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Training Skills of Divided Attention among Older Adults

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The current study examined whether video game training would help improve divided attention skills among older adults. Twenty-nine (4 males, 25 females) participants aged 50 to 84 years (*M* = 70) were tested for their skills of divided attention using a memory and reaction time task. Participants were randomly allocated to the experimental group and control group and only those in the experimental group trained with the computer game, *Pac-Man Adventures in Time* for three hours. Results show that three hours of training are not sufficient to enhance skills of divided attention amongst older adults as the differences in these skills were not significantly different between control and experimental groups. These findings suggest that greater amounts or other methods of training may be required to enhance older adults' ability to perform dual tasks.

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Skills of divided attention can be defined as the ability to simultaneously attend to more than one activity (McDowd & Craik, 1988). These skills are required for occupations or tasks that demand skills in attending to several simultaneously occurring stimuli which include flying (Gopher, 1992; Gopher, Weil, & Bareket, 1994) and surgical skill (Rosser et al., 2004). They are also required for the performance of a number of everyday activities such as walking (Bootsma van der Wiel et al., 2003; Mezler & Oddsson, 2004) and driving (Howard & Connell, 2005; McKnight, 2003) which are crucial, in particular for older adults to maintain their independence (Fricke & Unsworth, 2001). However, research has shown that the ability to perform concurrent tasks decline with age (Craik & McDowd, 1987; McDowd & Craik, 1988). It is therefore important to investigate ways to enhance skills of divided attention among older adults.

Theories such as the resource allocation theory (Kahneman, 1973) explain that there is a unitary pool of resources or attention that needs to be divided among multiple tasks and when the demand exceeds the available resources, performance on either one or both tasks declines. Furthermore, the attentional resources theory states that the number of available attentional resources declines in old age (Craik, & Byrd, 1982; Craik, 1986; McDowd & Craik, 1988); consequently, they retain fewer attentional resources which they can allocate to dual tasks, which lead to a decrement in the performance of either one or both of the tasks.

Dual Task Performance among Older Adults

Age related differences in dual task performance have been documented by a number of studies (Gother, Oberauer, & Kliegl, 2007; Sit & Fisk, 1999; Voelcker-Rehage & Alberts, 2007) using various dual task paradigms. Nevertheless, the recurrent finding in recent years has been that older adults can improve their dual task performance given appropriate training (Bherer et al., 2006; Maquestiaux et al., 2004). These findings are similar to those of younger adults who showed improvement in dual task performance after practice (Oberauer & Kliegl, 2004). In spite of this, studies have indicated that dual task costs remain for older adults (Rogers, Bertus, & Gilbert, 1994). These findings suggest that older adults' executive system functions remain in a serial processing constraint even after extensive practice (Gother et al., 2007). This consequently hinders the effective coordination of concurrent tasks (McDowd, 1986). It is possible that older adults require further training to eliminate dual task costs (Gother et al., 2007).

Improving Dual-Task Performance Though Practice

A review of the literature has revealed that the amount of practice provided is crucial in determining the elimination of age related dual task costs (Rogers et al., 1994). For example, Baron and Mattila (1989) and Wickens, Braune, and Stokes (1987) found that age related dual task costs could be eliminated after 11,800 trials of memory scanning practice or three sessions (3.5 hours) of practice, respectively. Furthermore, the ability to automatise a task allowing it to require fewer attentional resources is equally important in eliminating dual task costs among older adults. Despite this, the extant literature has revealed limited research investigating strategies to improve such skills among older adults. It is therefore necessary to investigate effective methods to enhance older peoples' divided attention skills.

Improving Cognitive Skills through Video Game Training

A method of training which could benefit the development of divided attention skills is video game training. Recent investigations have shown that video game play has many positive effects on a range of cognitive skills including spatial skills (Okagaki & Frensch, 1994), visual attention skills (Dye & Bavelier, 2004; Dye, Green, & Bavelier, 2009; Green & Bavelier, 2003) and reaction time performance (Clark, Lanphear, & Riddick, 1987; Dustman, Emmerson, Steinhaus, Shearer, & Dustman, 1992; Goldstein et al., 1997) among children, adolescents, and older adults. Video game training could also benefit the development of divided attention (Greenfield, DeWinstanley, Kilpatrick, & Kaye, 1994; Satyen, 2003) because video games require consistent monitoring of several concurrent targets appearing at several locations on a video screen (Gagnon, 1985) as well as controlling different buttons on the controller or keyboard.

In spite of the above findings which indicate that visual and attentional skills can be enhanced via video game training, Boot, Kramer, Simons, Fabiani, and Gratton (2008) have shown that these skills cannot be improved through such training. Boot et al. (2008) have indicated that greater amounts of training may be required for non video game players to show the same beneficial effects observed in expert video game players. Furthermore, a study by Murphy and Spencer (2009) has been unable to replicate findings of past studies (e.g., Dye & Bavelier, 2004; Dye et al., 2009; Green & Bavelier, 2003) which show an enhancement of visual attention following video game training. Similarly, the findings by Owen et al. (2010) revealed that after a minimum of 10 minutes a day, three times a week (for six weeks) of computerised brain training no improvements were observed in general cognitive abilities such memory, attention or visuospatial skills. These findings suggest that video games may have a limited role in modifying cognitive skills such as attention. Otherwise, as Basak, Boot, Voss, and Kramer (2008) have indicated extensive training may be needed before cognitive skill can be improved. Hence, the contrary findings in relation to whether video game training is effective in enhancing attentional capacity warrant the need for further research.

