World Journal on Educational Technology

Volume 5, Issue 2 (2013) 281-290

Computerizing the Cancellation Test1: Design, Development and Validation Study2

Sinan Hopcan *, Department of Computer Education and Instructional Technologies, İstanbul University, Turkey.

Elif Polat, Department of Computer Education and Instructional Technologies, İstanbul University, Turkey.

Metehan Irak, Department of Psychology, Bahçeşehir University, Turkey.

Tufan Adıgüzel, Department of Computer Education and Instructional Technologies, Bahçeşehir University, Turkey.

Suggested Citation:

Hopcan, S., Polat, E., Irak, M. & Adıgüzel, T. Computerizing the Cancellation Test1: Design, Development and Validation Study2. *World Journal on Educational Technology.* 5(2), 281-290.

Received May 09, 2012; revised June 19, 2013; accepted July 23, 2013

Selection and peer review under responsibility of Prof. Dr. Servet Bayram, Marmara University, Turkey.

Abstract

This study is about the design, development and validation of computerized version of the Cancellation Test the paper - pencil version of which was first developed by Weintraub and Mesulam (1985). This computerized version consists of four sub-tests (organized letters, random letters, organized shapes and random shapes) and administration panel where only researchers can access. The test was designed and developed according to universally accepted interface design principles. The test was formatively evaluated by administering to a small group of university students and was accordingly revised. The final version of the test was validated on 52 university students and the results were discussed together with the design and development processes.

Keywords: neuropsychological tests, cancellation test, sustained attention, computerized tests, learning

* ADDRESS FOR CORRESPONDENCE: **Sinan Hopcan,** Department of Computer Education and Instructional Technologies, Istanbul University, Turkey, *E-mail address:* sinan.hopcan@gmail.com / Tel: +09 212 440 00 00

1. Introduction

One way the cognitive processes are used in our daily lives is with learning. Some of these cognitive processes, which play important roles in individuals' learning, are attention, perception, repetition, automation and recalling. Attention has a key role in information processing system. Attention is the mechanism by which we restrict information processing to only a small fraction of the possible amount of information. Attention includes both conscious processes and unconscious processes. There are different type of attention, such as sustained attention (vigilance), signal detection, selective attention, divided attention, and search. Sustained attention can be defined that the ability to maintain a consistent behavioral response during continuous and repetitive activity. Vigilance also refers to the ability to attend to a situation for an extended period of time (Sternberg, 2009).

Due to the fact that the learning materials are developed and the learning atmosphere is designed ideally according to the differences of individuals' cognitive processes, the measurement of such unobservable processes provides valuable information for teachers and psychologists who might benefit from, and the best ways for any individual to learn. Bayram and Mutlu Bayraktar (2012) also emphasize the importance of measuring attention for the educational multimedia environments. Neuropsychological tests are used for measuring the cognitive processes that are not directly observable and explaining the behavior that results from these processes (Karakaş & Başar, 1995; Karakaş, 2006). The Cancellation Test is one of the well-known neuropsychological tests measuring the sustained attention and requiring individuals to simultaneously locate some stimuli (targets) while ignoring others (distracters). The Cancellation Test was first developed by Weintraub and Mesulam (1985) and measures the audiovisual perception, searching, sustained attention and reaction time (Karakaş & Kafadar, 1999).

Cancellation Test consists of four A4 sized sub-tests that are composed of organized and random letters, and organized and random shapes. There are some necessary materials for administration: Four recording sheets, four answer sheets, two sample cards including target letter and shape, at least six colored pencils with different colors, an eraser; scotch tape, and a stopwatch (Karakaş, 2004). There are 60 target stimuli in each sub-test. The targets located on the each quarter of the page with an order that there will be 15 ones in each part. The target stimuli for organized and random letter sub-test is letter 'A', on the other hand a shape look like a sun (see Figure 1) is target stimuli for organized and random shapes sub-test (Karakaş, 2004). The targets are distributed in a special order and scattered randomly in organized and random sub-tests respectively, but their locations remain the same in each sub-test (Kılıç, Irak, Koçkar, Şener & Karakaş, 2002). A sample card is used before a person passes from one sub-test to another sub-test of the Cancellation Test. The original forms are not used for sampling of the target. During administration, the forms should be fixed on the tables according to the participant's view. The color of the pencil must be changed in each 10^{th} cancellation for both letters and shapes. The stopwatch starts at the beginning of the test and stops when the participant says 'finished' all the forms; then this time period is recorded. The highest score is 60 for *Number of Correct Target Detection* for each sub-test. The time of administration is approximately 20 minutes (Karakaş, 2004).

