Mild-to-moderate schizotypal traits relate to physiological arousal from social stress

Preethi Premkumar[1], Prasad Alahakoon[2], Madelaine Smith[1], Veena Kumari[3],

Diviesh Babu[1], Joshua Baker[1]

[1]Department of Psychology, School of Social Sciences, Nottingham Trent University,

Nottingham, UK

[2] Department of Agricultural Extension, Faculty of Agriculture, University of Peradeniya, Sri

Lanka

[3]Centre for Cognitive Neuroscience, College of Life and Health Sciences, Brunel University

London, Uxbridge, UK

Correspondence address

Dr Preethi Premkumar

Department of Psychology

Nottingham Trent University

Tel: +44 (0)115 848 4511

Email: preethi.premkumar@ntu.ac.uk

Abstract

Schizotypy denotes psychosis-like experiences, such as perceptual aberration, magical ideation and social anxiety. Altered physiological arousal from social stress is found in people with high schizotypal traits. Two experiments aimed to determine the relationship of schizotypy to physiological arousal from social stress. Experiment 1 tested the hypotheses that heart rate from social stress would be greater in high, than mild-to-moderate, schizotypal traits, and disorganised schizotypy would explain this effect. Experiment 1 tested social stress in 16 participants with high schizotypal traits and 10 participants with mild-to-moderate schizotypal traits. The social stress test consisted of a public speech and an informal discussion. The high schizotypal group had higher heart rate than the mild-to-moderate schizotypal group during the informal discussion, but not during the public speech. Disorganised schizotypy accounted for this group difference. Experiment 2 tested the hypothesis that mild-to-moderate schizotypal traits would have a linear relationship with physiological arousal from social stress. Experiment 2 tested 24 participants with mild-to-moderate schizotypal traits performing the abovementioned social stress test while their heart rate and skin conductance responses were measured. Mild-to-moderate schizotypal traits had a linear relationship with physiological arousal during the discussion with a stranger. Distress in disorganised schizotypy may explain the heightened arousal from close social interaction in high schizotypy than mild-to-moderate schizotypy. Mild-to-moderate schizotypal traits may have a linear relationship with HR during close social interaction because of difficulty with acclimatising to the social interaction.

Keywords: Heart rate; schizotypy; skin conductance; social stress; physiological arousal; public speech

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Schizophrenia and other psychotic disorders are often characterised by hearing threatening voices and having beliefs that others are going to harm them (American Psychiatric Association, 2013). Schizophrenia has more severe psychopathology and a poorer rate of remission than other psychotic disorders (Harrow, Sands, Silverstein, & Goldberg, 1997). These psychosis-like experiences occur at a subclinical level, referred to as schizotypy. Schizotypy is a latent personality organisation that reflects psychosis-like experiences at a sub-clinical level and a putative liability for these schizophrenia-spectrum disorders and the psychoses (Grant, Green, & Mason, 2018; Fonseca-Pedrero, et al., 2018). Schizotypy is a multidimensional construct that consists of a cluster of personality traits that feature both normal and aberrant variations of psychosis-proneness (Cohen, Mohr, Ettinger, Chan, & Park, 2015; Oezgen & Grant, 2018). Schizotypy consists of three main dimensions, namely positive, negative and disorganised, and a fourth possible dimension, namely eccentricity (Oezgen & Grant, 2018). Positive schizotypy consists of perceptual aberrations, paranormal experiences and spiritual and magical beliefs. Negative schizotypy consists of social anhedonia and emotional withdrawal. Disorganised schizotypy refers to cognitive slippage and loosening of association (Mason, Claridge, & Jackson, 1995; Fonseca-Pedrero, Ortuño-Sierra, De Álbeniz, & Cohen, 2017; Meehl, 1962). The eccentric dimension is characterised by odd behaviour, odd speech and impulsive non-conformity (Oezgen & Grant, 2018). These schizotypal traits are common in the British population, where 75% of a representative sample (n=1,000) has encountered a paranormal experience (Pechey & Halligan, 2012). The incidence of such positive schizotypal traits in the general population is 100 times higher than that of schizophrenia (Hanssen, Bak, Bijl, & Vollebergh, 2005). Whether schizotypal

traits decompensate to schizophrenia-liability or psychosis-proneness depends on the prominence of the positive schizotypal traits (Schultze-Lutter, Nenadic, & Grant, 2019).

Disorganised schizotypy includes social anxiety (Mason, Claridge, & Jackson, 1995) and poor verbal fluency (Tan & Rossell, 2017). Disorganised schizotypy is also considered to be an analogue of thought disorder in psychosis (Rossell, Chong, O'Connor, & Gleeson, 2014). Thought disorder features illogical thinking, loose association and peculiar language (Grant & Beck, 2009), as well as communication deviance within the family (Tompson, Asarnow, Hamilton, Newell, & Goldstein, 1997). Disorganised schizotypy and thought disorder being related to elements of social anxiety, such as sensitivity to social rejection (Grant & Beck, 2009; Premkumar, Onwumere, Betts, Kibowski, & Kuipers, 2018), could make those with a high level of disorganised schizotypal traits inherently perceive casual social encounters as stressful.

Vulnerability to social stress along the psychosis continuum

Physiological arousal from stress is a multisensory response aimed at restoring the body's homeostasis (Day T. , 2005). Stress is characterised by nervousness, becoming upset, overreacting easily and/or having difficulty relaxing (Lovibond & Lovibond, 1995). To experience social stress, one must believe that their social surroundings are taxing, exceed their resources to manage them and/or endanger their well-being (Lazarus & Folkman, 1984). During stress, the hypothalamic-pituitary-adrenal axis stimulates the secretion of epinephrine and norepinephrine from the adrenal medulla (Naughton, Dinan, & Scott, 2014; Carlson & Birkett, Physiology of Behaviour, 2017, pp. 98-100) (Figure 1a). Secretion of epinephrine and norepinephrine increases blood flow to the cardiac muscles, and increases heart rate (HR) and cortisol release from the adrenal cortex. Separate from the hypothalamic-pituitary-adrenal axis, stress activates the sympathetic branch of

the vegetative nervous system, also known as the autonomous nervous system but no longer regarded autonomous because of the partial regulatory control of this nervous system (Rasia-Filho, 2006). Activating the sympathetic branch of the vegetative nervous system increases HR and the skin conductance response (SCR), and increases cortisol release from the adrenal cortex upon stimulating the secretion of epinephrine and norepinephrine from the adrenal medulla (Carlson & Birkett, Physiology of Behaviour, 2017, pp. 98-100) (Figure 1b). SCR occurs when sympathetic preganglionic neurons within the vegetative nervous system transmit impulses across synapses to the sympathetic postganglionic neurons in the sweat glands and results in secretion of acetylcholine within the sweat glands (Carlson, 2001).

The change in HR, SCR and cortisol level due to stress can be tested *in vitro* by the Trier Social Stress Test (TSST) (Kirschbaum, Pirke, & Hellhammer, 1993). The TSST is a public-speaking task and an ecologically valid measure of daily social stress (Kirschbaum, Pirke, & Hellhammer, 1993). The standard TSST consists of a 30-minute baseline resting phase, followed by a three-minute anticipatory phase to prepare a speech on the participant's suitability for a job, delivering a short public speech in front of a small audience for five minutes, performing a mental arithmetic test for five minutes, and lastly a 60-minute recovery phase (Allen, Kennedy, Cryan, Dinan, & Clarke, 2014). The long baseline and recovery phases allow for samples of plasma cortisol to be obtained whilst hypothalamic-pituitary-adrenal axis activity normalises (Allen, Kennedy, Cryan, Dinan, & Clarke, 2014). Higher HR and cortisol release during the public speech than the mental arithmetic task (Kirschbaum, Pirke, & Hellhammer, 1993) suggests that the public speech is more stressful than the arithmetic task.

Social stress often precedes the onset of psychosis (Lange, et al., 2017). The stress diathesis model posits that psychosis arises from stressors, including prolonged unpleasant social interaction.

