# Bilingual Lexical Activation in Sentence and Non-sentence Context: A Study of Cross-language Lexical Processing

*Mehraban Hamavandy*
Tarbiat Modares University, Tehran, Iran
Mehraban2544@gmail.com

*Mohammad Golshan*
Azad University of Meibod, Yazd, Iran
mohammadd_golshann@yahoo.com

**Abstract**

Research on word recognition across languages has gained popularity in recent years, due to its overall bearing on the psycholinguistic account of language acquisition. To this end, this study was an attempt to demonstrate the differential influences of L2 proficiency, and type of context on the lexical recognition and retrieval of bilinguals. For this purpose, ten participants who were native speakers of Persian and were learning English at the two distinct levels of elementary and advanced were requested to recite two texts, one in Persian and one in English, which were specifically modified for the current research purpose. The results revealed that while advanced learners were better performers on L2 lexis retrieval, their bare word recognition in L1 lagged behind in latency from elementary learners.

**Keywords:** lexical access, bilingualism, cross-language differences, sentence processing

## 1. Introduction

The expanding awareness on the importance of becoming a bilingual[1] in modern world has stimulated a plethora of research on the different processes of turning into a bilingual, including studies on how bilinguals recognize words in their first or second language. A core concern, especially in the psycholinguistic account of bilingualism (and SLA as well) has been the nature with which bilinguals activate lexical representations from both of their languages when reading a language.

A central issue with regard to this area (Macnamara & Kushnir, 1971) was related to the debate of whether the process of word recognition for a bilingual undergoes the initial activation of word representations from a target language only (language-selective lexical access) or whether all words known to an individual, including those from a non-target language, are considered as potential candidates for recognition (nonselective access). Many studies have endeavored to disambiguate the phenomenon, among which most have revealed that the two languages do interrelate and interact during the process of word recognition. As an example, it has been shown that when bilinguals recognize words in one of their languages, they process identical words in another language (e.g. the words None in English as compared with Naan [meaning bread] in Persian).

Assuming the dominance of non-selective lexical activation for bilinguals, what remains is to understand the nature of the lexical items that become activated (e.g., orthographic, phonological, and/or semantic) and the way context and linguistic task can probably influence the process of activation. For example, in the monolingual domain, much research has been devoted to determine the extent to which phonological codes within a language are automatically activated during visual word identification. These studies gave proof that phonological codes become activated and affect the visual identification of words (Glushko, 1979; Perfetti & Bell, 1991; Van Orden, 1987). Further it has been specified that visual word identification is influenced by the consistency of mappings between orthographic and phonological codes. When an orthographic code (e.g., lead) maps on to multiple phonological codes (e.g., [lid] and [lod]), feed-forward activation from those competing

[1] Bilingual in this article refers to both professional speakers of two languages as well as second language learners

codes inhibits performance (Hino, et. al., 2002; Stone, et. al., 1997). These studies were significant in revealing that, even in orthographically based tasks, phonological codes are activated and influence performance. Similarly, when a phonological code (e.g., [meid]) maps onto multiple orthographic codes (e.g., maid,made), feed-backward activation from those competing codes inhibits performance (Pexman, et. al., 2001; Pexman, et. al., 2002). In the present study one of the questions raised was whether similar 'phonological dynamics' (as stated by Schwarts et. al., 2005) across the two languages of English and Persian take place.

Among other factors (variables) that have been identified in previous studies which might contribute to the understanding of how certain lexical items in the repertoire of the language speaker (learner) are demonstrated during L1/L2 word recognition one can refer to the following.

***Word Frequency***

The word frequency influence (more frequent words are recognized faster than words with a lower frequency) is one of the most robust findings in the visual word recognition literature (Howes & Solomon, 1951; Schilling, et. al., 1998; Whaley, 1978).This factor has been treated as a predominant variable in almost every model of word recognition. For instance, interactive activation models of lexical access assume that frequency affects the resting activation levels of word representations (McClelland & Rumelhart, 1981). Although the degree of the effect is to a large extent reported to be task dependent, it has been assumed for all standard tasks of word recognition. For the bilingual domain, some evidence suggests that the frequency effect might even be larger in the second as compared with the first language (van Wijnendaele & Brysbaert, 2002). Akamatsu (2002) showed that bilingual speakers with Chinese, Japanese, or Persian as L1 and English as L2 displayed differential effects of word frequency but comparable effects of phonological regularity in English word naming. Finally, Baayen et al. (2006) demonstrated that the relative frequency in written compared with spoken English (quantified as the ratio between the two) played an important role in both English monolingual lexical decision and word naming: The more frequent a word was in spoken relative to written English, the faster it was recognized.

