

The impact of working memory training in young people with social, emotional and behavioural difficulties

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ABSTRACT

This study examined the impact of a working memory (WM) training programme on measures of WM, IQ, behavioural inhibition, self-report test and trait anxiety and teacher reported emotional and behavioural difficulties and attentional control before and after WM training and at a 3 month follow-up. The WM training group ($N = 7$) showed significantly better post-training on measures of IQ, inhibition, test anxiety and teacher-reported behaviour, attention and emotional symptoms, compared with a non-intervention passive control group ($N = 8$). Group differences in WM were also evident at follow-up. The results indicated that WM training has some potential to be used to reduce the development of school related difficulties and associated mental health problems in young people. Further research using larger sample sizes and monitoring over a longer time period is needed to replicate and extend these results.

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1. Introduction

Around 5% of children and young people experience clinical levels of anxiety (Rapee, Schniering, & Hudson, 2009) and symptoms often show continuity over time (Mesman & Koot, 2001). Research has found that negative emotional states are associated with several indicators of educational outcome, including lowered performance in coursework (Keogh, Bond, French, Richards, & Davis, 2004) and school tests (Owens, Stevenson, Norgate, & Hadwin, 2008), decreased attendance (Richards & Hadwin, *in press*), an increased likelihood of dropping out of school (Duchesne, Vitaro, Larose, & Tremblay, 2008) and a lowered probability of pursuing further education or training (Woodward & Fergusson, 2001). Some evidence suggests that the relationship between feelings of negative affect and educational engagement is reciprocal. For example, one study showed that indicators of school failure in adolescence (e.g., number of suspensions) predicted increased negative affect in adulthood (McCarty et al., 2008).

Attentional processes have been found to be important in understanding chronically elevated and increasing trajectories of anxiety across middle to late childhood (Duchesne, Larose, Vitaro, & Tremblay, 2010) and are increasingly the focus of cognitive models of anxiety (Eysenck & Derakshan, 2011; Rueda, Checa, & Rothbart, 2010). Attentional Control Theory (ACT), for example, outlines the significance of associations between anxiety and executive functions (i.e., inhibition, set-shifting and updating information in working memory (WM)), in understanding task performance (Eysenck,

Derakshan, Santos, & Calvo, 2007; Eysenck & Derakshan, 2011). Consistent with this framework, research with adults (Elliman, Green, Rogers, & Finch, 1997) and children (Hadwin, Brogan, & Stevenson, 2005; Ng & Lee, 2010) highlighted that anxiety was negatively associated with performance on WM tasks relative to the time taken to complete these tasks. Similarly, Aronen and colleagues found negative links between performance in WM tasks with anxiety and academic ability in school (Aronen, Vuontela, Steenari, Salmi, & Carlson, 2005). Further research has demonstrated that the association between negative affect and academic performance in school is mediated (Owens et al., 2008) or moderated by WM functioning (Ashcraft & Krause, 2007) or attentional processing more broadly (Valiente, Lemery-Chalfont, & Swanson, 2010).

Researchers and practitioners are interested in the development of interventions that can improve educational outcomes for children and young people who experience anxious affect. Previous interventions to improve school performance have focused on anxiety reduction through stress management techniques (e.g., Keogh, Bond, & Flaxman, 2006). Given that WM has been found to play a role in understanding the link between negative emotional states and academic performance, then a second complementary approach is to improve WM skills. Findings from research which highlight a causal effect of attentional processes on emotion (Duchesne et al., 2010) or that suggest a reciprocal relationship between emotion and attention (Rueda et al., 2010) raise the possibility that increasing academic performance via improvements in WM may reduce feelings of negative affect. In support, several studies have found that WM training leads to positive outcomes that go beyond increasing WM skills and include increased IQ (Jaeggi, Buschkuhl, Jonides, & Perrig, 2008), improved mathematical ability (Holmes, Gathercole, & Dunning, 2009) and inhibitory control (Klingberg et al., 2005), as well as parent

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report reductions in symptoms of inattention and hyperactivity (Klingberg, Forssberg, & Westerberg, 2002; Klingberg et al., 2005).

