Original article

Relationship between mode of sport training and general cognitive performance

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Running head: Sport mode and cognition

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Abstract

Purpose: To investigate whether athletes who engage in different modes of sports training correspondingly exhibit different patterns of performance on general cognition tasks.

Methods: Sixty participants were recruited into an endurance, motorically complex, or control group, and were administered a series of physical tests and neuropsychological assessments.

Results: Athletes in the endurance group demonstrated the highest levels of cardiovascular fitness and those in the motorically complex group exhibited the highest levels of motor fitness. Nonetheless, no differences in cognitive performance were observed between the three groups.

Conclusion: These findings indicate that the mode of sport training, which results in either high cardiovascular or high motor fitness, bears no relationship to measures of general cognition in elite athletes. The present findings suggest that coaches and athletic trainers should be encouraged to monitor athletes' stress levels during training in order to maximize the beneficial effects of such training on general cognitive performance.

Keywords: Executive control; Expert; Motor fitness; Physical fitness

1. Introduction

Recent research has provided promising evidence for the positive relationship between exercise and cognition across the lifespan.[1-4] In particular, studies that employed a cross-sectional design have indicated that people with higher fitness levels or those participating in habitual physical activity exhibit superior cognitive functions when compared to those with lower fitness levels, or those who exercise infrequently.[5,6] Similar results have been reported in studies employing longitudinal designs, which have indicated that long-term exercise training and improved fitness levels are associated with better cognitive functions or a delay in age-related cognitive decline.[7]

Meta-analyses have examined the possible moderator of exercise effects on cognition and have identified mode of exercise or training, age, and the type of cognitive task that is employed.[8] Most studies have addressed endurance or aerobic-type exercise and the corollary cardiovascular fitness effects on cognitive functions. Chaddock et al.[5] demonstrated that pre-adolescent children with high cardiovascular fitness levels exhibited superior memory performance when compared to those with low fitness status. Accordingly, Netz et al.[6] reported that older adults with moderate levels of cardiovascular fitness performed better in global cognitive functions when compared to those with lower fitness. The prominence of cardiovascular fitness has been positively associated with specific aspects of brain anatomy that are implicated in cognitive processes; these include hippocampal volume, basal ganglia volume, and neural functional connectivity.[9,10]

Other activity modes that require a high level of motor control (e.g., gymnastics and martial arts) can improve both physical fitness (e.g., cardiovascular capacity, muscular strength, and muscular duration) and motor fitness (e.g., power, agility, balance, and flexibility), which might have a bearing on cognition, beyond the effects attributable to enhanced cardiovascular fitness. Cross-sectional studies have indicated that, not only cardiovascular fitness, but also muscular strength, agility, balance, motor coordination, and flexibility were associated with improvements in multiple cognitive functions in older adults[11] and children.[12] Further, a functional magnetic resonance imaging (fMRI) study showed that individuals with higher motor fitness exhibited higher levels of activation in certain brain regions (e.g., frontoparietal network) during cognitive tasks, indicating a link among participation in a complex motor task, motor fitness, and cognition.[11] Nonetheless, given that only a few such studies have examined the effects of training modality on cognition, there is an insufficient evidence base with which to arrive at any firm conclusion.

With intense and prolonged training for competitive sport, athletes who reach the elite level are generally characterized by high physical and motor fitness. A reasonable assumption is that such athletes would exhibit adaptations in a range of cognitive functions. Indeed the expert performance approach hypothesis holds that when compared to non-experts, athletes with a high level of expertise should show superior outcomes across a range of sport-specific cognitive domains (e.g., decision making, declarative memory, perception, and visual searching capacity), with sports demanding high levels of coordination showing the most superior outcomes.[13,14] Nevertheless, whether the effects of sports expertise might transfer from a sport-specific domain to a general cognitive domain has not been the topic of systematic investigation, albeit that initial findings do appear promising.[15,16] Using the Delis–Kaplan Executive Function System (D-KEFS) test battery, Vestberg et al.[15] reported that both high and low division players displayed superior general cognitive performances compared to control groups, whereas higher division players showed additional improvements. Chaddock et al.[16] also examined sports expertise and general cognition, as assessed by a virtual reality street-crossing paradigm. They observed that division I athletes had fewer collisions and faster processing speeds than non-athletes. While these recent studies provided some encouraging initial evidence regarding levels of athletic experience, it is not yet clear whether exposure to different types of sport may also influence general cognitive functions.

