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Investigation of the Impact of Central and Environmental Visual Feedback Resulting from Organ, Keyboard and Text on Motor Control of Keyboarding Skill

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ABSTRACT

The present research investigates the impact of central and environmental visual feedback resulting from keyboarding components including used organ, keyboard elements and typed text on motor control of this subtle skill. Statistical population of the research included students of Allameh Tabatabaei University who were familiar with typing skill and aged 25±3.3 years. 12 students were selected randomly as sample members. Group members were tested in 9 steps and in each step, they received one of the various states of elimination of central and environmental visual feedback resulted from keyboarding components including: used organ, keyboard elements and typed text. In the end, individuals received tests and implementation times were recorded. The number of correct words typed per minute and also the number of typing mistakes was criteria for scoring individuals. After investigation of normality of data using Shapiro and Belk test and congruency of variances with Levene's test, data were analyzed using repeated measurement variance test. Considering the significance level (0.05), results revealed that elimination of environmental and central visual feedback resulted from organ, keyboard and text has a significant impact on reduction of typing speed and increasing typing mistakes. Finally, results of the research showed that vision has a decisive role in controlling typing skill.
KEYWORDS: central vision, environmental vision, keyboarding, keyboarding visual control

INTRODUCTION

In today's world, use of electronic equipment like personal computers, laptops, tablets, cell phones and … has become commonplace. Application of such devices raises some questions. One important question is concerned with the method of controlling user's movements when he or she uses these devices. Visual system is an important system in controlling human movements. Visual flow provides information regarding balance, speed and direction of movement towards objects, movement of objects with respect to user and … (Smith, 2005). Visual range refers to visual range accessible by an individual without moving his or her head which has a horizontal range of 200 degrees and vertical range of 160 degrees (Migel, 2009).

Theoretical framework

Central and environmental visual system:

Two visual systems are the bases for human movements' control. Central visual system sweeps 2 o 5 degrees away from the center of visual range and is responsible for conscious identification and recognition of objects, which weakens seriously in darkness and its main function is answering the question: "what's that?". Environmental visual system includes all visual range whether central or environmental vision. It does not get weakened in darkness; it is unconscious and is specifically designed for movement control. Its function is recovering a movement and providing information for it. It tries to answer the question "where is that?". This visual system is relatively quick and inflexible and its information is sent to lower levels of central nervous system (Smith, 2005) (Carlson, 1942).

Keyboarding/typing:

Keyboarding skill is a subtle and important skill of the present world which involves manipulating keyboard keys with emphasis on output keyboarded words and the outputs are displayed on monitor at the same time (Rosenbaum, 1900) (Bartholome, 2002). In fact, keyboarding is inserting information into a computer via keyboard. Important advantages of typing include: 1. Improvement in using computer as a writing, editing and calculating instrument. 2. Development of verbal skills like reading, spelling and writing, the latter being true for children. 3. Improvement in speed of doing actions at home or work office. 4. Improvement of creativity in

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individuals' thought (Rogers et al, 2003). There are different methods of evaluating typing skill; some of these methods include: 1. Skill implementation technique: an appropriate technique should be used for typing in best manner (like 10-finger proper typing with maximum efficiency). 2. Investigation of touch: children use their vision for seeing their hands and correcting mistakes when children lose their hands on a keyboard. 3. mistake evaluation: the fact that why children come across mistakes when typing is more important than the mistake itself. Many mistakes are resulted from weakness in keyboarding technique. Wrong fingers movement and inappropriate visual attention are important causes for mistakes. Common mistakes include: reverse typing, typing letters in place of each other(like neighboring letters or letters which are typed with similar fingers in both hands), typing excess letters or not typing a needed letter, which occur due to wrong planning or inappropriate location of fingers on keyboard. Other causes for typing mistakes include pressure, absence of focus on attention, reading template text wrongly, or wrong planning in mind (bartholome, 2002).

