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Computer Use and Its Effect on the Memory Process in Young and Adults

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Abstract. This work investigates the effect of computer use in the memory process in young and adults under the Perceptual and Memory experimental conditions. The memory condition involved the phases acquisition of information and recovery, on time intervals (2 min, 24 hours and 1 week) on situations of pre and post-test (before and after the participants took part on a *Basic Computing* course), in which the participants studied the map of Brazil during 7 minutes and the estimates of different areas of Brazilian states were performed according to the magnitude estimation method, without the presence of the map. On the Perceptual condition, the estimates were made in the presence of the Brazilian map. The study made possible to verify that the use of a computer, as a new activity enables a differentiation on the memory process in relation to the different experimental conditions proposed and to the time intervals used between acquisition, processing and information recovery, showing that the use of a computer as a pedagogical tool may promote the improvement of the memory process in academic activities.

Keywords: computer, education, memory.

1. Introduction

In the cognitivist proposal, from the model of information processing, the functioning of computers becomes an explanatory model of the mental function (Vosniadou, 1996 and Zimmerman and Schunk, 2003) and the researchers start to conceive the mental functions as an image of a CPU that receives, organizes and interprets the information to produce a cognitive behavior (Vosniadou,1996). For Sternberg (2000), Cognition is the act or process of knowing, including attention, perception, memory, reasoning, judgment,

imagination, thinking and language. It refers to the ensemble of mental processes used for thinking and perceiving, classify, recognize and solve problems. On this theoretical perspective, this work has as an object of study the memory process. Considering that, as pointed by Straub (2002, 2005), the global world will demand more and more, new ways to learn, the dominion of computers has been one of the challenges. Therefore, aiming to inspect if the use of computers has some effect on the memory process in young and adults, from the perspective of information processing, Modern Psychophysics was used as the investigation method.

From the perspective of Modern Psychophysics, various studies have shown that psychophysical judgments of countless perceptual modalities are related to physical properties by power function described by the equation $S = K \cdot I^n$, where S is the magnitude of sensation, K is a scalar constant that depends on the unity of measurement, I is the physical magnitude of stimulus and n is the exponent of the function (Stevens, 1975), which portrays the sensitivity index of the subject in relation to the sensory attribute. This function describes a situation where a geometric increase on the scale of physical magnitude corresponds to a geometric increase on the subjective psychological scale, with the exponent reflecting the relative rate of increase over the range of the two scales. The exponent n is an index of perceptual sensitivity and, therefore, the size of the exponent is directly related to sensitivity.

On this case, if the exponent is exactly 1.0, the function follows a straight line where the magnitude of the registered sensation (response) varies linearly with the intensity of the stimulus. If exponent (n) is lower than 1.0, the curve is monotonically decreasing and when the exponent (n) is higher than 1.0, the curve representing this function is monotonically increasing (Stevens, 1975). For an extensive review, see Da Silva and Macedo (1983) and Da Silva, Dos Santos and Da Silva (1983).

From this model expressed by the power function, is being demonstrated that similar functions, seem to be relevant for the judgment of memorized stimuli (Bjorkman, Lundberg and Tarnblom, 1960; Osaka, 1983a, 1983b; Kerst and Howard, 1978).

On this direction, several works are investigating questions related to the interactions among age, memory and level of education. For example, Van Der Linden *et al.* (1997) tested the effect of age on the performance of episodic verbal memory considering two possible sources of individual variation: education and verbal intelligence and concluded that aging seems to affect different cognitive components involved in a task of episodic verbal memory. The differences related to age are modulated by several characteristics of subjects, and more particularly by the level of education, verbal efficiency and age. On this sense, when investigating the variability of the exponents of the power function on observers with different age and levels of education, Alliprandini *et al.* (1999), Alliprandini and Da Silva (1998, 2000) found an effect of the education level in area estimates on young, adult and elderly observers.

