NR6-052: A Randomized Controlled Trial of Two Forms of Computerized Working Memory Training in ADHD

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Abstract

Background: Working memory (WM) deficits are frequently found in subjects with Attention-Deficit Hyperactivity Disorder (ADHD). Previous studies have suggested that computerized training on (particularly) visuospatial WM tasks can improve WM deficits and reduce ADHD symptoms.

Design: Randomized double-blind trial comparing two forms of computerized WM training (CWMT).

Participants: 46 children aged 7-12 with ADHD attending an intensive 8-week, behaviorally based, summer treatment program

Method: Subjects were randomized to receive Verbal (n=22) or Visuospatial (n=24) WM training. This commenced in week 2 and was continued 4 days/week until week 7 for a maximum of 25 sessions. Pre-post assessments of WM capacity were made before (week 2) and after (week 7), blind to group assignment using 5 sub-tests from the Automated Working Memory Assessment (AWMA). Weekly counts were also recorded of positive behaviors observed during the camp.

Results: Visuo-spatial training was associated with significantly greater gains in visuospatial WM: Dot Matrix (Effect Size (ES)=0.52, p=0.01) and Block Recall (ES=0.40, p=0.06). There were no differences between groups in verbal WM. There were significantly greater numbers of positive behavior points earned in the camp during weeks 4, 5 & 6 by the group receiving visuospatial WM training compared to the verbal WM training group (ES=0.50, p=0.03).

Conclusions: This pilot study suggests that computerized training on visuospatial tasks can produce changes in WM performance on tasks that were not specifically trained upon. Visuospatial, but not verbal WM training was associated with improvements in observed behaviors during training.

Background

Deficits in executive functions (EF), especially of working memory (WM), are thought to be of central importance in explaining cognitive and behavioral problems in ADHD[1,2]. Large impairments in both the visual spatial storage and visual spatial central executive (CE) components of WM are seen, whereas more modest deficits are found in verbal storage and verbal CE domains[3].

Computerized Working Memory Training (CWMT) has recently been developed in Sweden. Two previous trials have evaluated the effect of CWMT in children with ADHD[4,5]. Training of specific WM tasks significantly increased performance of other non-trained WM tasks as well as other measures of EF. Improvement in WM was associated with improvement in parent rated symptoms of ADHD. It has been suggested that the effects of WM training on ADHD symptoms are most strongly associated with training on visuo-spatial (VS) tasks, and that minimal improvements are found when training is carried out using tasks that train verbal working memory.

Purpose

To compare two forms of CWMT (verbal and visuospatial) as an additional intervention to standard behavioral treatment in a summer camp (NYU Summer Program for Kids: SPK) for children aged 7-12 with ADHD.

Method

At baseline, during the first week of the SPK, the children were administered 5 sub-tests from the Automated Working Memory Assessment (AWMA)[6]. Subjects were randomized to receive one of two training protocols within the CWMT software (RoboMemo®): either 6 visuospatial training tasks (CTWM-VS) or 5 verbal and 1 visuospatial training tasks (CTWM-VER). To protect the blind, one visuospatial task (SpaceWhack) was carried out by all subjects. Both training protocols automatically increased the difficulty level of the working memory tasks, depending on individual progress. Randomization was stratified for reading ability and academic skills.

Training was done in a computer classroom, for 30-35 minutes per day, 4 days/week beginning in week 2 and continuing through week 7 to achieve a target of 25 training days. The standard training behavioral reward scheme used in previous studies was enhanced and modified to be compatible with the behavioral reward systems used at the SPK. Within CWMT subjects were rewarded on a daily basis for (a) the quality of training plus (b) progress on each working memory task. At the end of each successfully completed training session, students were also able to play a brief video-game (Robo-Racing).

After completing 25 days of training each child was reassessed.The effectiveness of CWMT was measured using two primary outcomes: (1) Changes in the 5 (non-trained) measures of working memory within the AWMA, and (2) The number of positive behavioral points the children earned each week from counsellors, blind to group assignment, as part of their day-to-day progress in the camp

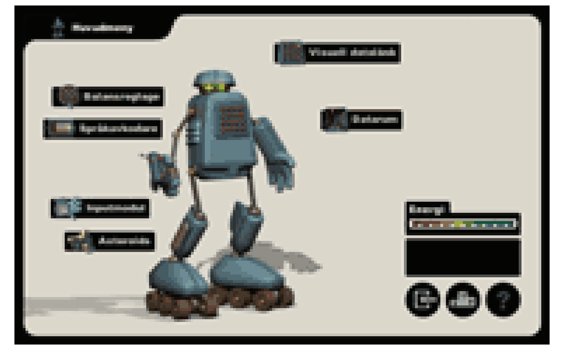
Results

46 subjects consented to be in the study and provided baseline data. 22 were randomized to Group 1 (CWMT-VER) and 24 to Group 2 (CWMT-VS).