Keyboarding visual control:

Feedback plays an important role in motor controlling of keyboarding skill. Different types of feedbacks including visual feedback, hearing feedback, touch feedback and depth feedback are used in controlling keyboarding skill. Many studies have been conducted on the influence of different feedbacks on controlling keyboarding skill. For example, it has been shown that typing with virtual keyboards which do not have production feedback, have smaller keys and more inappropriate display reduces typing speed and letters accuracy and increases writing mistakes (Riadi, 2012). Studies on the impact of feedback in typing with mobile keyboard revealed that although most mobile phones provide visual feedback but small size of their displays makes it hard to use feedback information. Further, studies showed that providing other feedback information like hearing or touch feedback improves individuals' performances. Further, studies have revealed that use of hearing feedback in crowded and noisy environments is not appropriate and touch feedback is more acceptable in such environments. Moreover, it has been confirmed that touch feedback can improve accuracy and speed of typing with mobile (Riadi, 2012). On the other hand, depth touch feedback resulted from keys is eliminated when typing with touch screens and therefore the typist becomes more dependent on vision and hearing. For instance, results of a research showed that when typing with a touch screen, if a hearing feedback like a special sound is heard, the typist's performance is accelerated significantly and the number of mistakes is decreased (Deron, 2000). As it was said before, the typist's cognitive loading is different in the case of visual feedback, hearing feedback and elimination of both when typing with a computer keyboard. The highest level of cognitive loading occurs in the case of presence of visual feedback and the lowest cognitive loading occurs in the case of elimination of both feedbacks (Tarniceriu et al, 2010). Studies which have been conducted on evaluation of keyboarding in primary school children have revealed that when children lose depth sense resulted from keyboard resort to vision and continue typing with their looks at their hands (bartholome, 2002). Results of Byres research showed that individuals look at their fingers freely when they do not have any restriction for typing, some look at only one hand and some of them type only with one hand (Byres et al, 2005). Moreover, children looked more at template text and monitor screen when their hands were covered off their sights. In cases the individuals' hands were not covered, however, they first looked at their fingers, then they looked at monitor and finally their looks went to template text (Byres et al, 2005). Further, children whose fingers were covered were able to type words well without using their vision and it could probably be said that their dependences on visual information were eliminated (Byres et al, 2005). Moreover, it was revealed that although use of covered typing was more appropriate for typing but in this case there was no significant difference between individuals. The number of mistakes committed by individuals who used cover was more and keyboarding speed of individuals who typed without cover was more. Starr believes that vision improves harmony between eyes and hands of students. Students who had practiced with cover looked less at their fingers when keyboarding and were able to type words without looking at their fingers (Byres et al, 2005). Deron's study showed that typist's mistakes are increased while he or she types with touch screens and eliminating visual feedback. Elimination of visual feedback resulted from screen led to maximum mistakes and elimination of feedback resulted from keyboard or writing separately led to typing mistakes increase (Deron, 2000). Another research supported the important role of visual and hearing feedbacks in typing with Chord mobile keyboards. In this kind of mobiles, several letters are typed by one single key and pressing a key for a certain number of times types one special letter and pressing more or less times types another letter (such as 9-key mobile keyboards) (Tarniceriu et al, 2010). Silverberg conducted a study on the impact of visual feedback and depth sense on using 3*4 mobile keyboards. He found that reduction in touch feedback increases typing mistakes. Moreover, reduction in visual feedback also increases mistakes and reduces individuals' accuracy (Tarniceriu et al, 2010). Clawson et al also investigated the impact of visual feedback on typing with qwerty mini-keyboards of mobiles and supported the importance of seeing keys in typing, although difference between the case of absence and the case of presence of vision was not significant (Tarniceriu et al, 2010). Further, results showed that presence or absence of visual or hearing feedback when typing with 3*4 mobile keyboard does not influence typing speed and individuals' mistake patterns were not significantly different (Tarniceriu et al, 2010).

Riadi used small to large keyboards for investigation of the importance of keyboard feedback. For the cases of novice and skilled typists, increase in keyboard size and therefore increase in its touch feedback resulted in a increase in individuals' typing speed. On the other hand, the number individuals' mistakes also reduced as keyboard size increased. This reduction was stronger in novice typists and this is indicative of their dependence on keyboard feedback information (Riadi, 2012).