The aim of the present study was to examine the impact of a WM training programme on young people who experience social, emotional and behavioural difficulties (SEBD) in school. Young people with SEBD typically experience symptoms of internalising or externalising disorders, and, although they can show a range of academic ability, their behavioural difficulties are often viewed as obstacles to learning (Kauffman & Landrum, 2008). This study explored whether WM training would increase performance on IQ measures and reduce symptoms of anxiety, attention and behavioural difficulties more generally. Following Klingberg et al. (2005) and theoretical frameworks that focus on anxiety-related inhibition (Eysenck et al., 2007); it also investigated whether improvement in WM would increase inhibitory control.

2. Method

Ethical approval for the study was obtained from the Psychology Ethics Committee (ID779) and the University's Research Governance.

2.1. Participants

We sent parents of young people ($N=27$) with SEBD an information sheet about the study and 17 (63%) gave written consent for their child to take part ($M=12.94$ years, $SD=0.65$, 10 males).¹ Twelve adolescents were on 'School Action' curriculum² and 5 on 'School Action Plus' curriculum.³ Participants were matched in pairs on age, gender, anxiety, and IQ. One member of each pair was randomly allocated to a WM training group ($N=9$; 5 males, $M=12.78$ years, $SD=0.83$) or a passive control group ($N=8$, 5 males, $M=13.13$ years, $SD=0.35$).⁴ T-tests confirmed there was no significant difference in age, IQ or anxiety measures between the two groups. The WM compliance criterion (>20 days training) was met by 7 participants. Two male participants withdrew from the training group approximately 1 week into the training.⁵

2.2. Pre-intervention and outcome measures

2.2.1. Working memory and inhibition

We used a backward digit span and an adapted version of a spatial span task to generate a composite WM span score (Pickering & Gathercole, 2001). In each task, participants were required to remember and repeat in reverse increasing numbers of verbal or spatial sequences (i.e., watching a series of spatial locations being tapped out on a board and repeating these locations in reverse order) and the score reflected the span length participants reached (0–7). To measure the broader impact of training on executive functioning, we measured response inhibition using a behavioural inhibition Go/No-Go computer task (Bitsakou, Psychogiou, Thompson, & Sonuga-Barke, 2008). Participants were asked to respond to left and right arrows and to inhibit a response

to a double ended arrow. This task generated an inhibition score based on the proportion of successfully inhibited responses from the overall number of possible response omissions.

2.2.2. IQ

We measured IQ using the Raven's Standard Progressive Matrices (SPM; Raven, Raven, & Court, 2000) and the Mill Hill Vocabulary Scale (MHVS; Raven, Court, & Raven, 1994). The MHVS comes in two versions to allow re-testing to occur without practice effects.

2.2.3. Negative affect

We measured self-report test anxiety (Children's Test Anxiety Scale, CTAS; Wren & Benson, 2004) (30 items, score 30–120) and trait anxiety (Beck Youth Inventory Second Edition; Beck, Beck, Jolly, & Steer, 2005) (20 items score 0 to 60), as well as teacher-report emotional symptoms (Strengths and Difficulties Questionnaire (SDQ); Goodman, 1997) (5 items; score 0–10). Internal consistency in the present study was good for all scales (in all cases, $\alpha>.79$).

2.2.4. Teacher-report behaviour and attention

We measured teacher-report behavioural difficulties (SDQ; Goodman, 1997) (20 items; $\alpha>.80$, score 0–40) and attentional control (inattention, hyperactivity and impulsivity; DuPaul, Power, Anastopoulos, & Reid, 1998) (18 items, $\alpha=.97$, score 0–54).

