Speed of Lexical Access to Arabic and English Letters

Hesham H. Alasali* Suliman S. Aljomaa
Department of psychology, King Saud University, P.O. Box2458, Riyadh-11451
E-mail of the corresponding author: halasaly@ksu.edu.sa

Abstract
To examining the role of cultural differences in speed of lexical access, we employed two types of Posner (1967) name matching task: Arabic and English types. We have conducted an experiment on 30 native Arabic speakers from King Saud University. The results showed that the lexical access to physically identical letters is faster than lexical access to the nominally identical letters. However, there was a significant effect of task's type in the speed of lexical access. Also, the correlations coefficients varied with task's type. In its entirety, these results suggest that the cultural aspects have a role in the speed of lexical access.
Keywords: Lexical Access, long term memory, letters matching.

1. Introduction

Posner and Mitchell proposed letters matching task for the first time in 1967. The task requires the subjects to discriminate between two stimuli, presented simultaneously or sequentially, on the basis of some predetermined stimulus characteristics. The procedure measures the speed of which highly overlearned information stored in long term memory can be retrieved. In each experimental trail, pairs of stimuli are presented to the subject, which are physically identical (e.g., AA, aa, BB, bb), physically different (e.g., Aa, bB, AB), semantically identical (Aa, Bb), or semantically different (AB, aB, ab). Subjects are required to press a key buttons if the pairs are the same, and press another key buttons if the pairs are different.

Posner letter matching task used to study speed of retrieve information from long-term memory, which is referred to as the speed of lexical access. Hunt considered speed of lexical access as a component of the intelligence (Hunt, 1980). Letter matching task was classified within elementary cognitive tasks (ECT). In these tasks, Participants are asked to perform very simple cognitive acts, such as selection, coding, comparison or matching (Jensen, 2006; Rijsdijk, Vernon & Boomsma, 1998 for reviews). Because ECTs are free of content and relatively from the effect of academic experience, many researchers suggested that the relationship between the speed of performing these tasks and intelligence reflect the basic properties of the nervous system: transmission time, conduction time and neural efficiency. So, researchers suggests that the variation in IQ due to individual differences in one or more of these neural characteristics (Eysenck, 1986; Jensen, 1987; Vernon, 1987). In Sheppard and Vernon (2008) review, the results revealed a moderate significant correlation between intelligence measures and speed of performing ECTs. The average correlation coefficient was -0.24.

Although the existence of average correlation between the ECTs speed and IQ scores, but this correlation remains controversial. Sternberg (1984) suggested that the ECTs performance is affected by higher cognitive processes such as attention. Moreover, the studies of the relationship between ECTs speed and intelligence were conducted in industrialized Western countries. In fact, the culture of Western countries gives great importance to the time and speed of performance. Therefore, people in Western countries are more likely to perform tasks requiring speed which affects the performance of ECTs. Thus, it seems that ECTs measure performance components for subject of western countries. However, ECTs may measure something different for the non-Western countries, which does not confirm in its culture on the speed of performance and rarely perform tasks under time pressure; it seems that the same ECTs measure metacognitive components in non-Western countries. Based on this argument, the validity of ECTs as culture- free may be questionable.

In a meta-analysis by Van der Vijer (1997) for studies of cognition across cultures, he found that “even cognitively simple tasks have characteristics that give rise to cross-national performance differences. It could be speculated that these include familiarity with stimuli, response procedures, and testing situations in general (Van der Vijer, 1997). Neubauer & Benishke, (2002) compared the speed - intelligence relationship in Western country (Austria) vs. a non – Western country (Guatemala) by testing 73 Austrian and 73 Guatemala school children with Standard Progressive Matrices and two tests for processing speed. They found the expected significant speed – intelligence relationships, which did not differ significantly between the cultures. However, Neubauer and Benishke, (2002) referred to that they observe significant cultural differences in average performance.

Hunt (1980) has been assumed that the lexical access speed associate with verbal ability. He assumed that the speed of lexical access to the information that have been stored in long term memory one of the basic components which correlated with high verbal ability. Also, speed of lexical access play an important role in reading skill. For example, the central feature of the interactive activation model (McClelland et al., 2009; Rumelhart & McClelland, 1982) is that the processing of information during reading consists of series of levels corresponding to visual features, letters and words. Other researchers have indicated that recognition of letters and words is happening under separate processing processes (e.g., Paap et al., 1982).