As it was shown, several studies have been conducted on the impact of visual control on keyboarding skill. However, more studies seem to be necessary on details of visual control of typing skill such as "which of the central and environmental visual systems are more important in controlling keyboarding skill?" or "is there any difference between visual influence of typing elements including: used organ, keyboard keys or typing product- which is demonstrated in the form of text on screen- in controlling keyboarding skill?". Finally, the main goal of the present research is to investigate the influence of central and environmental vision resulted from keyboarding elements (including: used organ, keyboard elements and typed text) on motor control of this skill. The present research can be considered as a fundamental research in the field of motor control and its results can be used in teaching keyboarding skill to children and novice typists, designing typing instruments like monitor and keyboards, rehabilitation and teaching the skill to the disabled.

RESEARCH METHODOLOGY

The present research is a semi-empirical study and its statistical population included Allameh Tabatabaee University students who were familiar with typing and had characteristics like: complete visual and hearing health, satisfaction with participating in survey, were right-handed and aged 25± 3.3. 12 students were randomly selected as sample. Implementation method was pretest-posttest and involved repeated measurements over different states of elimination of vision (central and environmental) resulted from keyboarding elements (including: used organ, keyboard elements and typed text). Data collection instruments in the present research were: 1. Two laptops model HP Pavilion. 2. Chronometer, 3. Microsoft Office Software (version 2010), 4. Paper cover for covering keyboard keys (in the 4^{th} test). 5. A thin plastic cover non-transparent for covering entire keyboard (in the fifth test), 6. An external keyboard (for implementation of 9^{th} test), 7. Briggs-nibbes questionnaire for determining respondents' left-handedness or right-handedness

Research execution method

An appropriate text was selected and printed on a piece of paper. Considering the fact that one of the scoring criteria was the number of words typed per minute, typing time of every participant was measured during each test. There were two methods for testing: in the first method, it was possible to do all tests of each participant in one single day. In this case, it would be possible for respondents to do unwanted practice due to continuous execution of tests and the respondent reach automaticity in typing the text. Consequently, a disturbing variable might enter the test and the impact of independent variable, i.e. vision would be disturbed by the impact of disturbing variable, i.e. automaticity in skill. In the second method, it was possible to do tests on appropriate intervals. In this case, automaticity would be disappeared due to time intervals between tests and individuals' forgetting the text. Therefore, the second method was used and each test was conducted in one same day on all respondents. The tests included: 1. Keyboarding in standard visual conditions: in this case, no visual restriction was imposed and individuals implemented the skill having complete access to central and environmental vision resulted from typing elements. Typing time of individuals were recorded by a chronometer for final evaluation. 2. Elimination of central and environmental vision resulted from used organ (hand) and keyboard: in this case, we eliminated central and environmental vision by placing an appropriate paper cover on keyboard and respondent's hands, but visual feedback of monitor screen was accessible by the respondent. The cover was in a way that did not have any physical contact with the respondent and did not change depth sense and touch sense of the respondent. 3. Elimination of central vision feedback resulted from used organ and keyboard: in this case, we gave verbal instructions and asked respondents to concentrate on screen texts to avoid looking directly at screen in spite of visual access to keyboard and hand. For example, we instructed: "dear respondent, please look at screen texts while typing and avoid looking directly at your hands and keyboard.". 4. Elimination of central and environmental visual feedback resulted from alphabet letters on keyboard keys: in this case, we stuck labels on keyboard keys and eliminated central and environmental visual feedback resulted from letters. 5. Elimination of visual feedback resulted from letters and feedback resulted from keyboard keys framework: in this case, we placed a thin plastic cover through which keys frameworks and letters were not seeable and conducted typing test. This resulted in elimination of central and environmental visual feedback resulted from the letters and frameworks of keyboard keys. 6. Elimination of central and environmental visual feedback resulted from text: in this case, we placed a physical obstacle like a piece of paper on screen and eliminated visual feedback resulted from text. 7. Elimination of central visual feedback resulted from text: in this case, we issued a verbal instruction and distracted central visual attention of the respondents from screen text and asked them to look at their hands and keyboard. An example of verbal instruction is : "deer participant, please look at your hands and keyboard and avoid looking directly at screen text when typing." With this instruction, although the typed text was in visual range of the individual and therefore he or she has access to environmental visual feedback resulted from the text but central visual feedback is eliminated as he or she avoids looking at the text. 8. Elimination of all central and environmental visual feedbacks resulted from all typing elements: in this case, we placed a non-transparent physical obstacle like a piece of paper on screen and a non-transparent cover on participants' hands and keyboard, and therefore eliminated visual feedback resulted from all typing elements and the participants must have typed using other types of feedback. 9. Changing touch feedback: in this case, participants used an external keyboard which had different physical structure and therefore produced a different depth-touch sense with respect to the main keyboard. Individuals' scoring was conducted based on two criteria: first, the number of correct typed words per minute which was obtained by dividing the number of typed text words by typing time of individuals. The second criteria were the number of typing mistakes occurred during typing.

