Written word recognition by the elementary and advanced level Persian-English bilinguals

FerdosTaleb
(MA, Islamic Azad University, Najafabad Branch, Isfahan, Islamic Republic of Iran)
ferdostaleb@gmail.com
Zahra Fotovatnia
(PhD, Islamic Azad University, Najafabad Branch, Isfahan, Islamic Republic of Iran)
z.fotovatnia@iaun.ac.ir

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Abstract
According to a basic prediction made by the Revised Hierarchical Model (RHM), at early stages of language acquisition, strong L2-L1 lexical links are formed. RHM predicts that these links weaken with increasing proficiency, although they do not disappear even at higher levels of language development. To test this prediction, two groups of highly proficient and two groups of elementary L2 learners were tested on noncognate stimuli with episodic recognition tasks in both forward (L1-L2) and backward (L2-L1) directions. The pattern observed for the elementary L2 learners in both directions wasconsistent with the prediction of the RHM. The results showed the existence of strong lexical links in the backward direction at the elementary level but no such links were found in the forward direction. Contrary to the predictions of the RHM, however, L2-L1 lexical links are lost at higher levels of proficiency.

Keywords: lexical links, conceptual links, episodic recognition task, language priming, RHM

Introduction

As about half of the world's population know more than one language (Grosjean, 1982), research on bilingualism has been on the rise (Costa, Santesteban, & Cano, 2005; Kroll, Bobb, &Wodniecka, 2006; Kroll & Curley, 1988; Kroll & Stewart, 1994; Ju& Luce, 2004; Lagrou, Hartsuiker, &Duyck, 2011; Marian & Spivey, 2003; Potter, So, Von Eckardt, & Feldman, 1984; Schulpen, Dijkstra, Schriefers, &Hasper, 2003; Spivey & Marian, 1999; Weber & Cutler, 2004; Weinreich, 1953). Two main models explore the mental representation of languages in a bilingual mind. According to traditional models, two separate lexicons exist, one for L1 and the other for L2. When reading in one language, only words from the relevant lexicon are activated. In this sense, the bilingual lexical memory is activated selectively; the language used determines the words to be retrieved. As a result, only orthographic and phonological representations of words from the same language are activated and no activation spreads to the orthographic and phonological representation of the other language. This view works for a number of models such as the Word Association Model (Kroll & Curley, 1988), the Concept Mediation Model (Kroll & Curley, 1988; Potter et al., 1984), and the Revised Hierarchical Model (Kroll & Stewart, 1994).

Nonetheless, many studies have provided evidence for an alternative viewpoint that incorporates an integrated lexicon (Dijkstra,

2005). These studies suggest that lexical representations of L1are accessed when the bilingual is reading in L2 (Brysbaert, van Dyck, & van de Poel, 1999; Costa, Caramazza& Sebastian-Galles, 2000; Dijkstra, Grainger, & Van Heuven, 1999; Dijkstra, Timmermans, &Schriefers, 2000; Duyck, 2005; Duyck, Diependaele, Drieghe, &Brysbaert, 2004; Haigh& Jared, 2007; Jared & Kroll, 2001; Lemhöfer&Dijkstra, 2004; Schwartz, Kroll, & Diaz, 2007) and vice versa (Duyck, 2005; Van Assche, Duyck, Hartsuiker, &Diependaele, 2009; Van Hell &Dijkstra, 2002). For example, Distributed Lexical/Conceptual Feature Model (Kroll & De Groot, 1997) proposes that lexical and conceptual features are shared between languages and are stored in a distributed mode. There are language-specific lemmas including syntactic information mediating these mental representations. Such processing leads to the assumption of nonselectivity of language in reading. The bilingual interactive activation model+ (BIA+) is based on the same assumption (Dijkstra& Van Heuven, 2002). Additionally, BIA+ postulates one unified lexicon for both languages.

There has been continuous debate over the selectivity vs. nonselectivity assumptions. A number of researchers have argued that cross-language orthographical differences may restrict language nonselectivity when the two scripts differ (Nakayama, Sears, Hino, &Lupker, 2012).The reason seems to be that orthographical differences guide incoming sensory information toward the appropriate lexical system such that nontarget language representations are never contacted. If this is the case, Persian-English bilinguals are supposed to show language selectivity when reading in English due to cross-script differences between Persian and English. Therefore, we base the theoretical foundation of this study on the models that support the language selective view.

Literature review

RHM is a dominant model in psycholinguistics research (Kroll & Steward, 1994; Kroll &Tokowicz, 2001). This model acknowledges two levels of word representation: the conceptual and the lexical. The model proposes that both languages of a bilingual share the same conceptual store; however, each language has its own separate store at the lexical level. There are connections between the two languages of a bilingual speaker at both lexical and conceptual levels. The conceptual store is connected to L1 and L2 lexical stores via routes called the conceptual connections. There are also some links connecting the L1 lexical store to the L2 lexical store called the lexical links. Lexical processing may occur at the lexical level through lexical routes or at the conceptual level via conceptual connections (Figure 1).