***Language Orthographic Neighborhood***

Effects of orthographic neighborhood (i.e., words that are different from their neighboring word in one letter only) are deemed to influence word selection through activation of multiple words during word recognition. The relative importance of various neighborhood measures for the different standard word recognition tasks has been discussed extensively in the literature on word recognition (e.g. Andrews, 1997; Perea & Rosa, 2000; Carreiras et al., 1997; Grainger & Jacobs, 1996). The number of higher frequency neighbors has repeatedly been found to slow down recognition latencies for the target word, whereas the total number of neighbors had no or only little effect on recognition performance. Grainger & Jacobs(1996) found that higher frequency neighbors delay the pass of the recognition threshold for a target word through lateral inhibition.

***Morphological Family Size***

Findings of many studies have revealed that the amount of derivations and compounds, from which a word occurs, named as the morphological size, facilitates response latencies in monolingual and bilingual lexical decision (de Jong, et. al., 2000; Dijkstra, et. al. 2005; Schreuder & Baayen, 1997). It is contended that the number of morphological family members have effect on recognition latencies, and not only their frequency. This argument is against a purely frequency-based account of the morphological family size effect.

***Word Length***

Results of most word recognition tasks have indicated that for words that are longer, more time is demanded to recognize them. Consequently, as McGinnies, et. al. (1952) have stated, owing to the possible transfer of reading strategies from L1 to L2, word length effects may also differ for

bilingual readers varying in their L1 when reading words in their L2. Ziegler et al. (2001) have also shown that word length effects were larger in German as opposed to English, due mainly to the more shallow orthography of German language than English.

***Number of Meanings***

Lexical items which have several meanings have been subject to many studies whose main aim has been to perceive the relationship between the form and semantic level of word representation. Yet, there has been no hard-and-fast compliance on whether, why, and how this factor can be influential on word recognition (e.g., Borowsky & Masson, 1996; Duffy, et. al. , 1988; Hino, et. al., 2006), and whether related word senses have to be discriminated from unrelated word meanings (Klein & Murphy, 2001; Rodd, et. al., 2002). It has been hypothesized that native/nonnative speakers of a certain language are heavily influenced by the number of word meanings during a word recognition task that probably entails relatively little semantic processing. Considering that representations of L2 words have been regarded as less "richly populated" (i.e., possessing fewer senses) than L1 words it is possible that the number of meanings affects word recognition in the first but not in the second language (Finkbeiner, et. al., 2004).

***Familiarity***

The respondents' familiarity with the word has been assumed to be a highly determinant factor during word recognition process (especially in the setting of the native language speakers (Kreuz, 1987; Williams & Morris, 2004). Gernsbacher (1984) for instance reported that effects of other variables (word frequency, word length, and number of meanings) on lexical decision latencies disappeared when familiarity was controlled for.

In addition to the mentioned studies which mainly investigated the variables which influence word recognition, a number of other relevant researches tried to shed light on the process of the activation of the pronunciation of the words, usually taking place cross-linguistically. As an instance, Jared and Szucs (2002) in their study asked French-English and English-French bilinguals name words in three blocks of trials; two in English only and a third in French separating the two English blocks. The English words included heterophonic homographs of French words [e.g., pain (meaning ''bread'')] and unambiguous controls (e.g., camera). Their initial hypothesis was that if phonological representations from the non-target language are active, then competition between alternative pronunciations of the same word should delay naming for the heterophonic homographs. Therefore, the French naming block was included to test the hypothesis that the requirement to produce in the non-target language would further increase this 'cost'. When bilinguals named words in their weaker L2, there were increased latencies for the interlingual homographs, both before and after the French naming block. When bilinguals named words in their L1( as their more dominant language), in this case English, there was once again a cost for naming the homographs, yet the influence was found only after the L2 was activated by a block of French word naming. The finding being in line with non-selective theory of language activation, since bilinguals seemed to activate phonological codes from both of their languages, even when reading in their L1. Though, how influential L1 is, depends upon the time when L2 had been activated.