Considering that variables such as: personality of the individual, cultural influences, health and access to health care, socio-economic and educational level and genetic predispositions may have a marked influence on the aging quality, Compton *et al.* (1997) examined changes on the mental performance associated with age in individuals with similar

educational level, socio-economic level and cultural experiences. The results suggest that training and education may bring some protection against cognitive losses common on old age. Some works are investigating the perceptive and mnemonics processes related to different ages, with respect to recognition and identification of objects. On this sense, Harker and Riege (1985) verified an equivalence of results to recognition of drawings in subjects with mean age of 31 and 61 years. However with regards to word recognition, the young were more accurate. The decline of hit rate as a function of time interval was different for words and drawings, however similar for both groups. The decision criterion and reaction time on answers were also equivalent.

Madden (1985), using groups of young and elderly subjects, investigated the information recovery in memory on long-term and found a higher reaction time on the elderly group, evidencing a difference related to age on recovery of words related to long-term memory. Using ages varying between 18–39 years, 40–59 years and 60–87 years and time intervals from 2 to 182 days, Coon and Earles (1984) examined the activity of recovery. The results gathered indicate that there is a difference among ages on memory activity. Furthermore, data suggest that the reason for loss as a function of time intervals is similar for young and elderly.

Research are evidencing that the level of education is an important variable that is bringing a large effect over the learning process and memory (Van Der Linden and Heinen, 1997; Alliprandini *et al*., 1999; Alliprandini and Da Silva, 1998).

Those results confirm data of researchers from neuroscience such as Izquierdo (2004) and Damásio (2000, 2003 and 2004) who claim that the brain systems are plastic and, because of that, the possibility of setting new cellular connections is extraordinary, throughout human existence.

In this way, the objective of the research was to verify the effect of computer use on the value of the exponents of the power function under Perceptual and Memory experimental conditions (2 minutes, 24 hours and 1 week) in observers of age group 1 (11 to 14 years old) and age group 2 (35 to 50 years old), in situations of pre-test and post-test (before and after participation on the course of *Basic Computing*). It is expected that the development of activities involving logical reasoning, textual production, organization and a investigative activity, by participating on a course of Basic Computing, that will demand the acquisition of new information, enabling the setting of new neural connections, may contribute on the learning and memory processes, independently of the age of the observers groups, on the possibility of prevention/reduction of decay of the memory process in function of age, as proposed by Stuart-Hamilton (2002).

2. Methodology

2.1. *Participants*

Two hundred and twelve subjects took part on this research during the pre-test (before taking the *Basic Computing* course), 55 from 11 to 14 years old (group 1) and 157 from

Table 1

Number of observers distributed according to different experimental conditions and groups 1 and 2 on pre-test and post-test situation

Experimental conditions	Age Group 1		Age Group 2	
	Pre-test	Post-test	Pre-test	Post-test
Perceptive	19	15	27	13
Memory 2 minutes	18	12	40	18
Memory 24 hours	11	08	59	52
Memory 1 week	07	06	31	32
Total observers	55	41	157	115

35 to 50 years old (group 2). On the post-test situation (after taking the *Basic Computing* course), 41 subjects of group 1 and 115 subjects of group 2 participated, showing that not all subjects who answered the research instrument during pre-test also did it on post-test. Those participants were distributed according the experimental condition that they took part in. None of the participants had previous experience in computer use and the experiment purpose. To better understand the distribution of the experiment participants, according to experimental conditions (Perceptive and Memory on intervals of 2 minutes, 24 hours and 1 week, age groups 1 and 2), see Table 1.

We inform that data collection was made according to Resolution CNS 196/96, after signature of the Statement of Consent, the process approved by the Research Ethics Committee involving human beings of the State University of Londrina ("*Universidade Estadual de Londrina*", CEP/UEL), according to report 124/08.