These stressors interact with a pre-existing vulnerability for psychosis and increase the likelihood of the onset of psychosis (Nuechterlein & Dawson, 1984). There is evidence for both elevated and diminished basal cortisol levels in psychosis (Bradley & Dinan, 2010), and elevated basal cortisol levels in high schizotypy (Walter, Fernandez, Snelling, & Barkus, 2018). Elevated cortisol at baseline may indicate that individuals with schizotypal traits have a hyper-aroused stress response system by default. Sustained daily stress could disrupt cortisol secretion in psychosis. Against this backdrop of altered basal cortisol level, patients with psychosis have a blunted cortisol response to the TSST at both the anticipatory stage and the post-speech stage (Ciufolini, Dazzan, Kempton, Pariante, & Mondelli, 2014). Individuals with high schizotypal traits and those at risk for psychosis have been shown to have diminished cortisol release in the post-speech phase of the TSST (Walter, Fernandez, Snelling, & Barkus, 2018; Pruessner, Béchard-Evans, Boekestyn, & Iyer, 2013). Diminished cortisol release following the public speech could imply an attenuated endocrine response to an already over-exerted hypothalamic-pituitary-adrenal axis due to chronic arousal from daily stressors and/or slow recovery after the stressful event has passed (Collip, et al., 2013; Walter, Fernandez, Snelling, & Barkus, 2018). The change in cortisol level due to daily stress differs according to the type of at-risk group. Lower cortisol during the TSST relates to higher daily stress in individuals at risk for psychosis (Pruessner, Béchard-Evans, Boekestyn, & Iyer, 2013). Higher cortisol from daily stress relates to greater momentary psychosis-like experiences in siblings of patients with psychosis (Collip, et al., 2011a).

HR is another measure of physiological arousal. Evidence suggests increased HR under social stress along the psychosis continuum. Increased HR during the TSST is greater-than-normal in patients with psychosis (Lange, et al., 2017). However, the increased HR during the TSST seen in individuals at risk for psychosis is comparable to that of healthy individuals (Pruessner,

Béchard-Evans, Boekestyn, & Iyer, 2013). People at risk for psychosis have greater HR than health controls after listening to criticism (Weintraub, et al., 2019), suggesting that elevated HR depends on the social context in at-risk individuals. No study to our knowledge has measured HR in people with schizotypal traits during social stress. Walter and colleagues (2018) did not measure HR or SCR during the TSST in individuals with high schizotypal traits. When experiencing other forms of threat, such as imagining alien abductionl people with high schizotypal traits elicit greater-than-normal HR and SCR (Mcnally, et al., 2004). Greater positive schizotypy relates to greater HR while viewing aversive pictures and films (Karcher & Glenn, 2012; Phillips & Seidman, 2008). People with high schizotypal traits and at-risk mental states may have elevated HR from perceiving social threat when imagining paranormal scenes, viewing aversive scenes and listening to criticism.

An inverted U-shaped model of stress (Sapolsky, 2015; Yerkes & Dodson, 1998) could explain the conflicting evidence of increased and decreased physiological arousal from social stress in schizotypy and at-risk mental states. An inverted U-shaped relationship exists between HR when performing a task under observation and social anxiety (Pujol, et al., 2013). Increased HR during social stress, i.e. performing a task under observation, is seen in people with low social anxiety, but decreased HR is seen in patients with social anxiety disorder (Pujol, et al., 2013). This finding suggests that persistent stress could diminish physiological arousal from social stress in high social anxiety. A similar association may be found in schizotypy because social anxiety and neuroticism contributes to the distress in high schizotypal traits (Premkumar, et al., 2015). Neuroticism is the preoccupation with negative emotions. Neuroticism in disorganised schizotypy relates to the blunted cortisol response during the TSST (Grant & Hennig, 2018). Thus, elevated anxiety in high schizotypy could diminish physiological arousal from social stress. By studying

individuals at different strata of schizotypal traits, the experiments conducted in the current study sought to test the U-shaped association between HR during social stress and schizotypy.

The different conditions under which social stress is measured could confound evidence of altered physiological arousal from social stress. The cortisol level was blunted in individuals with high schizotypy and at-risk mental states when the social stress was tested *in vitro* (Walter, Fernandez, Snelling, & Barkus, 2018; Pruessner, Béchard-Evans, Boekestyn, & Iyer, 2013). Yet, cortisol levels were elevated in genetically at-risk individuals when daily social stress was assessed *in vivo* (Collip, et al., 2011a). Stress induction may be greater *in vitro* than *in vivo*. An informal discussion administered *in vitro* might mimic daily social stress that elevates cortisol levels in at-risk individuals (Collip, et al., 2011a). Hence, physiological arousal from interpersonal interaction might be different from a public speech which is a performance-based social situation.

People with high schizotypal traits could experience more stress in close interpersonal interaction than public-speaking situations because of their paranoia in interpersonal situations (Horton, Barrantes-Vidal, Silvia, & Kwapil, 2014). Paranoia constitutes suspiciousness, perceived hostility and blaming others in ambiguous social situations, having less social engagement and more social problems (Combs, Finn, Wohlfahrt, Penn, & Basso, 2013). Individuals with a moderate level of paranoia are more alert to social threat from strangers and exhibit more momentary paranoia than those with a low level of paranoia (Collip, et al., 2011b). High paranoia in adolescents with social anxiety disorder would further suggest that paranoia is a part of social anxiety (Pisano, et al., 2016). People with high schizotypal traits are more anxious in interpersonal situations than people with depression-like tendencies (Miller & Lenzenweger, 2012). Hence, interpersonal sensitivity could be a hallmark of schizotypy.

Distress from disorganised schizotypy could explain the link between positive schizotypy and social stress because distress is more pronounced in disorganised schizotypy than positive schizotypy. Disorganised schizotypy includes social anxiety and has stronger correlations with sensitivity to rejection, criticism and praise than other schizotypal traits (Premkumar, Onwumere, Betts, Kibowski, & Kuipers, 2018; Premkumar, Dunn, Onwumere, & Kuipers, 2019). Furthermore, anxiety in schizotypy rather than 'benign/happy schizotypy' *per se* could relate to physiological arousal from social stress (Grant, Green, & Mason, 2018). Benign positive schizotypy, such as magical ideation, can be a positive experience, but not distressing (Grant & Hennig, 2019; Fumero, Marrero, & Fonseca-Pedrero, 2018). Disorganised schizotypy due to being overwhelmed, nervous or confused could explain the emergence of psychosis-like experiences when performing the TSST over and above positive and negative schizotypy (Grant & Hennig, 2019). Hence, the study sought to test the assumption that HR during social stress would be more strongly associated with anxiety in schizotypy, rather than benign schizotypy.

To summarise, the psychosis continuum is characterised by altered physiological arousal to social stress, namely blunted cortisol levels on the one hand but heightened HR on the other. Ambiguity about the direction of the relationship between schizotypal traits and physiological arousal from social stress could arises from social anxiety (Pujol, et al., 2013) having a non-linear relationship with physiological arousal during social stress, and (2) the type of social stressor being administered, namely performance-related or interpersonal. The aims of the following experiments were (1) to determine the relation of schizotypy to physiological arousal from social stress, (2) to determine whether this relationship differs according to the type of social stressor, namely public-speaking which is a performance-related social situation, and a discussion which is an

interpersonal social situation, and (3) to distinguish between the positive and disorganised schizotypal traits in their relationship with physiological arousal from social stress.

*** Insert Figure 1 about here ***

Experiment 1

The main aim of the first experiment was to examine physiological arousal from social stress in schizotypy. It was hypothesised that,

1. People with high positive schizotypal traits would have greater HR than people with mild-to-moderate positive schizotypal traits during a close interpersonal interaction, namely an informal discussion,

2. Disorganised schizotypy would account for greater HR during an informal discussion in high positive schizotypy than mild-to-moderate positive schizotypy because disorganised schizotypy constitutes social anxiety (Mason, Claridge, & Jackson, 1995; Oezgen & Grant, 2018), and

3. Overall schizotypy would have a non-linear positive relationship with HR during an informal discussion, such that mild-to-moderate schizotypal traits would have a positive relationship with physiological arousal and high schizotypal traits would have a weak relationship with physiological arousal. Evidence suggests a non-linear relationship of social anxiety with HR during social stress (Pujol et al., 2013). We hypothesised a relationship between overall schizotypy, not positive schizotypy, and HR during an informal discussion because an overall schizotypal index captures social anxiety and distress from positive schizotypal traits better than either the positive or disorganised subscales alone.