In fact, there is a large body of research indicates that expert readers perform faster and accurately during tasks that involve letters from the known language compared to tasks that involve unfamiliar letter- like forms (e.g., pseudoletters: Burgund, Lugar, Schlaggar, & Petersen, 2005; Burgund, Schlaggar, & Petersen, 2006; Lachmann & van Leeuwen, 2004).

This means that the frequent exposure to letters of native language, and using it in everyday interactions increasing the automaticity of processing tasks that based on it. Thus, it isn't surprising that subject performing these tasks speeder than other tasks which based on unfamiliar language. These expectations line with theories of perceptual expertise (e.g., McCandliss, Cohen, & Dehaene, 2003) and with neurological studies which have found that neural regions within the left occipito-temporal cortex respond preferentially to real letters compared to non-letter forms (Cohen et al., 2000, 2002; Tagamets et al., 2000; Baker et al., 2007), and unfamiliar letters (James, et al, 2005). Other studies have suggested that the degree of left -lateralization depends on the linguistic familiarity of the characters (Appelbaum et al, 2011; Tagamets et al., 2000), the task demands (Bokde et al, 2001; Burgund et al, 2005; Ruz & Nobre, 2008), or other linguistic and developmental factors (Schlaggar & McCandliss, 2007).

These finding provided evidence that performing even very simple tasks such as letter matching is affected by culture differences, familiarity and task demands. Most of these studies have used letters and unfamiliar letter- like forms (e.g., Burgund et al, 2005; Burgund, Schlaggar, & Petersen, 2006; Lachmann & van Leeuwen, 2004; van Leeuwen & Lachmann, 2004), but the current study used two type of Posner name matching task: English and Arabic matching letters. The experiment was conducted on university students, with native Arabic language. They have studied English language from the beginning of the primary stage, and there studding continued through various stages of education. Thus, if the speed of lexical access to both types of Posner name matching tasks depends on performance components only, then there wouldn't be any differences in responses of subjects to them.

2. Method

2.1 Participants

Thirty right-handed undergraduate students from psychology department at King Saud University participated in the experiments (mean age = 20.6 - years ± 2.2). They volunteered to participate in the experiments. All of them are Arabic native speakers. Participants reported learning Arabic as their first language and rated Arabic as their dominant language at the time of testing. English is the second language of the participants. Participants had normal or corrected-to-normal vision and no self-reported speech or hearing disorders.

2.2 Stimuli

The stimuli appeared on the screen of a color monitor. The background was white, while the stimuli were black. The English type of name matching task, that was used here, contains the same four letters utilized by Posner and Mitchell (1967): A. B. C, and E in both upper-case and lower-case. Posner and Mitchell (1967) classified them as: 'physically' identical (e.g., AA), 'nominally identical (e.g., Bb). The letters were written by 14 Times New Roman Bold Font.

Because Arabic letters differ from the English letters we used 16 letters in the Arabic version of letter matching task (ب، ت، ث، ج، ح، خ، س، ش، ص، ض، ع، غ، ف، ق، م، ي). The letters were written by 14 Traditional Arabic Bold Font.

The participants task were to press one key if the names of the two letters were the same (e.g., AA, Aa), and the other key if they were different (e.g., AB, aB).

2.3 Apparatus and procedures.

Subjects were seated in front of a 21 inch monitor and used the two Shift keys on the keyboard as response buttons. Tasks were counterbalanced across subjects. Half of the participants perform the Arabic version of letter matching first and the English version of letter matching secondly. The other half of participants performs the English version of letter matching first and the Arabic version of letter matching secondly. Viewing distance was approximately 60 cm; subject's heads were not restrained, but viewing distance was measured and adjusted before each set of trials.

Before the session beginning, participants received instructions for the task, including which hand to use in performing responses. They were instructed to press the appropriate Shift key with the index finger. Then they received one block of 24 practice trials followed by 270 test trials for each task, with a brief rest period after each set of 90 trials.

Before each trial beginning, the fixation cross appeared for 150 ms at the center of the monitor. After the fixation cross disappeared, the stimuli were presented at the center of the monitor. Stimuli continue on the screen until the participant pressed response key. The computer program that generated and displayed the stimuli also recorded the keypress and response latency for each trial. Trials on which the subject responded faster than 100 ms or slower than 2000 ms were scored as errors and not included in the analyses of response latencies.

3. Results

Reaction times for correct responses were analyzed in a oneway, repeated-measures ANOVA with task's type (Arabic physically identical letters vs. Arabic nominally identical letters and English physically identical letters vs. English nominally identical letters) as the independent variable. The results reveal a significant main effect of the task's type [F(2.040)= 51.791, P <0. 0001] for reaction times. Bonferroni pairwise comparison tests showed that the differences between Arabic physically identical letters vs. Arabic nominally identical letters, and Arabic nominally identical letters vs. English physically identical letters insignificant. However, the differences between other conditions were significant. Reaction times for the four conditions are shown in table 1 and in Fig.1.