Figure 1. The target stimulus for random and organized shapes sub-test.

The paper - pencil version of Cancellation Test has been used in many studies (e.g. Bailey, Riddoch & Crome, 2004; Byrd, Touradji & Tang, 2004; Laurent-Vannier, Chevignard, Pradat-Diehl, Abada & De Agostini, 2006). This test was standardized into Turkish culture by Karakaş and Başar (1993). The

standardization project was done on adult population by Karakaş, Eski & Başar (1996). The nine months test-retest reliability analysis showed that the reliability coefficients were .80 -.81 for Total Time of Completing scores, and .32 -. 57 for Number of Correct Target Detection, Number of Omission Errors, Number of Commission Errors, and Number of Total Errors scores *(*Karakaş, Eski & Başar, 1996). The Turkish adult form was also used in various studies (e.g. Cantez et al., 1996; Çağlar & Koruç, 2006; Karakaş, Eski & Başar, 1996; Karakaş & Kafadar, 1999; Kılıç et al., 2002; Küçük, Dolu & Erdoğan, 2009), results of which supported psychometric properties of the test. Kılıç et al (2002), was completed standardization of children version of Cancellation Test on Turkish culture. The test-retest time interval was two months. Results showed that reliability coefficients were .45 - .83 for all sub-tests. Overall, these two test standardization projects indicated that both adult's and children's version of the Cancellation Test have acceptable psychometric skills for Turkish culture.

Given computers' increasing influence demands for data collection, researchers and educators have been asked to utilize them in psychological measurement and data collection. Computerized data collection systems offer eight key benefits relative to traditional, time-consuming paper - pencil methods: (1) less missing data, (2) accurate data recording, (3) more timely transmission of data, (4) less need for post-collection editing and coding, (5) immediate and objective feedback, (6) less use of test materials, (8) easy management and grading, and (7) ongoing monitoring of data quality (Barak & English, 2002; Cernich, Brennana, Barker & Bleiberg, 2007; Hadwin, Winne & Nesbit, 2005; Huang & Wang, 2005; Lichtenberger, 2006; Mandell & Sackett, 2008; Paul et al., 2005). Regarding such benefits, some neuropsychological tests—Chinese version of Cancellation Task (Wang, Huang, & Huang, 2006), Line Orientation Test and Enhanced Cued Recall Test (Aşkar et al., 2010)—were computerized as well. The aim of this study was to develop a computerized version of the cancellation test (CCT). In this context, the design, development and validation of computerizing process were also discussed.

2. Method

This study used a developmental research model which is pragmatic and suggests a way to test the application to verify the theory (Richey & Klein, 2005). The following steps were carried out in this study to satisfy the needs of this research design: (1) development of CCT, (2) design of CCT and (3) validation of CCT.

2.1 Materials

2.1.1 Development of CCT

The Computerized Cancellation Test was designed and coded in Adobe Flash CS5 platform with Action Script 3.0 (AS3). The Flash applications are the ones, which provide for mixing the coding and visuals, and can run on every operating system. The CCT has three main screens: Instructions, sub-tests and results. (1) Instruction screen (see Figure 2) displays general information about the planned operation. There is also a button just under the instruction to start the test for the participant. (2) There are five Cancellation sub-tests one of which is the example for practice. In the practice sub-test (see Figure 3) to eliminate learning effect, characters (numbers) different from the original sub-tests are used. The aim of this sub-test is to introduce the system to the participant and explain the planned operation and steps clearly.

