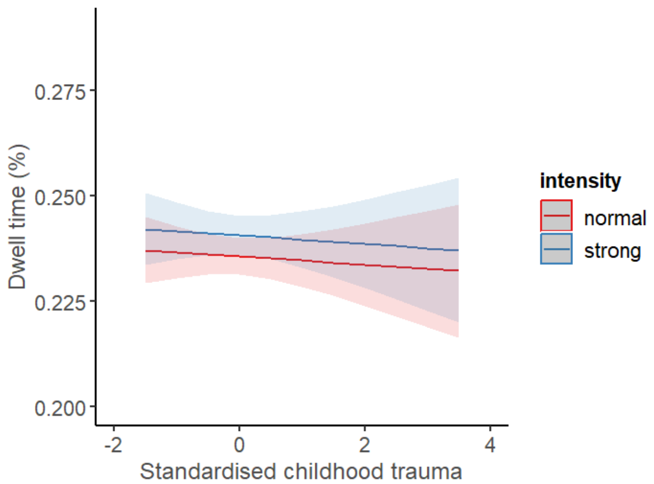
The Fixed Effects Parameter Estimates table for emotion recognition accuracy for childhood trauma, intensity, alexithymia, and psychopathy.

Fixed effects	Estimate	Standard Error	exp(B)	95% CI (lower, upper)		z	*p*
Intercept	0.24	0.00	1.27	0.23	0.25	54.85	**<.001***
Childhood trauma	-0.00	0.00	1.00	-0.01	0.00	-0.73	.468
Intensity (Strong – Normal)	0.00	0.00	1.00	-0.00	0.01	1.53	.125
Alexithymia	0.01	0.00	1.01	-0.00	0.01	1.62	.110
Psychopathy	-0.00	0.00	1.00	-0.01	0.00	-0.81	.421
Childhood trauma * Intensity	-0.00	0.00	1.00	-0.01	0.01	-0.00	.996

*** represents significant values (*p* < .05)**

Figure 66

Average dwell time of a standardised total score for childhood trauma (derived from the CTQ-SF), when controlling for alexithymia and psychopathy traits, across intensity. The shaded area represents the 95% confidence interval.



Does the relationship vary across interest area?

A mixed model was employed to explore the effect of childhood trauma on emotion recognition accuracy. The fixed factors were childhood trauma and interest area and the covariates were alexithymia and psychopathy. There was not a significant effect of childhood trauma, *F* (1) = 0.53, *p* = .468, alexithymia, *F* (1) = 2.62, *p* = .110, or psychopathy, *F* (1) = 0.65, *p* = .421. There was a significant effect of interest area, *F* (1) = 1530.61, *p* < .001, with a higher percentage of dwell time for the eyes compared to the nose and the mouth. There was also a significant interaction between childhood trauma and interest area, *F* (2) = 162.52, *p* < .001. The effect of childhood trauma significantly differed across interest areas; as childhood trauma experience increased the percentage of dwell time increased for the eyes, but decreased for the nose and mouth (Figure 67). Fixed effects parameter estimates are presented in Table 46.

Figure 67

Average dwell time (%) of a standardised total score for childhood trauma (derived from the CTQ-SF), when controlling for alexithymia and psychopathy traits, across interest area. The shaded area represents the 95% confidence interval. The Y axis is different for this graph compared to previous dwell time graphs (previous graph groups were indistinguishable when the current axis was used (0 – 0.5) but the current graph was incomplete with the previous axes (0.2 – 0.28)).

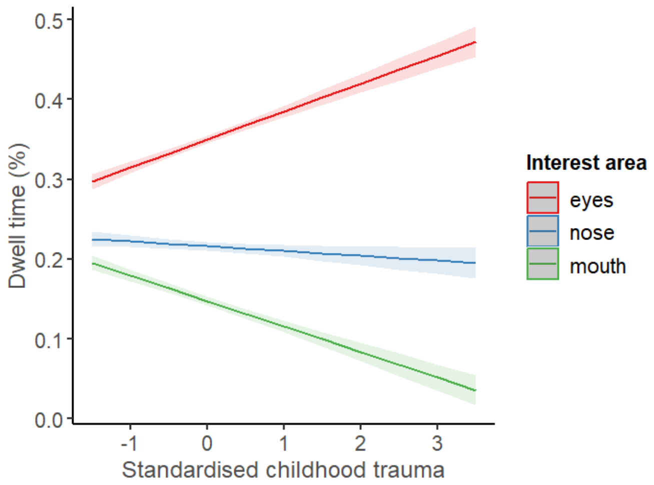


Table 46

The Fixed Effects Parameter Estimates table for emotion recognition accuracy for childhood trauma, interest areas, alexithymia, and psychopathy.

Fixed effects	**Estimate**	**Standard Error**	**exp(B)**	**95% CI (lower, upper)**		***t***	***p***
Intercept	0.24	0.14	1.27	2.17	3.71	7,58	**<.001***
Childhood trauma	-0.00	0.00	1.00	-0.01	0.00	-0.73	.468
Nose (Nose – Eyes)	-0.13	0.00	0.89	-0.14	-0.13	-35.90	**<.001***
Mouth (Mouth – Eyes)	-0.20	0.00	0.82	-0.21	-0.20	-54.41	**<.001***
Alexithymia	0.01	0.00	1.01	-0.00	0.01	1.62	.110
Psychopathy	-0.00	0.00	1.00	-0.01	0.00	-0.81	.421
Childhood trauma * Nose	-0.07	0.00	0.93	-0.07	-0.06	-17.87	**<.001***
Childhood trauma * Mouth	-0.04	0.00	0.96	-0.05	-0.03	-10.97	**<.001***

*** represents significant values (p < .05)**