In a very similar approach, Jared and Kroll (2001) investigated whether and to what extent sub-lexical phonology was influenced by similar cross-language effects. Participants of their study who were English-French bilinguals named English words that either had word body 'enemies' in French (e.g., pain), English (e.g., steak) or no enemies in either French or English (e.g., stump). The final finding revealed a very analogous pattern with that of Jared and Szucs (2002), mentioned earlier. Participants who were bilinguals of English & French, named words in English (that had word body enemies in French), in a longer duration of time, yet this 'cost' was found to take place only after naming the French word block.

Taken together, these studies mainly imply that effects of cross-language activation are constrained when production is in the L1 and lexical selection is required by the task

Another related question sought for in the literature is, how the cognitive nature of L2 reading is distinct from reading in the native language (L1) and how might this difference account for the probable decreased reading rate?

There are at least two fundamental characteristics mentioned in SLA literature that distinguish L2 reading. First, basic word recognition processes may be slowed in L2 due to decreased familiarity and frequency of use of the language (as mentioned earlier). Second, there is now abundant evidence from psycholinguistic research suggesting that bilinguals are not able to selectively turn o? one of their languages during comprehension (Dijkstra, et. al. 2001; Dijkstra, et. al., 2000; Dijkstra, et. al., 1999; Dijkstra, et. al., 1998). It is believed that information embedded in the context at the sentence level can also guide lexical access in L1( and at times L2) of bilinguals

***Lexical access out of context: Monolingual and bilingual studies***

If lexis is presented to the readers in an out-of-context fashion, it can be expected that they will face ambiguity with regards to lexical selection. This ambiguity has been shown to take place at multiple lexical levels including semantic (e.g., bugs) and phonological (e.g., lead). What has aroused many studies in this field has been the dexterity of many skilled readers, who irrespective of the extent pf lexical ambiguity, can quickly prompt to process words such as homonyms and homo graphs and integrate them into the text being read. This issue has been a source of interest for many researchers to see how multiple meanings of words are represented, activated, and ultimately selected. Other studies have also investigated the processing of ambiguous words out of context, for instance, in a lexical decision task. The obtained results showed that recognition performance for homonyms are facilitated relative to unambiguous words (Pexman & Lupker, 1999; Rodd, et. al. , 2002). Rod et. al., for instance, suggest that the multiple representations of homonyms are activated in parallel. They maintain that lexical access, at least in isolated word recognition tasks, involves the initial activation of numerous lexical competitors within the lexicon.

***Lexical access in sentence context: Monolingual and bilingual studies***

In every day communication, words are most often encountered in a meaningful context and not in isolation. The question can therefore be whether the presence of a meaningful context constrains cross-language activation? Putting it another way, can information activated top-down from semantics in?uence the bottom-up processes of lexical access? In the monolingual domain, it has been contended that context aids in the interpretation of ambiguous words.

However, what is still debated is the point at which selection of the appropriate meaning takes place and how early in the process of lexical access context can exert its effect. According to context-dependent accounts, the conceptual representations of sentences that readers build have an early influence on lexical access. Thus, language processing is seen as being highly interactive, such that lexical knowledge, world knowledge, and the semantic and syntactic information provided by a sentence interact with the bottom-up processes that drive lexical access. This account is based on the ending that words are processed faster when they are embedded in a congruent sentence context than a neutral or incongruent context (e.g., Simpson et al., 1989; Stanovich & West, 1979).

This study was directed toward finding answer to two questions. First, to investigate the lexical access and the amount of word recognition with regard to the proficiency level of the subjects, and second, to probe the role of context in accessing lexical items with consideration of the differences between the two languages (L1 and L2).

## 2. Method

***Participants***

Participants of this study were ten learners of English (as their L2) whose L1 was Persian. The gender variable was controlled for in the study (all subjects were male), and the subjects' ages ranged 17-29. They were at different levels of proficiency in English (five were Elementary and five at the advanced level), who were under education for their foreign language (English) by the

time the experiment was conducted. The participants were rewarded for participation in the experiment by giving 3 extra hours of instruction on their listening comprehension.