2.2. *Procedures*

Initially, the instructions were verbally transmitted by the researcher to all participants on Perceptive and Memory experimental conditions, in 2 minutes, 24 hours and 1 week intervals. The stimulus used was the drawing of the map of Brazil, with the division of all its states and their names. For data collection was used the psychophysical method of magnitude estimation. According to this method, Mato Grosso State was considered as the standard stimulus, and it received the modulus 100. The subject's task was to estimate the geographical area of other states of Brazil, always in comparison to the area of Mato Grosso State, attributing values to the respective areas of different states that represent the reasoned comparative judgment with the pattern that received the value 100. The Mato Grosso State area was presented first, and the others were presented randomly for each subject. The estimative were appointed by the subjects in a notebook, which had the name of each Brazilian state on different sheets.

For subject part of the group characterized as Perceptive Condition, the Brazilian map was observed freely by the participant during the judgments of the different areas of Brazilian states.

On the condition described as Memory Condition, the subjects initially examined the Brazilian Map during 7 minutes, to get a good idea of the location of different Brazilian states. After this phase of information acquisition, the subjects estimated the different state areas, according to the following time intervals: 2 minutes, 24 hours and 1 week, without the presence of the Brazilian map (recovery phase). After the time interval designed to each group, the researcher showed the instructions about the task and gave to each participant the notebook were the answers were noted.

Data were collected on a pre-test situation (before the subjects took part on the *Basic Computing* course) and post-test (after taking the course). The *Basic Computing* course was offered together with "*Casa Brasil – Unidade Sinop*, *Escola Técnica Estadual de Educação Profissional e Tecnológica de Sinop-Secitec/MT, Núcleo de Tecnologia Educacional do Município de Sinop, Escola Municipal Armando Dias and Escola Estadual Edelí Mantovani*", by volunteers, academicals of different courses in Higher Education institutions (*UNEMAT/Sinop, UNIC/Sinop and UFMT/Sinop*).

Besides allowing to identify if the usage of computational resources improves the information retrieval, as previously mentioned, the offer of the *Basic Computing* course allowed the digital inclusion of young and adults, part of a less favored socio-economical class, therefore having and important social role.

After pre-test, all observers took part on the course of *Basic Computing* during 40 hours, which consisted on the following topics: (I) Basic notions of computing – evolution of computers and their applications, computer hardware, processing unity, memory, peripherals, data storage, computer software, types of software, operating system concept, main operating systems, use of the drawing program; (II) Text editor – operation; (III) Presentation software – operation of presentation slides; (IV) Spreadsheets – operation of the spreadsheet; (V) Internet – logical constitution of the network, operation of the Internet.

After the course, in which the student should have at least 75% of attendance, subjects were submitted to the post-test situation, according the established in the experimental conditions (Perceptive and Memory, on the different time intervals). In this situation, all participants were submitted to the same procedures used in pre-test situation.

In all experimental conditions, data collections were made individually.

3. Results and Discussion

Using the estimates of subjects according to experimental conditions, the exponents of the power function (n), the scalar constant (K) and the coefficient of determination (r^2) were calculated, as proposed by Stevens (1975). Then, were calculated the averages for each experimental condition (Perceptive and Memory on intervals 2 min., 24 hours and 1 week) on situation of pre-test and post-test for participants of age groups 1 and 2.

The Means (M) and Standard Deviations (SD) of Exponent of Power function and Means of Determination Coefficient (r^2) derived from Perceptive and Memory conditions for participants in different age groups, on pre-test and post-test situations can be observed in Table 2.

Table 2

Means (M) and Standard Deviations (SD) of Exponent of Power function and Means of Determination Coefficient (r^2) derived from Perceptive and Memory conditions for participants in different age groups, on pre-test and post-test situations

Experimental conditions	Age group 1						Age group 2					
	Pre-test			Post-test			Pre-test			Post-test		
	M	SD	r^2	M	SD	r^2	M	SD	r^2	M	SD	r^2
Perceptive	0.73	0.17	0.65	0.76	0.33	0.74	0.55	0.22	0.63	0.60	0.23	0.62
Memory 2 min.	0.52	0.12	0.52	0.51	0.16	0.64	0.36	0.15	0.35	0.36	0.18	0.45
Memory 24 hours	0.41	0.12	0.44	0.43	0.14	0.43	0.43	0.17	0.45	0.54	0.21	0.54
Memory 1 week	0.36	0.10	0.37	0.62	0.09	0.62	0.40	0.14	0.36	0.48	0.21	0.48
Overall averages	0.55	0.13	0.50	0.60	0.18	0.61	0.44	0.17	0.45	0.50	0.21	0.52