Testing the validity of an informal discussion as a control task

The second aim was to determine if an informal discussion is a valid control task for the public speech task. A control task must match the experimental task in terms of social context, unpredictability and challenge (Dickerson & Kemeny, 2004). An informal discussion is like a free speech which is a non-evaluative speaking task that matches a public speech in the level of social exposure and unpredictability (Het, Rohleder, Schoofs, Kirschbaum, & Wolf, 2009). An informal discussion is also like a social problem-solving task, such as solving an interpersonal problem or an informal discussion. A social problem-solving task is a standard social assessment and a good control task for public speaking because it matches public speaking in the level of social context, unpredictability and challenge (Horan & Blanchard, 2003; Bellack, Sayers, Mueser, & Bennett, 1994).

Change in mood and physiological arousal are good measures of the successful manipulation of stress. Change in mood can assess the ecological validity of the TSST because it relates to the change in mood following an actual oral exam (Henze, et al., 2017). Furthermore, social interactions alter mood and physiological arousal (Horan & Blanchard, 2003; Henze, et al., 2017). A control task is valid if it elicits less negative mood and greater positive mood and less physiological arousal than the experimental task (Giles, Mahoney, Brunyé, Taylor, & Kanarek, 2014). Hence, mood change and physiological arousal are valid means of testing the effectiveness of an emotional manipulation. It was hypothesised that:

4. Physiological arousal will be higher during a public speech than an informal discussion, and

5. Positive mood would be lower, but negative mood would be greater during a public speech than a discussion.

Method

Participants

Twenty-six participants (mean age = 25.8, S.D. = 6.2, 16 females) took part in the experiment. Participants were aged between 18 and 60 years and did not have a current diagnosis of psychosis. Participants were recruited by advertising the experiment on social networking websites for people with spiritual or paranormal beliefs, on the psychology department website in return for research credits and at a wellbeing event that offered psychic communication and spiritual remedies. It is thought that people with alternative spiritual beliefs score highly on schizotypal traits (Day & Peters, 1999). Eleven participants with high positive schizotypal traits were recruited from the well-being event and scored one S.D. above the mean score of a normative sample on O-LIFE-Unusual Experiences (Mason & Claridge, 2006). Sixteen participants were psychometrically defined as having high positive schizotypal traits by scoring ≥ 15 on the Unusual Experiences subscale of the O-LIFE, which represents the 75th percentile of the subscale (Mason & Claridge, 2006). Participants scoring <15 (n=10) were classified as having mild to moderate positive schizotypal traits. Scores on the O-LIFE-Unusual Experiences subscale ranged from 16-29 in the high schizotypal group and from 0-12 in the mild-to-moderate schizotypal group. Participants provided informed consent before the experiment began. The experiment was approved by the University's School of Social Sciences Research Ethics Committee.

Assessments

O-LIFE (Mason & Claridge, 2006; Mason, Claridge, & Jackson, New scales for the assessment of schizotypy, 1995): The O-LIFE has 104 questions to which participants answer 'Yes' or 'No'. The scale measures Unusual Experiences (positive schizotypy), Introvertive Anhedonia

(negative schizotypy due to solitude and lack of enjoyment from general activity), Cognitive Disorganisation (social anxiety and difficulty focusing attention) and Impulsive Nonconformity (reckless behaviour). The internal reliability of these subscales ranges from acceptable to good in the current sample according to Cronbach's alpha (α), with scores 0.88, 0.86, 0.74 and 0.69 on reliability, respectively.

Positive and Negative Affect Schedule (PANAS) (Watson, Clark, & Tellegen, 1988): The PANAS was administered to measure the change in mood during the social stress test and to test whether the informal discussion would be a valid control task for the public speech. Ten positive mood descriptors denote a state of high energy and pleasurable engagement. Ten negative mood descriptors denote aversive mood. Participants indicated how much they felt about each descriptor at that moment on a five-point Likert scale. The positive and negative subscales have good internal reliability in the current sample, namely 0.94 and 0.86, respectively.

Social stress test

Speech: Participants were asked to deliver a two-minute speech in front of an audience of two members. Participants spoke about their favourite subject in school and had five minutes to prepare and make notes beforehand. Participants were asked to stand while delivering the speech. The panel gave no emotional or verbal feedback during the speech and maintained a neutral expression to minimize external cues that may affect the participant's performance.

Informal discussion: Participants were asked to engage in a three-minute informal discussion with the two-member audience. Participants spoke about their favourite hobby and had five minutes to prepare beforehand. The panel members engaged in the discussion by asking

questions and sharing their thoughts about the participant's hobbies. Participants remained seated during the discussion.

HR measurement

HR was recorded from a Biosemi Active Two electroencephalography amplifier and three Ag/AgCl electrodes. An Ag/AgCl electrode was placed close to the heart and two Ag/AgCl electrodes (reference electrodes) were placed one inch apart on the neck. HR was measured as the peak-to-peak intervals of the heartbeat and calculated as the average number of heart beats per minute (Weintraub, et al., 2019). Heartrate was averaged over 30-second epochs, resulting in four speech epochs and six discussion epochs (Owens & Beidel, 2015).

Procedure

The experiment was approved by the University's School of Social Sciences research ethics committee. Participants who met the screening criterion for schizotypy were invited to take part in the social stress test. Participants gave informed consent before the social stress test began and HR was monitored. The PANAS was administered before and after the public speech and the informal discussion.

Statistical analyses

Analyses of variance (ANOVAs) compared the group with high schizotypal traits and the group with mild-to-moderate schizotypal traits on age and O-LIFE scores. ANOVAs on HR during the social stress test tested the first hypothesis. To test the second hypothesis, these ANOVAs were repeated on the standardised residual of the HR variable obtained from regressing Cognitive

Disorganisation on each HR variable. To test the third hypothesis, logarithmic and linear regressions were performed between positive schizotypy and HR during the six epochs of the discussion. Analyses were performed in SPSS, version 24. One-tailed tests were performed due to the directional nature of the hypotheses.

HR data and PANAS data were combined from experiment 1 (n = 26) and experiment 2 (n = 24) to test the fourth and fifth hypotheses. ANOVA was performed with task type (speech and discussion) and time (first 4 epochs, 0-30 s, 31-60 s, 61-90 s and 91-120 s) as the independent variables and HR the dependent variables. Skin conductance response (SCR) was measured in addition to HR in Experiment 2 (see Experiment 2, Methods). Hence, the ANOVA with task and time as independent variables was repeated with SCR as the dependent variable in Experiment 2. ANOVAs were performed with time (baseline, post-speech and post-discussion) as the independent variable and positive mood and negative mood as the dependent variables to test the fifth hypothesis. The Greenhouse-Geisser correction was applied when the sphericity assumption was violated. Analyses were performed in SPSS, version 24.

Results

Group comparisons of demographic characteristics, schizotypy and HR during the social stress test

The high positive schizotypal group had higher overall schizotypal traits, Unusual Experiences, Cognitive Disorganisation and Impulsive Non-conformity than the mild-to-moderate positive schizotypal group (Table 1). The high positive schizotypal group had significantly higher HR at each epoch from 31 s to 180 s of the discussion than the mild-to-moderate positive

schizotypal group. The group difference remained significant after covarying for Cognitive Disorganisation at 61-90 s, $F_{(1, 24)}=3.14$, $p=0.044$ and at 121-150 s, $F_{(1, 24)}=3.93$, $p=0.029$. The group differences were no longer significant after covarying for Cognitive Disorganisation at 31-90s, $F_{(1, 24)}=2.31$, $p=0.07$; at 91-120 s, $F_{(1, 24)}=2.93$, $p=0.05$; and at 151-180 s, $F_{(1, 24)}=2.70$, $p=0.057$.

Relation between schizotypal traits and HR during the discussion

At 91-120 s of the discussion, the logarithmic regression between total schizotypal traits and HR was statistically significant, $R=0.36$, $R^2=0.13$, $F_{(1,25)}=3.51$, $p=0.036$. At 151-180 s of the discussion, the logarithmic regression between total schizotypal traits and HR was statistically significant, $R=0.35$, $R^2=0.12$, $F_{(1, 25)}=3.35$, $p=0.040$ (Figure 2).