***Materials***

Two similar texts, one in the L1 of the participants (Farsi) and one in their L2 (English) was used in the study. The texts were similar in meaning and its lexical items met the following criteria: They were between five to eight letters long each; the first and last letter was left in its place and the in-between letters were randomized. Only content words were used (i.e., nouns, verbs, adjectives, and adverbs); they were monosyllabic; and each word had only one possible spelling and one pronunciation.

To make sure all the lexical items would be known by the participants, the unjumbled text was given to two other students in each level to indicate the unfamiliar words. Words that were indicated as unknown were excluded from the text, and were replaced with their synonyms. Also, two lists of lexical items (which met the above-mentioned criteria) one in Persian and one in English each consisting of ten words were given to the participants for recitation. (See Appendix)

***Design and Procedure***

Participants were presented with the two texts and the words (in the L1 and L2 of subjects) and were asked to read them aloud, while their responses were recorded. Participants were instructed to respond quickly and accurately and to guess if they did not know a word's pronunciation. Reaction time (RT) was recorded in seconds from the onset of stimulus presentation to the end of articulation. Participants were given 3-5 practice trials prior to the experiment.

**4. Results of the Experiment**

Analyses of variance were performed on naming latencies and mean percent error scores. Mean naming latencies (in seconds) and percent error rates for naming the lexical items in English (L1) and Persian (L2) were also calculated.

***Latency data***

A two-way ANOVA was performed to determine whether and to what degree overall effect of language and proficiency level could be detected on lexical recognition time duration. There was significant effect of language, F1 (1, 8) = 17.63, $p < 0.05$, MSE=12597.28; F2 (l, 8) =328.01, $p < 0.05$, MSE=0.401.29, reflecting longer naming latencies in L2 than L1. This main effect was qualified by an interaction with level of proficiency in the subject analysis, F3 (1, 8) = 485.32, $p < 0.05$, MSE=0.386.6. Paired t-tests performed with a Bonferroni correction showed that elementary learners named slower than advanced peers in L2, t (l, 1) = - 6.10, $p < 0.05$, while this difference in latency was not observed in L1, t (1, 1) = 0.17, $p < 0.05$.

Also, a three-way (language type [L1 or L2], proficiency level, phonological similarity) ANOVA was performed on the mean naming latencies and percent error rates.

In the analysis of naming latencies, the main effect of the proficiency level of the subjects turned out as the most significant factor, F1(2, 17) = 16.35, $p < 0.05$, MSE = 22399.95; F2(2, 43) = 43.71, $p < 0.05$, MSE = 3370.15 indicating longer latencies for the advanced participants who were reciting in L1 (Persian) relative to that of elementary learners. Another central research question addressed in the present study was the significant interaction between the proficiency level of the subjects and phonological similarity of the lexical items. The ANOVA results indicated that, as mentioned earlier, advanced learners were slower in their L1. Probably naming latencies were delayed when a highly similar phonological representation in the L1 mapped on to two, or more distinct phonological representations in L2, lengthening the lexical activation. Other studies with a similar finding have considered it as an evidence for feed-forward activation from orthography to phonology across the subjects' two languages.

***Error data***

A two-way ANOVA (language, proficiency) revealed a main effect of language, reflecting increased error rates in L2 relative to L1. F1 (l, 8) = 10.55, $p < 0.05$, MSE = 4.6. There was no significant effect of proficiency observed on error rates for the subjects' L1. F2 (1, 12) = 3.10, $p < 0.05$, MSE = 55.5

## 5. Discussion and conclusion

Results of the present study imply that the degree to which lexical items become activated across languages highly depends on the proficiency level as well as the phonological distance (feed-forward or –backward ness) of lexical items. This differential effect of phonological distance on word recognition has also been reported in previous studies, which demonstrated that under some circumstances language-specific phonologic (orthographic) distance cues can be indicative of word recognition timing (Vaid, et. al., 2002, Thomas & Allport, 2000).