According to Boot, Blakely, and Simons (2011) one reason for the controversial findings in relation to whether or not video game training is effective in enhancing cognition could be caused by methodological shortcomings. Boot et al. (2011) explain that observed gaming benefits on cognition could simply be a result of participants' expectations and motivations about their gaming experience. Boot et al. (2011) thus express the need for more experimental design studies (i.e., training experiments) to avoid methodological limitations, such as the placebo effect, when investigating for any cause and effect relationships of video game training and cognitive improvement.

Recent research has shown that playing online games can transfer acquired skills to untrained measures of executive functioning such as inhibition and inductive reasoning (Muijden, Band, & Hommel, 2012). Similarly, Karbach and Kray (2009) demonstrated transfer to other untrained measures of executive tasks such as the Stroop Test following task switching training among older adults. Such findings are important for older adults given the implications of transfer effects of cognitive skills to tasks of everyday living. To date however there has been no study conducted to investigate for transfer effects of improved skills of divided attention among older adults. The current study thus assessed for possible transfer effects of divided attention skills to tasks that have not been directly trained. To do so, a training regime (i.e., a video game *Pac-Man: Adventures in Time*) was adopted which required the use of both reaction times and divided attention skills that did not directly match the experimental dual task (i.e., the divided attention paradigm) which included a memory and RT task.

Improvement of memory and RT skills using video game training was deemed possible in light of the interaction which exists between attention and memory. Past research has shown that under conditions of divided attention at encoding, people's ability to encode information is hindered (Anderson, Craik, & Naveh-Benjamin, 1998; Anderson, 1999; Naveh-Benjamin, Craik, Guez, & Kruger, 2005; Park, Smith, Dudley, & Lafronza, 1989). This is because fewer attentional resources are allocated to the primary task not allowing information to be adequately elaborated (Craik, Govoni, Naveh-Benjamin, & Anderson, 1996). Indeed, past findings (Naveh-Benjamin, Kilb, & Fisher, 2006; Rohrer & Pashler, 2003) have shown that people's ability to retrieve information is affected by their divided attention at retrieval, given that the secondary task is very attention demanding. This is because extra attentional effort is required for response selection when a demanding secondary task is performed which consequently affects memory retrieval (Naveh-Benjamin et al., 2006). Similarly, performance on the secondary task presents a decline when inadequate resources are allocated to its performance (Craik et al., 1996). Furthermore, findings have shown that secondary task performance is affected to a greater extent when attention is divided at retrieval rather than at encoding (Craik et al., 1996).

In light of this interaction, the current study assessed whether memory performance could be enhanced through an improvement in skills of divided attention. Training with a computer game which is attention demanding and requires the performance of concurrent tasks may enable older adults to practice their skills of divided attention. This could possibly enhance their skills of divided attention and level of attentional resources that could be allocated to the performance of concurrent tasks. Thereby, it may be possible to reduce memory and secondary costs associated with divided attention and enhance skills of memory and RT. An improvement in both tasks would thus be considered as an ultimate improvement in skills of divided attention.

Current Study

Overall, there seems to be a potential for video game training to improve cognitive skills. Despite this potential, video game training has not been effectively adopted to improve divided attention skills of older adults. Although past studies (e.g., Greenfield et al., 1994; Satyen, 2003) demonstrate a link between training and skills of divided attention, the minimum amount of training that would be required to improve such skills is unclear. This is because although past studies have provided considerable amounts of training, the amount of training provided has varied across each study. For example, while Greenfield et al. (1994) provided a minimum of five hours, Satyen (2003) provided six hours, Baron and Mattila (1989) and Wickens, et al. (1987) provided 3.5 hours of practice and all revealed significant results. The current study thus examined for the minimum level of training that is required to enhance skills of divided attention among older adults.

Therefore, the objectives of the current study were to examine the influence of a total three hours of video game training to enhance older adults' divided attention skills in line with the reduced processing resources theory (Craik, & Byrd, 1982; Craik, 1986). It was hypothesised that there would be an increase in the skills of divided attention under two attention conditions: (a) division of attention at encoding and, (b) division of attention at retrieval.

Method

Participants

A total of 29 (4 males, 25 females) (experimental group *N* = 14, control group *N* = 15) participants aged between 50 to 84 years (*M* = 70) took part in the current study. Participants were recruited from senior citizen clubs, bowling clubs, and senior community groups from the cities of Melbourne and Geelong in Australia. The selection criteria for participation included older adults who: (a) achieved an adequate level of competency on certain cognitive skills as assessed by the Mini Mental State Examination, and (b) had no prior experience with playing the experimental video game, *Pac-man Adventures in Time*. Having no prior experience with playing this game was important so that participants were not aware of the strategies associated with playing the game well. However, nine out of the 29 participants (all in the experimental group) had previous exposure to other video games and spent approximately 3 hours per week playing computer games such as puzzle games.