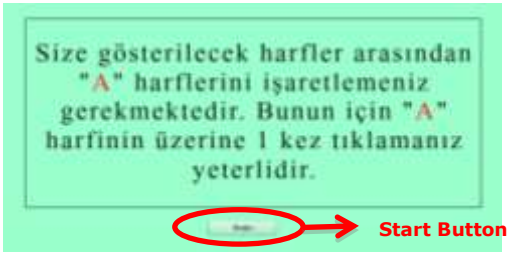
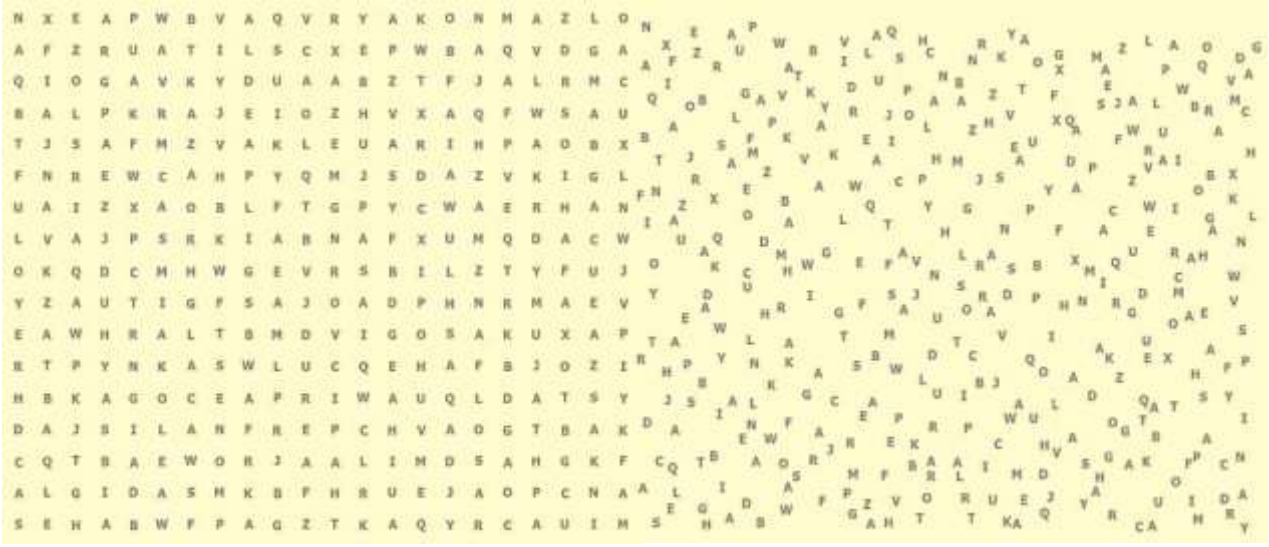


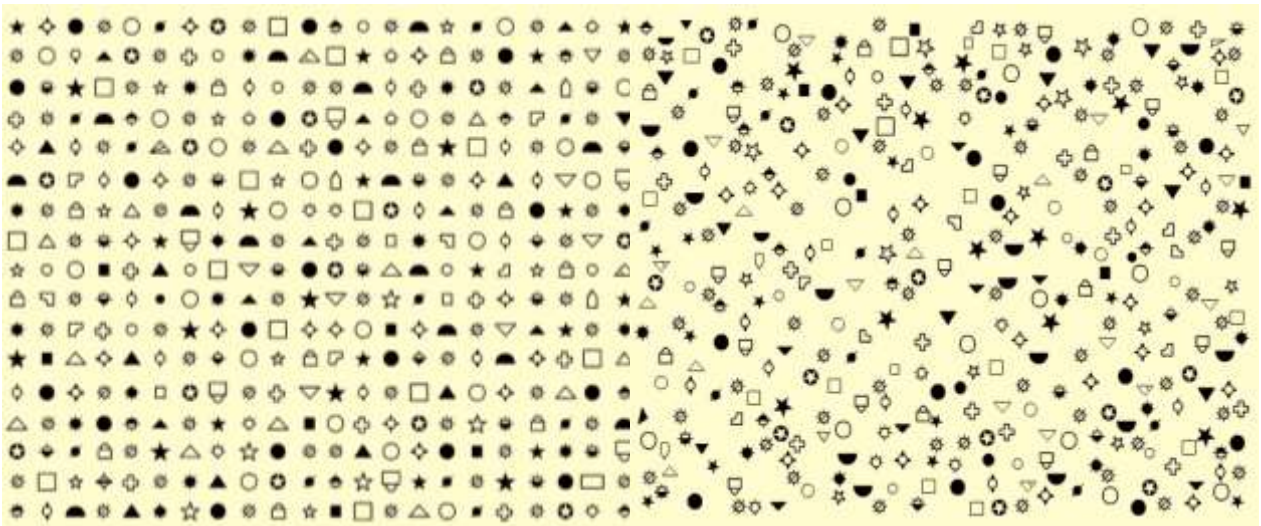
Figure 2. Screen Example of Instructions