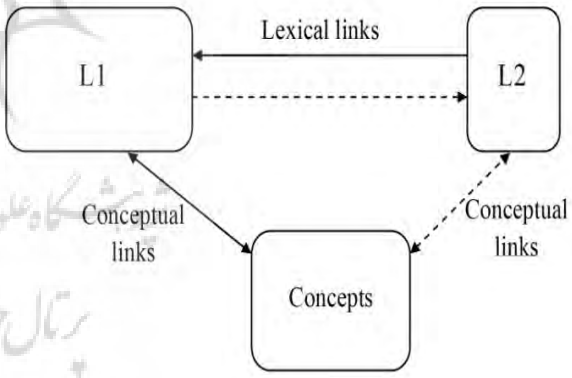

Figure 1: Revised Hierarchical Model

A number of studies have provided evidence for such mental structure. Kroll and Stewart (1990), for example, made Dutch-English learners translate two groups of words in both forward and backward directions. One of the lists included semantically categorized while the other contained randomly organized words. It was assumed that forward translation would be affected

by the semantic manipulation of words because it occurs at the conceptual level but backward translation would not be affected by the semantic categorization of wordsbecause it occurs at the lexical level. The findings of the study confirmed these two assumptions.

Other studies concluded that for both early and advanced L2 learners, forward translation takes more time and is more sensitive to semantic manipulation than backward translation (de Groot, Dannenburg& Van Hell, 1994; Sanchez-Casas, Davis & Garcia-Albea, 1992; Sholl, Sankaranararyanan& Kroll, 1995).

One basic assumption made by RHM (Kroll & Stewart, 1994) is that at early stages of language acquisition, L2 learners rely mainly on lexical links between L2 words and that their L1 translation equivalence is established once a language is learned. Hence, the lexical links from L2 to L1 translation equivalents are stronger than the reverse links. The existence of strong L2 to L1 lexical links means strong priming from L2 to L1. Several cross-language studies have failed to find translation priming effects from L2 to L1 for noncognates although strong priming effects have been found from L1 to L2(Basnight-Brown &Altarriba, 2007; Gollan, Forster, & Frost, 1997; Jiang, 1999, Jiang & Forster, 2001; Kim & Davis, 2003; Voga& Grainger, 2007; Williams, 1994). Generally, the magnitude of forward priming is greater than backward priming, although the evidence for L2- L1 translation priming is less consistent.

What these aforementioned studies have in common is that they have failed to report significant masked translation priming effects when a lexical decision task was used. Bradley (1991) observed L2-L1 priming when he tested unrelated word pairs in a speed recognition memory task. The task was to decide as rapidly as possible whether the presented word was one of the words already learned. The words were preceded by a masked version of an already learned or a completely new word. What he found was strong L2-L1 priming.

In order to see if the task presented would influence priming effects in forward or backward directions, Jiang and Forster (2001) gave episodic and lexical decision tasks to a number of Chinese–English bilingual speakers using masked priming paradigm. The results of the study demonstrated significant masked translation priming effects in the backward direction when an episodic task was used and significant priming effects in the forward direction when a lexical decision task was used. To interpret the findings, these authors put forward a separate memory system model. According to this model, lexical memory and episodic memory constitute separate memory modules (Figure 2).

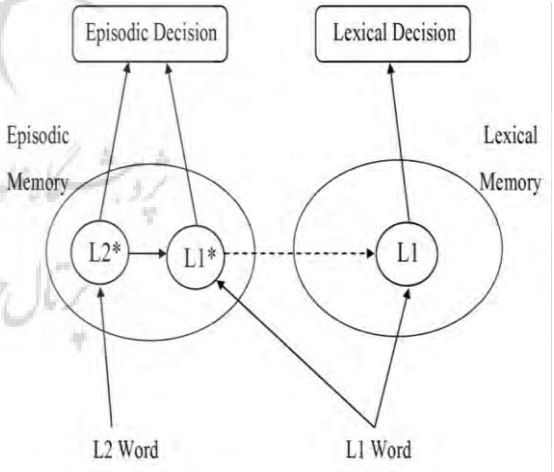

Figure 2: Separate Memory System Model

Jiang and Forster (2001) argued that in the case of L2-L1 priming, both the prime (L2 word) and the episodic memory trace of the L1 target are represented within episodic memory. As overt response to the target is controlled by information coming from the

same memory (episodic), L2-L1 priming occurs. Moreover, the L1-L2 priming was effective in the lexical decision task because the L1 prime activates the shared semantic features through strong L1 conceptual connections. Nonetheless, in the backward direction, as the conceptual connection between the L2 prime and the conceptual store is weak, the target is not preactivated (Kroll & Stewart, 1994). In fact, the results of the study suggest that different tasks involve different links in a bilingual memory and the presence of both lexical and conceptual connections cannot be demonstrated in one particular task. Lexical links show priming effects in episodic recognition tasks but conceptual connections show priming in lexical decision task.

The present study

RHM predicts strong L2-L1 lexical connections at the early stages of language learning, which do not disappear with increasing proficiency, although the nature of the links might change. There is little evidence whether or not initial dependence on L1 would play a continuing role during L2 processing even at higher levels of proficiency. If L1 simply provides a way for L2 to find its way into the cognitive system, the same sort of activity might be absent at higher stages as L2 learners become more proficient. Very little information from the existing literature tells us how and through what process the nature of these connections change with increasing proficiency. The main purpose of this study is to further investigate the issue. According to Jiang and Forster (2001), testing L2 learners in an episodic recognition task can explain the existence and strength of lexical links. Hence, to serve the main goal of the study, four experiments were designed to test two groups of elementary and two groups of high proficiency L2 learners with an episodic task in forward and backward directions as summarized in the following questions:

- If according to RHM there are strong L2-L1 lexical links at low levels of language proficiency, will significant priming be obtained in episodic recognition tasks for elementary L2 learners in the backward direction?
- If according to RHM L2-L1 lexical links do not disappear even at high stages of language proficiency, will significant priming be obtained in episodic recognition tasks for highly proficient L2 learners in the forward direction?