As in the present study, Gottlob et al. (1999) found that words that mapped on to two phonological representations for the readers' L2 (e.g., lead) were delayed in a naming task. They explained this effect of phonological ambiguity within a 'resonance approach' to lexical access. According to this view, word recognition occurs through resonance, which is achieved when feed forward and -backward activation between orthographic, phonological, and semantics codes is mutually reinforcing. Thus, lexical processing will be delayed whenever there is a mismatch between the codes.

In a similar vein Kroll et. al. (2002) and Schwarts et. al. (2005) found close results with the present study. In those studies the researchers also observed difference in lexical representations across the languages of their subjects with regard to their L2 proficiency level. Kroll et. al., for instance, conclude that lexical representations in the L2, even for relatively proficient bilinguals, are weaker than those in the LI, lengthening the time in which information becomes activated and increasing the likelihood that competitive dynamics will influence processing

Another objective of the present study was to examine the nature of bilingual lexical activation in sentence context. More speci?cally, it was hoped to determine whether the presence of a sentence context would modify cross-language, non-selective activation. Overall the ?ndings demonstrated that the mere presence of a sentence context, and the language cues it might provide, were not su?cient to constrain non-selectivity since e?ects of cross-language activation persisted in low-constraint sentences. Instead, e?ects of non-selectivity were decreased only when the sentences provided rich semantic information. This can be an indication that the top-down processes of sentence comprehension can interact directly with the bottom-up processes of lexical access and reduce the number of lexical entries that compete for selection.

Although findings of the present study are indicative of interactions between the top-down processes of sentence comprehension and the bottom-up processes of lexical access, it could not definitively be concluded that actual selective access had taken place.

During L1 lexical recognition for advanced learners an interfering context effect was obtained. This effect was absent in bare noun naming. The question therefore can be what caused the interference effect in word naming within a textual constraint? One claim can be that in bare noun naming, phonological codes can be directly accessed from the orthographic input codes, as the task does not require lexical-semantic retrieval of other words. In the framework proposed by Levelt et al. (1999), an accessed lemma (i.e. abstract lexical representations) spreads activation to the corresponding lexical concept, which co-activates related concepts and their lemmas. This, in turn, will lead to competition among semantically related lemmas, which can be a cause of the observed interference effect in this study.

The semantic interference effect observed in this study is also compatible with findings reported by Vitkovitch and Humphreys (1991) that demonstrated increased error rates in picture naming when targets were preceded by items from the same semantic category. The authors claim that most probably lexical competition has been at the root of that effect there, too.

In future research it will be critical to understand whether and how these interactions are constrained by contextual support in situations that may better reflect the real-life language experience of bilinguals.

**References**

[1] Akamatsu, N. (2002). A similarity in word-recognition procedures among second language readers with different first language backgrounds. *Applied Psycholinguistics.* 23, 117–133.

[2] Andrews, S. (1997). The effect of orthographic similarity on lexical retrieval: Resolving neighborhood conflicts. *Psychonomic Bulletin & Review*.4, 439–461.

[3] Baayen, R. H., Feldman, L., & Schreuder, R. (2006). Morphological influences on the recognition of monosyllabic monomorphemic words. *Journal of Memory and Language*, 55, 290–313.

[4] Borowsky, R., & Masson, M. E. J. (1996). Semantic ambiguity effects in word identification. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 22, 63–85.

[5] Carreiras, M., Perea, M., & Grainger, J. (1997). Effects of orthographic neighborhood in visual word recognition: Cross-task comparisons. *Journal of Experimental Psychology: Learning, Memory, and Cognition,* 23, 857–871.

[6] de Jong, N. H., Schreuder, R., & Baayen, R. H. (2000). The morphological family size effect and morphology. *Language and Cognitive Processes,* 15, 329–365.

[7] Dijkstra, T., & van Heuven, W. J. B. (2002). The architecture of the bilingual word recognition system: From identification to decision. Bilingualism: *Language and Cognition*, 5, 175–197.

[8] Dijkstra, T., Grainger, J., & van Heuven, W. J. B. (1999). Recognition of cognates and interlingual homographs: The neglected role of phonology. *Journal of Memory and Language,* 41, 496–518.

[9] Dijkstra, T., Moscoso, F., Schulpen, B., Schreuder, R., & Baayen, R. H. (2005). A roommate in cream: Morphological family size effects on interlingual homograph recognition. *Language and Cognitive Processes,* 20, 7–41.