The analysis of variance applied to the exponents of the power function (n) obtained by participants of age group 1 evidenced a significant effect of the different experimental conditions when comparing the averages obtained. [$F_{(3.70)} = 16.44, p < 0.0001$]. Through Duncan Test was found that Perceptive condition differs from Memory condition, not being observed a difference between the averages obtained on different time intervals (2 min., 24 hours and 1 week). Those results were also found when analyzed the averages obtained on pre-test situation, [$F_{(3.33)} = 19.32, p < 0.0001$] and post-test, [$F_{(5.23)} = 5.87, p > 0.0039$], evidencing a difference between the Perceptive condition and all other conditions.

When checking the averages of exponents obtained by estimates on Perceptive and Memory conditions on different time intervals (see Table 1), we verified that the averages corroborate data presented by Kerst and Howard (1978), since the exponents obtained during Memory condition approached the square of the exponent obtained on Perceptive judgments, that explained their results in terms of a Reperceptual model, in which two separate transformations relate the memory judgments with the physical properties.

According to results obtained by Algom (1991), in relation to exponents (n) obtained on Memory condition, there is a trend towards the reduction of the exponent of power function as a function of the time intervals. This trend may be confirmed in our results, with the exception of the average obtained for the interval of 1 week, on the post-test simulation (Table 2).

It was also observed, by the general averages obtained on pre-test situation ($M = 0.55$) and post-test ($M = 0.60$) by participants of age group 1, that there is an increase on the exponents value (n) of the power function, when both situations are compared, although there was no evidence of significant differences between the averages obtained on those situations (pre-test and post-test). However, when compared to averages obtained on the different experimental conditions on situations pre and post-test, a significant difference was found on Memory condition (1 week), in which an increase could be observed on the value of the exponent of the power function, and that the average obtained on the pre-test situation was ($M = 0.36$) and on post-test situation ($M = 0.62$). This datum may indicate that on larger time intervals between the acquisition of information and its re-

covery, the use of the technological tool (computer) may have had an effect, which brings us to suppose that the use of computer on educational context has enabled the setting of new neural connections. As can be observed on Table 1, there was an increase on the value of r^2, on most of the experimental conditions, when analyzed the values obtained on pre and post-test situations. Especially on Memory experimental condition (1 week), the value went from ($M = 0.37$) to ($M = 0.62$), indicating a higher correlation between the physical value of stimulus and the subject estimation.

Considering yet that, as presented by Van Der Linden and Heinen (1997), Alliprandini *et al.* (1999) and Alliprandini and Da Silva (1998), the educational level is an important variable that brings a large effect over the learning process and memory. Several results are evidencing that educational level also has an effect on the memory process. It is worth to highlight that, in this study the participants are on age group from 11 to 14 years old and attended basic education, fact that might have contributed for the results obtained on this research.

The analysis of variance applied to the exponents of the power function (n) obtained by participants of age group 2, evidenced a significant effect of the different experimental conditions when comparing the obtained averages. [$F_{(3.202)} = 10.77$; $p < 0.0001$]. Through Duncan Test, it was verified that the Perceptive condition differs from the Memory condition, and that no difference was observed between the averages obtained on intervals 24 hours and 1 week, and that those intervals differed on time interval 2 minutes. Significant differences were also found when analyzed the averages obtained on pre-test situation, [$F_{(3.91)} = 7.48$; $p < 0.0001$] and post-test, [$F_{(2.58)} = 5.94$; $p < 0.001$]. Through Duncan Test was evidenced a difference between the perceptive condition and the other ones, on pre-test situation. On post-test situation, the Perceptive condition differed only from Memory condition on 2 minutes interval, without differences between other intervals.