There was a significant difference between the two types of name matching tasks. The reaction time to the Arabic letter matching was shorter (M= 773 ms, SD= 140 ms) than English letter matching (M=1091 ms, SD=244 ms), the difference was significant [T(29) = 7.879, P <0. 0001].

The pattern of the correlation between nominally identical letters matching and physically identical letters matching varied with the language of the task. Although there wasn't significant correlation between nominally identical Arabic letters matching and physically identical Arabic letters matching (r= 0.17, P >0. 3), there was significant correlation between nominally identical English letters matching and physically identical English letters matching (r= 0.46, P <0. 01). Also, the pattern of correlation between the two tasks varied with the experimental condition. There wasn't significant correlation between nominally identical Arabic letters matching and physically identical English letters matching (r= 0.15, P >0. 4). However, There was significant correlation between nominally identical Arabic letters matching and nominally identical English letters matching (r= 0.40, P <0. 02). On contrary, there were significant correlations between physically identical Arabic letters matching with physically identical English letters matching (r= 0.54, P <0. 002), and with nominally identical English letters matching (r= 0.41, P <0. 02).

Table 1
Reaction times during name matching

Task's type	Reaction time (ms)	
	Mean	Std. Deviation
Arabic name matching		
physically identical letters	729	149
nominally identical letters	816	213
English name matching		
physically identical letters	892	202
nominally identical letters	1290	328

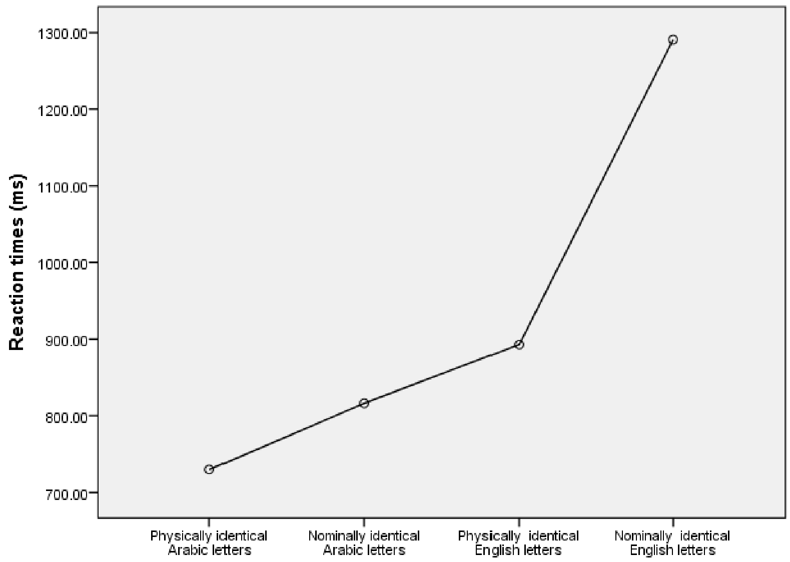

Fig. 1. Reaction times displayed as a function of task's type (Arabic physically identical letters, Arabic nominally identical letters, English physically identical letters and English nominally identical letters).

4. Discussion

Posner and Mitchell (1967) employed two forms of a visual letter matching task: physical matching and name matching. These tasks were used to study the speed of lexical access to information which stored in long term memory. According to Jensen (1982), discrimination of a physical difference does not require access to a prior learned semantic code, whereas discrimination of semantic differences requires access to information stored in long term memory. So, we used name matching task to investigate possible differences within native Arabic speakers on name matching tasks (Arabic and English). We were looking for differences since Arabic is the participants dominant language.

The results of Posner and Mitchell (1967) showed that on name matching tasks 'same' responses to physically identical letters (e.g., AA) were faster than to letters simply having the same name (e.g., Aa). These results suggest that the response to physically identical letters, which must have the same name, can be based solely upon the initial visual codes rather than the slower forming acoustic codes required for such pairs as Aa. The results of the present study showed that reaction times for physically identical letters were faster than reaction times for nominally identical letters in both types of name matching tasks.