2.3. Intervention

The training intervention consisted of a software product for children aged 7 to 15 years of age (Cogmed, 2006). It includes a range of tasks that train simple and complex visuospatial and verbal WM skills. The training plan specifies that participants must complete 90 trials each day (taking approximately 30–40 min) five days a week for five weeks. The criterion for sufficient compliance is >20 days of training over the given period. The software includes a rewarding computer game at the end of each session, implemented via scores.

2.4. Procedure

All participants completed a battery of tests and questionnaires before training (Time 1; T1), 3 weeks following training (Time 2; T2) and at follow-up (Time 3 (T3); 3 months after T2) in small groups or individually. One control participant was unable to provide T3 data; leaving T3 comparisons between 7 participants in each group. The School Inclusion Officer completed the behaviour and attentional control questionnaires for each participant at each time point. Training was completed each morning before school and took between 25 and 45 min. We gave participants positive verbal feedback on performance, as well as weekly progress reports to increase motivation, identify any difficulties and to set targets for the coming week. Training took place over 7 weeks and participants received a daily monetary reward token for each training session that was redeemed when all training was completed.

3. Results

3.1. Approach to analysis

We calculated T1 T2 difference scores for each dependent variable and compared these between groups using ANOVA. Positive difference scores indicate improved performance for WM, inhibition, IQ and negative scores indicate lowered negative affect, behavioural difficulties and improved attentional control. Maintenance of change was assessed using T1 T3 difference scores. In all analyses we measured effect sizes (ES; partial eta-squared and effect size estimate, r) to reflect the magnitude of change. With small sample sizes, reliance on tests of mean differences can underestimate the magnitude of

¹ We implemented exclusion criteria at selection, where this related to adolescents on medication or those with a diagnosis of ADHD.

² School Action is an intervention process that enables children with learning and behavioural difficulties to access the curriculum and improve academic progress. The current sample experienced difficulties with emotional and behavioural difficulties; defined as a failure to make progress and evident signs of distractibility, frustration, anxiety, mood swings, peer relationship difficulties and lowered attendance.

³ School Action Plus is an intervention process involving regular engagement with external services to plan and design interventions for individual pupils with limited progress despite assistance in school.

⁴ Random allocation to the intervention and control groups was carried out for all pairs except one: one male within a pair did not provide consent to take part in the training, therefore, the group allocation in this case was switched.

⁵ Significant group differences did emerge for baseline WM and self-report test anxiety when $N=2$ participants were no longer part of the intervention group (see Appendix A).

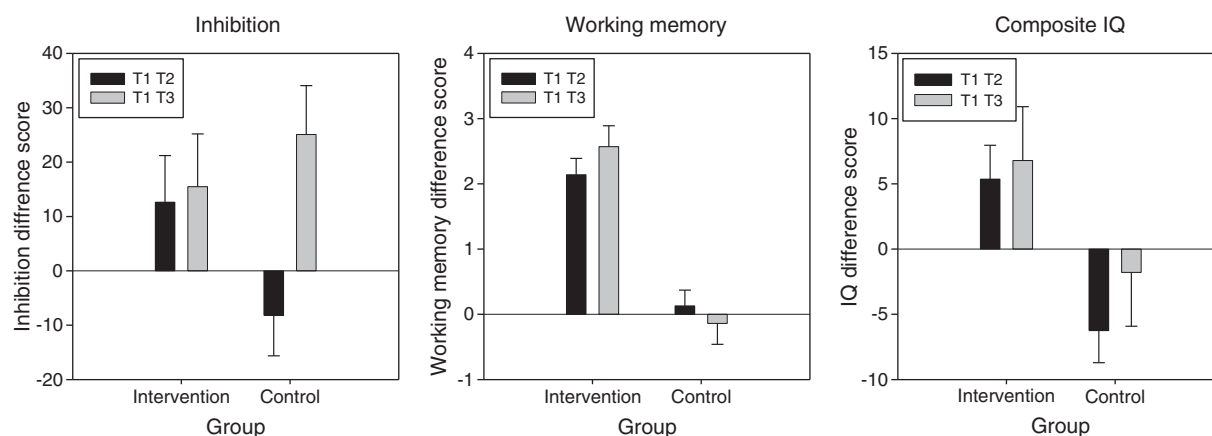


Fig. 1. Probability of inhibition, working memory and IQ Time 2 (T2)–Time 1 (T1) and Time 3 (T3)–Time 1 (T1) difference scores and standard errors for the intervention and control groups.