Materials

The Mini Mental State Examination (MMSE), divided attention tasks, memory tasks, distraction task: arithmetic filler task, the Reaction Time (RT) task, and the computer game.

The mini mental state examination (MMSE). The MMSE is a standardised tool designed to assess the mental status of adults (Folstein, Folstein, & McHugh, 1975). It is an 11-item measure that tests five areas of cognitive function including orientation, registration, attention and calculation, recall and language and is an effective screening tool for cognitive impairments such as dementia with older, community dwelling, hospitalised and institutionalised adults. The MMSE was used to assess their mental status and screen for any participants who may have cognitive impairments.

Divided attention measures. To assess for skills of divided attention, the measures used by Craik et al. (1996) and Naveh-Benjamin, Craik, Guez, and Dori (1998) were considered appropriate as the aims of the current study were similar to their objectives. These studies included memory and reaction time tasks presented under full attention and divided attention conditions which served as a dual purpose. When the memory and reaction time tasks are analysed together, they are used in the measurement of divided attention.

Memory tasks. Memory was assessed under free recall and divided attention conditions. The full attention condition served as a basis for comparison against the divided attention conditions. The memory task used was a Free Recall task.

Word lists for the free recall memory task. Word lists to be used for the free recall memory task to measure divided attention were selected from the online 'The Grocery List Collection' (The Grocery List Collection retrieved January 2006 from www.grocerylists.org.). The words selected met the following criteria: (a) they were two to three syllable shopping items which older adults would be familiar with, (b) they had to be familiar words to allow older adults to use their prior knowledge to support their episodic memory

(Castel, 2005), (c) they had to be familiar to the Australian population, and (d) no word was repeated in any of the lists so that practice effects did not interfere with recall.

To develop the nine (three each for pretest, post-test and practice tests) word lists, 96 words (6 x 12 words in each list for pre- and post-test lists and 3 x 8 words in each list for practice trials) were selected. It was ensured that no word was repeated in any of the lists, so that practice effects did not interfere with recall.

Distraction task: arithmetic filler task. To eliminate the recency effect, a distractor task was employed. Participants were required to perform an arithmetic filler task between the presentation of the words and the testing of recall. Participants were presented with numbers between 1-50 at a presentation rate of one number per second and asked to add three to each digit and report the sum orally. The numbers were presented in a different order (from 1 to 50) after each task. A total of seven number lists were prepared including six for the pre-test and post-tests and one for the practice trials.

Reaction time (RT) task. The RT task was used as the secondary task in the measurement of the faculty of divided attention. Reaction time was measured using the software program SuperLab Pro Ver. 4 (Cedrus Corporation, 1999), which operates on the Microsoft Windows operating system. Each experiment consisted of 152 trials. The reaction time from the onset of to the completion of each trial was recorded by the computer program with millisecond accuracy.

Computer game. The computer game used in the current study was one that was appropriate to train older adults and that was of interest to them. The game '*Pac-Man Adventures in Time*' was selected based on a range of criteria developed from previous research (Durkin & Aisbett, 1999; Hollander & Plummer, 1986) in relation to a game of interest to this age group and the relevant level of skills required to play the game. These included that the game had: (a) a 'G' rating, (b) a minimum level of difficulty to play and control, (c) several levels to maintain motivation for game play, (d) many features to be attended to simultaneously (thereby requiring the use of divided attention skills) and, (e) the ability to be played on a computer system using the keyboard for control. No prior video game experience was necessary to play this game.

Procedure

Pre-test phase. All participants first completed the MMSE to examine older adult's competence on a number of cognitive skills. Those who achieved an adequate level of competency on the test i.e., achieved a score of 21 were invited to further partake in the study. These participants were randomly allocated to either a control or experimental group and allowed to practice on all the different tasks including the free recall under full attention and divided attention, the reaction time task, the arithmetic task, and the computer game (for only those in the experimental group). They were then assessed on their skills of divided attention using a range of word lists (each word list contained 12 words) and RT tasks under different attention conditions. A Latin Square was completed to construct the order of the attention conditions for each participant. Thus the order of the conditions and lists were counterbalanced across participants and this removed the order effects of the attention conditions.

Full attention-Full attention condition.

In the full attention condition, the free recall memory task and RT tasks were performed separately. In the free recall task, the experimenter verbally presented a list of 12 words at a four second rate at the time of encoding while the participants tried to remember these words. They then performed the distractor task, wherein a number between 1-50 was orally presented to them by the experimenter at a presentation rate of one number per second and they added three to each digit and reported the sum orally. Older adults did not lose marks if they were unable to correctly report the calculations or gain marks for accurately reporting the calculations. Following the distraction task, participants recalled as many words as possible in any order and these were recorded by the experimenter. Participants had approximately two minutes to recall the words. Participants then performed the RT task under full attention conditions for exactly one minute.