The purpose of the present study was to investigate differences between types of sport (i.e., a sport with long-duration/simple motoric skills *vs.* a sport involving complex motor skills) on general cognition in high-level athletes. We drew upon athletes who were accomplished in marathon running (endurance sport) and Wushu (a Chinese routine-based martial art involving a series complex motor skills), given that we expected elite marathon runners to be endowed with high cardiovascular fitness, and professional martial artists to be endowed with cardiovascular fitness and high motor fitness. We hypothesized that both sports expertise groups would perform better when compared to a control group who were infrequent exercise participants, and sport expertise would influence cognitive performance differentially; the Wushu athletes would exhibit superior cognitive functions.

2. Methods

2.1. Participants

Sixty college students (42 males, 21.12 ± 1.37 years; 18 females, 21.78 ± 1.47 years) were recruited from Taoyuan, Taiwan, China. All participants met the criteria of being free of cardiovascular, pulmonary, and metabolic diseases, as well as any mental disorders. They were screened using a demographic questionnaire (Table 1), their medical history, and the Physical Activity Readiness Questionnaire (PAR-Q).[13] Participants in the endurance group were elite athletes involved in marathon running while those in the motorically complex group were elite athletes involved in Wushu training. Control group participants engaged infrequently in exercise/recreational activity. Athletes in both sport groups had reached either national or international level in their respective disciplines and engaged in intensive training for at least 6 months prior to their recruitment into the study. Participants were required to read and sign an informed consent form, in accordance with the requirements of the Institutional Ethics Committee of the National Taiwan Sport University.

2.2. Cardiovascular fitness assessment

Cardiovascular fitness is one of the main components of physical fitness and has been linked to cognitive performance. The peak oxygen consumption (VO_{2peak}) for each participant was assessed using the Bruce Treadmill Protocol, which is a maximal graded exercise test (GXT). Each participant was required to undergo the fitness test on a motorized treadmill (h/p/cosmos airwalk, Traunstein, Germany). Several criteria were applied in determining each participant's maximal cardiovascular capacity including (a) a plateau in heart rate with increasing exercise intensity, (b) a respiratory exchange ratio above 1.15, (c) rating of perceived exertion on Borg's original RPE scale of 17 or above.

2.3. Muscular, muscular endurance, and flexibility assessment

Other physical fitness components pertaining to muscular strength, muscular endurance and flexibility were assessed following exercise testing guidelines.[17] Specifically, muscular strength was assessed using a handgrip dynamometer for each hand. Muscular endurance was assessed using a protocol that entailed 60-s press-ups (male), 60-s bent knee press-ups (female), as well as both 30-s and 60-s abdominal curl-ups. A sit-and-reach test was conducted using a flexometer to measure lower back and hamstring flexibility. Body composition was assessed by means of body mass index (BMI) as well as bioimpedance spectroscopy techniques (InBody 3.0 DS12B887; Biospace Co. Ltd, Seoul, Korea) with which percentage body fat mass was calculated.

2.4. Agility and power of motor fitness assessment

In regard to motor fitness, emphasis was placed upon two components: agility and power. These were assessed using a T-test and a vertical jump test, respectively.[18] In the T-test, each participant was required to run as fast as possible to four cones that were arranged in a "T" formation. In the vertical jump, each participant jumped as high as possible from a static position to facilitate assessment of their explosive strength.

2.5. Intelligence test

We applied digit span and picture completion tests from the Wechsler Adult Intelligence Scale (WAIS-III, 3rd ed.) that was designed to identify multiple intelligence quotients in adults.[19] In the digit span test, each participant was asked to immediately repeat a series of digits presented by an experimenter (e.g., 7, 2, 8, 6), the length of the list would increase once the participant successfully repeated the list (up to 9 digits), and the longest digit number was recognized as their digit span. Each participant repeated the list in the given order or reverse order, and this was referred to as a "forward digit-span task" or a "backward digit-span test", respectively. The digit span scores used for analysis were standardized (z) scores of the sum of the forward and backward digit-span tasks. During picture completion tests, each participant was asked to identify an item missing from a series of 20 pictures. These two subsets of WAIS-III represented the working memory and perceptual organization, respectively.

2.6. Neuropsychological assessment

The primary outcome variable was cognitive function as assessed by several cognition-related measurements: Stroop test, Wisconsin Card Sorting Test (WCST), and Tower of London Task.

