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The Effect of Age on Attention Level: A Comparison of Two Age Groups

Dubi Lufi[1], Shahar Segev[1], Adi Blum[1], Tal Rosen[1], and Iris Haimov[1]

Abstract

In the present study, a computerized test was used to compare the attention level of a group of healthy older participants aged 75 with that of a group of students aged 31. The second part of the study examined only the older participants and sought to discover how three measures of lifestyle were related to measures of attention. The results showed that the young group performed better on measures of attention. No differences between the two age groups were found on measures of impulsivity and on four measures of sustained attention. A discriminant function analysis found that reaction time and standard deviation of reaction time can explain 87.50% of the variance in both groups. The older participants' answers to the lifestyle questions showed that variables of attention correlated significantly with time spent watching television and reading. The results indicate that attention level declines with age; however, no decline was observed on measures of impulsivity and sustained attention.

Keywords

attention, age, computerized test, impulsivity, sustained attention

Growing older is a biological fact, while reaching old age is one of the most significant scientific achievements of our time. In the past, not many people enjoyed old age, but many more will enjoy it in the future (Bergman, 1991; Laybovitch, 1994). Modern scientific and medical advancements have extended

[1]The Center for Psychobiological Research, the Yezreel Valley College, Israel

Corresponding Author:

Dubi Lufi, The Center for Psychobiological Research, the Yezreel Valley College, Yezreel 19300, Israel.
Email: dubilufi@gmail.com; dubil@yvc.ac.il

life span and increased quality of life (Sinof, 2008). It has been estimated that every year, the average life expectancy increases by about three months (Oeppen & Vaupel, 2002).

Getting old involves changes within the individual that are affected by physiological, psychological, emotional, and cultural factors (Alwin, 2009). The phenotypic attributes of growing old include gray hair, wrinkled skin, decreased physical and cognitive abilities, and diminished health (Magalhaes, 2011). Growing old is not homogeneous. Research has shown that in the process of normal aging, education was found to have a greater influence on neuropsychological performance than actual chronological age (Ardila & Rosselli, 1989).

Growing older has physiological, cognitive, and social aspects. Welsh-Bohmer et al. (2009) claimed that "advanced age and low education are related to lower test scores across nearly all of the neurocognitive measures" (p. 77). Willis et al. (2006) stated that a decline in cognitive functioning leads to increased risk of functional disabilities and loss of independence. Part of this process involves a decrease in the ability to process information, affecting various functions such as inductive reasoning, spatial orientation, perceptual speed, attention level, and verbal memory; this decline is more evident after the age of 55 (Schaie, 1996). No decline was found in verbal and numeric ability (Park & Reuter-Lorenz, 2009; Schaie, 1996). Attention is one of these abilities affected by age; the aim of this study is to assess the influence of age upon attention level by comparing younger and older participants.

Successful aging involves maintaining effective physiological and psychological functioning while keeping inefficient functioning to a minimum (Hertzog, Kramer, Wilson, & Lindenberger, 2009). Intellectual involvement and physical activities can help make aging successful (Bielak, Anstey, Christensen, & Windsor, 2012), while regular cognitive activity across the life span was found to be associated with slower late-life cognitive decline, a process that is independent of common neuropathologic disorders (Wilson et al., 2013). Others (Parisi, Stine-Morrow, Noh, & Morrow, 2009) claimed that predispositional engagement and commitment to activity are discrete constructs that contribute independently to various aspects of fluid ability. Furthermore, even engagement without specific ability training may lessen cognitive declines of fluid ability (Stine-Morrow, Parisi, Morrow, & Park, 2008).

Several studies have found connections between educational level and cognitive ability in old age (Tun & Lachman, 2008; Yen, Yang, Shih, & Lung, 2004), while higher education level has been shown to correlate significantly with higher cognitive functioning during aging (Cagney & Lauderdale, 2002). These findings are supported by the finding of a lower educational level associated with reduced cognitive functioning in old age (Lachman, Agrigoroaei, Murphy, & Tun, 2010; Yen et al., 2010). Others have claimed that higher educational level had been shown to serve as a buffer against a decline in cognitive ability (Alley, Suthers, & Crimmins, 2007; Christensen et al., 1997; Le Carret, Lafont, Mayo, &

Fabrigoule, 2003; Tun & Lachman, 2008). Even leisure activities such as playing board games, reading, dancing, and playing musical instruments may help stave off cognitive decline in old age and are also associated with a reduced risk of dementia (Verghese et al., 2003).