Method

Four experiments were conducted to explore two main predictions of RHM. In experiments 1 and 2, two groups of elementary and highly proficient L2 learners were tested in an episodic task in the backward direction. The same method was followed in experiments 3 and 4 to test the two other groups of elementary and highly proficient learners in an episodic task in the forward direction.

Participants

Twenty four Persian learners of English were selected out of 60. All the participants were undergraduate students of TEFL at the Islamic Azad University, Najafabad Branch. They were Persian native speakers; however, they had received formal instruction in English in high school, at the university, and in language institutes. They had no exposure to English in natural settings.

The grammar part of the Oxford Placement Test (OPT, Allan, 2004), including 100 grammatical multiple choice questions, was administered to homogenize the learners based on their general knowledge of

English. Those who scored between 52 and 59 were identified as elementary participants and were selected. The reliability index of the test was estimated through Chronbach's alpha ($\alpha = .78$).

The participants were randomly assigned to two groups for the first and third experiments. Group 1 consisted of L2 participants who took part in an episodic task in the backward direction while group 2 involved L2 participants who anperformed episodic task in the forward direction.

Another sample of 24 was selected from the same pool delineated above; this time, however, these learners were identified as highly proficient participants based on the OPT manual. The participants were randomly assigned to two groups for the second and fourth experiments. Group 1 consisted of L2 participants, who took part in an episodic task in the backward direction and group 2 involved L2 participants who performed an episodic task in the forward direction.

Stimuli and design

The stimuli used in experiments 1 and 2 included 60 English-Persian translation pairs and 60 Persian nonwords (Appendix A).The Persian target words were divided into two sets (A & B) of 30 in the study phase (Appendix B) and two sets of the same words in the test phase (Appendix C).In the study phase, each set was shown to half of the participants in each group. This set, therefore, was considered as old and the other as new. The same was followed for the second group. In the test phase, two presentation lists were constructed, each with 30 old items and 30 new items. Half of the Persian targets (both old and new) on each presentation list were paired with English translation primes, and the other half were paired with English control primes that were unrelated to the target. In order to make the stimuli homogenous, the control primes were matched with the translation primes on length, frequency, and concreteness.The translation and its control prime were similar to each other in terms of length, frequency and concreteness, yet different from each other in terms of semantic relation to the target; i.e., related (translation prime) vs. unrelated (control prime). Thirty English control primes were generated by the MRC Psycholinguistic Database (Cullings, 1988).

The same Persian-English translation pairs were used in experiments 3 and 4(Appendix E).The English target words were divided into two sets (A & B) of 30(Appendix F).The same procedure was adopted to create two presentation lists (Appendix G).Half of the English targets (both old and new) on each presentation list were paired with Persian translation primes, and the other half were paired with Persian control primes. Bijankhan corpus (Amiri&AleAhmad, n.d.) was used for this purpose. Moreover, 60 nonwords were generated by the ARC nonword database (Rastle, Harrington, &Coltheart, 2002).All the nonwords were preceded by unrelated primes. Ten additional translation pairs were selected to be used as practice items.

Procedure

The procedure was divided into study phase and test phase. In the study phase, the participants were given a list of 30 Persian target words as well as 10 practice Persian words to study and memorize so that they would be tested on a memory test(test phase) later on. Each group of participants was divided into two groups of 6. The first half received the Persian target words in set A and the other half received Persian target words in set B. In other words, each group received only one set of Persian words considered as old in the test phase. They

were given as much time as they needed to memorize the words on the list. Then they received an initial recognition task on paper, in which they were asked to circle the words they had studied on the study list. In cases when the performance was 90% or more accurate, they received the computer version of the recognition task in which the participants were to decide as quickly as possible whether the word presented on the screen was one of the words they had studied in the study phase.

Following Forster and Davis (1984), presentation of items in experiments 1 and 2 included the following masked priming sequence: First, the participants were presented with a row of 10 hash marks for 500 ms which served to mask the subsequently presented prime. Second, the prime word immediately appeared for 50 ms. Next, a blank interval, consisting of a row of hash marks, was presented for 150 ms. The target immediately followed the backward mask. The target remained on the screen until the participants made a response (Appendix D). The inclusion of the blank space and the backward mask was for the purpose of increasing the amount of prime processing time (see Jiang 1999, Experiment 4). Normally when the prime is in the L2, its processing is slower than when it is in the L1; as a result, there would be no chance for the L2 prime to have any effect on the L1 target (see Jiang 1999, Experiment 4). After each trial was completed, the participants received feedback on the speed and accuracy of their performance.

In experiments 3 and 4, each trial consisted of the following sequence: First, a forward mask of 10 hash marks appeared for 500 ms.This forward mask was followed by the prime which was presented for 50 ms. Finally, the target word immediately followed the prime and remained on the screen until the participants made a response (Appendix H). The participants were asked to decide as rapidly as possible whether the word presented on the screen was one of the words on the study list.

Apparatus

The DMDX package developed at the University of Arizona by J.C. Forster (Forster & Forster, 2003) was used to presentthe stimuli.