*** Insert Table 1 and Figure 2 about here ***

Differences in physiological arousal and mood between the public speech and informal discussion

Heart rate: An ANOVA was performed with task (speech vs. discussion) and time as within-subject factors and HR as the dependent variable. The task-by-time interaction was not significant, $F_{(3, 144)}=1.31$, $p=0.276$, $\eta^2=03$. The main effect of task was statistically significant, $F_{(1, 48)}=10.54$, $p=0.002$, $\eta^2=0.15$, which indicated higher HR during the speech than the discussion (Figure 3a). There was a main effect of time, $F_{(1.7, 129.9)}=19.4$, $p<0.001$, $\eta^2=0.251$. Separate ANOVAs for each task revealed that HR changed during the discussion (6 epochs), $F_{(3.4, 45)}=4.046$, $p=0.006$, $\eta^2=0.08$, but not the speech, $F_{(2.5, 120.1)}=1.5$, $p=0.223$, $\eta^2=0.03$. *Post hoc*

Bonferroni-corrected pairwise comparisons revealed higher HR at 0-30 s of the discussion than at 31-60 s, t=3.14, p=0.021, Cohen's d=0.44, and 121-150 s, t=3.81, p=0.003, Cohen's d=0.54. No differences between time were observed during the speech.

Skin conductance: An ANOVA with task (speech vs. discussion) and time as within-subject factors and SCR as the dependent variable revealed a task-by-time interaction, F (3, 69)=5.51, p=0.002, η^2=0.19 (Figure 3b). In addition, the main effect of task was statistically significant, F (1, 69)=11.22, p=0.003, η^2=0.3, indicating higher SCR during the speech than the discussion. The main effect of time was not significant, F (1.1, 46.9)=2.32, p=0.139, η^2=0.09. To test the task-by-time interaction further, separate ANOVAs were performed with time as the independent variable and SCR during the speech and discussion as the dependent variables. The ANOVA with speech as the dependent variable was significant, F (1.1, 26.3)=9.99, p=0.003, η^2=0.3. *Post hoc* Bonferroni-corrected pairwise comparisons revealed change in SCR over time during the speech, with greater SCR at 0-30 s than at 31-60 s, t (23)=3.18, p=0.025, Cohen's d=0.65; 61-90 s, t (23)=3.37, p=0.016, Cohen's d=0.69; and 91-120 s, t (23)=3.16, p=0.03, Cohen's d=0.64. SCR was greater at 31-60 s than at 61-90 s, t (23)=3.08, p=0.032, Cohen's d=0.63. In addition, the ANOVA with discussion as the dependent variable was significant, F (2.2, 51.6)=5.30, p=0.006, η^2=0.19. SCR was greater at 0-30 s than at 121-150 s, t=3.26, p=0.051, Cohen's d=0.67.

Positive mood changed over time (baseline, post-speech and post-discussion), F (2, 98)=8.63, p<0.001, η^2=0.15 (Figure 3c). *Post hoc* Bonferroni-corrected pairwise comparisons revealed lower positive mood during the speech than the discussion, t (49)=-3.15, p=0.008, Cohen's d=0.45; and at baseline than the discussion, t (49)=-3.68, p=0.002, Cohen's d=0.52. Negative mood also changed over time, F (2, 98)=15.7, p <0.001, η^2=0.24. *Post hoc* Bonferroni-corrected pairwise comparisons revealed greater negative mood during the speech than the

discussion, t (49)=5.37, p<0.001, Cohen's d=0.759, and at baseline than the discussion, t (49)=4.5, p<0.001, Cohen's d=0.64.

*** Insert Figure 3 about here ***

Discussion

The first experiment tested the hypotheses that (1) physiological arousal would be higher between people with high and mild-to-moderate positive schizotypal traits during a social stress test, (2) disorganised schizotypy would account for the group differences in HR during an informal discussion, and (3) the relation of schizotypy to physiological arousal from social stress would be non-linear. The first hypothesis was supported. As hypothesised, HR was higher in the group with high schizotypal traits than the group with mild-to-moderate schizotypal traits during 31 s to 150 s of the discussion. This relationship was absent from the public speaking stage of the social stress test. Hence, schizotypy may affect social stress in close social interaction more than performance situations. Social interactions, such as delivering a public speech, have anticipation (the minute before the interaction), confrontation (first minute) and adaptation stages (last minute) (Sawyer & Behnke, 2002). Having higher HR during the discussion in the group with high schizotypal traits would suggest that people with high schizotypal traits have difficulty acclimatising to a close interaction with strangers. People with high schizotypal traits may continue to feel nervous and have difficulty relaxing when interacting with strangers. Individuals at a high risk of psychosis have increased HR following criticism from a stranger which constitutes communication in an interpersonal situation (Weintraub, et al., 2019). Being sensitized to criticism and rejection, people

with high schizotypal traits may anticipate more social threat than normal in interpersonal interaction situations (Premkumar, Dunn, Onwumere, & Kuipers, 2019; Premkumar, Onwumere, Betts, Kibowski, & Kuipers, 2018). People with high positive schizotypal traits may have also found the informal nature of the discussion particularly stressful because of their propensity for anomalous experiences and paranoia during daily social interactions (Horton, Barrantes-Vidal, Silvia, & Kwapil, 2014). The topic for the informal discussion was one's favourite hobbies which is more informal than the topic of one's favourite subject in school for the public speech. The personal nature of the discussion could have provoked anxiety. The finding concerning the second hypothesis supports this view. As hypothesised, disorganised schizotypy fully accounted for differences in HR between the high and mild-to-moderate positive schizotypal groups at early and late stages of the informal discussion. This finding supports the view that disorganized schizotypy accounts for the distress in positive schizotypy (Grant & Hennig, 2019). Engaging in a discussion with a stranger may require more cognitive control than just "giving a prepared speech", as holding a discussion involves following a conversation and interacting with others. Thus, the informal discussion may have emphasised the cognitive difficulties found in disorganised schizotypy.

The third hypothesis was supported. There was a non-linear relationship between schizotypy and HR during the middle-to-late stages of the discussion. An inverted U-shaped pattern of physiological arousal from stress is also seen in social anxiety, extraversion and neuroticism (Burkhard & Wolfgang, 1992; Sapolsky, 2015; Werre, 1987; Pujol, et al., 2013). Physiological arousal during an informal discussion with strangers may co-vary linearly with mild-to-moderate schizotypal traits but reach a plateau at a high level of schizotypal traits owing to emotional dysregulation during close social interaction at a high level of schizotypal traits (Collip, et al., 2013). A larger sample of n=25 of people with mild-to-moderate schizotypal traits would

have 80% power to test a linear relation between mild-to-moderate schizotypal traits and HR during a discussion.

Differences in HR, SCR and mood changes between the speech and informal discussion

As hypothesised, the levels of HR and SCR were higher during the public speech than the informal discussion. Furthermore, HR and SCR were higher at the confrontation stage (0-30 s) than at the adaptation stage (121-150 s) of the discussion task. HR is highest at the confrontation stage of social situations because people habituate to the social stressor following sensitization (Sawyer & Behnke, 2002). The higher physiological arousal during the public speech than the discussion and the habituation to the discussion over time signature would suggest that the discussion is a suitable control task. SCR was also higher at the start of the speech than at later stages. Positive mood was lower, but negative mood was higher after the public speech than after the discussion, which was as hypothesised. These results suggest that an informal discussion is a suitable control task for the speech task. As a control task, the discussion elicited less physiological arousal and change in mood than the experimental task (Giles, Mahoney, Brunyé, Taylor, & Kanarek, 2014). Future testing should counterbalance the task order to account for differences in task difficulty. It is possible that any difference in response between the two paradigms may be due to participants receiving verbal and non-verbal feedback (which is potentially rewarding) during the informal discussion. Although the panel maintained a neutral stance, the reciprocal nature of the discussion might have contributed towards improvement in mood during the informal discussion.