Figure 3. Screen Example of Practice Sub-Test

The other four sub-tests (see Figure 4) are the main sub-tests of the Cancellation Test and each of these was designed exactly the same as the original paper - pencil version. Shapes and the letters were created one by one by the help of the Flash Program's drawing tools and components; and located on the screen regarding the original location in paper - pencil version. There are eight pencils with different colors at the top of the forms, which were used by the participant during the test.



Organized Letters Random Letters



Organized Shapes Random Shapes

Figure 4. Screen Examples of Four Sub-Tests

(3) The results for all participants are displayed in tabular form on the last main screen of the CCT (see Figure 5). The table is given for each sub-test with the following information: total time for completing the test in milliseconds, number of correct target detection, number of commission errors and the image of the completed test for each participant with their nicknames. The images displaying completed forms of each sub-test done by the participants can be reached via the "Göster (Display)" button here. The table header contains the total number of participants together with the three buttons having functions: printing the whole table, starting a new practice, and exiting from the CCT (see Figure 6).

Ad	TEST 1				TEST 2				TEST 3				TEST 4			
	F	T	Time	Img	F	T	Time	Img	F	T	Time	Img	F	T	Time	Img
ya_ce_0512	0	59	83.895	Display	0	60	120.271	Display	0	60	120.316	Display	2	60	144.798	Display
ez_bo_0512	0	50	73.029	Display	0	51	63.259	Display	1	60	61.034	Display	0	58	56.668	Display
ka_de_0512	0	60	64.469	Display	0	60	143.326	Display	0	59	91.251	Display	0	60	109.921	Display
tu_ho_0512	0	60	81.952	Display	0	60	96.865	Display	0	60	71.617	Display	0	60	68.306	Display
uf_di_0512	0	60	82.735	Display	0	60	96.239	Display	0	60	80.568	Display	0	60	63.500	Display

Figure 5. Screen Example of the Results (F: False, T: True, Time (ms), Img: Image)

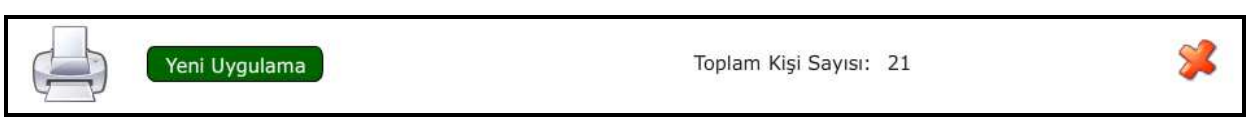


Figure 6. Screen Example of the Table Header

2.1.2. Design of CCT

Interface design is a significant element of user-computer interaction by providing the following actions: influencing user's performance, minimizing the burden of this interaction and maximizing the usability. Therefore, interface design principles should be considered for the computerized instruments with the purpose of gathering quality data (Hansen& Lee, 2010). In this study, not only the principles for the paper-pencil version; but also universally accepted principles (user-friendliness, minimal surprise, consistency, recoverability, the use of color, visual discrimination, coherence, accessibility, cognitive overload and etc.) of various interface designs existing in the literature were considered in the process of designing computerized cancellation test.