treatment effects (Kazdin, 1980) and ES is argued to provide a more appropriate interpretation of results (Ozonoff & Miller, 1995). ES is reported as small ($>.10$), medium ($>.25$) or large ($>.4$; Portney & Watkins, 2000). Where variables were not normally distributed we used non-parametric analyses. Means scores for each measure at each time point and for each group are shown in Appendix A.

3.2. WM training effects in the intervention group

The mean number of training days was 22.3 ($SD=2.1$). A univariate ANOVA indicated a significant improvement in trained WM tasks for all ($N=7$) participants as measured by the difference between WM scores at the start of training ($M=74.8$, $SD=12.4$) and the maximum score obtained ($M=94.7$, $SD=9.3$).⁶ The mean Improvement Index score was 19.86 ($SD=12.40$, range = 7–38) ($F(1, 6)=17.95$, $p<.01$, $\eta=.75$).

3.3. Intervention evaluation

3.3.1. Working memory

The T1 T2 difference score analysis showed a significant group difference ($F(1, 14)=34.48$, $p<.001$, $\eta=.73$) indicating that participants in the intervention group showed WM larger difference scores ($N=7$, mean = 2.14, $SD=.69$, range = 1–3) compared with those in the control group ($N=8$, mean = .12, $SD=.64$, range = -1 to 1). The T1 T3 analyses showed that this group difference was maintained over time ($F(1, 13)=36.1$, $p<.001$, $\eta=.75$). The mean T1 T3 difference score was 2.57 ($SD=.97$, range = 1 to 4, $N=7$) and -.14 ($SD=.69$, range = -1 to 1, $N=7$) for the intervention and control groups respectively (see Fig. 1).

3.3.2. Inhibition

This analysis showed a trend towards a significant group effect for the T1 T2 difference score with a small to medium ES ($F(1, 14)=3.35$, $p=.092$, $\eta=.22$), indicating that positive change was greater in the intervention group ($N=6$,⁷ mean = 12.61, $SD=15.89$, range = -4 to 33.7), compared with the control group ($N=8$, mean = -8.19, $SD=.69$, range = -58 to 21). The group effect was not significant in the T1 T3 analysis (see Fig. 1).

3.3.3. IQ

Considering T1 T2 IQ difference scores, the analysis revealed a significant group effect with a large ES ($F(1, 14)=10.37$, $p<.01$, $\eta=.44$);

the intervention group showed increased IQ difference scores ($N=7$, mean = 5.36, $SD=6.52$, range = -2.5 to 17.5) compared with the control group ($N=7$, mean = -6.35, $SD=7.21$, range = -15 to 5). T1 T3 analyses indicated that the T1 T3 difference was not significant (see Fig. 1).

3.3.4. Negative affect

In relation to self-report test anxiety, the T1 T2 analysis showed a trend toward a significant group difference, with a small to medium ES ($F(1, 14)=3.29$, $p=.09$, $\eta=.20$). There was a greater difference score in the intervention group ($N=7$, mean = -13.57, $SD=9.31$, range = -29 to -3) compared with the control group ($N=8$, mean = -4.25, $SD=10.44$, range = -15 to 10). T1 T3 analyses showed no group difference. With respect to trait anxiety, there was no group difference between T1 and T2 or between T1 and T3 (see Fig. 2). T1 T2 teacher-report of emotional symptoms showed a significant group difference and with a large ES ($z=2.36$, $p<.05$, $r=.61$) indicating lowered emotional symptoms in the intervention group ($N=7$, mean = -1.29, $SD=1.11$, range = -3.00 to 0.00) compared with the control group ($N=8$, mean = -.23, $SD=.35$, range = -1.00 to 0.00). There was no T1 T3 group difference (see Fig. 3).