Experiment 2

Evidence from multiple measures of physiological arousal can strengthen the validity of finding a relationship between schizotypy and social stress. SCR is another sensitive measure of physiological arousal besides HR (Coren & Bill Mah, 1993; Rozenman, Vreeland, & Piacentini, 2017). Emotional arousal tasks elicit heightened SCR across the psychosis continuum (Kring & Moran, 2008). Having a high level of positive schizotypal traits coincides with having greater SCR when watching aversive pictures (Ragsdale, Mitchell, Cassisi, & Bedwell, 2013) and hearing innocuous acoustic tones (Allen, Freeman, & McGuire, 2007). Hence, the second experiment measured SCR and HR in response to social stress.

Experiment 1 found that disorganised schizotypy explained the difference in physiological arousal between high and mild-to-moderate positive schizotypal groups. This experiment aimed to explore this relationship further. Disorganised schizotypy comprises distress because it includes items about neuroticism when it is measured by the O-LIFE Cognitive Disorganisation. Items about neuroticism within O-LIFE Cognitive Disorganisation explain the relationship between disorganised schizotypy and a blunted cortisol response to the TSST (Grant & Hennig, 2018). This finding suggests that distress in disorganised schizotypy relates to social stress. Stress when engaging in a discussion with strangers may correspond with features of disorganised schizotypy concerned with social anxiety, including maintaining cognitive control over the direction of the conversation, difficulty with speech expression and comprehension, and discomfort when speaking on topics of a personal nature. So, social anxiety could specifically explain the relationship between positive schizotypy and increased SCR from social stress. Social anxiety is an intense fear of being rejected, embarrassed or humiliated in social and performance situations (American Psychiatric Association, 2000). People with social anxiety avoid looking at positive

and negative facial expressions before delivering a speech (Mansell, Clark, Ehlers, & Chen, 1999; Singh, Capozzoli, Dodd, & Hope, 2015). People with social anxiety are vigilant for rejection and expect to be more accepted than people with low social anxiety (Harrewijn, van der Molen, van Vliet, Tissier, & Westenberg, 2018). Furthermore, anxiety in disorganised schizotypy may be related more closely to social threat when interacting with strangers than in a public speech, since anxiety and neuroticism explain the relationship between mild-to-moderate schizotypal traits and vigilance for rejection (Kwapil, Brown, Silvia, Myin-Germeys, & Barrantes-Vidal, 2012; Premkumar, et al., 2015).

The aims of this experiment were to test (1) the linear relation of mild-to-moderate schizotypal traits to multiple indices of physiological arousal during a social stress test, and (2) the role of social anxiety in disorganised schizotypy in this relationship. It was hypothesised that:

1. Mild-to-moderate schizotypal traits will relate to greater physiological arousal (HR and SCR) during social stress, and

2. Disorganised schizotypy as social anxiety will explain the relation between mild-to-moderate positive schizotypal traits and physiological arousal in a close interaction.

Methods

    Participants

Twenty-four participants (mean age = 24.4 years, S.D. = 9.5, range = 20 to 57) were recruited from the University student population by social networking and advertising the experiment in the psychology department in return for research credits. A third of the sample (n = 16) was female. Participants who scored ⩽13 out of 74 on the SPQ total were classed as having

mild-to-moderate schizotypal traits. A score below 13 on the SPQ denotes the 90th percentile of schizotypal traits in the healthy population with the local region (Castro & Pearson, 2011),

Assessments

Schizotypal Personality Questionnaire (SPQ) (Raine, 1991): The SPQ has 74 items to which participants respond 'Yes' or 'No'. The SPQ was used instead of the O-LIFE, because the SPQ contains nine subscales that are based on the diagnostic criteria of Schizotypal Personality Disorder (Asai, Sugimori, Bando, & Tanno, 2011; Oezgen & Grant, 2018). Hence, it is possible to examine these finer constructs in relation to physiological arousal (Table 2). These subscales combine into the three dimensions of schizotypal traits, namely Cognitive-Perceptual (positive schizotypy), Interpersonal (social anxiety, no close friend) and Disorganised (odd speech and behaviour). However, the SPQ is less adept at measuring psychometrically-defined schizotypy than the O-LIFE (Oezgen & Grant, 2018). The internal reliability of the three main subscales in the current sample ranges from poor to acceptable, having Cronbach's α values of 0.55, 0.83 and 0.72 respectively.

Leibowitz Social Phobia Scale (LSPS) – self-report version (Liebowitz, 1987; Safran, et al., 1999): The scale measures anxiety and avoidance in 11 social interaction situations and 13 performance-related situations, resulting in four subscales, namely Social Interaction-related Anxiety and Social Interaction-related Avoidance, Performance-related Anxiety and Performance-related Avoidance. Participants rate each item on anxiety and avoidance (0 = none to 3 = severe). The subscales have good internal reliability in the current sample, with Cronbach's α values of 0.81, 0.81, 0.87 and 0.88 respectively.

HR and SCR measurement

HR and SCR were recorded from a Biopac MP160 system with a Bionomadix wireless photoplethysmograph. HR was recorded from a pulse transducer placed on the fifth-digit finger of the left hand that recorded the pulse pressure waveform. SCR was recorded from Ag/AgCl electrodes placed on the second-digit and third-digit fingers of the left hand that were connected to an SCR amplifier. HR and SCR data were recorded at 75 kiloHz and transmitted to the AcqKnowledge computer software (Nassar, Elsamahy, Awadallah & Elmahalawy, 2018). HR was measured as the peak-to-peak intervals of the heartbeat. HR was calculated as the number of heart beats per minute (Weintraub, et al., 2019) and averaged over 30 s epochs (Owens & Beidel, 2015). SCR was calculated as the absolute conductance averaged over 30 s epochs (Öhman, 1981, p. 91).

Procedure

The experiment was approved by the University's School of Social Sciences research ethics committee. Participants gave informed consent and proceeded to complete the self-report assessments. The social stress test was administered in an identical manner to that of experiment 1. Participants rated the PANAS before and after the public speech and the informal discussion.

Statistical analyses

One-tailed Pearson correlations between schizotypy and physiological arousal tested the first hypothesis. A mediation analysis (Baron & Kenny, 1986) tested the second hypothesis. Zero-order correlations first tested for statistically significant relationships among SPQ-Cognitive-Perceptual (the predictors), SPQ-social anxiety, SPQ-odd speech and LSPS-Social Interaction

Anxiety (the mediators) and the physiological responses (the outcome variable). Mediation analyses were performed with SPQ-Cognitive-Perceptual as the predictor (X), SPQ-social anxiety, SPQ-Odd Speech and LSPS-Social Interaction Anxiety as the mediators (M), and HR at 0-30 as the outcome variable (Y). HR at 0-30 s alone was used as the outcome variable because it correlated with schizotypal traits and LSPS-Social Interaction Anxiety (see results). The SPQ Disorganised subscale was not used as a mediator because it does not measure 'true' disorganised schizotypy as well as O-LIFE Cognitive Disorganisation (Oezgen & Grant, 2018). Instead, many items from the Social Anxiety and Odd speech subscales of the SPQ go to form the 'adjusted factor' for disorganised schizotypy (Oezgen & Grant, 2018). Hence, the SPQ-Odd Speech subscale of Disorganised dimension alone was used in the mediation analyses. The mediation analyses were performed using PROCESS, version 3.3 (Hayes, 2018).

Results

   Total SPQ and all three SPQ dimensions were correlated with HR at 0-30 s of the discussion (Table 2). SPQ Cognitive-Perceptual was also correlated with HR at 31-60 s of the discussion. Of the SPQ Cognitive-Perceptual dimension, the Magical Thinking subscale was correlated with HR at 31-60 s, 91-120 s and 121-150 s of the discussion, and the Unusual Experiences subscale was correlated with HR at 0-30 s, 31-60 s, 61-90 s and 151-180 s of the discussion. LSPS – Social Interaction Anxiety was correlated with total SPQ, the Interpersonal and Disorganised SPQ dimensions, and the SPQ subscales of Magical Thinking, Suspiciousness, Social Anxiety, Odd or Eccentric Behaviour and Odd Speech. LSPS – Social Interaction Anxiety was correlated with HR at 0-30 s and 31-60 s of the discussion. In a mediation analysis, the following mediators – namely,

SPQ-Social Anxiety, SPQ-Odd Speech and LSPS-Social Interaction Anxiety – fully mediated the relation between SPQ Cognitive-Perceptual and HR at 0-30 s of the discussion (Table 3).