To perform the RT task, participants were informed that the computer screen would display four large boxes and that in one of the boxes a smiley face would randomly appear. They were informed that each box corresponded to a different key on the keyboard and that their task was to press the correct corresponding key on the keyboard to the box in which the smiley face was appearing. Sometimes the smiley face reappeared in the same box and older adults were instructed to keep pressing the correct key until the smiley face moved to another box. They were instructed to perform this task as accurately and as quickly as possible. Older adults were made aware that if they pressed the incorrect key the smiley face would not move from the original box until the correct response was chosen. Participants were instructed to press the space bar to begin the RT task.

Divided attention-Full attention condition.

Participants performing the divided attention-full attention condition were informed that the experimenter would read aloud a list of words and their task was to remember and recall these words. Participants were informed that this condition differed from the full attention condition in that there was an added task (the reaction time task) which the participant had to perform during the encoding phase while the experimenter read the list of words. Participants were instructed to place equal emphasis on the reaction time and memory task.

During encoding, the experimenter instructed the participant to press the space bar when they were ready to begin the reaction time task while the experimenter read aloud a different list of 12 words at a rate of four seconds per word. Once the experimenter completed reading the list of words she pressed the escape button on the keyboard to stop the reaction time task. Following this, participants performed the distractor task and upon completion of this task they were asked to recall as many words as possible in any order under full attention and these were recorded by the experimenter. Participants had approximately two minutes to recall the words.

Full attention-Divided attention condition.

Participants performed the free recall memory task under conditions of full-attention-divided attention. For this condition, participants heard a list of words which they encoded and recalled at the time of retrieval. They only performed the reaction time task during the retrieval phase. Participants were instructed to place equal emphasis on the reaction time and memory tasks. They had approximately two minutes to recall the words from the memory task.

During the encoding phase, the experimenter read aloud a different list of 12 words at a four second rate per word while the participants tried to remember these words under full attention. At the completion of reading the words the retrieval phase began, participants pressed the space bar to begin the reaction time task and at the same time recalled as many words as possible from the list in any order. If at any time whilst recalling the words the participant stopped performing the reaction time task the experimenter instructed them to continue on with the task while also trying to recall the words. The experiment ceased either when the participant indicated that they could not remember any more words and the experimenter stopped the reaction time task or when two minutes had elapsed.

Training phase. Upon completion of the pre-test phase, only participants in the experimental group were trained with the computer game, *Pac-Man Adventures in Time* for three hours across three sessions. They were required to play the computer game for one hour during each session and all three sessions were scheduled to take place across a two to three week period. Participants in the control group were not exposed to a computer game over this period of time.

Post-test phase. Upon completion of the training session, participants in both the experimental and control groups were requested to complete the post-test phase to once again assess their skills of divided attention. This phase was identical to the pre-test phase; thus they performed the memory and RT tasks while using different word lists to that used in the pre-test phase. At the completion of the study, participants were thanked for their participation in the study and were given a gift voucher. A $15 gift voucher was given to participants in the control group and a $30 gift voucher was given to those in the experimental group to compensate for the time they accordingly spent in the study.

Results

Data Preparation

Before any analyses were conducted, the memory and Reaction Time (RT) data distribution was normalized. Initially, for the analysis of reaction times, the first two trials were excluded from analysis. The first two RT trials were removed as they included reading time for instructions and the preparation time to start the RT task. Furthermore, only correct RTs greater than 100milliseconds were included in the RT data analysis.

Data Analysis

An alpha level of 0.05 was used for all the statistical inferential tests. Initially, a paired samples t-test was conducted to examine for the effect of divided attention on both the memory and RT tasks. For this analysis, only the pre-test scores for both the trained and untrained groups were included in the analysis. Performance in the full attention condition was used as a baseline to compare against the divided attention at encoding and divided attention at retrieval conditions. Any decline in the memory task and any increases in RT scores from full attention to the divided attention conditions would reveal the effect of reduced attention on memory and RT task performance.

Secondly, the current study aimed to determine whether training with the computer game would lead to an improvement in performance on the memory (primary task) and the RT (secondary task) tasks performed under full attention and dual attention conditions. The effects of training were assessed in the Full Attention condition using a Repeated Measures

Analysis of Variance (ANOVA). Performance on this task was used as a baseline against performance in the divided attention conditions. Therefore, a 2 (Attention conditions: Full attention vs. Divided attention at encoding and retrieval) x 2 (Training: Trained vs. Untrained groups) mixed design Repeated Measures ANOVA was conducted to measure memory and RT task performance under divided attention conditions. Any differences in the memory and RT tasks between the pre and post-test data were the dependent measures. The within-subjects variable was Test Type: Pretest vs. Post-test data with Training as the between-subjects variable.

The Effect of Divided Attention on Memory and Reaction Time

Word recall. The paired samples t-test revealed that there were significant differences between the full attention and divided attention at encoding and retrieval condition for the memory task, $t(1,28) = 5.30$, $p = 0.000$, $t(1,28) = 3.81$, $p = 0.001$, respectively. It was found that there was a higher recall of words in the full attention condition ($M = 4.44$, $SD = 1.70$) than the divided attention at encoding condition (M = 2.13, SD = 1.66) or divided attention at retrieval condition ($M = 2.82$, $SD = 1.51$). Results further showed that there were no significant differences in word recall between the divided attention at encoding condition and divided attention retrieval condition, $t(1,28) = 1.63$, $p = 0.113$.