The differences between reaction times for physically identical letters and nominally identical letters were very similar within both type of tasks, but there were differences in reaction times across the two types of the name matching tasks, which suggest that the speed of lexical access is affected by the subject's expertise and familiarity with tasks. These results consistent with the general pattern of previous research, which indicated that expert readers perform faster during tasks that involve letters from the known language compared to tasks that involve unfamiliar letter- like forms (e.g., pseudoletters: Burgund, Lugar, Schlaggar, & Petersen, 2005; Burgund, Schlaggar, & Petersen, 2006; Jackson, 1980; Lachmann & van Leeuwen, 2004; van Leeuwen & Lachmann, 2004), unfamiliar characters (James, 2005; Pernet, Celsis, &Dmonet, 2005).

As noted above, there is no significant difference between reaction times for Arabic physically identical letters and Arabic nominally identical letters. However, there is a significant difference between reaction times for English physically identical letters and English nominally identical letters. Thus, the relationship between the pairs of letters solely cannot explain the speed of lexical access. Accordingly, we conclude that this finding is not surprising given the subjects were native Arabic speakers, and the frequent exposure to letters that individuals in literate cultures experience daily, which make them skilled expertise in using letters. This mean that the processes of processing information that related to Arabic letters become automatic, and the response to them can be based solely upon the initial visual codes. On contrary, for native Arabic speakers, naming the English letters require more processes and more efforts, which appear in increasing reaction times as compared to naming Arabic letters.

On the other hand, the pattern of correlations between subject's reaction times varied with type of name matching tasks. These results suggest that subjects were consistently modifying their strategies according to the type of matching task, and that there could be a common underlying process mediating the performance of subjects on the type of matching task. Therefore, for native Arabic speakers, naming Arabic letters may be based on performance components, while naming English letters may be based on metacognitive components.

In conclusion, results from the present study indicate that the speed of naming letters varied with the type of matching task. Thus, the speed of lexical access does not necessarily emerge as a consequence of relationship between the letters pairs. The results entirely reflect the possibility that the processes underlying performing ECTs are affected by some aspects of culture. Therefore, the validity of ECTs as culture- free may be questionable.

References

Appelbaum, L.G.1., Smith, D.V., Boehler, C.N., Chen, W.D., & Woldorff, M.G. (2011). Rapid Modulation of Sensory Processing Induced by Stimulus Conflict. *Journal of Cognitive Neuroscience*, 23, 2620–2628.

Baker C. I., Liu J., Wald L. L., Kwong K. K., Benner T., Kanwisher N. (2007). Visual word processing and experiential origins of functional selectivity in human extrastriate cortex. *Proc. Natl. Acad. Sci.* U.S.A. 104, 9087–909210.1073/pnas.0703300104 [PMC free article][PubMed] [Cross Ref].

Bokde, A.L.W., Tagaments, M.-A., Friedman, R.B., & Horwitz, B. coil. (2001). Functional interactions of the inferior frontal cortex during the processing of words and word-like stimuli. *Neuron*, 30, 609–617.

Burgund, E. D., Lugar, H. M., Schlaggar, B. L., & Petersen, S. E. (2005). Task demands modulate sustained and transient neural activity during visual matching tasks. *NeuroImage*, 25, 511–519.

Burgund, E. D., Schlaggar, B. L., & Petersen, S. E. (2006). Development of letter specific processing: The effect of reading ability. *Acta Psychologica*, 122, 99– 08.

Burgund, E.d., & Abernathy, E.A. (2008). Letter-specific processing in children and adults matched for reading level. *Acta Psychologica,* 129 , 66–71.

Cardoso-Martins, C., Rodrigues, L. A., & Ehri, L. C. (2003). Place of environmental print in reading development: Evidence from nonliterate adults. *Scientific Studies of Reading*, 7, 335–355.

Cohen L., Lehericy S., Chochon F., Lemer C., Rivaud S., Dehaene S. (2002). Language-specific tuning of visual cortex? Functional properties of the Visual Word Form Area. *Brain,* 125, 1054–

106910.1093/brain/awf094[PubMed] [Cross Ref]

Cohen, L., Dehaene, S., Naccache, L., Lehéricy, S., Dehaene-Lambertz, G., Henaff, M. A., et al. (2000). The visual word form area: Spatial and temporal characterization of an initial stage of reading in normal subjects and posterior split-brain patients. *Brain*, 123, 291–307.

Eysenck, H.J. (1986). Intelligence: The new look. *Psychologische Beiträge*, 28, 332-365.

Greenberg, D., Ehri, L. C., & Perin, D. (1997). Are word-reading processes the same or different in adult literacy students and third-fifth graders matched for reading level? *Journal of Educational Psychology*, 89, 262–275.

Greenberg, D., Ehri, L. C., & Perin, D. (2002). Do adult literacy students make the same word-reading and spelling errors as children matched for word-reading age? *Scientific Studies of Reading*, 6, 221–243.