The user-friendliness principle was handled in CCT by locating the clear instructions, guiding buttons and test (practice) screens for the participants. Similarly, the minimal surprise principle, the situation that participants can estimate how to do the operations, was implemented by providing the practice sub-test screens in CCT. The buttons with the same functions, the letters and diagrams, and pens, shapes and lines were kept the same and the images were located well balanced on the screen regarding the consistency principle of CCT interface. Recoverability principle was issued in CCT by including 'saving feature' to provide particular flexibility for participant's faults, namely to recover participants' unsaved data in case of possible shutting down.

Of the other design principles, the effective use of color brings an extra dimension in interface and helps participants understand the complex elements (Sommerville, 2004). And, its incorrect use may endanger the readability and affect the material unfavorably (Yalın, 2006). Therefore, limited numbers of colors were used in CCT. The colors used for sub-tests were consistent and eye-friendly, and they provided more visibility to the images and also attracted the participants' attention to the actual stimulators instead of the background. The colors used for instruction screens had the same features, but they varied in order to be discriminated from the sub-test screens (Sommerville, 2004).

Admittedly, there should be a visual discrimination between questions and different elements by utilizing different fonts, smaller letters and different colors. In CCT, the different color was displayed to the participants to emphasize the stimulator (Hansen& Lee, 2010). Furthermore, regarding the cognitive overload principle, it was avoided to use unnecessary texts, images and sounds in CCT to ensure the continuity of attention and prevent participants from being cognitively overloaded because of large numbers of stimulators. As Mayer (2001) determined that discarding unnecessary texts, sounds and images from media would be better, media and message in CCT were made compatible to be presented effectively and coherently (Rogers, 2001). Lastly, it can be said that the CCT satisfies the accessibility principle (Norman, 2001) since it can run on all operating systems and its images cannot deform.

2.2 Participants

Participants of the study were fifty-two healthy university students in two groups: (a) 26 participants (11 female, 15 male & age range 18-26 years) who received paper-pencil version of the cancellation test and (b) 26 participants (14 female, 12 male & age range 19-27 years) who received computerized version of the same test. Independent sample t-test was not significant for age comparison of two groups (computerized vs. paper pencil), $t = 1.86$, $df = 50$, $p = .069$. In addition, the chi-square test for goodness of fit was not significant for gender, $\chi^2(1, N = 52) = 0.405$, $p = .290$. Thus, these analyses indicated that groups are similar according to gender and age.

2.3. Validation of CCT

To validate CCT, both versions of cancellation test (paper-pencil and computerized) were administered on fifty-two healthy university students individually under standard instructions that were given at the beginning of test administration and before each sub-test. While taking the CCT, the expected action by the participant was to click on the correct target that was then circled. No

feedback was given when the participant made a commission error. Because the participant could do up to 20 commission errors, there were 8 pencils. The pencil color changed after each 10th cancellation and the following pencil came to the place where cursor had been (see Figure 7). The participant had to click on this pencil to continue to the cancellation, which made participant felt the reality of the test in virtual atmosphere. The test continued until the participant clicked the "Bitti (Finish)" button.

To investigate validity of the computerized version of cancellation test, another independent sample *t*-test was carried out. In the analysis, the test version (paper-pencil and computerized) was independent variable, on the other hand, number of correct target detection and total time of completing scores of four sub-tests (total eight scores) were dependent variables. Results of analysis indicated that test version effect was not significant on any cancellation test (paper-pencil and computerized) scores (p = .089 or bigger), which reveals that the CCT has an acceptable validity. Means and standard deviations of eight cancellation test scores according to two different test versions (computerized and paper-pencil) were also calculated and presented in Table 1. Regarding means for total time of completing cancellation sub-tests, they were less in all computerized sub-tests except the random letters sub-test compared to the paper-pencil ones. On the other hand, means for number of correct target detection in both test versions were close to each other.