Total SPQ, the Cognitive-Perceptual dimension, its subscale of Referential Thinking, the Interpersonal dimension and its subscale of No Close Friends correlated with greater SCR at each epochs of the discussion from 31 to 180 s of the discussion. LSPS-Social Interaction Anxiety correlated with greater SCR at 31-120 s of the speech.

*** Insert Tables 2 and 3 about here ***

Discussion

This is the first experiment to our knowledge to study the relationship between mild-to-moderate schizotypal traits and physiological arousal during a social stress test and the role of social anxiety in this relationship. As hypothesised, a linear relationship between mild-to-moderate schizotypal traits and physiological reactivity to social interaction was found. The relationship between schizotypy and social stress was linear when examining mild-to-moderate schizotypy. Social anxiety and odd speech fully mediated the relation between positive schizotypy and HR at 0-30 seconds. Greater overall schizotypy and its three dimensions, namely Cognitive-Perceptual, Interpersonal and Disorganised, related to greater HR at the start of the discussion. The Magical Thinking and Unusual Experiences subscales of SPQ-Cognitive-Perceptual related to greater HR from 31 s to 180 s of the discussion. The subscales of Referential Thinking and No Close Friends related to greater SCR throughout the discussion.

The first minute of taking part in a social interaction is known as the confrontation stage. HR is highest at the confrontation stage (Sawyer & Behnke, 2002). The Cognitive-Perceptual, Interpersonal and Disorganisation dimensions of the SPQ related to greater HR at the confrontation stage of the discussion. The rise in the level of these dimensions of schizotypal traits from mild to moderate levels may be associated with more stress of encountering close social interaction with strangers. A greater level of certain positive schizotypal traits, namely Referential Thinking, Magical Thinking and Unusual Experiences, and the interpersonal trait of having No Close Friends could accompany higher HR and SCR. The finding that these relationships were present at each time point suggests that stress is elevated throughout the close social interaction with strangers. Stress is characterised by difficulty relaxing, getting nervous and overreacting (Lovibond & Lovibond, 1995). Experiencing moderate levels of these positive and interpersonal schizotypal traits could make it difficult to relax with a stranger. Specifically, referential thinking could increase judgemental biases during social interaction and social anxiety (Meyer & Lenzenweger, 2009; Morrison & Cohen, 2014). Referential thinking is when casual external events, such as social encounters, are interpreted incorrectly as having an unusual meaning. Also, experiencing interpersonal schizotypal traits, such as having no close friends, relates to poor recognition of non-verbal cues during social interaction (Shean, Bell, & Cameron, 2007).

Social anxiety and odd speech denote disorganised schizotypy (Oezgen & Grant, 2018). The Social Anxiety and Odd Speech subscales of the SPQ mediated the association between the positive schizotypy as measured by Cognitive-Perceptual dimension of the SPQ and HR at the beginning (0-30 s) of the discussion. This finding supports the view that disorganisation can account for the distress in positive schizotypy (Grant & Hennig, 2019) and 'effects of disorganised schizotypy are likely to be mis-attributed to positive/negative schizotypy' (Grant & Hennig, 2019).

The finding mirrors the mediation of the effect of positive schizotypy on physiological arousal during social interaction by disorganised schizotypy found in Experiment 1. Among the schizotypal dimensions, disorganised schizotypy relates most strongly to social anxiety due to sensitivity rejection, criticism and praise (Premkumar, Dunn, Onwumere, & Kuipers, 2019; Premkumar, Onwumere, Betts, Kibowski, & Kuipers, 2018). Hence, disorganised schizotypy may contribute towards distress in positive schizotypy (Oezgen & Grant, 2018). Social anxiety in disorganised schizotypy may be characterised by more confusion and nervousness in social gatherings making it hard for people with disorganised schizotypal traits to follow the conversation (Oezgen & Grant, 2018). Social anxiety due to perceiving more criticism and rejection and less praise in schizotypy may play out in casual social interactions. Latent anxiety from past social interactions, either with family or peers, may relate to increased momentary stress in casual social interactions.

Limitations and directions for future research

Physiological arousal was not measured at baseline before the social stress test. Thus, the effect of antecedent extraneous stressors on HR and SCR or increased basal physiological arousal cannot be ruled out. Participants delivered the speech while standing but engaged in the discussion while sitting which could have confounded the differences observed in physiological arousal between the speech and the discussion. Future research could include a non-social condition as an additional control task. Administering different schizotypal scales in Experiments 1 and 2 would make it difficult to directly compare the findings from both experiments. Still, both experiments showed that schizotypy relates to social stress and this relationship is consistent across measures of schizotypal traits. The absence of a relation between schizotypy and physiological arousal

during the public speech contrasts with previous findings (Grant & Hennig, 2018; Walter, Fernandez, Snelling, & Barkus, 2018). The public speech task lasted for two minutes in the current study, while the public speech task lasts for five minutes in the TSST. Participants were given five minutes to prepare the speech in the current study compared to 10 minutes in the original TSST. Furthermore, the public-speaking task may have been less stressful in the current study than in the original TSST. The topic of the speech in the current study was about participants' favourite subject in school, whereas the topic of the speech in the original TSST and the modified TSST (Grant & Hennig, 2018; Walter, Fernandez, Snelling, & Barkus, 2018) which was about applying for their dream job. Future research could examine altered functioning of the hypothalamic-pituitary-adrenal cortex axis (Walter, Fernandez, Snelling, & Barkus, 2018) and the vegetative nervous systems in terms of the pituitary volume, because the pituitary volume varies with the severity of psychosis (Shah, et al., 2015) and is amenable to psychological intervention (Premkumar, et al., 2018).

Conclusion

An informal discussion with strangers is a valid control task for a public speech task in the social stress test as well as a sensitive test of social stress in schizotypy. The study found that participants with a high level of positive schizotypal traits had heightened physiological arousal during this informal discussion than participants with low-to-moderate positive schizotypal traits. A non-linear relationship exists between overall schizotypal traits and HR when interacting with strangers in Experiment 1, which could imply dysregulation of the vegetative nervous system in high schizotypal traits, but upregulation of the physiological arousal system in mild-to-moderate schizotypy. These findings lend support to the U-shaped relationship between arousal and stress

(Sapolsky, 2015; Yerkes & Dodson, 1998). Having high positive schizotypal traits could inhibit the ability to acclimatise to informal social interaction. Acclimatisation to social stress may co-exist with mild-to-moderate positive schizotypy, since mild-to-moderate positive schizotypal traits have a positive linear relationship with physiological arousal during social interaction. Distress in disorganised schizotypy could mediate the relationship between mild-to-moderate positive schizotypy and physiological arousal during social interaction (Grant & Hennig, 2019). Social anxiety in disorganised schizotypy may allow stress to persist in casual social interactions with strangers. Sensitivity to criticism and rejection are forms of social anxiety that relate strongly to disorganised schizotypy (Premkumar, Dunn, Onwumere, & Kuipers, 2019; Premkumar, Onwumere, Betts, Kibowski, & Kuipers, 2018). Such social anxiety could be associated with experiencing heighten arousal during social interaction with strangers.