Attention is one of the cognitive functions prone to a decline in old age. In research investigating the effect of aging on attention, Algom (2003) reported that older individuals retrieve information more slowly and are less able to screen information while avoiding irrelevant information. Moreover, their ability to overcome distractions decreases, as does their ability to use divided attention. Pawlowski et al. (2012) found that attention and executive functions were influenced by age and that these changes can be attenuated by practice. Gomez-Perez and Ostrosky-Solís (2006) found that among 521 Spaniards aged 16–85, level of education was associated with sustained attention and selective attention. Hsieh et al. (2005) used a computerized test to show that age and level of education were important factors in quality of performance, with older participants and participants with lower levels of educational experiencing difficulties in completing the test. Similar results were found by Tun and Lachman (2008), who claimed that advanced education moderated age differences on tasks requiring central executive processes. Contrary to these studies, Stawski, Silwinski, and Hofer (2013) compared two age groups on several measures of attention. They stated that they did not find strong evidence of age differences when they searched for associations either within or between persons. These findings are intriguing. One of the goals of this study is to assess whether attention declines with age.

Like many cognitive functions, attention has been found to deteriorate among older individuals. Mani, Bedwell, and Miller (2005) used a Continuous Performance Test (CPT)-type test (a group of computerized-type tests aimed to assess attention level) in their study. They found that the number of commission and false alarm errors increased with age. They summarized their results by stating that age-related deterioration of attention was associated with inhibition difficulties. Ben-David and Schneider (2010) claimed that reduction in selective attention may be a result of an increase in Stroop effects with age. Reuter-Lorenz and Park (2010) asserted that the main difference between older groups and younger groups is not so much their failure to attend to task-relevant cognitive information but in their compromised ability to suppress task-irrelevant cognitive information. Not enough studies have compared various aspects of attention across age groups.

The present study is an attempt to compare attention level between two age groups. A younger group (mean age 31.3 years) was compared with an older group (mean age 75.2 years). In accordance with previous findings, the hypothesis of the study was that the younger participants would perform better on all aspects of attention compared with the older group. The study also has an exploratory purpose, in that it aimed to discover which variables of attention can better distinguish between the older and the younger groups. In addition, the relationships between three lifestyle habits, related to topics discussed previously in the introduction, were compared with the results of the attention measures.

Method

Participants

Two age groups participated in the study. The older group comprised 30 participants, 21 women and 9 men, with a mean age of 75.2 years ($SD = 4.7$). Based on self-reports of the older participants, none of them was taking neurological or psychiatric medications, and none of them had learning disabilities or attention deficit hyperactivity disorder (ADHD). Sixteen of the participants were married, four were divorced or separated, and 10 were widows or widowers. Nineteen of the participants were born in Israel, while 11 were born outside of Israel. The mean number of years of retirement was 9.9 ($SD = 8.5$). The level of education was 14.3 years. The older group was recruited randomly by contacting various places, such as kibbutzim and old-age homes.

The second group included 42 participants with a mean age of 31.3 years ($SD = 2.9$). Twenty-three were men, and 19 were women. All the participants were students studying for academic degrees at a regional college in northern Israel. Based on self-reports of the young participants, none of the participants had learning disabilities or ADHD.

The clinical experiment conformed to the principles outlined by the Declaration of Helsinki, and the complete study protocol was approved by the institutional ethics committee of the Yezreel Valley College. After receiving a complete description of the study, all participants gave their written informed consent. All of them volunteered to participate in the study without any financial reward.