[10] Dijkstra, T., van Jaarsveld, H., & ten Brinke, S. (1998). Interlingual homograph recognition: Effects of task demands and language intermixing. *Bilingualism: Language and Cognition*, 1, 51–66.

[11] Duffy, S. A., Morris, R. K., & Rayner, K. (1988). Lexical ambiguity and fixation times in reading. *Journal of Memory and Language,* 27, 429–446.

[12] Gernsbacher, M. A. (1984). Resolving 20 years of inconsistent interactions between lexical familiarity and orthography, concreteness, and polysemy. *Journal of Experimental Psychology: General,* 113, 256–281.

[13] Grainger, J., & Jacobs, A. M. (1996). Orthographic processing in visual word recognition: A multiple read-out model. *Psychological Review*, 103, 518–565.

[14] Hino, Y., Lupker, S. J., & Pexman, P. M. (2002). Ambiguity and synonymy effects in lexical decision, naming, and semantic categorization tasks: Interactions between orthography, phonology, and semantics. *Journal of Experimental Psychology: Learning, Memory and Cognition*, 28, 686-713.

[15] Hino, Y., Pexman, P. M., & Lupker, S. J. (2006). Ambiguity and relatedness effects in semantic tasks: Are they due to semantic coding? *Journal of Memory and Language*, 55, 247–273.

[16] Howes, D. H., & Solomon, R. L. (1951). Visual duration threshold as a function of word-probability. *Journal of Experimental Psychology*, 41, 401–410.

[17] Jared, D., & Kroll, J. F. (2001). Do bilinguals activate phonological representations in one or both of their languages when naming words? *Journal of Memory and Language*, 44,2-31.

[18] Jared, D., & Szucs, C. (2002). Phonological activation in bilinguals: Evidence from interlingual homograph recognition. *Bilingualism: Language and Cognition*, 5, 225 239.
[19] Klein, D. E., & Murphy, G. L. (2001). The representation of polysemous words. *Journal of Memory and Language,* 45, 259–282.
[20] Kreuz, R. J. (1987). The subjective familiarity of English homophones. *Memory & Cognition,* 15, 154–168.
[21] Kroll, J. F.,Michael, E., Tokowicz, N., & Dufour, R. (2002). The development of lexical fluency in a second language. *Second Language Research,* 18, 137-171.
[22] Levelt, W. J. M., Roelofs, A., & Meyer, A. S. (1999). A theory of lexical access in speech production. *Behavioral and Brain Sciences*, 22, 1-38.
[23] Macnamara, J., & Kushnir, S. L. (1971). Linguistic independence of bilinguals: The input switch. *Journal of Verbal Learning and Verbal Behavior*, 10, 480–487.
[24] McClelland, J. L., & Rumelhart, D. E. (1981). An interactive activation model of context effects in letter perception: Part 1. An account of basic findings. *Psychological Review*, 88, 375–407.
[25] McGinnies, E., Comer, P. B., & Lacey, O. L. (1952). Visual-recognition thresholds as a function of word length and word frequency. *Journal of Experimental Psychology*, 44, 65–69.
[26] Perea, M., & Rosa, E. (2000). The effects of orthographic neighborhood in reading and laboratory word identification tasks: A review. *Psicologica,* 21, 327–340.
[27] Perfetti, C. A., & Bell, L. (1991). Phonemic activation during the 40 ms of word identification: Evidence from backward masking and priming. *Journal of Memory and Language*, 30, 473-485.
[28] Pexman, P. M., Lupker, S. J., & Jared, D. (2001). Homophone effects in lexical decision. *Journal of Experimental Psychology: Learning, Memory and Cognition*, 27, 139-156.
[29] Pexman, P. M., Lupker, S. J., & Reggin, L. D. (2002). Phonological effects in visual word recognition: Investigating the impact of feedback activation. *Journal of Experimental Psychology: Learning, Memory and Cognition,* 28, 572-584.
[30] Rodd, J. M., Gaskell, G., & Marslen-Wilson, W. (2002). Making sense of semantic ambiguity: Semantic competition in lexical access. *Journal of Memory and Language*, 46, 245–266.
[31] Rodd, J. M., Gaskell, G., & Marslen-Wilson, W. (2002). Making sense of semantic ambiguity: Semantic competition in lexical access. *Journal of Memory and Language*, 46, 245–266.
[32] Schwartz, A. Kroll, J., Diaz, M. (2007). Reading words in Spanish and English: Mapping orthography to phonology in two languages. *Journal of Language and cognitive processes.* 22 (1), 106-129.
[33] Schilling, H. E. H., Rayner, K., & Chumbley, J. I. (1998). Comparing naming, lexical decision, and eye fixation times: Word frequency effects and individual differences. *Memory & Cognition,* 26, 1270–1281.
[34] Schreuder, R., & Baayen, R. H. (1997). How complex simplex words can be. *Journal of Memory and Language*, 37, 118–139.
[35] Simpson, G. B., Peterson, R. R., Casteel, M. A., & Burgess, C. (1989). Lexical and sentence context e?ects in word recognition. *Journal of Experimental Psychology: Learning Memory and Cognition*, 15, 88–97.
[36] Stanovich, K. E., &West, R. F. (1979).Mechanisms of sentence context effects in reading: Automatic activation and conscious attention. *Memory & Cognition*, 7, 77–85.
[37] Stone, G. O., Vanhoy, M., & Van Orden, G. C. (1997). Perception is a two-way street: Feed forward and feedback phonology in visual word recognition. *Journal of Memory and Language,* 36, 337 359.