When verifying the averages of exponents obtained through estimates on Perceptive and Memory conditions on different time intervals (see Table 1), we found that the averages obtained for this group of participants also corroborate data presented by Kerst and Howard (1978), as noted for the age group 2.

It was also noted that, by the general averages obtained by participants of age group 2 on pre-test situation ($M = 0.44$) and post-test ($M = 0.50$), there is an increase on the value of exponents (n) of the power function, when both situations are compared, although there were no significant differences evidenced between the averages obtained on those situations (pre-test and post-test). However, when compared the averages obtained on different experimental conditions on pre and post-test situations a significant difference on Memory Condition (24 hours) was found, where an increase in the value of the exponent of the power function was observed, being the average obtained on pre-test situation of ($M = 0.43$) and on post-test ($M = 0.54$). On Memory condition 1 week, although no significant difference was verified, the average of exponents obtained on pre and post-test situations were respectively, (0.40) and (0.48), evidencing a trend to differentiation on exponents values, presenting the same indicative that on larger time intervals, the use of the technological tool (computer) might have had an effect for this age group.

Observing also the values of the coefficients of determination (r^2), according to Table 1, there was an increase on r^2 value on Memory experimental conditions. Therefore, those results lead us to suppose that the use of computer contributed on the setting of new neural connections, because, as Izquierdo (2004) and Damásio (2000, 2003 and 2004), brain systems are plastic and because of that, the possibility of setting new cellular connections is extraordinary, throughout human existence. And more, as proposed by Stuart-Hamilton (2002) the use of a computer may act on prevention/reduction of the decline of memorization process due to age.

4. Conclusions and Future Research

Generally, those results signal the importance of investigating the effect of computer use in larger time intervals between information acquisition and recovery and also its effect on participants who present other educational levels, such as high school, graduation and post-graduation. Besides that, as suggested by Compton and collaborators (1997), training and education may bring some protection against the cognitive impairment common on old age. In this sense, it is relevant to also investigate the effect of computer use in other age groups, since computer use may prevent losses of information with age.

In general, it is important to underline that the development of researches on the theoretical perspective of information processing may lead to a better understanding about mental processes related to the teaching-learning process, from information retrieval, its storage and recovery and consequently may contribute on the area of education, since it will allow the educator to know the way that the student processes and stores information, on different age groups, using methods and strategies adequate for improving the teaching-learning process. Specially, data obtained in this research, although not yet conclusive, may encourage teachers to use the technological resources, that will demand the acquisition of new information, as a tool in the teaching-learning process, thus enabling that filed and processed information stays stored longer and able to be recovered.

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Kompiuterių naudojimas ir jų įtaka jaunuolių ir suaugusiųjų atminties lavinimui

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Šiame straipsnyje tiriama kompiuterių naudojimo įtaka jaunuolių ir suaugusiųjų atminties lavinimo procesams. Tyrimas buvo atliktas sumodeliavus specialias eksperimentines suvokimo ir atminties lavinimo sąlygas. Atminties lavinimas buvo tiriamas dviem fazėmis – informacijos įgijimo ir informacijos atgaminimo – skirtingais laiko intervalais (2 minučių, 24 valandų ir 1 savaitės). Abiejų eksperimentų metu eksperimento dalyviai mokėsi skaičiavimo pagrindų. Eksperimento dalyviai nagrinėjo Brazilijos žemėlapį septynias minutes ir vertino įvairias Brazilijos vietoves taikydami svarbos įvertinimo metodą be žemėlapio. Esant suvokimo sąlygoms, vertinimai buvo atlikti pasitelkus Brazilijos žemėlapį. Tyrimas patvirtino hipotezę, kad kompiuterio naudojimas, kaip nauja veikla, įgalino atminties proceso diferencijaciją esant skirtingoms eksperimento sąlygoms ir skirtingiems laiko intervalams. Vadinasi, kompiuterio kaip pedagoginės priemonės naudojimas gali pagerinti atminties procesus akademinės veiklos metu.