2.6.1. Stroop test

The Stroop test is a widely used neuropsychological assessment of perceptual speed and executive function and has been employed in exercise–cognition research.[20,21] Participants were requested to verbalize the 50 stimulus words (10 rows × 5 columns) that were presented in five conditions: Stroop congruent, Stroop word, Stroop square, Stroop neutral, and Stroop incongruent.[16] The Stroop congruent condition entailed the presentation of names of colors printed in the same color as the name. For the Stroop word, the stimuli were names of colors written in black ink. For the Stroop square, the stimuli were rectangles presented in color. For the Stroop neutral, the stimuli were non-color related words written in coloured ink (e.g., tea, telephone, staple). For the Stroop incongruent, the stimuli were the names of colors printed using a different color to the name (e.g., “RED” printed in green ink). During the test, each participant was instructed to name the color of each stimulus word as fast and as accurately as possible. Each participant was required to make a further attempt when errors were made.

2.6.2. WCST

The WCST is a leading neuropsychological assessment of the shifting aspect of executive functions.[22,23] The WCST: Computer v.4 (Research Edition) was used. The WCST involved four key cards and 128 response cards that can be categorized based upon color (i.e., red, green, yellow, and blue), shape (i.e., triangle, star, cross, and circle), or number (i.e., one, two, three, and four). The task required the respondent to determine how the response card corresponded with one of four key cards based upon its potential match characteristics (by pressing the F, G, H, or J keys on a computer keyboard). The computer provided the immediate feedback “Correct” or “Incorrect” after participants performed each response card trial to identify whether the card was correctly matched. The sorting category (i.e., color, shape, or number) changed after 10 consecutive correct sorts. The WCST was terminated after the participant either successfully performed six categories or completed 128 response cards. Generally, participants were able to complete the test administration within 20 min.

The variables used in the statistical analyses were indices of categories completed, total correct, perseverative errors, perseverative response, conceptual level response, non-perseverative error, and failure to maintain set.

2.6.3. Tower of London Task DX

A version of the Tower of London Task[DX] (ToL Task) was used in this study. The ToL Task is a widely administered neuropsychological assessment for measuring the planning aspects of executive functions. The ToL Task consists of two identical wooden boards (30 × 7 × 10 cm), one for the participant and one for the experimenter, and two sets of three beans (blue, green, and red). Each board consists of three vertical pegs with graded heights, where the longest, middle, and shortest peg can hold three, two, and one bean, respectively. Each participant was asked to move beans as few times as possible from the starting configuration to one of 10 goal configurations while not violating the rules.[24,25] Administration of the ToL Task took 20 min. Total correct scores and total move scores were derived for statistical analysis given that these scores have been found to be influenced by aerobic and resistance (anaerobic) exercises.[24,25]

2.6.4. Experimental procedure

Participants visited the laboratory individually for three sessions, each of 90 min. All sessions were completed within 2 weeks and separated by at least a 2-day interval. During the first session, each participant completed an informed consent form as well as demographic, medical history, PAR-Q, and International Physical Activity Questionnaire (IPAQ)[26] to identify whether they met the inclusion criteria. Resting heart rate was assessed after each participant sat quietly in a comfortable chair for 20 min. Participants who met the inclusion criteria were then instructed to perform the cognitive tasks of WAIS-III, Stroop test, WCST, and ToL Task. Participants in the second and third sessions either had their cardiovascular fitness assessed using the GXT or were administered other physical and motor fitness tests. In the third session, there was a semi-structured interview to assess participants' views on their sport training and this was followed immediately by the test phase of the study.

2.7. Statistical analyses

A between-subjects design was applied. One-way ANOVA or chi-square (χ^2) was used to evaluate differences across groups (i.e., endurance, motorically complex, and control) and variables for which χ^2 was used are highlighted in Table 1. A mixed-model 3 (group) × 5 (condition) ANOVA was employed for the Stroop test. One-way ANOVA was used to detect the differences across groups in other cognitive measures including WCST and the ToL Task. The identification of significant differences on physical and motor fitness, Stroop test, WCST, and ToLTask among groups were followed by multiple comparisons that were Bonferroni-adjusted.

3. Results

3.1. Participant characteristics

There was no significant difference ($p > 0.05$) across groups in regard to age, height, gender, father and mothers' education level, and socio-economic status of the family. In addition, no significant difference ($p > 0.05$) across groups was observed in digit span and picture completion tests of WAIS-III. These results suggest a degree of homogeneity across the three groups of participants in terms of demographic data.