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Tables

Table 1. Differences in demographic characteristics and heart rate between high and mild-to-moderate positive schizotypal traits groups in Experiment 1

	High positive schizotypal traits (n=16) Mean (S.D.)	Range	Mild-to-moderate positive schizotypal traits (n=10) Mean (S.D.)	Range	F or Chi-square value (df=24)	*One-tailed p value*	Effect size, η^2
Age	26.8 (7.5)		24.2 (3.2)		1.01	0.307*	0.04
Gender: male/female	6/10		4/6		0.02	0.899*	
O-LIFE							
Unusual experiences	22.1 (3.9)	16-29	5.6 (4.1)	0-12	107.79	**<0.001**	0.82
Introvertive anhedonia	10.7 (5.9)	3-20	8.4 (5.9)	5-20	0.98	0.116	0.04
Cognitive disorganisation	17.5 (5.9)	5-23	12.9 (5.1)	1-21	4.09	**0.027**	0.14
Impulsive non-conformity	12.7 (4.1)	5-19	9.2 (2.7)	6-14	5.70	**0.012**	0.19
Total	63.1 (14.5)	42-87	36.1 (11.9)	15-53	24.19	**<0.001**	0.50
Heart rate							
Speech							
(0-30 s)	101.95 (15.35)		92.95 (20.74)		1.61	0.108	0.06
(31-60 s)	99.65 (14.72)		89.34 (22.67)		1.99	0.085	0.08
(61-90 s)	98.75 (13.77)		90.76 (23.87)		1.17	0.144	0.05
(91-120 s)	99.78 (15.37)		91.61 (21.80)		1.26	0.136	0.05
Discussion							
(0-30 s)	94.09 (12.64)		86.03 (17.71)		1.84	0.093	0.07
(31-60 s)	91.25 (13.12)		79.62 (19.13)		3.40	**0.039**	0.12
(61-90 s)	91.64 (12.87)		79.82 (15.51)		4.43	**0.023**	0.15

Table 1 continued

	High positive schizotypal traits (n=16) Mean (S.D.)	Range	Mild-to-moderate positive schizotypal traits (n=10) Mean (S.D.)	Range	F or Chi-square value (df=24)	*One-tailed p value*	Effect size, η^2
(91-120 s)	89.57 (12.10)		77.55 (15.88)		4.78	**0.019**	0.17
(121-150 s)	90.47 (12.16)		79.00 (13.95)		4.90	**0.018**	0.17
(151-180 s)	89.95 (11.89)		77.76 (18.76)		4.16	**0.026**	0.15

Values in bold indicate statistically significant group differences; * two-tailed p-values are reported.

Table 2. One-tailed Pearson correlations, r (p), between schizotypal traits (total and subscale scores of the SPQ), social anxiety and heart rate averaged over 30 s epochs during a public speech test and an informal discussion in Experiment 2

	Mean (S.D.)	Range	LSPS – social interaction fear	Speech				Discussion					
				0-30	31-60	61-90	91-120	0-30	31-60	61-90	91-120	121-150	151-180
						Heart rate							
SPQ													
Total	19.2 (9.4)	2-40	0.53**	-0.25	-0.22	0.001	-0.15	0.48**	0.36*	0.20	-0.15	0.31	0.25
Cogper	6.4 (3.1)	0-13	0.21	-0.15	-0.10	0.10	-0.08	0.42*	0.42*	0.26	-0.08	0.34	0.36*
Reference.	2.0 (1.4)	0-6	-0.19	0.09	0.15	0.26	0.15	0.07	-0.03	-0.14	0.15	0.01	-0.03
Magic.	1.6 (1.0)	0-3	0.52**	-0.51**	-0.37*	-0.15	-0.45*	0.32	0.41*	0.32	-0.45*	0.43*	0.39*
Unu. Exp.	1.5 (1.1)	0-3	-0.17	-0.005	0.03	0.18	0.26	0.37*	0.44*	0.42*	0.26	0.35*	0.48**
Suspic.	1.4 (1.3)	0-5	0.39*	-0.03	-0.13	-0.07	-0.20	0.38*	0.33	0.17	-0.20	0.18	0.20
Interper	8.3 (5.2)	0-21	0.63***	-0.25	-0.25	-0.05	-0.17	0.44*	0.33	0.16	-0.17	0.24	0.18
Soc. Anx.	3.5 (1.9)	0-8	0.82***	-0.17	-0.21	0.01	0.04	0.57**	0.48**	0.34	0.04	0.32	0.29
No Cl. Friends	1.9 (1.9)	0-7	0.38	-0.37*	-0.16	-0.02	-0.28	0.22	0.10	0.06	-0.28	0.24	0.15
Const. Affect	1.5 (1.5)	0-5	0.34	-0.14	-0.28	-0.10	-0.09	0.18	0.09	-0.15	-0.09	-0.04	-0.13
Disorg	5.8 (3.1)	1-12	0.53**	-0.20	-0.21	-0.04	-0.17	0.44**	0.26	0.16	-0.17	0.27	0.17
Ecc. Behave.	2.1 (1.7)	0-6	0.23*	-0.02	-0.09	0.01	-0.14	0.38*	0.29	0.13	-0.14	0.27	0.15
Odd Speech	3.7 (1.9)	1-7	0.52**	-0.32	-0.27	-0.08	-0.16	0.39*	0.17	0.16	-0.16	0.20	0.15
LSPS – Social Interaction Anxiety	12.2 (6.5)	1-28	1.00	-0.16	-0.16	0.16	-0.07	0.46*	0.40*	0.30	-0.07	0.27	0.33

Table 2 continued

	LSPS – social interaction fear		Speech				Discussion					
	Mean (S.D.)	Range	0-30	31-60	61-90	91-120	0-30	31-60	61-90	91-120	121-150	151-180
							Skin conductance					
SPQ												
Total			0.06	0.07	0.06	0.04	0.26	0.47*	0.48*	0.46*	0.45*	0.52**
Cogper			-0.05	-0.10	-0.09	-0.11	0.39	0.50*	0.53**	0.42*	0.48*	0.59**
Reference.			-0.16	-0.24	-0.23	-0.24	0.35	0.50*	0.52**	0.48*	0.50**	0.55**
Magiec.			0.04	0.13	0.16	0.16	0.08	0.14	0.18	0.14	0.19	0.22
Unu. xp.			-0.07	-0.24	-0.27	-0.29	0.41*	0.23	0.23	0.12	0.21	0.31
Suspic.			0.07	0.11	0.11	0.09	0.16	0.36	0.38	0.28	0.28	0.38
Interper			0.13	0.17	0.16	0.15	0.21	0.42*	0.42*	0.44*	0.41*	0.48*
Soc. Anx.			0.23	0.33	0.35	0.34	0.16	0.24	0.26	0.24	0.26	0.38
No Cl. Friends			0.03	-0.01	-0.03	-0.04	0.22	0.45*	0.48*	0.52**	0.48**	0.46*
Const. Afect			0.06	0.07	0.04	0.03	0.09	0.22	0.15	0.28	0.20	0.24
Disorg			0.04	0.07	0.05	0.04	0.13	0.38	0.37	0.36	0.32	0.36
Ecc. Behave.			-0.14	-0.12	-0.13	-0.15	-0.01	0.32	0.29	0.32	0.25	0.29
Odd Speech			0.19	0.22	0.20	0.20	0.23	0.34	0.36	0.30	0.31	0.32
LSPS – Social Interaction Anxiety			0.38	0.55**	0.58**	0.57**	0.01	0.16	0.17	0.21	0.22	0.32

Note: * $p \leq 0.05$, ** $p \leq 0.01$, $p \leq 0.001$; Cogper – Cognitive-Perceptual dimension; Const. Affect - Constricted Affect; Disorg – Disorganised dimension; Ecc. Behave. - Odd or Eccentric Behaviour; Interper – Interpersonal dimension; LSPS: Leibowitz Social Phobia Scale; Magic. - Odd Beliefs or Magical Thinking; No Cl. Friends. - No Close Friends; Suspic. – Suspiciousness; Reference. - Ideas of Reference; Soc. Anx. - Excessive Social Anxiety; SPQ: Schizotypal Personality Questionnaire; Unu. Exp. - Unusual Perceptual Experiences.

Table 3. Mediation analyses with Schizotypal Personality Questionnaire Cognitive-Perceptual as the predictor variable (X), heartrate at 0-30 s of the discussion (Y) and SPQ-Social Anxiety, SPQ-Odd Speech and Leibowitz social phobia scale (LSPS) – Social Interaction Anxiety as the mediators (M)

Mediators	a_n, X$\rightarrow$M (p-value)	b_n, M$\rightarrow$Y (p-value)	Indirect effect, a_n x b_n (95% C.I.)	Total effect, c (p-value)	Direct effect, c' (p-value)	Total R^2
				0.43 (0.039)	0.26 (0.065)	0.36
SPQ-Social Anxiety	0.48 (0.017)	0.40 (0.340)	0.63 (-0.94 to 2.97)			
SPQ-Odd Speech	0.58 (0.003)	-0.11 (0.700)	-0.20 (-1.56 to 0.94)			
LSPS-social anxiety	0.21 (0.333)	0.13 (0.706)	0.09 (-0.72 to 1.02)			

Footnote: Standardised coefficients are reported.