Results

Elementary L2 learners (forwardddirection)

RTs longer than 1400 ms and incorrect responses, which included 25.5 % of the data, were excluded from the analysis (Gollan et al., 1997; Keatley, Spinks, & de Gelder, 1994). The descriptive statistics of the RTs in the forward direction are provided in Table 1 (tables appear after References).

The means for response times were 13.63 ms faster for the translation items in the old group and 0.7 ms faster for the control items in the new group. To compare the means of the noncognate translation and the noncognate control items in the old and new groups, two paired samples *t*-tests were run, the results of which showed that the noncognate translation and the noncognate control items were processed similarly by both groups (see Table 2).

Elementary L2 learners (backwarddirection)

As in the previous analysis, 7.22 % of the data, which included the scores over 1400 ms and incorrect responses, were excluded from the analysis (Gollan et al., 1997; Keatley et al., 1994). The descriptive statistics of the RTs in the backward direction are provided in Table 3.

The mean RTs were 83.81 ms faster for the translation items in the old and 25.83 ms

faster for the translation items in the new group.

In order to compare the means of the noncognate translation and the noncognate control items in old and new groups, two paired samples *t*-tests were applied. The results show that noncognate translation the noncognate control items were processed similarly in the forward direction; however, the noncognate translation items were reacted to significantly faster than the noncognate control items in the backward direction (see Table 4).

Highly proficient L2 learners (forward direction)

The incorrect responses and the RTs longer than 1400 ms, which included 17.5 % of the data, were excluded from the analysis (Gollanet al., 1997; Keatley et al., 1994). The descriptive statistics of the RTs for the noncognates in the forward direction are provided in Table 5.

The mean RTs were 37.55 ms faster for the control items in the old and 24.64 ms faster for the control items in the new group.

Two paired samples *t*-test were run to compare the means of noncognate translation and the noncognate control items in old and new groups. The results show that noncognate translation and noncognate control items were processed similarly (see Table 6).

Highly proficient L2 learners (backward direction)

Response times longer than1400 ms and incorrect responses, which included 21.52% of the data, were excluded from the analysis (Gollan et al., 1997; Keatley et al., 1994). The descriptive statistics of the RTs for the noncognates in the forward direction are provided in Table 7.

The mean response times were 41.51 ms faster for the translation items in the old and 6.98 ms faster for the control items in the new group.

Two paired samples *t*-test run to compare the means of the noncognate translation with the noncognate control items in old and new groups show that the noncognate translation and the noncognate control items were processed similarly by both groups (see Table 8).

Discussion and conclusion

The main purpose of the experiments conducted in this study was to evaluate predictions made by RHM indicating whether or not the strong L2-L1 lexical links formed at the beginning stages of language learning remain unchanged at higher stages. Two groups of elementary and two groups of high proficiency L2 learners were tested on noncognate stimuli with an episodic recognition task in both forward and backward directions.

The results obtained for the elementary learners showed no significant priming in the forward but significant priming in the backward direction. This pattern is consistent with the basic prediction made by RHM regarding elementary stages of language learning; however, no such links seem to exist in the forward direction.

Two other lines of research confirm this pattern. In a series of experiments done by Kroll and Curley (1988), beginner English-German L2 learners were tested on picture naming and translation tasks in the backward direction. Kroll and Curley came to the conclusion that for beginners, backward processing occurs at the lexical level.

In another experiment done by Kroll and Stewart (1994), a number of L2 learners were tested on picture naming and translation tasks in either semantically categorized or randomized context. The findings of the study showed slower RTs for the picture naming and forward translation in the semantically categorized context. Moreover, semantic manipulation of the context did not affect backward translation. The authors suggested that forward translation and picture naming tasks proceed along the conceptual routes; however, backward translation exploited lexical links between L1 and L2.

Shorter RTs for backward translation proves the existence of the strong lexical connections in the backward direction. Moreover, the fact that backward translation is not sensitive to semantic factors when compared with forward translation can be taken as evidence suggesting that backward translation occurs through L2-L1 lexical routes. The present study shed more light on this issue by showing consistent priming effects in the backward direction.

The observed pattern also supports the Word Association Model (Figure 3). According to this model, there is a common conceptual system for the lexical systems of the two languages. L2 learners retrieve the meaning of L2 lexical items via links to their translation equivalents in the first language (L2-L1 lexical links).

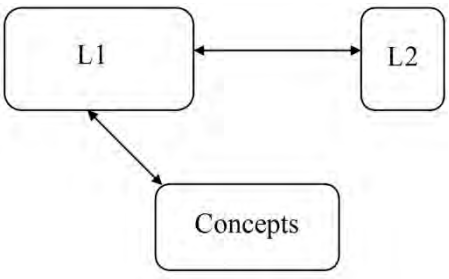

Figure 3: Word Association Model

Another finding of the study was that no significant priming was obtained in either direction for highly proficient L2 learners. This pattern shows that at higher levels of proficiency, L2-L1 lexical links are lost and L1 has almost no role in retrieving the semantic content of L2 words. This is not consistent with the prediction of RHM, as this model predicted the existence of these routes even at higher stages of language learning. The observed pattern shows that as L2 learners become more proficient, they begin to make direct conceptual connections from the L2 lexicon. In fact, at higher stages of L2 acquisition, the role of L2-L1 lexical access decreases and is replaced by L2 conceptual connections. As L2 learners increasingly rely on these connections, such connections gradually become stronger (Figure 4). This finding is consistent with the Concept Mediation Model.