3.2. Sport characteristics

In regard to sport characteristics, there were significant differences in the number of years engaged in sport training, daily training hours, and daily hours of vigorous training (all at $p < 0.001$). Post hoc analyses revealed that both sport groups had a longer training year and more daily hours of training than those in the control group. Further, the motorically complex group had the most daily training hours across three groups.

3.3. Physical characteristics measures

Results of the measures across groups revealed that there were significant differences in VO_{2peak}, muscular endurance, flexibility, agility, and power (all at $p < 0.001$), as well as body composition and BMI (both at $p < 0.05$). *Post hoc* analyses indicated that the endurance group had the highest VO_{2peak} and lowest body composition (BMI and % body fat mass), followed by the motorically complex and control groups. Regarding muscular endurance (press-ups, 30-s and 60-s crunch curl-ups), flexibility, agility, and power, the motorically complex group recorded the highest values, followed by the endurance group, and the control group (all at $p < 0.001$). A similar trend was recorded for muscular strength, although this did not reach significance ($p > 0.05$).

3.4. Cognitive performance

Table 2 contains descriptive data for cognitive performance outcomes. Regarding the Stroop test, a mixed-model ANOVA revealed no significant group × condition interaction or main effect of group; whereas there was a significant main effect of Stroop test condition ($F = 266.5$, $p < 0.01$). *Post hoc* analyses indicated that the Stroop incongruent condition was associated with the longest response time, and following this were the Stroop neutral, Stroop square, and then Stroop word, with no significant differences among the latter three conditions, while Stroop congruent exhibited the shortest response time. One-way ANOVA revealed no significant differences ($p > 0.05$) across the three groups in WCST and ToL Task performance.

4. Discussion

The present study investigated whether elite athletes with high fitness levels exhibited superior performances on general cognition tests when compared to a recreationally active control group, and whether the type of sport that athletes participated in (endurance *vs.* motorically complex) had a bearing on cognitive performance.

As predicted, both sport groups demonstrated superior physical and motor fitness when compared to the control group. Specifically, marathon runners had the highest cardiovascular fitness and lowest percentage of body fat, whereas Wushu athletes exhibited the highest levels of local muscular endurance, flexibility, agility, and power. Interestingly, in contrast to our research hypothesis, there was no significant difference across the three groups for the battery of general cognitive tasks assessed in the present study.

Although the findings did not replicate those of previous exercise–cognition studies that demonstrated positive effects of fitness on cognitive function among non-sport populations,[27,28] our findings did support those of a small number of sport-related studies.[29,30] The latter studies indicate that the experiences of accomplished sports persons have limited influence on general cognition that is assessed under laboratory conditions. Helson and Starkes[30] found that only domain-specific cognition rather than non-specific cognition could differentiate between expert and intermediate-level soccer players. Similarly, Lum et al.[29] indicated that, compared to non-athletes, athletes with static (e.g., swimming) or dynamic (e.g., soccer) experience exhibited no difference in automatic orienting of general cognition domain, but voluntary orienting and modulation of automatic orienting of sport-specific cognition domain. Therefore, our findings indicate that whether level of expertise accounts for specific aspects of general cognition remains a matter of considerable debate.[31,32]

In addition to the perceptual speed aspect of cognition (e.g., Stroop congruent, Stroop word conditions), the present study examined the executive control aspects of cognition using neuropsychological assessments (e.g., Stroop incongruent condition, WCST, ToL Task), which adds to the existing knowledge base. The present findings fall in line with those of previous studies that demonstrated a Stroop interference effect (i.e., longer response times of Stroop incongruent condition compared to Stroop neutral condition) and a Stroop facilitation effect (i.e., shorter response time of Stroop congruent condition compared to Stroop neutral condition). Both Stroop effects are the consequence of multiple competitive cognitive processes during naming the color word and identifying the meaning of words.[21,33] Additionally, we applied the neuropsychological assessments recommended by Etnier and Chang[22] including the Stroop test, WCST, and ToL Task, in order to measure interferences, shifting, and planning aspects of executive control. These represent higher level cognitive functions that are responsible for goal-oriented behavior.[18] However, whether these executive functions that relate to general cognition domains could match the complexities of the sports environment and therefore be influenced by expert experiences has been the subject of debate.[34] Given that meta-analytic reviews have indicated that in sport-related perception–cognitive domains, athletes exhibited better performances (e.g., greater accuracy, shorter attentional cuing time, faster processing speeds when responding to environmental stimuli, fewer fixations),[13,35] the findings of the present study suggest that any beneficial effects on cognition might be associated with sport-specific cognitive domains rather than general cognition-domains, particularly executive function.