Reaction time. The paired samples t-test revealed significant differences between the full attention and divided attention at encoding and retrieval condition for the reaction time task, $t(1,28) = 5.13$, $p = 0.000$, $t(1,28) = 6.25$, $p = 0.00$, respectively. Results showed that reaction time was slower for the divided attention at encoding condition ($M = 2359.64$, $SD = 1678.24$) and divided attention at retrieval condition ($M = 2734.68$, $SD = 1728.56$) than the full attention condition ($M = 1138.92$, $SD = 532.17$). Results further showed that reaction times were significantly slower at the divided attention at retrieval condition than the divided attention at encoding retrieval, $t(1,28) = 2.15$, $p = 0.040$.

Memory and Reaction Time Tasks
Full Attention

Word recall. The main effect of training was statistically significant for word recall in the Free Recall task, $F(1, 27) = 4.91$, $p = 0.03$, $d = 0.47$, indicating that the training provided improved recall levels. The main effect of test type however was not statistically significant for word recall in the Free Recall task, $F(1, 27) = 0.62$, $p = 0.42$, $d = 0.11$, indicating that there were no differences in the number of words recalled across time i.e., from pre- to post-test (Table 1 & Figure 1). Results further showed that the interaction between 'training' and 'test type was non significant, $F(1, 27) = 2.01$, $p = 0.16$, $d = 0.32$. Thus there were no significant differences in the mean number of words recalled between the trained and untrained groups under the full attention condition following training.

Reaction time. The main effect of training was not statistically significant for the RT task, $F(1, 27) = 0.29$, $p = 0.59$, $d = 0.22$. This result indicates that reaction times did not decrease as a result of training. The main effect of test type was statistically significant for the RT task in the Free Recall task, $F(1, 27) = 12.50$, $p = 0.00$, $d = 0.01$, indicating that there were differences in reaction times across time i.e., from pre to post-test (Table 1 & Figure 2). Results further showed that the interaction between training and test type in relation to RT task performance was non significant, $F(1, 27) = 0.51$, $p = 0.47$, $d = 0.00$. Thus there were no significant differences in participants' mean RT accuracy scores between the trained and untrained groups under the full attention condition following training.

Table 1: *Means and Standard Deviations for Correct Word Recall in the Free Recall tasks and RT scores (in ms) in the Full Attention Condition Across Pre and Post-tests.*

Task	Trained Group				Untrained Group			
	Pretest		Post-test		Pretest		Post-test	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Free Recall	4.42	1.54	5.64	1.08	4.53	1.88	4.80	1.56
RT accuracy	787.14	138.11	766.21	190.60	1406.80	133.43	1555.28	184.18

Divided Attention (DA)-Full Attention Condition (FA)

Word recall. The main effect of training ($F(1, 27) = 1.26$, $p = 0.27$, $d = 0.25$) and test type ($F(1, 27) = 1.51$, $p = 0.22$, $d = 0.9$) were not statistically significant for word recall in the Free Recall task under the DA-FA, indicating that there were no differences in word recall as a result of the training provided or across time i.e., from pre- to post-test. Results further showed that the interaction between training and test type was non significant for word recall in the Free Recall task under the DA-FA condition, $F(1, 27) = 0.35$, $p = 0.55$, $d = 0.15$. Thus there were no significant differences in the mean number of words recalled between the trained and untrained groups under the DA-FA condition following training (Table 2 & Figure 1).

Reaction time. The main effect of training were not statistically significant for RT scores in the Free Recall task performed under the DA-FA condition ($F(1, 27) = 1.19$, $p = 0.28$, $d = 0.02$), indicating that there were no differences in reaction times as a result of the training provided. The main effect of test type was statistically significant for RT scores in the Free Recall task performed under the DA-FA condition ($F(1, 27) = 24.20$, $p = 0.00$, $d = 0.00$) , indicating that there were differences in RT scores across time i.e., from pre- to post-test. The results further showed that the interaction between training and test type was non significant for RT scores in the Free Recall task performed under the DA-FA condition, $F(1, 27) = 0.99$, $p = 0.32$, $d = 0.00$. Thus, there were no significant differences in reaction times between the trained and untrained groups under the DA-FA condition following training (Table 2 & Figure 2). Overall, the results show that dual task performance i.e., performance on both the memory and RT task did not improve following training when attention was divided at encoding.