[38] Thomas, M. S. C., & Allport, A. (2000). Language switching costs in bilingual visual word recognition. *Journal of Memory and Language,* 43,44 -66.
[39] Vaid, J., & Frenck-Mestre, C. (2002). Do orthographic cues aid language recognition? A laterality study with French-English bilinguals. *Brain and Language*, 82,47 -53.
[40] Van Orden, G. C. (1987). A ROWS is a ROSE: Spelling, sound and reading. *Memory & Cognition*, 15, 181-198.
[41] van Wijnendaele, I., & Brysbaert, M. (2002). Visual word recognition in bilinguals: Phonological priming from the second to the first language. *Journal of Experimental Psychology: Human Perception and Performance,* 28, 616–627.
[42] Vitkovitch, M., Humphreys, G. W., & Lloyd-Jones, T. J. (1993). On naming a giraffe a zebra: picture naming errors across different object categories. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 19, 243-259.
[43] Whaley, C. P. (1978). Word–nonword classification time. *Journal of Verbal Learning and Verbal Behavior,* 17, 143–154.
[44] Williams, R. S., & Morris, R. K. (2004). Eye movements, word familiarity, and vocabulary acquisition. *European Journal of Cognitive Psychology,* 16, 312–339.
[45] Ziegler, J. C., Perry, C., Jacobs, A. M., & Braun, M. (2001). Identical words are read differently in different languages. *Psychological Science,* 12, 379–384.

**Appendix: Materials of the study**

English Text

Aoccdrnig to rscheearch at Cmabrigde Uinervtisy, it deosn't mttaer in waht oredr the ltteers in a wrod are, the olny iprmoetnat tihng is taht the frist and lsat ltteer be at the rghit pclae. The rset can be a total mses and you can sitll raed it wouthit porbelm. Tihs is bcuseae the huamn mind deos not raed ervey lteter by istlef, but the wrod as a wlohe. Amzanig huh?

**متن فارسی**

**برپایه تقحیقات داشنگاه کمیربج ، مهم نسیت حروف واژگان به چه تربیتی چنیش شده اند ، بلکه تهنا درست بودن حرف اول و آخر اهیمت دارد. بقیه متیواند کاملا در هم رتخیه باشد ولی شما قادر به خواندن باشید بی هیچ ملشکی. این به این دلیل است که مغز انسان هر حرف را به تهنایی نمی خاوند بکله هر واژه را به صورت کلی درک مکنید. جالب بود، مگر نه؟**

| **English Words** | **لغات فارسی** |
|---|---|
| Agnry | آماشیدنی |
| Dreive | ترلیی |
| Cenvoy | التکریسته |
| Nitoce | مبانع |
| Batceria | باتکری |
| Stertch | کتنور |
| Frezeer | وادلین |
| Radaiotr | مباسقه |
| Borad | موجدوات |
| Chnace | اتنخاب |