Research conceptual model:

The present research conceptual model is extracted from Deron (2002), Tarniceriu (2010), Byres (2005) and Riadi (2012) studies and it was adjusted to develop the following hypotheses:

H0: central visual feedback resulted from typing elements (including used organ, keyboard elements and typed text) influences motor control of keyboarding.

H1: environmental visual feedback resulted from typing elements (including used organ, keyboard elements and typed text) influences motor control of keyboarding.

Data analysis:

The present research is a semi-empirical study and its implementation method was pretest-posttest and involved repeated measurements in a group. In order to analyze data, Shapiro and Belk's statistical test (for investigation of normality of data), levene's test (for investigation of congruency of variances) and repeated measurement variance analysis test were used. SPSS 18 package was used for statistical analysis. We analyze data as follows: first, Shapiro and Belk's test was used for investigation of normality of data. Then, Levene's test supported congruency of variances. Variance analysis with repeated measurements was used for investigation of the impact of environmental and central visual feedback resulted from organ, keyboard and text. First, we investigate variations in individuals' typing speed due to elimination of visual feedback resulted from type elements. Mauchly test was used for investigation of spherecity of data. Results ($p<0.001$) showed that spherecity assumption does not hold. Therefore, Greenhouse-Gaser test data were used:

Table 1: table of internal respondents impacts

test	F	df	$\eta2p$	Sig. level*
Greenhouse-Gaser	108.341	3.734	0.508	0.001

*significance level of the test is equal to 0.05.

Considering the table of internal respondents impacts ($p=0.001$, ${}_p\eta^2=0.508$, $F=54.48$), significant impact of environmental and central visual feedback resulted from organ, keyboard and text on typing speed was verified. In the next step, we have paired comparisons table:

Upper limit	Lower limit	Sig. level*	Standard error	Means difference	pairs	
28.280	16.058	0.001	1.441	22.169	2	1
25.706	13.722	0.001	1.413	19.714	3	
18.467	13.346	0.001	0.604	15.907	4	
26.729	17.729	0.001	1.132	21.929	5	
27.120	17.303	0.001	1.158	22.212	8	

*significance level is equal to 0.05.

Considering the above table, there is difference between typing in standard conditions and typing in the following steps: 2, 3, 4, 5, 8. Therefore, elimination of central and environmental feedback resulted from organ and keyboard, elimination of central visual feedback resulted from organ and keyboard, elimination of visual feedback resulted from letters on keyboard keys, elimination of visual feedback resulted from letters and keys framework and elimination of environmental and central visual feedback resulted from all typing elements have significant impacts on individuals' typing speed and other cases are not significant.

In the next sentences, we investigate the number of typing mistakes when visual feedback resulted from typing elements are eliminated. Mauchly test was used for investigation of spherecity of data. since spherecity assumption does not hold ($p<0.001$), we used Greenhouse-Gaser test data:

Table 2: internal respondents' impacts test

test	F	Df	$\eta 2p$	Sig. level*
Greenhouse-Gaser	0.001	47.778	3.358	0.813

Significance level was 0.05.

Considering the above table results (p=0.001, ${}_{p}\eta^{2}$=0.813, F=47.778), elimination of central and environmental visual feedback resulted from typing elements (including: organ, keyboard and text) has significant impact on the number of typing mistakes.