Table 2: *Means and Standard Deviations for Correct Word Recall and RT Scores (in ms) in the Free Recall Tasks in the Divided Attention-Full Attention Condition Across Pre and Post-tests.*

Task	Trained Group				Untrained Group			
	Pretest		Post-test		Pretest		Post-test	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Free Recall	2.14	1.86	2.78	1.13	1.86	1.45	2.06	1.48
RT	1174.14	290.31	1193.35	276.79	2641.03	280.46	3062.13	267.41

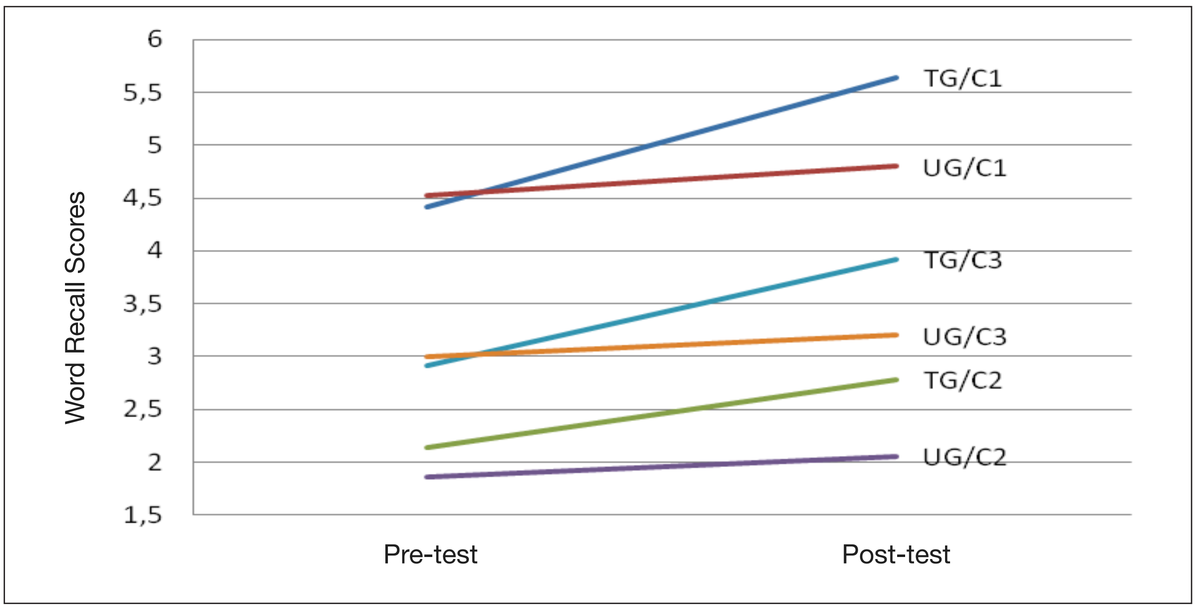

Figure 1: *Mean Scores for Correct Word Recall in the Full Attention-Full Attention Divided Attention-Full Attention, and Full Attention-Divided Attention Condition Across Pre- and Post-tests. Note: TG: Trained Group, UG: Untrained Group, C1:Full Attention condition, C2: Divided Attention at Encoding, C3: Divided Attention at Retrieval.*

Full Attention (FA)-Divided Attention Condition (DA)

Word recall. The main effect of training ($F(1, 27) = 3.11$, $p = 0.89$, $d = 0.25$) and test type ($F(1, 27) = 0.48$, $p > .04$, $d = 0.08$) was not statistically significant for word recall in the Free Recall task under the FA-DA, indicating that there were no differences in the mean number of word recalled as a result of the training provided across time i.e., from pre- to post-test (Table 3 & Figure 1). The results further showed that the interaction between training and test type was non significant for word recall in the Free Recall task under the FA-DA condition, $F(1, 27) = 1.38$, $p = 0.25$, $d = 0.34$. Thus, there were no significant differences in the mean number of words recalled between the trained and untrained groups under the FA-DA conditions following training.

Reaction time. The main effect of training was not statistically significant for RT scores in the Free Recall task performed under the FA-DA conditions $F(1, 27) = 0.38$, $p = 0.53$, d = 0.02. This result indicates that there were no differences in RT scores as a result of the training provided (Table 3 & Figure 2). The main effect of test type was statistically significant for RT scores in the Free Recall task performed under FA-DA conditions $F(1, 27) = 12.13$, $p = 0.00$, $d = 0.00$, indicating that there were differences in RT scores across time i.e., from pre- to post-test. Results further showed that the interaction between training and test type was non significant for RT scores in the Free Recall task performed under the FA-DA conditions, $F(1, 27) = 0.29$, $p = 0.59$, $d = 0.00$. Thus there were no significant differences in reaction times between the trained and untrained groups under the FA-DA conditions following training. Overall, the results show no improvement in dual task performance i.e., performance on the memory and RT task following training when attention was divided during retrieval.

Table 3: *Means and Standard Deviations for Correct Word Recall and RT Scores (in ms) in the Full Attention-Divided Attention Condition Across Pre and Post-tests.*

Task	Trained Group				Untrained Group			
	Pretest		Post-test		Pretest		Post-test	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Free Recall	2.92	1.73	3.92	1.57	3.00	1.30	3.20	1.82
RT	1146.50	631.07	1113.00	336.97	3327.03	609.67	2827.93	325.55