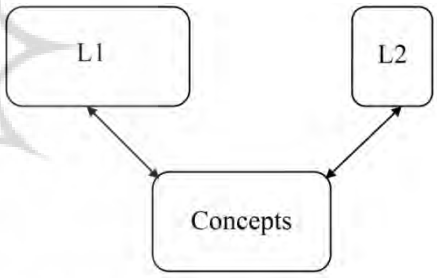

Figure 4: Concept Mediation Model

A study conducted by Kroll and Curley (1988) confirms this pattern. In this study, advanced and elementary English-German learners performed translation and picture naming tasks. It was concluded that early L2 learners performed picture naming task through conceptual connections and backward translation through lexical routes. However, proficient L2 learners relied on the conceptual connection whendoing both tasks.

RHM predicts that lexical links would remain unchanged even at higher stages of language development. However, the

absence of lexical links for highly proficient learners in the present study shows that they are lost at this stage. As proficiency in L2 increases, learners begin to use the conceptual connections instead of the lexical routes. The presence of the lexical links in early learners and the absence of such links in highly proficient learners provide enough support for a shift from word association to concept mediation.

Based on the discussion, the following implications seem to be in order for L2 vocabulary teaching and learning. The use of L1 has several advantages. It provides the core meaning of words,which is the first step in associating the form with meaning and reinforcing the connection. As Grabe and Stoller (1997, p.114) put it, "perhaps, for adults, there are times when it is important to know that a word is understood accurately." Furthermore, using L1 may link an L2 word to its firm semantic and linguistic structure which can serve as the steadiest “cognitive hook to hang the new item on"(Fraster, 1999, p.238). This way, learners canretain the words in long term memory more efficiently.

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Table 1: Descriptive statistics of RTs (ms) in forward direction

		Mean	*N*	Std. Deviation	Std. Error Mean
Pair 1	ctrl/old	941.3060	126	172.47378	15.36519
	trans/ old	927.6794	126	172.45006	15.36307
Pair 2	ctrl/ new	1000.6944	133	182.66317	15.83891
	trans/new	1001.3949	133	182.76293	15.84756

Table 2: Paired sample test (forward priming with episodic task)

		Paired Differences					t	df	Sig.(2tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Upper	Lower			
Pair 1	ctrl old - trans old	13.62	252.247	22.47	-30.84	58.10	.606	125	.545
Pair 2	ctrl new- trans new	-.7005	270.225	23.43	-47.05	45.64	-.030	132	.976

Table 3: Descriptive statistics of RTs (ms)

		Mean	*N*	Std. Deviation	Std. Error Mean
Pair 1	ctrl old	970.622	124	183.34514	16.4648
	trans old	886.813	124	192.79180	17.3132
Pair 2	ctrl new	926.724	135	199.45865	17.1666
	trans new	900.899	135	178.38317	15.3527

Table 4: Paired sample test (backward priming with episodic task)

		Paired Differences					t	df	Sig.(2tailed)
		Mean	Std. Deviation	Std.Error Mean	95% Confidence Interval of the Difference Upper	lower			
Pair 1	ctrl old - trans old	83.80	264.75	23.77	36.74	130.8	3.525	123	.001
Pair 2	ctrl new - trans new	25.82	275.53	23.71	-21.0	72.72	1.089	134	.278

Table 5: Descriptive statistics of RTs (ms)

		Mean	*N*	Std. Deviation	Std.Error Mean
Pair 1	ctrl old	770.8611	152	272.26222	22.08338
	trans old	808.4125	152	206.96369	16.78697
Pair 2	ctrl new	818.9561	152	219.86327	17.83327
	trans new	843.5961	152	170.69690	13.84535

Table 6: Paired sample test (forward Priming with episodic task)

		Paired Differences					t	df	Sig.(2tailed)
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Upper	Lower			
Pair 1	ctrl old – trans old	-37.5	311.70	25.28	-87.5	12.40	-1.48	151	.140
Pair 2	ctrl new – trans new	-24.6	282.84	22.94	-69.9	20.68	-1.07	151	.285

Table 7: Descriptive statistics of RTS (ms)

		Mean	*N*	Std. Deviation	Std. Error Mean
Pair 1	ctrl old-	793.6472	152	303.67523	24.63131
	trans old	752.1337	152	310.82759	25.21145
Pair 2	ctrl new-	831.4486	152	266.72770	21.63447
	trans new	838.4218	152	288.54751	23.40429

Table 8: Paired sample test (backward priming with episodic task)

		Paired Differences					t	df	Sig.(2tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Upper	Lower			
Pair 1	ctrl old -trans old	41.51	277.44	22.50	-2.94	85.97	1.845	151	.067
Pair 2	ctrl new - trans new	-6.97	286.48	23.23	-52.8	38.93	-.300	151	.765

Appendix A: 60 English-Persian translation pairs and 60 Persian nonwords selected as the stimuli for experiments 1 and 2