There were no significant baseline differences between groups in terms of gender (90% male), academic abilities (reading, phonics or math scores), positive behavioral points earned (in week 2), or in the proportion of subjects treated with ADHD medications. Subjects in Group 1 (CWMT-VER) were on average 9.6 months younger than Group 2 (CWMT-VS) children (p=0.046).

6 (13%) children were missing post-treatment WM variables. The missing values were handled by multiple imputations (with PROC MI in SAS®) using pre-treatment AWMA data and gains in trained WM tasks as regressors.

Group 2 (CWMT-VS) showed statistically significant greater gains than Group 1



(CWMT-VER) on two non-trained visuospatial tasks within the AWMA: Dot Matrix (DM) and Block Recall (BR). Standardized effect sizes (ES) in favor of visuospatial training were 0.52 for Dot Matrix (p=0.01) and 0.40 for Block Recall (p=0.06).

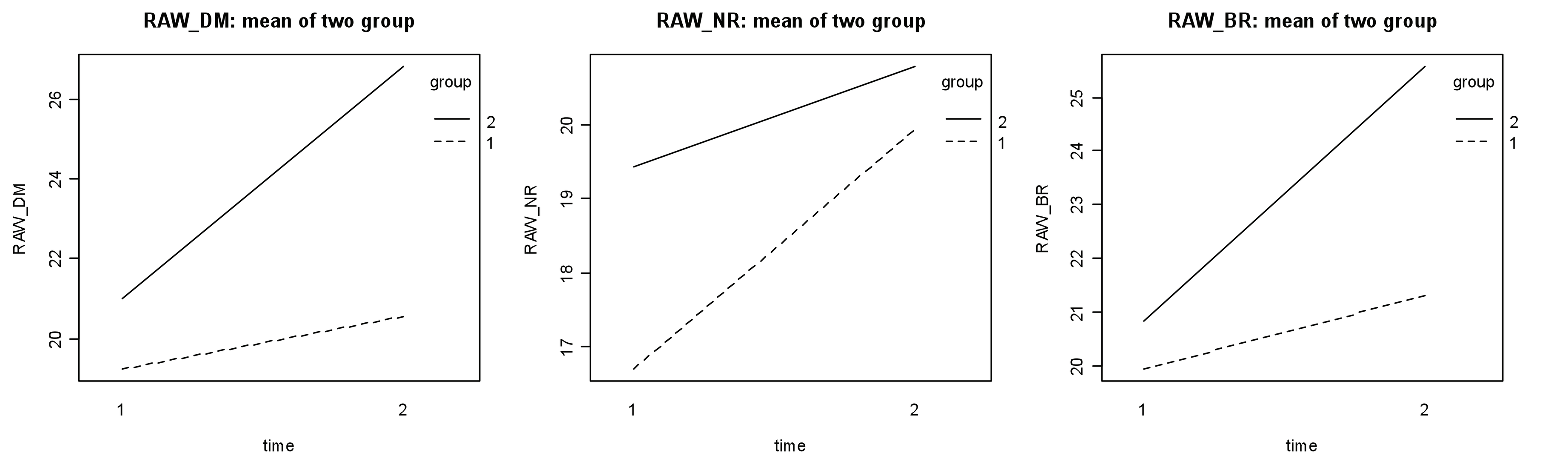
Outcome Variable	Group 1									Group 2									Difference between 2 groups*		
	Time 1			Time 2			Change			Time 1			Time 2			Change			group 2 - group 1		
	N	Mean	Std	N	Mean	Std	N	Mean	Std	N	Mean	Std	N	Mean	Std	N	Mean	Std	Estimate	S.E.	P value
RAW_DM	22	19.36	5.84	17	20.53	6.7	17	1.29	7.28	23	20.78	5.69	23	26.83	7.81	22	5.59	7.58	5.53	2.21	0.0126
RAW_NR	22	16.36	7.21	17	19.94	4.42	17	3.24	6.31	24	19.33	6.05	23	20.78	5.12	23	1.35	6.37	0.12	1.36	0.9318
RAW_BR	22	20.14	5.74	17	21.29	8.48	17	1.35	4.97	24	20.5	5.33	23	25.57	8.21	23	4.74	7.96	4.57	2.40	0.0578
RAW_BDR	22	11.45	6.51	17	13.65	7.31	17	2.24	4.97	24	9.46	5.69	23	10.91	5.57	23	1.26	6.03	-1.00	1.64	0.5407
RAW_SS	22	12.91	7.57	17	16.06	7.77	17	1.94	6.58	24	15.75	9.12	23	18.7	8.62	23	2.78	6.1	1.54	1.85	0.4071

