The Effects of Working Memory Training (WMT) in Typically Developing Preschoolers and Second Graders on Working Memory, Analogical Reasoning and Self-Regulation

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Abstract

Working memory (WM) training programs involving 'hands-on' or computerized exercises have become increasingly popular since the year 2000 claiming to significantly improve WM capacity. Results have been somewhat inconsistent and often contradictory. While most research investigating the benefits of WM training involve adults or school age children, fewer studies have focused on the younger population when early training is likely to have the greatest impact on developing cognitive and neural structures.

In the current study, we offer a novel approach based on the *Mediated Learning Experience* theory (MLE, Feuerstein et al., 2002) in which a human mediator intervenes to mediate cognitive functions, domain-specific and domain-general strategies and metacognitive knowledge related to WM. Our main hypothesis is that these cognitive functions and strategies represent significant mechanisms underlying WM, ensuring maintenance and generalization and enabling transfer to more disparate cognitive measures.

Two studies were conducted. In Study 1, a sample of 118 typically developing kindergartners between the ages of 5 and 6 (59 boys and 59 girls) were randomly assigned to an experimental (n = 62, mean age = 70.48 months, SD =3.86) and control (n = 56, mean age = 68.29, SD =4.89) group. The experimental group received 40 minute bi-weekly sessions of mediated WM training using the Sequences Level-II (SQ-II) Subtest of the *Cognitive Modifiability Battery* (CMB, Tzuriel, 1995, 2000) during a 5-week period. The control group participated in a school

readiness training program, engaging in educational games for an equal amount of time. All children were administered tests of verbal and visuo-spatial WM, before and after the intervention (*Children's Working Memory, CWM; Children's Spatial Working Memory, CSWM; Understanding Instructions, UN; Digit Span, BDR; Head-Shoulders-Knee-Toe, HTKS*). The children were also administered the *Children's Analogical Thinking Modifiability (CATM)* test, a test of fluid intelligence.

The data was analyzed by a series of repeated measures MANOVA's. The total score of all WM tests revealed a significant Treatment x Time interaction, $F(1, 118) = 6.73$, $p < .01$, $\eta^2 = .06$. This finding indicates that the experimental group showed higher pre- to post-intervention improvement than the control group. Separate analyses for each WM test revealed a significant Treatment x Time interaction $F(1, 118) = 6.88$, $p < .01$, $\eta^2 = .06$ only for the *Understanding Instructions* test, a classroom analogue of WM. Analysis of the effects of WM training also showed a significant Treatment x Time interaction $F(1, 118) = 3.91$, $p < .05$, $\eta^2 = .03$ at the medium level of difficulty of the CATM analogies.

In Study 2, 130 typically developing second graders (73 boys and 57 girls) between the ages of 7 to 8, were randomly assigned to either an experimental or control group. Children in the experimental group (n =65, mean age = 93.31, SD = 4.57) participated in a shorter version of the CM-WMP program for a total of 3 sessions. The sessions lasted for 45, 90 and 45 minutes respectively. The program was administered during a 3-week period. The children in the control group participated in an alternative intervention program which did not involve WM, i.e. solving perceptual analogies problems from the *Children's Conceptual and Perceptual Analogical Modifiability's Test* (CCPAM, Tzuriel, 2002).

All the children were administered WM tests (*Children's Working Memory, CWM; Understanding Instructions, UND*) and a fluid intelligence test (*Children's Analogical Thinking Modifiability, CATM)* before and after the intervention. The last test served as a measure of far-transfer.

The data was analyzed by a series of repeated measures MANOVA's. The total score of all WM tests revealed a significant Treatment x Time interaction, $F(1, 130) = 5.76$, $p < .01$, $\eta^2 = .04$. This finding indicates that the experimental group showed higher pre- to post-intervention improvement than the control group. Separate analyses revealed a significant Treatment x Time interaction $F(1, 130) = 4.62$, $p < .05$, $\eta^2 = .03$ for the *Understanding Instructions* test indicative of classroom performance. A significant interaction of Treatment X Time $F(1, 130) = 10.86$, $p < .01$, $\eta^2 = .08$. was also found for the CATM Analogies.

The findings of both Study 1 and Study 2 support our hypotheses that a WM intervention program has a significant effect in enhancing WM abilities as well as improving analogical reasoning in younger children.

This study is novel in so far as it is among one of the first to attempt to prove that it is possible to train WM in preschoolers. This improvement was also evident in a group of second graders. The uniqueness of this study is in its implementation of a mediational approach based on a *t*ransactional model involving three interacting dimensions (a) MLE strategies, (b) cognitive functions and (c) task-specific characteristics. *This study seeks to further the understanding of WM and to identify the specific cognitive functions and mechanisms that underlie its activation.*