Upper limit	Lower limit	Sig. level*	Standard error	Means difference	pairs	
-34.699	-71.135	0.001	4.297	-52.917	2	1
-24.975	-69.192	0.001	5.214	-47.083	3	
-2.252	-51.081	0.026	5.758	-26.677	4	
-27.742	-73.091	0.001	5.348	-50.417	5	
4.619	-10.452	0.001	2.736	-58.250	8	

Significance level was 0.05.

Considering the results of the above table, there is significant difference between typing in standard conditions and typing in steps 2, 3, 4, 5, and 8. Other steps did not express any significant impact. Therefore, it can be concluded that elimination of central and environmental visual feedback resulted from organ and keyboard, elimination of central visual feedback resulted from organ and keyboard, elimination of visual feedback resulted from letters on keyboard keys, elimination of visual feedback resulted from letters and keys framework and finally elimination of central and environmental visual feedback resulted from all typing elements have significant impact on the number of typing mistakes.

CONCLUSION AND DISCUSSION

The main goal of the present research was to investigate visual control of keyboarding/typing skill. Results showed that elimination of central and environmental visual feedback resulted from typing elements including: used organ, keyboard elements and typed text has significant impact on reducing individuals' typing speed and increasing individuals' typing mistakes. In fact, research hypotheses were supported. In a more detailed report, it was verified that: a) elimination of central and environmental visual feedback resulted from organ and keyboard, b) elimination of central visual feedback resulted from organ and keyboard, c) elimination of visual feedback resulted from letters on keyboard keys, d) elimination of visual feedback resulted from letters and keys frameworks, and finally e) elimination of central and environmental visual feedback resulted from all typing elements significantly reduce typing speed and increase typing mistakes. These results conform to the results of studies conducted by Riadi (2012), Deron (2000), Tarniceriu et al (2010), Bartholome (2002), Rogers (2003) and Byres et al (2005).in the mentioned studies, impacts of different types of feedback including: visual, hearing, touch and depth sense resulted from elements of typing on controlling this skill were supported. In fact, Bartholome stated that when children lose their depth senses, they resort to vision for controlling typing skill and eyesight becomes important in this case. In Deron's research, it was stated that depth sense feedback resulted from keys was eliminated in typing with touch screens and therefore more dependence on vision and hearing is produced. Further, studies have shown that when typing with a touch screen, if a hearing feedback like a special sound is heard, individual's performance speed increases and the number of mistakes is reduced. Tarniceriu concluded that a typist's cognitive loading is different in the case of visual feedback, hearing feedback and elimination of both when typing with a computer keyboard. The highest level of cognitive loading occurs in the case of presence of visual feedback and the lowest cognitive loading occurs in the case of elimination of both feedbacks. Further, Deron's research showed that when typing with touch screens, the number of mistakes increased if visual feedback was eliminated and the highest level of mistakes occurred when visual feedback was completely eliminated and elimination of feedback resulted from writing or keyboard increases typing mistakes. Further, Silverberg investigated the impact of visual feedback and depth sense in using 3*4 mobile keyboards. He showed that reduction in sense feedback increases typing mistakes. Moreover, reduction in visual feedback also increases mistakes and reduces individual accuracy.

An interesting point which was mentioned in data analysis section was that when visual feedbacks resulted from text, organ and keyboard were eliminated simultaneously, a small increase was observed in typing speed of individuals. A reason for this might be more exact and visual control of typing with concentration on organ and keyboard and elimination of feedback resulted from text and non-correction of mistakes and therefore increases in typing speed. Of course, it must be mentioned that typing mistakes of individuals in this step were a little bit more than that of standard conditions. Therefore, it might be possible that participants traded off speed with accuracy. In other words, they increased typing speed and reduced typing accuracy and the number of typing mistakes increased. Finally, the present research results supported the impact of central and environmental visual feedback resulted from typing elements on motor control of this subtle skill.

Recommendation

Impacts of other kinds of feedback like depth sense feedback, touch feedback and hearing feedback on motor control of typing skill and other similar skills can be examined in future studies.

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