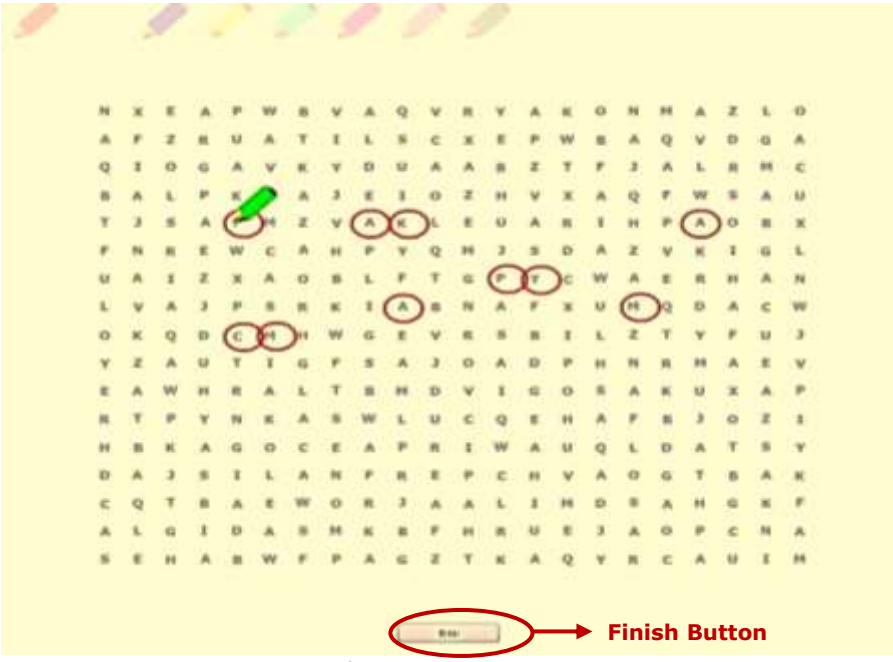


Figure 7. Screen Example of Circled Targets and Pencil with Color Change

Table 1: Descriptive values of eight cancellation test scores across by test versions

	Computerized	Paper-Pencil
Cancellation Sub-tests	Mean (SD)	Mean (SD)
Organized Letters total time of completing	74.73 (13.30)	75.73 (12.61)
Organized Letters number of correct target detection	58.54 (2.32)	59.00 (1.74)
Random letters total time of completing	89.60 (21.48)	79.96 (18.42)
Random letters number of correct target detection	58.85 (2.11)	59.15 (0.88)
Organized shapes total time of completing	69.85 (17.38)	77.04 (14.82)
Organized shapes number of correct target detection	59.00 (1.65)	59.00 (1.10)
Random shapes total time of completing	63.78 (19.32)	68.54 (17.43)
Random shapes number of correct target detection	59.46 (0.81)	59.19 (1.81)

3. Results and Discussion

In this study, all four sub-tests of the cancellation test were computerized by satisfying commonly accepted interface design principles in the literature. The number of correct target detection and total time of completing scores of four cancellation sub-tests were analyzed on both computerized and paper-pencil versions. The formative evaluation and validation results revealed that the CCT can definitely replace the paper-pencil version of the test by considering the target detection and time-spent factors. When means are evaluated one by one for each cancellation sub-test of both versions, only interesting finding which is not parallel to the study results is that participants in computerized group spent more time on random letter cancellation sub-test —designed exactly the same as traditional version— than the ones in paper-pencil group. One of the reasons might be that computer-based applications may exacerbate attention problems and have harmful effects on some aspects of cognitive control as discussed in several studies (Bioulac, Arfi & Bouvard, 2008; Bushman & Anderson, 2009).

Overall, this study supports the findings in the literature (Barak & English, 2002; Cernich, Brennana, Barker & Bleiberg, 2007; Huang & Wang, 2005; Lichtenberger, 2006; Paul et al., 2005) that the computerized version of the test has more advantages than the paper - pencil one: (1) it provides accurate and faultless measurement, (2) it provides time saving by putting into practice lots of participants at less time (approximately 10 minutes in this study) whereas this administration time is 20 minutes for paper - pencil version, and (3) it has the simulators and audiovisual animations to facilitate visual reception and administration of the test. Because of all these advantages, it can be

considered that successful computerization of neuropsychological tests (design, development and validation all together) is useful and should be done and tested more often. Besides these advantages, there are some limitations such as negative attitudes toward computers; concerns about using computers; an assumption of presenting the same features with standardized paper-pencil test; and privacy and security issues. In the long run, computerizing neuropsychological tests may contribute to design and development of computer/web -based learning environments to make them adaptive and individualized by considering the principle of individualized learning environments: "One Size Does Not Fit All."