3.3.5. Teacher-report behaviour and attentional control

For both behavioural difficulties and attention control the T1 T2 analyses showed significant group differences with moderate and large effect sizes ($F(1, 14)=7.41$, $p<.05$, $\eta=.36$ and $F(1, 14)=15.43$, $p<.01$, $\eta=.54$) for total behavioural difficulties and attentional control respectively. The mean T1 T2 behavioural difficulties difference scores for the intervention and control groups were -3.71 ($SD=3.73$, range = -9.0 to 1.0, $N=7$) and .63 ($SD=2.38$, range = -2.0 to 6.0, $N=8$). The mean T1 T2 attentional control difference scores for the intervention and control groups respectively were -10.14 ($SD=7.03$, range = -23 to -1.0, $N=7$) and -.13 ($SD=1.64$, range = -2 to 3, $N=8$). There was no T1 T3 difference for total behavioural difficulties or attentional control (see Fig. 3).

4. Discussion

The present study found that (compared with a non-intervention passive control group) young people with SEBD who completed WM training showed short-term positive change in WM, IQ and behavioural inhibition, as well as teacher-report emotional symptoms, behavioural difficulties and attentional control, and self-report test anxiety. Group differences in WM were also evident three months following training. These findings indicate that the immediate impact of WM training goes beyond simply increasing WM capacity and suggests that it could have a positive impact on performance in school and behaviour more generally.

⁶ The Improvement Index is calculated within the CogMed training programme where the starting WM score is subtracted from the maximum score based on one spatial and one verbal WM task.

⁷ One participant's data was corrupted at T1 leaving $N=6$ for the T1 T2 comparison.

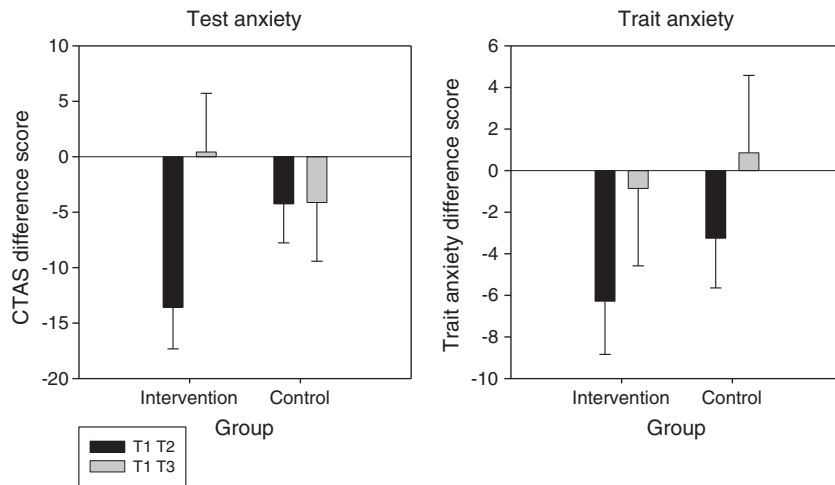


Fig. 2. Teacher-report emotional symptoms, behavioural difficulties and attentional control Time 2 (T2)–Time 1 (T1) and Time 3 (T3)–Time 1 (T1) difference scores and standard errors for the intervention and control groups.

The improvements in WM for the intervention group are consistent with the findings of previous studies in children with ADHD (e.g. Klingberg et al., 2002). Furthermore, the increase in IQ and behavioural inhibition for the intervention group is similar to the effects found after WM training in adults, typically developing children and those diagnosed with ADHD (Jaeggi et al., 2008; Klingberg et al., 2005). The improvements in IQ may be a result of increased attention, inhibition, concentration and the use of rehearsal strategies; all of which are suggested to be less established in children and young people who have lowered WM skills (Gathercole, Pickering, Knight, & Stegmann, 2004). This wider improvement can also be interpreted by examining theoretical models which suggest an association between inhibition and WM (Eysenck et al., 2007), as well studies that have found links between performance in WM and inhibition tasks (St Clair-Thompson & Gathercole, 2006).