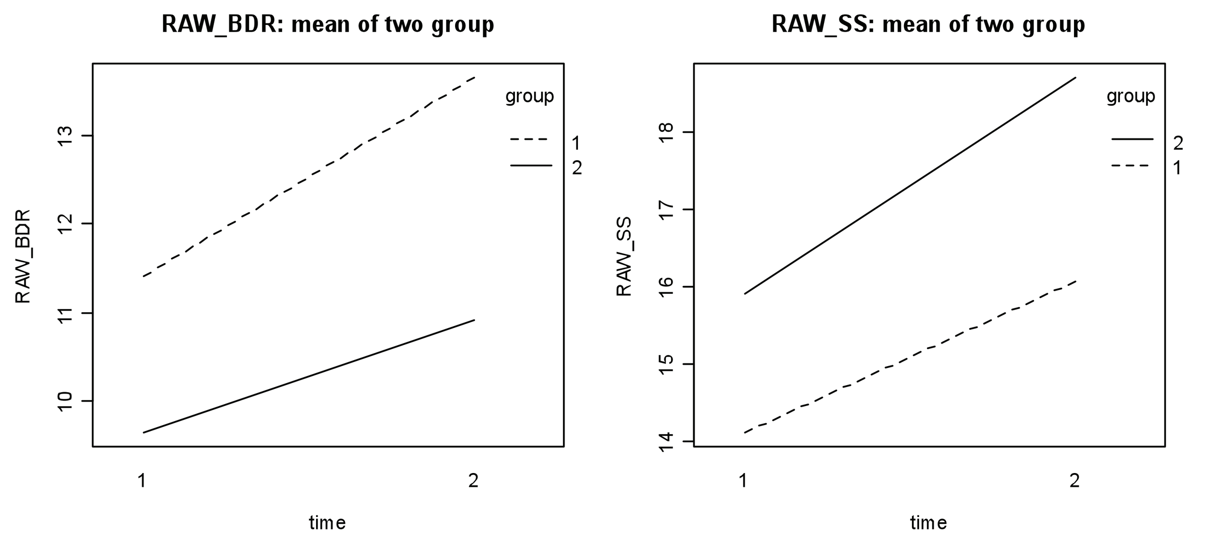
Similar treatment effects were seen in the weekly numbers of positive behavior points awarded by camp counselors (blind to group assignment). Between Weeks 4 and 6 children training on visuospatial tasks earned an average of 29.8 points more per week than did children in the verbal WM training group.

In view of baseline differences on age, adjusted analyses using this as a covariate were carried out, but this did not alter the significance of the results.

Group Differences in Positive Behavior Points earned weeks 3-7

	N	Week 3	Week 4	Week 5	Week 6	Week 7
Group 1: CWMT-VER Mean (SD)	20	281.0 (47.1)	243.5 (81.7)	269.1 (67.6)	269.9 (62.8)	235.2 (75.1)
Group 2: CWMT-VS Mean (SD)	24	276.3 (55.6)	269.0 (66.0)	293.6 (45.7)	300.8 (59.4)	253.2 (52.0)
Comparison of group means at each week group 2- group 1		-2.0 (14.2) P=0.89	30.0 (19.1) P=0.13	26.0 (17.0) P=0.13	33.5 (17.3) P=0.06	19.7 (19.0) P=0.31
Treatment effect Week 4-6			29.8 (13.3) P=0.03			
Treatment effect Week 3-7		21.4 (12.4) P=0.09				





Improvements in non-trained tasks on the AWMA

Group 1 - CWMT-VER
Group 2 - CWMT-VS

RAW_DM: Dot matrix
RAW_NR: Non-word recall
RAW_BR: Block recall
RAW_BDR: Backward digit recall
RAW_SS: Spatial Span

Conclusions

Computerized training of visuospatial working memory tasks can increase WM performance on tasks that were not specifically trained upon. Visuospatial, but not verbal WM training is associated with improvements in observed behaviors during training.

Future work should use more potent visuospatial training tasks and examine the effect of computerized working memory training on independent ratings of the core symptoms and behavioral deficits associated with ADHD.

References

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