Acknowledge

Adapted and recreated by special permission of Prof. Dr. Marsel Mesulam.
This paper was revised after being presented at the International Educational Technology Conference, Istanbul, Turkey, 25-27 May 2011.

References

Aşkar, P., Altun, A., Cangöz, B., Çevik, V., Kaya, G., & Türksoy, H. (2010). *Reliability and validity of computerized line orientation and enhanced cued recall test for educational purposes.* Neuroscience and Education-2010, Swiss Federal Institute of Technology, Zurich, Switzerland.

Bailey, M.J., Riddoch, M.J., & Crome, P. (2004). Test-retest stability of three tests for unilateral visual neglect in patients with stroke: Star Cancellation, Line Bisection, and the Baking Tray Task. *Neuropsychological Rehabilitation*, *14(4),* 403-419.

Barak, A., & English, N. (2002). Prospects and limitations of psychological testing on the Internet. *Journal of Technology in Human Services*, *19(2/3),* 65-89.

Bayram, S., & Mutlu Bayraktar, D. (2012). Using eye tracking to study on attention and recall in multimedia learning environments: The effects of design in learning. *World Journal on Educational Technology, 4*(2), 81-98.

Bioulac, S., Arfi, L., & Bouvard, M.P. (2008). Attention deficit/hyperactivity disorder and video games: A comparative study of hyperactive and control children. *European Psychiatry, 23*(2), 134-41.

Bushman, B.J., & Anderson, C.A. (2009). Comfortably numb: Desensitizing effects of violent media on helping others. *Psychological Science, 20*, 273-277.

Byrd, D.A., Touradji, P., & Tang, M. (2004). Cancellation test performance in African American, Hispanic, and White elderly. *Journal of the International Neuropsychological Society*, *10(3),* 401-411.

Cantez, E., Akça, Ş., Akkapulu, F., Bekçi, B., Canlı, P., Çakar, A., & Yıldırım, S. (1996). *BİLNOT bataryası testlerinden işaretleme ve sayı dizisi öğrenme testlerinin test-tekrar test güvenirliği.* IX. Ulusal Psikoloji Kongresi, İstanbul.

Cernich, A.N., Brennana, D.M., Barker, L.M., & Bleiberg, J. (2007). Sources of error in computerized neuropsychological assessment. *Archives of Clinical Neuropsychology, 22S*, 39-48.

Çağlar, E., & Koruç, Z. (2006). D2 dikkat testinin sporcularda güvenirliği ve geçerliği. *Journal of Sport Sciences, 17(2),* 58-80.

Hadwin, A.F., Winne, P.H., & Nesbit, J.C. (2005). Roles for software technologies in advancing research and theory in educational psychology. *British Journal of Educational Psychology*, *75*, 1-24.

Hansen, E.S., & Lee J.H. (2010). *Instrument technical design.* Retrieved December 21, 2011, from http://ccsg.isr.umich.edu/instrdev.cfm

Huang, H.C., & Wang, T.Y. (2005). *Computer-assisted cancellation tests for visual neglect patterns.* IADIS International Conference e-Society, 674-676.

Karakaş, S. (2004). *BİLNOT bataryası el kitabı: Nöropsikolojik testler için araştırma ve geliştirme çalışmaları* (1st ed.). Ankara: Dizayn Ofset.

Karakaş, S. (2006). Nöropsikoloji, nöropsikolojik değerlendirme, klinik uygulamalar: Ülkemizdeki durum. (Bölüm 8.2). N. Yüksel (Ed.), *Ruhsal Hastalıklar.* Ankara: MN Medikal & Nobel.