60 English-Persian translation pairs					
boy پسر	school مدرسه	table میز	deep عمیق	skirt دامن	fish ماهی
university دانشگاه	city شهر	water آب	wall دیوار	mixture مخلوط	sheep گوسفند
sin گناه	girl دختر	window پنجره	fire آتش	nice خوب	face صورت
house خانه	hand دست	sound صدا	bird پرنده	prize جایزه	village روستا
three سه	day روز	long بلند	neat تمیز	butcher قصاب	we ما
always همیشه	people مردم	year سال	line خط	memory حافظه	bread نان
woman زن	world جهان	able تونا	low پایین	night شب	passenger مسافر
room اتاق	head سر	love عشق	frog قورباغه	sergeant گروهبان	street خیابان
case مورد	mad دیوانه	end پایان	week هفته	scholar محقق	newspaper روزنامه
life زندگی	up بالا	was بود	bell زنگ	any هیچ	situation موقعیت
60 Persian nonwords					
لسته	کوزک	تغیین	زعنا	فواند	نختوا
ثصادف	زشد	خساس	نیره	نوجه	عوایی
فیگار	تخقیق	تسکیل	خلقه	زارا	فلمه
سماز	ثداعی	ریبا	فنابر	نجزیه	تونیف
مخور	نیوه	کاسل	تویبدن	مریب	آزفون
نرتقال	ازواع	صاخب	فمراه	ثهایی	نکی
مخرک	نقیده	تاخن	نوزه	نبارت	مهارث
فعنا	تمره	نقدار	فسعت	نرایش	خاض
ثاسخ	زرفت	نرواز	فهت	متابه	امتلال
فیستم	نجموع	ثایید	نانا	مرایط	زهارت

Appendix B: Set A and set B words for experiments 1 and 2

Set A			Set B		
پسر	مدرسه	میز	عمیق	دامن	ماهی
دانشگاه	شهر	آب	دیوار	مخلوط	گوسفند
گناه	دختر	پنجره	آتش	خوب	صورت
خانه	دست	صدا	پرنده	جایزه	روستا
سه	روز	بلند	تمیز	قصاب	ما
همیشه	مردم	سال	خط	حافظه	نان
زن	جهان	تونا	پایین	شب	مسافر
اتاق	سر	عشق	قورباغه	گروهبان	خیابان
مورد	دیوانه	پایان	هفته	محقق	روزنامه
زندگی	بالا	بود	زنگ	هیچ	موقعیت

Appendix C: two presentation lists constructed for experiments 1 and 2

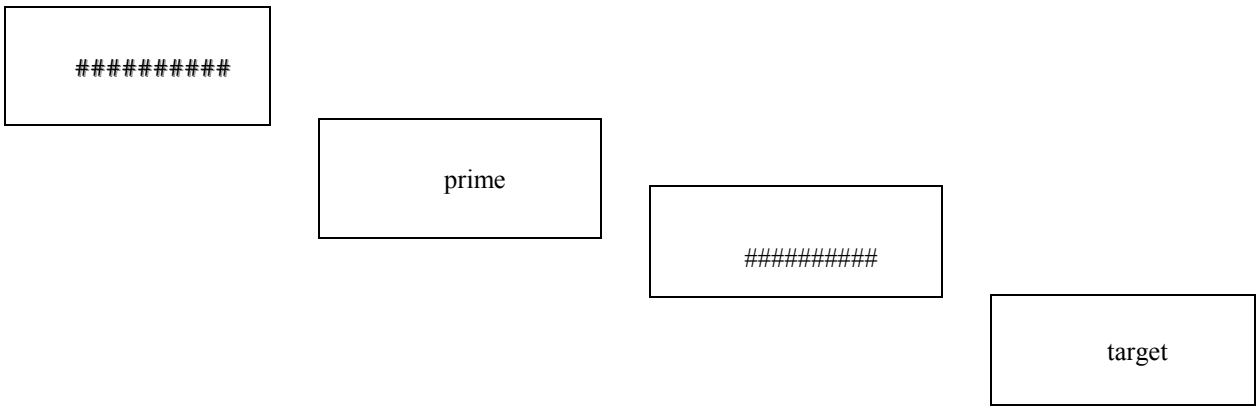
List 1

Set A				Set B			
15 targets preceded by control primes		15 targets preceded by translation primes		15 targets preceded by primes		15 targets preceded by translation primes	
control	target	translation	Target	control	target	translation	target
car	پسر	people	مردم	grow	عمیق	line	خط
department	دانشگاه	world	جهان	pool	دیوار	low	پایین
way	گناه	head	سر	clay	آتش	frog	قورباغه
place	خانه	mad	دیوانه	tail	پرنده	week	هفته
small	سه	up	بالا	calm	تمیز	bell	زنگ
enough	همیشه	table	میز	steak	دامن	memory	حافظه
board	زن	water	آب	combine	مخلوط	night	شب
wife	اتاق	window	پنجره	wise	خوب	sergeant	گروهبان
land	مورد	sound	صدا	beech	جایزه	scholar	محقق
both	زندگی	long	بلند	pianist	قصاب	any	هیچ
church	مدرسه	year	سال	wisdom	ماهی	fish	نان
form	شهر	able	تونا	point	گوسفند	passenger	مسافر
body	دختر	love	عشق	sunlight	صورت	street	خیابان
felt	دست	end	پایان	orderly	روستا	newspaper	روزنامه
men	روز	was	بود	two	ما	situation	موقعیت
Unrelated control				Persian nonword			
clew	achilles	clew	achilles	لسته	نرواز	نبارت	تمره
clerk	carte	clerk	carte	ثصادف	ثاييد	نرايش	زرفت
click	canto	click	canto	فيگار	نانا	متابه	نجموع
churn	ashen	churn	ashen	سماز	زعنا	مرايط	عوايی
cider	acheron	cider	acheron	مخور	نيره	نختوا	تغيين
cilia	camp	cilia	camp	نرتقال	خلقه	تونيف	خساس
and	cade	and	Cade	مخرک	فنابر	آزفون	تسکيل
seen	chapel	seen	chapel	فعنا	تووبدن	نکی	ريبا
chill	achieved	chill	achieved	ثاسخ	فمراه	مهارث	کاسل
used	cabin	used	cabin	فيستم	نوزه	خاض	صاخب
chore	cacao	chore	cacao	فلمه	فسعت	امتلال	تاخن
choke	cafe	choke	cafe	کوزک	فهت	زهارت	نقدار
serif	calf	serif	calf	زشد	فواند	نيوه	ثداعی
cauls	carat	cauls	carat	تخقيق	نوجه	نجزيه	ثهايی
achill	cask	achill	cask	ازواع	زارا	نقيده	مريب