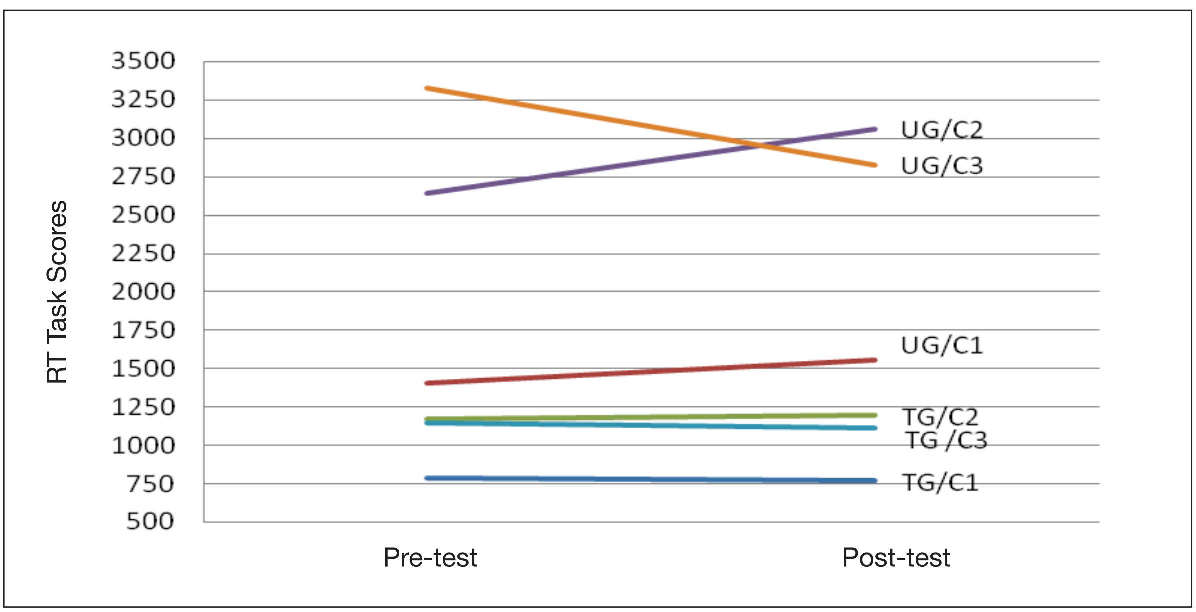

Figure 2: *Mean RT Task Scores in the Full Attention-Full Attention Divided Attention-Full Attention, and Full Attention-Divided Attention Condition Across Pre and Post-tests. Note: TG: Trained Group, UG: Untrained Group, C1:Full Attention condition, C2: Divided Attention at Encoding, C3: Divided Attention at Retrieval.*

Discussion

The findings of the current study showed that skills of divided attention among older adults could not be improved following three hours of video game training. Performance on the primary task, i.e., word recall, and the secondary task i.e., RT scores did not improve in the two divided attention conditions when: (a) attention was divided at encoding and, (b) attention was divided at retrieval using a free recall task. Since there were no improvements in either the memory or RT task, the findings demonstrate that video game training could not improve the skills of divided attention among older adults.

Memory and RT Task Performance under Divided Attention conditions

To assess for skills of divided attention among older adults, the memory and RT tasks were performed under two divided attention conditions, that is, divided attention at encoding and divided attention at retrieval. The findings of the current study showed that in comparison to the full attention condition, there was a decline in memory and RT task performance under the two divided attention conditions for both the trained and untrained groups using a free recall task prior to any training. This finding is in line with past studies (e.g., Craik et al., 1996) which show that memory performance declines when attention is directed away from the memory task.

The current findings however do not support that of past studies (e.g., Anderson et al., 1998; Craik et al., 1996; Park et al., 1989) which show that memory performance is affected more when attention is divided at encoding than when attention is divided at retrieval. Results of the current study showed that there were no differences between the number of words that could be recalled when attention was divided at encoding nor at retrieval. These findings unlike that of Craik et al. (1996) show that retrieval processes can be disrupted under conditions of divided attention. As suggested by Naveh-Benjamin et al. (2006) this may be because extra attentional effort is required for response selection when a demanding secondary task is performed which consequently affects memory retrieval.
In line with past studies (e.g., Anderson et al., 1998; Craik et al., 1996) results of the current study showed that secondary task performance i.e., the RT task, was disrupted to a greater extent when attention is divided during retrieval than when attention is divided during encoding. In conclusion, reduced attention at either encoding or retrieval affects an individual's ability to perform memory tasks, secondary tasks, and concurrent tasks.

Memory and RT Task Performance under Full Attention conditions

As expected, there was no improvement in either word recall or RT accuracy in the full attention condition following training as participants were not trained to enhance full attention skills. However as expected, performance on the word recall and RT task was better here than in the divided attention conditions. Performance in the full attention condition formed a baseline for comparison against performance in the divided attention conditions in the free recall test.

Training and Skills of Divided Attention Performance

Findings of the current study further showed that when using a free recall task there were no improvements in either the memory or RT task following training in the two divided attention conditions in comparison to the full attention condition. Older adults who had trained with the video game could not recall more words at post-test and could not concurrently perform the RT task faster in comparison to those older adults who had not trained with the game. These findings therefore, indicate that the training provided could not improve dual task performance.