Figures title:

Figure 1. (a) Flow diagram of the response of the hypothalamic-pituitary-adrenal cortex (HPA) axis to stress. Taken with copyright permission from Naughton, M., Dinan, T., & Scott, L. (2014). Corticotropin-releasing hormone and the hypothalamic-pituitary-adrenal axis in psychiatric disease. *Handbook of Clinical Neurology*, 124, 69-91, and (b) the vegetative nervous system showing how the sympathetic branch increases heart rate. Taken with copyright permission from Carlson, N. R., & Birkett, M. A. (2017). Physiology of behavior (Global edition [of] twelfth ed.). Harlow: Pearson Education Limited.

Figure 2. Scatterplot showing the non-linear relation between schizotypy and HR at (a) 91-120 s and (b) 151-180 s of the discussion based on level of schizotypal traits.

Figure 3. Change in (a) HR and (b) skin conductance between 30 second epochs during the 2 min speech (solid line) and 3 min discussion (dotted line), (c) positive affect (solid line) and negative affect (dotted line) before and after the speech and discussion. Values on the trend lines are means. Values in boxes are the standard error of the mean.
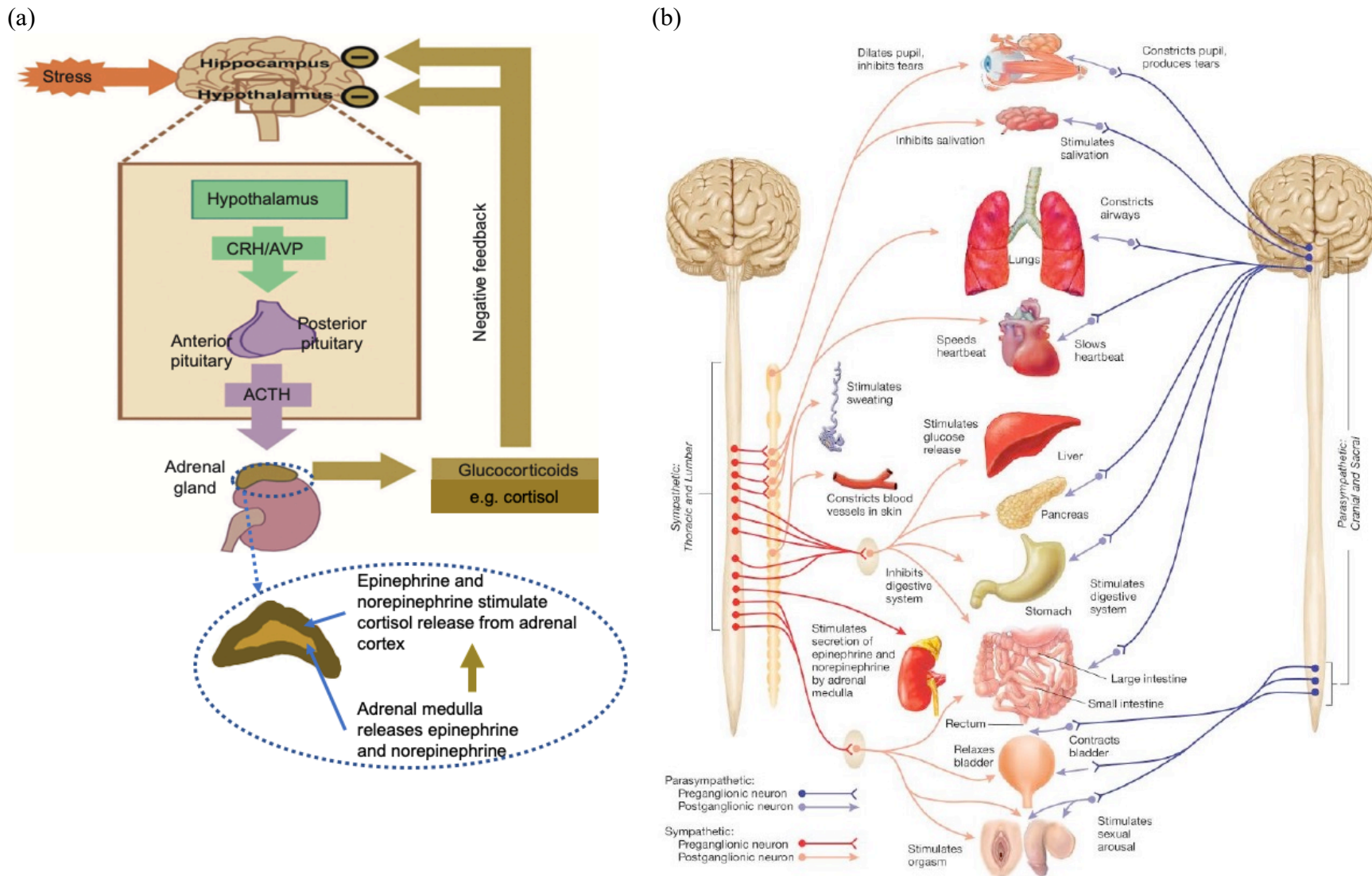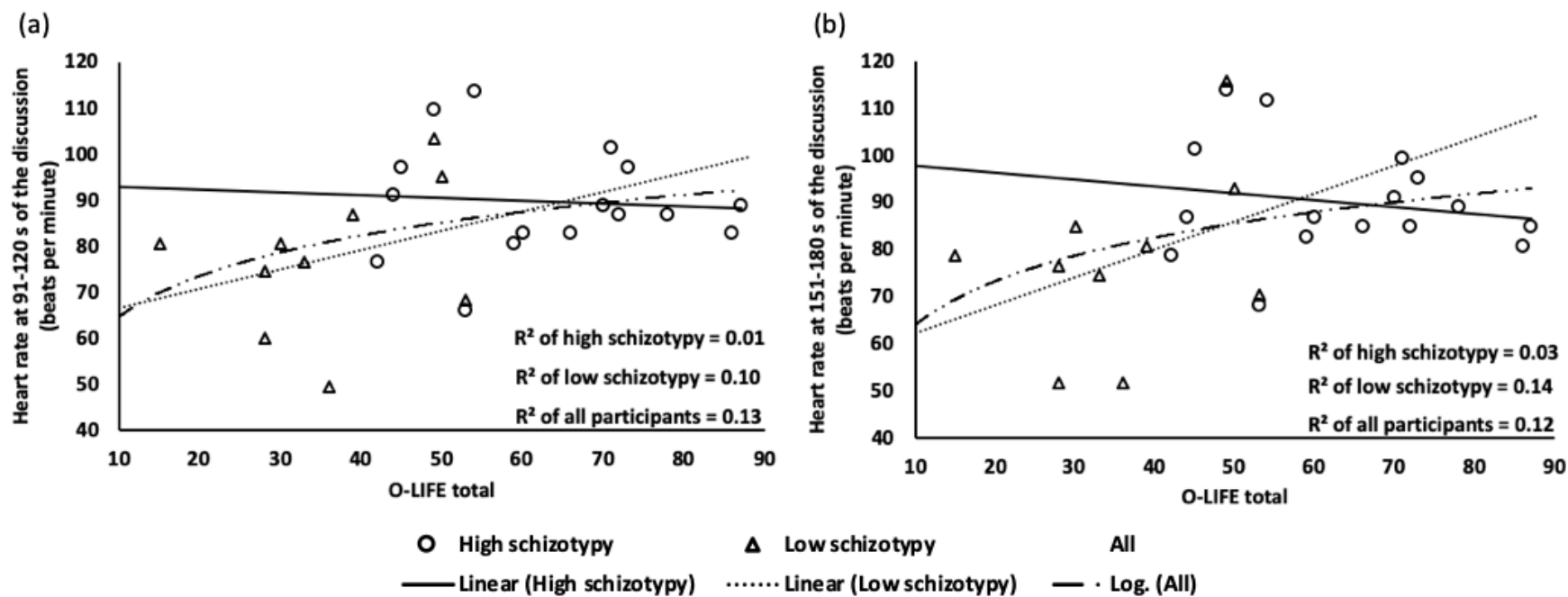
Figure 1

(a)

(b)

Figure 2

Figure 3