The failure to reveal any positive relationship between expertise in sports and general cognitive abilities may be also attributable to the dose–response trend involved between exercise and cognition, wherein extreme training doses would limit physiological and psychological functions.[36] Sport-related training improves physical abilities (e.g., cardiovascular fitness and motor fitness); nonetheless, excessive physical training might cause physiological maladaptations and, in turn, offset the potentially beneficial effects of exercise on cognition. Several studies have indicated that excessive or highly intense training/exercise results in oxidative stress, which is an imbalance between reactive oxygen species and antioxidant defense systems. This results in disturbances in the normal redox state by producing peroxides and free radicals, and consequently leads to damage to proteins and lipids of the cell plasma.[37] Oxidative stress has been linked to decreased cognition or increased cognitive decline symptoms[38,39] and research has further indicated that intense exercise can lead to oxidative stress in the brain, which in turn impairs basic information processes and executive cognitive performances.[40] Through the semi-structured interviews, we found that the two athlete groups indicated that with prolonged high-intensity training, they often experienced burnout-related symptoms and high levels of fatigue. For example, athletes engaged in marathon training ran at least 25 km per day, while Wushu athletes endured 5 h of training per day with almost 3 h of anaerobic-type training. There is a possibility that the effects of overtraining offset the beneficial cognitive functions associated with exercise in the general population.

Some limitations warrant consideration while interpreting the current data. First, although the screening procedure was intended to ensure a level of homogeneity, as indicated by a lack of difference across a range of demographic variables across the three test groups (e.g., age, education, working memory, and perceptual organization aspects of intelligence quotients, parents' education), the cross-sectional design could not control for other factors that might influence cognition (e.g., level of sporting attainment). Longitudinal studies that adopt an idiographic approach are therefore recommended in examining the impact of intensive sport-related training on cognition.

Second, the type of cognitive tasks employed should be carefully considered. While the current study applied multiple neuropsychological assessments, as suggested in the literature,[22] these assessments only measure cognitive function in terms of the information-processing, interference, shifting, and planning aspects of cognition; notwithstanding this, the results were unable to be generalized to other aspects of cognition. Third, studies that have found positive associations between exercise participation and cognition have examined predominantly either older adults or pre-adolescents,[5,12,41,42] while the present study targeted young adults. Clearly, additional work is required to examine other types of cognitive function, as well as populations of different ages in order to further understanding.

5. Conclusion

Athletes who engaged in contrasting training modalities did not exhibit any enhancements in general cognition when compared with a recreationally active control group. Given that only a few studies have examined the effects of sport-related training with reference to general cognition,[15,16] the present findings highlight the necessity to initiate additional studies that address whether individuals with a superior fitness status or long-term engagement in sports training of different types (e.g., motoric *vs.* cognitive) show that their physical training activities have influenced their general cognition. It is also the case that athletes who have been engaged in long-term programs of mental training as part of their preparation for competitive sport, might also exhibit enhancements in general cognition.

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Table 1. Descriptive data for participants' demographic and physical characteristics across three groups (mean ± SD).