Hunt, E. (1980). Intelligence as an information processing concept. *British Journal of Psychology*, 71, 449-474.

Jackson, M. D. (1980). Further evidence for a relationship between memory access and reading ability. *Journal of Verbal Learning and Verbal Behavior*, 19, 683– 694.

James, K. H., James, T. W., Jobard, G., Wong, A. C. N., & Gauthier, I. (2005). Letter processing in the visual system: Different activation patterns for single letters and strings. *Cognitive, Affective, and Behavioral Neuroscience*, 5, 452–456.

Jensen A. R. (1982) Reaction time and psychometric g. In *A model of intelligence*. (Edited by Eysenck H. J.). pp. 93-133. Springer, New York.

Jensen, A. R. (1987). The g beyond factor analysis. In R. R. Ronning, J. A. Glover, J. C. Conoley, and J. C. Witt (Eds.), *The influence of cognitive psychology on testing*. Hillsdale, NJ: Erlbaum. pp. 87—142.

Jensen, A. R. (2006). *Clocking the mind: Mental chronometry and individual differences*. Oxford: Elsevier.

Lachmann, T., & van Leeuwen, C. (2004). Negative congruence effects in letter and pseudo-letter recognition: The role of similarity and response conflict. *Cognitive Processing*, 5, 239–248.

McCandliss, B. D., Cohen, L., & Dehaene, S. (2003). The visual word form area: Expertise for reading in the fusiform gyrus. *Trends in Cognitive Science*, 7, 293–299.

McClelland, J. L., Rogers, T. T., Patterson, K., Dilkina, K. N., & Lambon Ralph, M. R. (2009). Semantic Cognition: Its Nature, Its Development, and its Neural Basis. In M. Gazzaniga (Ed.), *The Cognitive Neurosciences IV*. Boston, MA: MIT Press.

Neubauer, A.C. & Benischke, C. (2002). A cross-cultural comparison of the relationship between intelligence and speed of information processing in Austria vs. Guatemala. *Psychologische Beiträge*, 44, 521-534.

Paap, K. R., Newsome, S. L., McDonald, J. E., & Schvaneveldt, R. W. (1982). An activation-verification model for letter and word recognition. *Psychological Review*, 89, 573–594.

Pernet, C., Celsis, P., & Démonet, J. F. (2005). Selective response to letter categorization within the left fusiform gyrus. *NeuroImage*, 28, 738–744.

Posner, M. J., & Mitchell, R. F. (1967). Chronometric analysis of classification. *Psychological Review*, 74, 392–409.

Rijsdijk, F.V., Vernon, P.A., & Boomsma, D.I. (1998). The genetic basis of the relation between speed-of-information-processing and IQ. *Behavioural Brain Research*, 95(1), 77-84.

Rumelhart, D. E. & McClelland, J. L. (1982). An interactive activation model of context effects in letter perception: Part 2. The context enhancement effect and some tests and extensions of the model. *Psychological Review, 89,* 60-94.

Ruz, M.,& Nobre, A.C. (2008). Attention modulates initial stages of word processing. *Journal of Cognitive Neuroscience,* 20 (9), 1727-1736.

Schlaggar, B.L., McCandliss, B.D. (2007) Development of neural systems for reading. *Annual Reviews of Neuroscience,* 30:475-503.

Sheppard, L.D. & Vernon, P.A. (2008). Intelligence and speed of information-processing: A review of 50 years of research. *Personality and Individual Differences*, 44, 535–551.

Sternberg, R. J. (1984). Toward a triarchic theory of human intelligence. *Behavioral and Brain Sciences*, 7, 269-287.

Tagamets, M. A., Novick, J. M., Chalmers, M. L., Friedman, R. B. (2000). A parametric approach to orthographic processing in the brain: an fMRI study. *Journal of Cognitive Neuroscience*, 12, 281–297.

Thompkins, A. C., & Binder, K. S. (2003). A comparison of the factors affecting reading performance of functionally illiterate adults and children matched by reading level. *Reading Research Quarterly*, 38, 236–258.

van de Vijver, F. J. R. (1997). Meta-analysis of cross-cultural comparisons of cognitive test performance. *Journal of Cross-Cultural Psychology*, 28, 678-709.

van Leeuwen, C., & Lachmann, T. (2004). Negative and positive congruence effects in letters and shapes. *Perception & Psychophysics*, 66, 908–925.

Vernon, P. E. (1987). *Speed of information processing and intelligence*. Norwood, NJ: Ablex.