Measures

The Mathematics Continuous Performance Test (MATH-CPT; Lufi & Fichman, 2012) is a computerized CPT-type test designed to assess attention. The MATH-CPT uses a sequence of 450 simple mathematical problems involving addition, subtraction, multiplication, and division. The answer was never greater than 9 and was projected on a computer screen to serve as a visual stimulus. During the test, one problem appeared on the screen together with a result that could be right or wrong (e.g., $1 + 4 = 5$ or $4 \times 2 = 7$). The participants viewed one problem at a time on the computer screen and had to decide whether the solution was correct or incorrect by pressing “1” for a correct answer or “2” for an incorrect answer. The test stimuli were more complicated than most CPT-type tests, so an open reaction time (RT) allowed participants to react at their individual pace of activity. The test lasted approximately 10 to 20 minutes depending on the RT of each participant. The test included the following main measures: final overall attention level formula to assess a participant's overall attention level (based on discriminant function between individuals with ADHD and those without ADHD, where the formula's two main components are RT and number of correct responses); RT (time taken to respond to each problem); standard deviation of RT (a measure of RT variability); impulsive responses (a guessing fast response given at a speed less than 0.5 seconds and incorrect fast responses, both considered measures of impulsivity); and accuracy of responses (correct answers, considered a measure of attention). The test's secondary measures assessed sustained attention within the test and were as follows: sustained time (a measure of sustained attention of RT over nine parts of the test); sustained *SD* (sustained attention of RT *SD* over nine parts of the test); sustained correct responses (sustained attention of correct responses over nine parts of the test); and sustained impulsivity (a measure of sustained attention of impulsivity over nine parts of the test). These four measures of sustained attention assessed a possible reduction of performance on measures in their respective domains and were based on an algorithm designed specifically to assess these domains. The algorithm to assess sustained attention was based on a calculation of nine blocks. Each block, from the first to the ninth in ascending order, contributed more to the measure of sustained attention, with a single number assessing sustained attention in the four measures mentioned earlier. In addition, the results were presented in three and nine performance blocks from the beginning to the end of the test. During construction of the MATH-CPT (Lufi & Fichman, 2012), test–retest reliability after 1 week of testing with the main measures used in the MATH-CPT indicated an average correlation of .73. During development of the MATH-CPT, a discriminant function analysis was used to compare a control group (without ADHD) with a group with ADHD. The results indicated that the test can correctly identify 90.8% of the participants in both groups. The MATH-CPT was chosen for the study over other commonly used CPT because it has four different "on the test" measures of sustained attention.

Questions pertaining to educational level and lifestyle. The participants in the older group answered the following three questions: (a) How many years did you go to school? (b) How many hours do you watch television daily? (c) How many hours per day do you read? These questions were answered prior to being tested with the MATH-CPT.

Procedure

All participants gave their written consent to participate in the study of their own free will and without any financial benefits. The participants were informed they could stop the test any time they wished. The testers made sure that there were no outside interruptions during testing and that a proper testing environment without distractions was maintained throughout the testing period. First, participants answered the short demographic questions to verify that they do not have ADHD, learning disability, or any other neurological or psychiatry disorder. They then practiced on 30 sample problems of the MATH-CPT administered to every person who takes the test. After that they took the MATH-CPT. The participants performed their task individually in a small research chamber with a computer. This condition allowed quiet environment without outside distraction. A tester watched their performance to make sure there were no interruptions.

The data analyses included comparison the performance of the two groups in the MATH-CPT using *t* test. A stepwise discriminant function analysis was used to assess the contribution of each MATH-CPT variable, aimed at explaining the differences between the two groups. In addition, among the older group, correlations were calculated between the lifestyle questions and measures of the MATH-CPT.

Results

The task of extracting an appropriate variable out of many variables, as in the MATH-CPT, posed a risk of type I errors due to the many comparisons performed in the analysis. To reduce possible type I errors, we used only a .01 level of significance in comparing the older and younger groups.

Comparison of the results of the two age groups showed that on two of the five main MATH-CPT measures and on one of the four secondary measures, the young group performed better: "formula to assess an overall attention level," on RT for the main MATH-CPT measure, and the sustained attention-standard deviation measure. On the other measures, the differences between the two groups did not reach the .01 significance level (standard deviation of response rate, correct responses measure, impulsive responses, sustained attention of RT, sustained attention-correct responses, and sustained attention-total impulsive responses). These results are summarized in Table 1.

A stepwise discriminant function analysis was used to assess the contribution of each MATH-CPT variable in explaining the differences between the two groups. Results showed that a combination of two variables can differentiate attention levels between the young participants and the old participants: (a) RT (Wilks' Lambda .97) and (b) standard deviation of response (Wilks' Lambda .62) can explain 87.5% of the variance in both groups (90% of the old group and 85.7% of the young group).

Assessment of the correlations between lifestyle measures among the older group and the MATH-CPT results showed a correlation of .53 ($p < .01$) between

Table 1. Means, Standard Deviations, and *t* Values for the Two Groups, Older Group ($N = 30$) and Younger Group ($N = 42$), on the MATH-CPT.