The current study extended previous research to explore the impact of WM on negative affect in young people who experience SEBD. The results provide preliminary evidence to support the proposition that WM training can reduce negative affect in young people; where this relationship was clearest for teacher-report emotional symptoms and self-report test anxiety. The association between anxiety and academic underperformance in children is well established (e.g. Gumora & Arsenio, 2002) and research suggests that both factors are associated

with WM functioning (Aronen et al., 2005). In the current study improvements in negative affect were apparent immediately following the WM intervention; raising the possibility that improved attentional processing following WM training reduces negative affect. Further research with a larger sample size could explore whether any positive change in anxious affect is mediated or moderated by improved WM.

While group differences were found for WM over time, these were not evident for IQ or behavioural and emotional indicators more broadly. This lack of continuity suggests that this type of intervention might only work to reduce negative affect in the short term. In addition, improved WM over time suggests some dissociation between WM with IQ, negative affect and behaviour more generally. Other explanations of this pattern of results are, however, possible. The lack of a T1 T3 group difference, for example, was partially a function of improvements in all measures in the control group over time. This finding indicates a lack of stability in anxious affect, behaviour and performance in young people with SEBD over short time periods. The group difference in anxiety immediately following the intervention could also be a function of other aspects of WM training (e.g. increased positive feedback and praise) that work to build confidence and self-esteem around worries about performance. This interpretation would suggest that more traditional CBT methods might complement a WM intervention to ensure that any change in anxiety continues over time

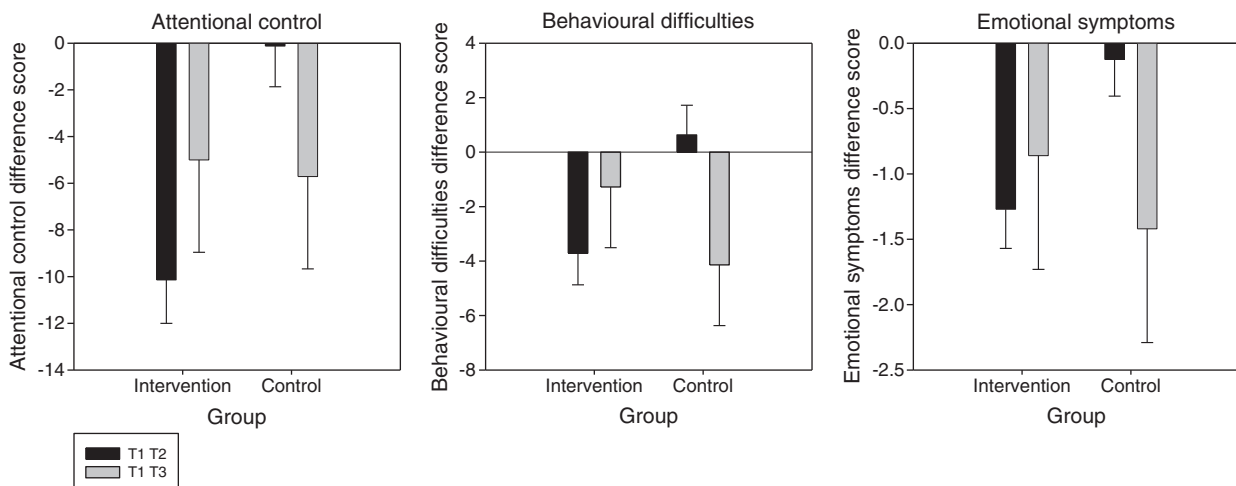


Fig. 3. Self-report test anxiety (CTAS; Children's Test Anxiety Scale) and trait anxiety Time 2 (T2)–Time 1 (T1) and Time 3 (T3)–Time 1 (T1) difference scores and standard errors for the intervention and control groups.