List 2

Set A				Set B			
15 targets preceded by control primes		15 targets preceded by translation primes		15 targets preceded by primes		15 targets preceded by translation primes	
translation	target	control	target	translation	target	control	target
boy	پسر	little	مردم	deep	عمیق	play	خط
university	دانشگاه	still	جهان	wall	دیوار	try	پایین
sin	گناه	high	سر	fire	آتش	wool	قورباغه
house	خانه	fun	دیوانه	bird	پرنده	told	هفته
three	سه	us	بالا	neat	تمیز	rice	زنگ
always	همیشه	music	میز	skirt	دامن	wisdom	حافظه
woman	زن	light	آب	mixture	مخلوط	point	شب
room	اتاق	island	پنجره	nice	خوب	sunlight	گروهبان
case	مورد	court	صدا	prize	جایزه	orderly	محقق
life	زندگی	come	بلند	butcher	قصاب	two	هیچ
school	مدرسه	well	سال	fish	ماهی	brick	نان
city	شهر	tell	تونا	sheep	گوسفند	physician	مسافر
girl	دختر	free	عشق	face	صورت	ground	خیابان
hand	دست	far	پایان	village	روستا	breakfast	روزنامه
day	روز	for	بود	we	ما	beginning	موقعیت
Unrelated control				Persian nonword			
clew	achilles	clew	achilles	لسته	نرواز	نبارت	تمره
clerk	carte	clerk	carte	ثصادف	ثاپید	نرایش	زرفت
click	canto	click	canto	فیگار	نانا	متابه	نجموع
churn	ashen	churn	ashen	سماز	زعنا	مرایط	عوایی
cider	acheron	cider	acheron	مخور	نیره	نختوا	تغیین
cilia	camp	cilia	camp	نرتقال	خلقه	تونیف	خساس
and	Cade	and	Cade	مخرک	فنابر	آزفون	تسکیل
seen	Chapel	seen	chapel	فعنا	تویپدن	نکی	ریبا
chill	achieved	chill	achieved	ثاسخ	فمراه	مهارث	کاسل
used	cabin	used	cabin	فیستم	نوزه	خاض	صاخب
chore	cacao	chore	cacao	فلمه	فسعت	امتلال	تاخن
choke	cafe	choke	cafe	کوزک	فهت	زهارت	نقدار
serif	calf	serif	calf	زشد	فواند	نیوه	ثداعی
cauls	carat	cauls	carat	تخقیق	نوجه	نجزیه	ثهایی
achill	cask	achill	cask	ازواع	زارا	نقیده	مریب

Appendix D: presentation of experiments' 1 and 2 stimuli in the test phase



Appendix E: 60 English-Persian translation pairs and 60 English nonwords selected as the stimuli for experiments 3 and 4

60 English-Persian translation pairs					
boy پسر	school مدرسه	table میز	deep عمیق	skirt دامن	fish ماهی
university دانشگاه	city شهر	water آب	wall دیوار	mixture مخلوط	sheep گوسفند
sin گناه	girl دختر	window پنجره	fire آتش	nice خوب	face صورت
house خانه	hand دست	sound صدا	bird پرنده	prize جایزه	village روستا
three سه	day روز	long بلند	neat تمیز	butcher قصاب	we ما
always همیشه	people مردم	year سال	line خط	memory حافظه	bread نان
woman زن	world جهان	able تونا	low پایین	night شب	passenger مسافر
room اتاق	head سر	love عشق	frog قورباغه	sergeant گروهبان	street خیابان
case مورد	mad دیوانه	end پایان	week هفته	scholar محقق	newspaper روزنامه
life زندگی	up بالا	was بود	bell زنگ	any هیچ	situation موقعیت
60 English nonwords					
kack	plym	cype	phrewd	nach	zepes
pows	ninn	orld	glidge	maith	tinse
goll	wa	sazz	knush	geald	shreethed
vope	av	jief	frult	plir	shroursed
kext	dirp	trebe	thruiced	gwux	spafts
selp	crus	reuth	blooched	sprugue	scinds
yoob	phuib	phlurg	whinxed	rhoiced	smeighths
yush	plect	clerps	gnoaped	ot	traunched
fape	gwushed	nang	zens	da	thraived
brox	thryles	sawl	gwid	fafes	phrompts

Appendix F: Set A and set B words for experiments 3 and 4

Set A			Set B		
boy	school	table	deep	skirt	fish
university	city	water	wall	mixture	sheep
sin	girl	window	fire	nice	face
house	hand	sound	bird	prize	village
three	day	long	neat	butcher	we
always	people	year	line	memory	bread
woman	world	able	low	night	passenger
room	head	love	frog	sergeant	street
case	mad	end	week	scholar	newspaper
life	up	was	bell	any	situation