Group	Older group		Younger group			
Variable	*M*	*SD*	*M*	*SD*	*t*	Cohen's *d*
Main measures of the MATH-CPT						
Attention formula[a]	0.92	1.63	−0.97	0.81	6.14**	1.20
Reaction time, RT (in seconds)[a]	2.66	0.81	1.61	0.42	6.44**	1.30
SD reaction time[a]	1.14	0.59	0.83	0.44	2.57	0.59
Impulsive responses[a]	12.93	9.70	10.04	7.76	1.17	0.32
Correct responses	428.00	16.38	435.00	8.80	2.26	0.54
Secondary measures of the MATH-CPT						
Sustained attention (time)[a]	14.65	12.87	14.41	8.26	0.09	0.02
Sustained attention *SD*[a]	0.06	0.27	−0.13	0.20	3.50**	0.77
Sustained attention correct	−0.37	1.44	−0.03	1.08	1.13	0.32
Sustained attention impulsivity[a]	0.75	1.16	0.29	1.00	1.51	0.23

Note. MATH-CPT = Mathematics Continuous Performance Test; Attention formula = summarizes overall attention level of the test; Reaction time = time taken to respond to each problem; *SD* time = variability of the RT; Impulsive responses = a combination of the anticipatory response faster than 500 ms and the fast wrong responses, wrong response answered faster than the average response time; Correct responses = total correct responses-measures of attention; Sustained attention (time) = sustained attention of RT over nine parts of the test; Sustained attention *SD* = sustained attention of *SD* over nine parts of the test; Sustained attention correct = sustained attention of correct responses over nine parts of the test; Sustained attention impulsivity = sustained attention of impulsive responses.
[a]lower score indicates better performance; Cohen's *d* (1988) rule signals 0.80 and above as large effect.
**$p < .01$.

sustained attention-impulsivity (with lower score indicating better performance) and the number of hours an individual watches television each day. Significant correlations were found between the total number of correct responses and the number of hours an individual watches television ($r = .41$, $p < .05$). Additional significant correlations were found between the number of hours an individual watches television a day and the number of total impulsive responses ($r = .37$, $p < .05$, with lower score indicating better performance). A significant correlation was found between the number of hours a day an individual reads and sustained attention-standard deviation ($r = -.42$, $p < .05$, with a lower score indicating better performance). Significant correlations were found between sustained attention of RT on the MATH-CPT (with lower score indicating better performance) and the number of hours an individual reads per day ($r = -.36$, $p < .05$). The last significant correlation was found between RT (with lower score indicating better performance) and the number of years of schooling ($r = -.38$, $p < .05$).

Discussion

The present study compared attention levels between an older group (mean age 75) and a younger group (mean age 31). In addition, the study examined correlations between lifestyle events and attention level. The results showed that on three out of nine measures of attention, the young group performed significantly better. These results are not surprising, considering the age differences between the two groups and the accumulated body of knowledge about a decline in cognitive functioning among older individuals. Similar results have been found in other studies (Algom, 2003; Gomez-Perez & Ostrosky-Solís, 2006; Pawlowski et al., 2012). More interesting are the results assessing the weight of the variables distinguishing the two groups. RT and standard deviation of RT were found to explain 85.70% of the variance between the two groups. These findings emphasize the fact that older participants do perform mental tasks slower and in a less consistent manner with increasing age, something already documented in the past (Georgiou-Karistianis et al., 2006; Schaie, 1996). Additional findings showed that the older group was less able to maintain consistent RT. These findings are indicative of other difficulties in attention among the older group, as already documented in another study (Hedden & Gabrieli, 2004).

The most substantial findings of our study are the variables on which the two groups did not differ (impulsivity and the following three measures of sustained attention: sustained attention-RT, sustained attention-correct responses, and sustained attention-impulsivity). Impulsivity describes a behavioral tendency to act with little consideration or evaluation of the consequences (Adan, Natale, Caci, & Prat, 2010). Researchers have described impulsivity as a specific deficit within a broader area of executive functioning (Shallice et al., 2002), expressed as behavioral disinhibiting, inability to inhibit, or delay a response. It is encouraging to know that older individuals, despite their difficulties in attention, do not have an excessive level of impulsivity. Their lives, experience, and accumulated wisdom may still remain intact even in old age and may help them behave patiently, inhibit problematic thoughts, and avoid inconsiderate behavior.