Variable	Control (*n* = 20)	Endurance (*n* = 20)	Motorically complex (*n* = 20)	Total (*n* = 60)
Female/male	7/13	6/12	5/15	18/42
Age (year)	21.60 ± 1.35	21.20 ± 1.83	21.15 ± 1.18	21.32±1.47
Education (year)	14.82 ± 0.69	15.00 ± 00	14.70 ± 0.92	14.85 ± 0.66
Height (cm)	172.90 ± 8.85	169.45 ± 8.92	168.30 ± 7.35	170.22 ± 8.49
Weight (kg)	65.50 ± 11.91	55.14 ± 12.69	66.90 ± 10.88	62.51 ± 12.79
WAIS-III				
Digit span test	10.75 ± 3.31	8.70 ± 2.75	9.25 ± 2.83	9.57 ± 3.05
Picture completion test	12.05 ± 2.09	10.00 ± 3.30	11.90 ± 3.35	11.00 ± 3.03
Sport characteristics				
Training years	0.9 ± 1.71	7.75 ± 2.38	8.55 ± 2.31	5.73 ± 4.06
Daily training hours	0.3 ± 0.62	3.40 ± 1.02	5.00 ± 1.28	2.90 ± 2.20
Daily hours of vigorous training	0.1 ± 0.30	2.40 ± 0.82	2.65 ± 0.81	1.72 ± 1.34
Achievement				
International (%)	–	5	25	–
National (%)	–	100	100	–
Fitness characteristics				
VO_{2peak} (mL/kg/min)	44.03 ± 8.28	70.81 ± 6.23	54.33 ± 7.94	56.14 ± 13.32
Muscular strength	77.20 ± 19.30	71.48 ± 16.13	85.11 ± 20.02	77.93 ± 19.09
Muscular endur./press-ups	8.60 ± 6.18	16.30 ± 6.71	22.40 ± 8.60	15.77 ± 9.11
Muscular endur./CCU 30-s	18.35 ± 3.50	24.26 ± 2.31	28.50 ± 2.74	23.69 ± 5.10
Muscular endur./CCU 60-s	33.85 ± 6.00	47.32 ± 4.90	53.25 ± 4.35	44.76 ± 9.67
Flexibility (cm)	30.25 ± 7.71	37.10 ± 8.13	50.50 ± 6.47	39.28 ± 11.22
% body fat mass	19.91 ± 7.71	14.96 ± 3.87	17.92 ± 4.52	17.68 ± 5.93
BMI (kg/m^2)	21.86 ± 3.22	19.23 ± 4.00	23.49 ± 2.59	21.53 ± 3.71
Agility (ms)	13.29 ± 1.49	11.82 ± 0.81	11.08 ± 0.99	12.07 ± 1.46
Power (cm)	48.85 ± 9.44	51.55 ± 7.48	62.45 ± 9.25	54.28 ± 10.46

Abbreviations: Training years = number of years engaged in sport training; WAIS-III = Wechsler Adult Intelligence Scale, 3rd ed.; Muscular endur./press-ups/CCU 30-s /CCU 60-s = muscular endurance/press ups, crunch curl-ups for 30 s and 60 s; BMI= body mass index.

Table 2. Descriptive data for participants' cognitive performances across control, endurance, and motorically complex groups (mean ± SD).

Variable	Control (n = 20)	Endurance (n = 20)	Motorically complex (n = 20)	Total (n = 60)
Stroop test				
Stroop congruent (s)	16.78 ± 4.07	17.50 ± 4.22	15.37 ± 2.15	16.55 ± 3.65
Stroop word (s)	17.81 ± 3.25	19.79 ± 4.28	17.88 ± 2.78	18.49 ± 3.56
Stroop square (s)	20.83 ± 4.22	22.43 ± 4.32	21.00 ± 2.99	21.43 ± 3.89
Stroop neutral (s)	22.20 ± 3.74	24.26 ± 4.61	22.76 ± 3.58	23.09 ± 4.03
Stroop incongruent (s)	34.33 ± 8.25	36.83 ± 8.74	34.31 ± 6.26	35.16 ± 7.78
Wisconsin Card Sorting Test				
Categories completed	5.85 ± 0.49	5.45 ± 1.32	5.60 ± 1.19	5.63 ± 1.06
Total correct	68.90 ± 6.21	70.75 ± 8.06	71.05 ± 8.63	70.23 ± 7.63
Perseverative errors	9.05 ± 6.52	12.95 ± 10.75	10.55 ± 6.51	10.85 ± 8.20
Perseverative responses	9.80 ± 7.88	14.70 ± 13.68	11.65 ± 7.25	12.05 ± 10.07
Conceptual level response	64.30 ± 6.23	64.80 ± 8.89	65.20 ± 9.17	64.77 ± 8.08
Non-perseverative errors	11.25 ± 9.84	14.55 ± 11.95	11.15 ± 8.76	12.32 ± 10.22
Failure to maintain set	0.35 ± 0.67	0.70 ± 1.30	0.55 ± 0.89	0.53 ± 0.89
Tower of London Task				
Total correct scores	4.55 ± 2.04	4.10 ± 2.47	2.90 ± 2.27	3.85 ± 2.33
Total move scores	28.45 ± 12.56	28.10 ± 16.08	37.55 ± 16.43	31.36 ± 15.51