The current findings are in contrast with the findings of past studies (Greenfield et al., 1994; Satyen, 2003) which have shown improvements in attentional skills following video game training. Greenfield et al. (1994) has shown that divided visual attention skills can be improved with as little as five hours of video game training while Satyen (2003) has shown that skills of divided attention among younger adults could be improved after six hours of training. Two important factors contribute to the differences found between the findings of the current study and that of Greenfield et al. (1994) and Satyen (2003). Both previous studies provided greater amounts of training and they trained younger adults who usually retain more available attentional resources to allocate to the performance of tasks as opposed to older adults which is in line with the reduced attentional resource theory (Craik & Byrd, 1982; Kahneman, 1973).

The current findings are however similar to Owen et al. (2010) who also found no improvements in skills of memory and attention following computerized training. As suggested by Boot et al. (2008) greater amounts of training may thus be required for non video game players to show the same beneficial effects observed in expert video game players, accounting for the non significant findings of the current study. The limited amount of training (three hours of video game training) provided may not have been sufficient to enhance older adults' level of attentional resources. As a result, older adults had insufficient amounts of attentional resources to allocate to the efficient performance of concurrent tasks which is a determinant of poor dual task performance (Kahneman, 1973).

It may be possible to enhance skills of divided attention among older adults through extensive video game training. Satyen (2003) found that through long-term video game training, players could attend to the tasks on the screen 'automatically'. The games could therefore improve individuals' ability to encode information while simultaneously attending to other tasks. As suggested by Basak et al. (2008) perhaps extensive training could have revealed significant improvements in skills of divided attention among older adults.

This study was not without limitations, one of which has been previously discussed, i.e., limited hours of training. Older adults' inability to perform concurrent tasks following training could also possibly be due to a lack of transfer from skills acquired through video game training to other tasks such as a memory and RT tasks. There is however, a lack of research investigating the potential transfer of skills gained through video game training to other tasks among older adults. Although Gopher (1992) and Gopher et al. (1994) suggest that many of the skills achieved through video game play could transfer directly to real life activities such as flight performance, this has not been investigated among older adults. It is therefore important for future studies to clarify whether any skills gained through training with a video game can transfer to other tasks such as a memory and RT tasks.

Furthermore, the lower level of RT skills at pre-test for participants in the trained group seems like a plausible cause for the lack of improvement in RT skills following training. A greater number of the participants in the experimental group in comparison to the control group had previous exposure to video games and had a significantly lower mean reaction time. Therefore, a floor effect could have occurred leaving limited room for any improvement following training. It thus appears that previous exposure to video games could explain the pre-test (and ultimately post-test) RT differences between the experimental and control groups. However, future research is required to clarify whether video game play can indeed improve cognitive skills or as suggested by Boot et al. (2011) individuals who prefer to play these games simply have the types of skills required to play well on these games.

Although the study had an overall large sample size, the sample size in each attentional condition was limited, yielding small effect sizes. This could therefore, in part account for the non significant findings of the current study. Perhaps, a larger sample size could increase the effect sizes and reveal significant improvements in divided attention skills among older adults. However, an examination of the means for the memory and RT tasks revealed that possible test-retest effects had taken place. This is because the control group had improved recall and RT scores at post-test in comparison to their pretest scores. According to Boot et al. (2011) a lack of training on measures of cognitive skills could be due to the expected test-retest improvements in both the control condition and experimental condition. In light of such findings, it may be possible that any training effects in the current study were obscured as a result of test-retest effects in the control group. On the other hand, it may be possible that training actually had no influence on divided attention skills. Any improvements in the experimental group would thus be related to test-retest effects. The use of a larger sample size could possibly shed light onto this matter. Future research is thus required to clarify this predisposition.

The use of a single video game to train older adults' divided attention skills was also a limitation of the present study. The video game selected required the use of divided attention skills. However, it is difficult to determine whether skills of divided attention could not be improved among older adults per se or whether the game used in the current study was ineffective to train for these skills sufficiently.

Although the current discussion has so far focussed on the lack of sufficient training to account for any improvement in skills of divided attention, the possibility that these skills among older adults simply cannot be improved remains. It may not be possible to alter older adults' executive system functions and allow for parallel processing of concurrent tasks or overcome a central bottleneck which remains intact even after extensive training (Ruthruff et al., 2003). It is currently unclear whether skills of divided attention can be improved among older adults. Further research is therefore needed to firstly, determine whether skills of divided attention could be improved among older adults and if so, the amount and method of training necessary to improve these skills.

There are significant implications for improving skills of divided attention. Improved dual task performance could aid older adults' ability to safely drive and walk. Safely performing these activities is important for older adults as it maintains older adults' independence and psychological well being. It is therefore important to investigate whether skills of divided attention could be improved among older adults and whether this can be accomplished through extensive video game training.

Overall, findings of the current study showed that there was no difference in the number of words recalled and RT scores between participants who had trained with the video game and those who had not. These findings indicate that three hours of video game training was not sufficient to enhance attentional capacity and to improve older adults' ability to coordinate dual tasks. To date, there is no study which has investigated the effects of extensive video game training on skills of divided attention among older adults using a divided attention paradigm. This thus warrants the need for future research in the area.

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