Karakaş, S., & Başar, E. (1993). *Nöropsikolojik değerlendirme araçlarının standardizasyonu nöropsikolojik ölçümlerin elektrofizyolojik ölçümlerle ilişkileri.* TÜBİTAK-TBAG. Project No:TÜBİTAK-TBAG 17-2.

Karakaş, S., & Başar, E. (1995). Nöropsikolojik testlerin Türk örneklemi üzerinde değişik yaş ve eğitim düzeylerine göre standardizasyonu. II. Sosyal Psikiyatri Sempozyumu. *Kriz Dergisi Özel Sayısı, 3*(1-2), 177-184.

Karakaş, S., Eski, R., & Başar, E. (1996). Türk kültürü için standardizasyonu yapılmış nöropsikolojik testler topluluğu: BİLNOT Bataryası. *32. Ulusal Nöroloji Kongresi* (pp. 43-70). İstanbul: Ufuk Mat.

Karakaş, S., & Kafadar, H. (1999). Şizofrenideki bilişsel süreçlerin değerlendirilmesinde nöropsikolojik testler: Bellek ve dikkatin ölçülmesi. *Şizofreni Dizisi, 2(4),* 132-152.

Kılıç, B.G., Irak, M., Koçkar, A.İ., Şener, Ş., & Karakaş, S. (2002). İşaretleme testi türk formu'nun 6-11 yaş grubu çocuklarda standardizasyon çalışması. *Klinik Psikiyatri Dergisi, 5(4),* 213-228.

Küçük, A., Dolu, N., & Erdoğan, H. T. (2009). İlköğretim öğrencilerinde yaş, cinsiyet ve sosyo-ekonomik seviye farklılıklarının dikkat düzeyine etkileri. Research Report, *Journal of Health Sciences*, *18(1),* 1-41.

Laurent-Vannier, A., Chevignard, M., Pradat-Diehl, P., Abada, G., & De Agostini, M. (2006). Assessment of unilateral spatial neglect in children using the Teddy Bear Cancellation Test. *Dev Med Child Neurol*, *48,* 120-5.

Lichtenberger, E.O. (2006). Computer utilization and clinical judgment in psychological assessment reports. *Journal of Clinical Psychology*, *62(1),* 19-32.

Mandell, D.J., & Sackett, G.P. (2008). A computer touch screen system and training procedure for use with primate infants: Results from pigtail monkeys (macaca nemestrina). *Developmental Psychobiology*, *50*, 160-170.

Mayer, R.E. (2001). *Multimedia learning.* New York: Cambridge University Press. ISBN 0-52178-749-1.

Norman, K.L. (2001). *Implementation of conditional branching in computerized self-Administered questionnaires.* Laboratory for Automation Psychology Technical Report, University of Maryland (LAP-TR-2001-1).

Paul, R.H., Lawrence, J., Williams, L.M., Richard, C.C., Cooper, N., & Gordon, E. (2005). Preliminary validity of "Integneuro": A new computerized battery of neurocognitive tests. *International Journal of Neuroscience*, *115,* 1549-1567.

Richey, R.C., & Klein, J.D. (2005). Developmental research methods: Creating knowledge from instructional design and development practice. *Journal of Computing in Higher Education, 16*(2), 23–38.

Rogers, P.L. (2001). *Designing instruction for technology enhanced learning*. London: IRM Press.

Sommerville, I. (2004). *Software engineering* (7th ed.). Wokingham: Addison-Wesley.

Sternberg, R.J. (2009). *Cognitive psychology* (5th ed). Belmont, CA: Wadsworth Publishing.

Wang, T.Y., Huang, H.C., & Huang, H.S. (2006). Design and implementation of cancellation tasks for visual search strategies and visual attention in schoolchildren. *Computers & Education*, *47,* 1-16.

Weintraub, S., & Mesulam, M.M. (1985). Mental state assessment of young and elderly adults in behavioral neurology. In M. M. Mesulam (Ed.), *Principles of Behavioral Neurology* (pp. 71-124). Philadelphia: F.A. Davis.

Yalın, H.İ. (2006). *Öğretim teknolojileri ve materyal geliştirme.* Ankara: Nobel Yayın Dağıtım.