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CHAPMAN UNIVERSITY
CREAN COLLEGE OF HEALTH AND BEHAVIORAL SCIENCES

Effect of Digitally Enhanced Learning Tasks on Cognitive Function

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Introduction

In recent years there has been an increase in commercial cognitive training programs that claim that their program improves memory, attention, processing speed or problem-solving skills. These programs are based on the assumption that improving working memory can lead to gains in related areas of cognition. This implication that working memory can improve other areas of cognition stems from the finding that working memory is a central component of general cognition. The increased access via portable electronic devices allows these digitally enhanced learning tasks to reach a greater amount of people. However, the literature does not have a clear answer as to whether these digitally enhanced learning tasks that train working memory actually improve other areas of cognitive functioning.

Working memory (WM) is defined as a storage system that is responsible for retaining small amounts of information over brief intervals of time. A cognitive function that is related to working memory is fluid intelligence, a persons ability to reason with novel information. A persons ability to reason with novel information can be largely attributed to WM capacity and vice versa. Another cognitive function that is related to working memory is attention control. People that have a high WM capacity are less likely to have their attention drawn from a distraction than their low WM counterparts. In 2014, Au et al., conducted a meta-meta-analysis across 20 different studies of working memory literature and found a small but statistically significant net effect of n-back training on fluid intelligence outcome measures. However, this finding's generalizability is restricted due to the limited age range of the population. However, in 2012, Shipstead, Redick, and Engle conducted a literature review in which they concluded that the literature did not provide sufficient evidence of the efficacy of WM training impacting other areas of cognition. Therefore, the current body of literature regarding the relationship between electronically enhanced learning tasks that train working memory and its impact on other areas of cognition is inconsistent at best.

Hypothesis

If an individual is exposed to a digitally enhanced learning task, then they will show an increase in cognitive functioning compared to an individual who is exposed to other learning task forms.

Key Definitions

Independent variables

Digitally enhanced learning tasks: Digitally enhanced learning tasks, also, known as cognitive training programs has begun to proliferate a variety of programs that state that their program will lead to transfer or gains in cognitive function. A majority of these programs focus on the training of working memory due to its role in cognition.

Working Memory: Working memory is defined as a storage system that is responsible for retaining small amounts of information over brief intervals of time. There are a variety of different working memory training tasks that have been created some of which include complex span tasks, n-back task and running memory span.

Dependent variable

Cognitive Function: Cognitive function is a collection of abilities that we possess such as memory, attention, executive function, fluid intelligence, crystallized intelligence and processing speed. Due to the variety of different aspects of cognitive functioning there is an array of measures for each specific realm of cognition.

Table Note

ability tests=Cognitive Abilities test battery; AWMA=Automated Working Memory Assessment-II; Cd=Digit Symbol Coding; CL=Classification; COWAT=Controlled Oral Word Association Test; CPM=Ravens Coloured Progressive Matrices; CPT=Continuous performance task; CSRQ-25=Cognitive Self-Report Questionnaire; D-CAT=Digit Cancellation Task; DS-B=Digit Span Backward; DS-F=Digit Span Forward; FAB=Frontal Assessment Battery; knowledge tests=Domain Knowledge tests; MMSE=Mini Mental Status Exam; NEPSY=Developmental NeuroPsychological Assessment; RAPM=Ravens Advanced Progressive Matrices; Raven SPM=Ravens Standard Progressive Matrices; RBANS=Repeatable Battery for the Assessment of Neuropsychological Status; RP=Repeated Patterns; RSPM=Ravens Standard Progressive Matrices; SO=Sequential Order; SS=Symbol Search; STM=Short term memory; TMT-B=Trail Making Test-B; TONI=Test of Nonverbal Intelligence; WAIS-III=Wechsler Adult intelligence Score III; WASI=Wechsler Abbreviated Scale of Intelligence; WAIS-R-NI=Wechsler Adult Intelligence Scale, Revised as a Neuropsychological Instrument; WISC-III=Wechsler Intelligence Scale for Children; WM tasks=Automated Operation Span, Automated reading span; WOND=Wechsler Objective Numerical Dimensions; WORD=Wechsler Objective Reading Dimensions; WPPSI-R=Wechsler Preschool and Primary Scale of Intelligence Revised; WPPSI=Wechsler Preschool and Primary Scale of Intelligence.