(e.g., Keogh et al., 2006). An increased sample size would allow researchers to address different explanations of change.

In summary, these results provide preliminary support for the proposition that a WM training programme can reduce anxious affect in young people, which may serve to alleviate the development of school-related difficulties and the prevention of later mental health problems in the longer term. There are, however, several limitations. The sample size is small and the results require replication with a larger number of children and young people. In addition, some T1 T2 group differences might have been partially explained by a negative change in the control group in some measures (e.g. IQ, inhibition). Furthermore, adults who completed the teacher report measures were not blind to the group and this knowledge could have

differentially influenced their reporting of behavioural change between the intervention and control participants.

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Appendix A

The mean \pm standard deviation of executive function tests (WM and inhibition), performance indicators (MHV and SPM), self-report anxiety (CTAS, BYI) and teacher report behaviour (SDQ total difficulties and emotional subscale and attentional control) at pre-training (T1), post-training (T2) and follow-up (T3) for the intervention ($N=7$) and control ($N=8$) groups. The number of children who showed positive (versus negative or no change) at T2 and T3 is shown in parentheses.

	Intervention					Control				
	T1	T2		T3		T1	T2		T3	
<i>Executive function</i>										
WM	9.00* ± 1.00	11.14 ± 1.22	(7/7)	11.57 ± 1.27	(7/7)	8.00 ± 0.76	8.13 ± 0.84	(2/8)	7.71 ± 1.11	(1/7)
Inhibition (%)	77.60 ± 17.33	90.21 ± 9.46	(3/6)	83.36 ± 26.91	(4/6)	64.52 ± 25.68	56.33 ± 19.97	(2/8)	84.54 ± 9.78	(5/7)
<i>Performance indicator</i>										
Composite IQ (SPM/MHV)	91.07# ± 11.62	96.42 ± 15.60	(5/7)	97.85 ± 15.71	(5/7)	81.87 ± 7.64	75.62 ± 10.41	(1/8)	80.00 ± 15.67	(3/7)
<i>Anxiety</i>										
CTAS	69.71* ± 9.67	56.14 ± 9.66	(7/7)	70.14 ± 14.70	(4/7)	58.00 ± 10.42	53.75 ± 17.56	(4/8)	50.71 ± 14.02	(5/7)
BYI trait anxiety	49.29 ± 6.44	43.00 ± 7.28	(6/7)	48.43 ± 8.36	(4/7)	43.13 ± 9.28	39.88 ± 7.24	(5/8)	43.57 ± 12.35	(3/7)
SDQ emotional subscale	5.0 ± 1.41	3.71 ± 1.60	(5/7)	4.14 ± 2.16	(3/7)	4.00 ± 2.00	3.88 ± 1.96	(1/7)	2.71 ± 2.49	(3/7)
<i>Teacher-report behaviour</i>										
SDQ total difficulties	17.29 ± 4.75	13.57 ± 4.89	(6/7)	16.00 ± 5.86	(5/7)	17.63 ± 6.56	18.25 ± 5.55	(2/8)	12.71 ± 6.60	(5/7)
Attentional control	22.71 ± 11.62	12.57 ± 11.12	(7/7)	17.71 ± 12.0	(4/7)	29.00 ± 11.63	28.88 ± 11.69	(3/8)	23.71 ± 15.81	(5/7)

Note. * indicates a T1 group difference $p < .05$ and # indicates a T1 group difference trend, $p < .1$. WM is working memory, CTAS and the BYI refer to the Children's Test Anxiety Scale and Beck Youth Inventory respectively. SPM and MHV relate to the Ravens Progressive matrices and the Mill Hill Vocabulary Scale and the SDQ to the Strength and Difficulties Questionnaire.

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