On all three measures of sustained attention, the older group performed at nearly the same level as the younger group. This finding needs further consideration. Sustained attention, also known as “vigilance” or “vigilance decrement” (Conners, 2000; Helton & Russel, 2010), is considered by many as one of the most important domains of attention (Sohlberg & Mateer, 2001; Tsal, Shalev, & Mevorach, 2005). Indeed, Green (1996) claimed that sustained attention is among the neurocognitive functions crucial for adequate problem solving, skill acquisition, and social outcome. Smith, Valentino, and Arruda (2002) defined sustained attention as “the maintenance of focused attention over extended time periods” (p. 828). It is somewhat remarkable that in the present study, the differences in measures of sustained attention were not significant.

These results may indicate that even in old age, we are capable of maintaining our attention as we did in the past and that on a measure of sustained attention, there is only a partial decline due to age.

The connection between measures of attention and questions depicting lifestyle variables must be considered with caution. Although the correlations can be considered as moderate to high, these correlations are based only on the older group of participants. Six of the correlations were significant at a mid to high level (.37 to .53). Of these six significant correlations, three included watching television, that more time watching television is associated with more impulsive reaction and that it is associated with poorer ability to avoid impulsive responses as the test progresses. In contrast, more time watching television is associated with better attention level (variable of correct responses). These contradictory correlations concerning time spent watching television and its effect on various aspects of attention indicate that even a passive activity such as watching television may have some effect on attention among older people. Two of the significant correlations indicated that more time spent reading per day is associated with the "ability to maintain RT" and with the "ability to maintain variability in RT." These are important findings because RT is one of the main functions that declines with age, a result that was confirmed in the present study. Deficiency in RT is an important factor among older individuals, as it can cause difficulties in different areas life, including road accidents and manipulation of various instruments and social life. A partial remedy for this decline may be reading. The last significant correlation showed that higher education level is associated with faster RT. This is an essential finding considering that less educated older individuals tend to react more slowly. As a result, they may have poorer daily functioning, and even physical risks due to slow RT. Similar results were found by Charron, Fischer, and Meljac (2008). This information supports the possibility that higher education level may serve as a buffer against the decline of cognitive ability, as discussed in the introduction.

Limitations of the study include the fact that having more participants may allow the researches to generalize the findings to other populations and even for those outside of Israel. To expand knowledge regarding attention level among older individuals and the rate of decline over the years, more diverse age groups from different cultures should be examined in the future. Additional instruments assessing attention level can shed more light upon this important topic. Our data are cross sectional, and age changes cannot be inferred so that the findings may reflect cohort effect.

In conclusion, we would like to emphasize that the results can be interpreted as positive from the viewpoint of theories showing and explaining a decline in cognitive ability with age. Based on the comparison of the older and the younger groups, impulsivity and measures of sustained attention were not significantly lower among the older group lead us to conclude that older individuals still perform well in some functions that require a reasonable level of attention.

Of course, their overall level of attention, their RT, and their ability to maintain consistent level of attention along tasks are lower. Nevertheless, impulsivity and measures of sustained attention remain intact. Correlations found in the study indicated that previous schooling, current reading, and to some extent hours spent watching television are associated with attention level in old age.

Declaration of Conflicting Interests

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Author Biographies

Dubi Lufi, Professor, is teaching at the Yezreel Valley College, Israel, at the department of Behavioral Sciences and the department of Education. His research interests include: assessment of attention; diagnosing and treatment of Attention Deficit Hyperactivity; and learning disabilities.

Shahar Segev, BA, completed her studies in the department of Behavioral Sciences at the Yezreel Valley College, Israel. She is in the middle of her studies in Developmental Education.

Adi Blum, BA, completed her studies in the department of Behavioral Sciences at the Yezreel Valley College, Israel. At present she teaches at a school for special education.

Tal Rosen, MA, completed her BA studies in the department of Behavioral Sciences at the Yezreel Valley College, Israel. At present she earned MA in Art Therapy.

Iris Haimov, Professor, Head, Department of Psychology and Director of the Center for Psychobiological Research, Yezreel Academic College, Israel. Her research interests include: Gerontology, assessment of Cognitive Function, Cognitive training, Sleep and Treatment of Sleep Disorders.