Results

Study/ Relation to Hypothesis	Study Design	Participants	Intervention Group	Dependent Measure	Results
Alloway et al. (2013) Support	Pretest/ Posttest with a follow up 8 months later.	94 students classified as having learning difficulties	Jungle Memory (2008) WMT-High Group	Working Memory: AMWMA General Ability: WASI Academic Attainment: WORD, WOND	Gains in untrained tests of verbal and visuo-spatial working memory. Maintenance effect for the high training group as well.
Smith et al. (2009) Support	Multisite randomized controlled double-blind trial with two treatment groups	N=487 Community-dwelling adults aged 65 and older from California and Minnesota	A broadly-available brain plasticity-based computerized cognitive training program	Primary Outcome: RBANS Secondary Outcome: CSRQ-25	RBANS significantly greater (P=.02) with 3.9 points, 95% confidence interval (CI)=2.7-5.1 Secondary measures showed significant improvement.
Nouchi et al. (2012) Support	Randomized controlled trial pretest/posttest design	N=32 Elderly, non-gamers	Brain Age (Nintendo)	MMSE, FAB, TMT-B, D-CAT, DS-F, DS-B, Cd, SS	Intervention group showed improvements in executive processing and processing speed.
Thorell et al. (2009) Support	Pretest/ posttest	N=65 Children between the ages of 4 and 5	Cogmed Program	WAIS-R-NI, Day-Night Stroop, Go/No-go task, word span task, WISC-III, CPT, WPPSI-R	Significant effect on WM tasks within spatial and verbal domains.
Borella et al. (2014) Support	Pretest/ posttest and follow up 8 months later	N=80 Young-old(65-75) Old-Old (76-84)	Participants were shown a series of matrices organized in the same way as the matrix task	Matrix task, Categorization Working Memory Task.	The results show gains in the criterion task, and in Working Memory in both young-old and old-old.
Thompson et al. (2013) Refute	Pretest/ posttest and follow up design	N=55 Between 18 and 45	Dual n-back training	Dual n-back task, Multiple object tracking, WM tasks, RAPM, WASI, WAIS- III	The results revealed no transfer of improvement to non-trained near transfer measures.
Ackerman et al. (2010) Refute	Within-participants procedure	N=78 Mean Age= 71 years old	Nintendo Wii Big Brain Academy	Wii performance measures, knowledge tests, ability measures	The results showed no significant transfer of training to measures of cognition
Soderqvist et al. (2009) Mixed	Randomized pretest/ posttest design	N= 41 ages 6-12, with an IQ <70	Nonverbal adaptive training program along with WM training program from Cogmed Systems	STM, WM, WPPSI, NEPSY, Ravens Matrices	There was significant improvement on verbal WM and language, however measures of reasoning ability were not significant.
Nutley et al. (2011) Mixed	Double blinded randomized, controlled investigation pretest/ posttest	N=112 Aged 4-4.5 years of age	WM task developed by Cogmed and Nonverbal reasoning task	RP, SO, CL, CPM, WPPSI, Visuo-spatial grid, AWMA, Odd One Out, WISC-III	Improvements in the NVR group was significant however improvement on dependent measures were not significant in the WM Group.

Discussion and Conclusions

The results of the supporting articles indicate that digitally enhanced learning tasks are capable of improving cognitive functioning to a certain degree. The current literature focuses primarily on young children, children with ADHD, and older adults that may be mildly cognitively impaired. Most of the supporting articles focus on these demographics to find a cost-effective intervention suited to the individual. For instance, in children with ADHD the goal is to control the symptoms in ADHD, while in older adults the programs goal is to protect against cognitive decline. Results from the refuting articles demonstrated no difference in participants in the intervention group and the active control group. The results from the mixed articles indicated that the area of cognitive function that improves is dependent on the population being tested. In one article, individuals with intellectual disability who were trained in visuo-spatial tasks only showed improvements in verbal working memory and language functioning. These findings are mixed because areas of cognition that are considered near transfer showed no effect, and there was no maintenance of improvement in the areas that did show an effect.

Based on the literature reviewed up to date, the results provide support for the thesis hypothesis. The use of digitally enhanced learning tasks can lead to improvements in measures of cognitive function. The ecological impact of these findings could lead to further discoveries in the field of cognitive science and the underlying mechanisms of cognition. Long term ecological effects in the study of working memory could lead to a better understanding of the environments influence on the brains plasticity. From a translational perspective, the general public should educate themselves about the programs they plan on subscribing to before they start a membership with a program like, Lumosity. Due to the current body of literature it is evident that not all programs are created equal, in the sense that they train different areas of cognition, therefore it is important to confirm that the program will be training the area of cognition where improvement is desired. Additionally, the cost-effective intervention programs that can be easily dispersed can reduce the impact of cognitive decline in older populations and reduce ADHD symptoms in individuals diagnosed with the disorder.

Future Study

Future studies should identify the interaction of cognitive functions so that specific dependent measures can be created as well as precise training programs that effectively target the desired area of cognition. Pending advancements in neuroscience it would be fascinating to perform a longitudinal study on the effects of digitally enhanced learning tasks on brain development.

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