Appendix G: two presentation lists constructed for experiments 3 and 4

List 1:

Set A				Set B			
15 targets preceded by control primes		15 targets preceded by translation primes		15 targets preceded by primes		15 targets preceded by translation primes	
control	target	translation	target	control	target	translation	target
لوله	boy	مردم	people	چوب	skirt	خط	line
بازي	university	جهان	world	واجب	mixture	پايين	low
راه	Sin	سر	head	بهتر	nice	قورباغه	frog
نفت	house	ديوانه	mad	مقاله	prize	هفته	week
فيلم	three	بالا	up	پيتزا	butcher	زنگ	bell
گسترده	always	ميز	table	الياف	sheep	حافظه	memory
گاز	woman	آب	water	رئيس	face	شب	night
زباله	room	پنجره	window	مغازه	village	گروهبان	sergeant
رئيس	case	صدا	sound	يا	we	محقق	scholar
وزير	life	بلند	long	نماز	bread	هيچ	any
تلفن	school	سال	year	خالي	deep	نان	fish
تيم	city	تونا	able	مربع	wall	مسافر	passenger
جرم	girl	عشق	love	بچه	fire	خيابان	street
دولت	hand	پايان	end	اقوام	bird	روزنامه	newspaper
گروه	day	بود	was	اعطا	neat	موقعيت	situation
Unrelated control				Persian nonword			
سرد	سيما	قلم	محله	yush	zens	reuth	spafts
مرد	شيشه	هماهنگ	دوردست	fape	gwid	phlurg	scinds
طلب	مشاور	نزد	ميراث	brox	nach	clerps	smeighths
صرف	خطير	اين	ابتدا	plym	maith	nang	traunched
عقل	نوشهر	بالغ	مبتني	ninn	geald	sawl	thraived
آنين	آن	درسي	تضمين	wa	plir	phuib	phrompts
آتي	برنامه	سايه	ورودي	av	gwux	plect	fafes
اخير	تجمع	مخاطب	حفاظت	dirp	sprugue	gwushed	kack
فساد	شديم	تحريم	حرم	crus	rhoiced	thryles	pows
تمرين	به	حساس	موظف	cype	ot	phrewd	goll
قدم	را	فرار	واسطه	orld	da	glidge	vope
تير	معاد	سد	اسناد	sazz	zepes	knush	kext
گير	اخلاق	امير	شغلي	jief	tinse	frult	selp
وعده	بيابان	سقف	سني	trebe	shreethed	thruiced	yoob
موضع	حملات	نداريم	پژوهشي	whinxed	shroursed	blooched	gnoaped

List 2:

Set A				Set B			
15 targets preceded by control primes		15 targets preceded by translation primes		15 targets preceded by primes		15 targets preceded by translation primes	
translation	target	control	target	translation	target	control	target
پسر	boy	تهران	people	عمیق	deep	شب	line
دانشگاه	university	تولید	world	دیوار	wall	روشن	low
گناه	sin	خبر	head	آتش	fire	منحني	frog
خانه	house	خوشحالی	mad	پرنده	bird	استان	week
سه	three	چشم	up	تمیز	neat	فلق	bell
همیشه	always	چوب	table	دامن	skirt	هیجان	memory
زن	woman	شما	water	مخلوط	mixture	چین	night
اتاق	room	داور	window	خوب	nice	پرتگاه	sergeant
مورد	case	سلاح	sound	جایزه	prize	همدان	scholar
زندگی	life	وام	long	قصاب	butcher	شدن	any
مدرسه	school	در	year	ماهی	fish	فولاد	fish
شهر	city	شیطان	able	گوسفند	sheep	موتور	passenger
دختر	girl	ذهن	love	صورت	face	دستگاه	street
دست	hand	توسط	end	روستا	village	انقلاب	newspaper
روز	day	نیز	was	ما	we	ویژگي	situation
Unrelated control				Persian nonword			
سرد	سیما	قلم	محله	yush	zens	reuth	spafts
مرد	شیشه	هماهنگ	دوردست	fape	gwid	phlurg	scinds
طلب	مشاور	نزد	میراث	brox	nach	clerps	smeighths
صرف	خطیر	این	ابتدا	plym	maith	nang	traunched
عقل	نوشهر	بالغ	مبتني	ninn	geald	sawl	thraived
آئین	آن	درسي	تضمین	wa	plir	phuib	phrompts
آتي	برنامه	سایه	ورودي	av	gwux	plect	fafes
اخیر	تجمع	مخاطب	حفاظت	dirp	sprugue	gwushed	kack
فساد	شدیم	تحریم	حرم	crus	rhoiced	thryles	pows
تمرین	به	حساس	موظف	cype	ot	phrewd	goll
قدم	را	فرار	واسطه	orld	da	glidge	vope
تیر	معاد	سد	اسناد	sazz	zepes	knush	kext
گیر	اخلاق	امیر	شغلي	jief	tinse	frult	selp
وعده	بیابان	سقف	سني	trebe	shreethed	thruiced	yoob
موضع	حملات	نداریم	پژوهشي	whinxed	shroursed	blooched	gnoaped

Appendix H: presentation of experiments' 3 and 4 stimuli in the test phase