TESTING ENCODING AND RETRIEVAL DYNAMICS OF PAIRS USING PROBED RECALL TASK

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I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

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ABSTRACT

TESTING ENCODING AND RETRIEVAL DYNAMICS OF PAIRS USING PROBED RECALL TASK

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In free recall, subjects tend to successively recall words studied in nearby positions, denoted as the contiguity effect, favoring the following word over the preceding one. Whereas in paired associates, recall probabilities of forward and backward recalls are approximately equal. The associative symmetry hypothesis (ASH) suggests holistic encoding of pairs, whereas the independent association hypothesis (IAH) separate the encoding of forward and backward. Two main classes of memory models aim to explain these effects: control process and contextual coding models. The contiguity effect with forward asymmetry and symmetric retrieval of pairs occurs automatically in various time scales. Probed recall task was initially developed to test the contiguity effect, which was combined with paired associates in this thesis to observe the encoding and retrieval of pairs and serial lists in one task. The results of the experiment showed across-pair within and between-list contiguity with forward asymmetry. In addition, consistent with the literature a symmetric retrieval was observed in paired associates. Therefore, this thesis supports the predictions of contextual coding models and provides further questions for encoding of pairs for both models.

Keywords: contiguity effect, paired associates, associative symmetry, probed recall

ÖZ

KELİME ÇİFTLERİNİN BELLEKTE KAYDEDİLME VE HATIRLANMA DİNAMİKLERİNİN YOKLAMALI HATIRLAMA TESTİYLE İNCELENMESİ

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Serbest hatırlama görevinde katılımcılar arka arkaya çalıştıkları maddeleri peş peşe hatırlama eğilimi gösterirler. Bu etkiye yakınlık etkisi adı verilir ve ileriye dönük bir asimetri gösterir. Ancak kelime çiftleri test edildiğinde ileriye ve geriye dönük hatırlama performanslarının yaklaşık olarak eşit olduğu görülmüştür. Bu doğrultuda simetrik çağrışım hipotezi (SÇH) kelime çiftlerinin bellekte bütünsel olarak kaydedildiğini öne sürerken bağımsız çağrışım hipotezi (BÇH) ileriye ve geriye dönük iki ayrı bağın belleğe kaydedildiğini söyler. Bellekteki etkileri açıklamaya çalışan iki model grubu vardır: tek ve çift depolu bellek modelleri. Yakınlık etkisindeki ileriye dönük asimetri ve kelime çiftlerinde görülen simetrik hatırlama örüntüleri farklı zaman aralıklarında görülebilir ve bellek modelleri bu örüntüleri açıklamaya çalışır. Yoklamalı hatırlama görevi yakınlık etkisini klasik çalışma ve test döngüsü dışında keşfetmek amacıyla geliştirilmiştir. Bu tezde ise hem yakınlık etkisinin gözlenmesi hem de kelime çiftlerinin kendi örüntülerinin test edilmesi amacıyla yoklamalı hatırlama görevinde kelime çiftleri kullanıldı. Bu doğrultuda bir ön deney bir de deney yürütüldü. Liste içi ve listeler arası yakınlık etkisi ileriye dönük asimetriyle beraber gözlemlendi. Ek olarak, literatürde de olduğu gibi, kelime çiftlerinde simetrik hatırlamaya yönelik bulgular bulundu. Sonuç olarak bu tezdeki bulgular tek depolu bellek modelinin tahminleri desteklemiş ve iki model grubu için de kelime çiftlerini kodlama açısından öneriler sunmuştur.

Anahtar Kelimeler: yakınlık etkisi, kelime çiftleri, simetrik çağrışım, yoklamalı hatırlama

To experimental introverts

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CHAPTER 1

INTRODUCTION

The term episodic memory was coined by Tulving in 1972 (Tulving, 1972), which he refers to as "mental time travel" to a particular point in time (Tulving, 2007). In the laboratory, processes involved in episodic memory is studied through a variety of experimental tasks. Participants are asked to study lists of stimuli that are mostly meaningful words or can be nonlinguistic stimuli, such as pictures of scenes, human faces, or artificially generated fractals. Each presented stimulus is encoded in memory which involves the information regarding the stimuli, contextual surroundings, and associations among context and different items. After studying a list of stimuli, participants are presented with a test session. These test sessions may include combinations of two main tasks: recognition and recall. The recognition task mainly requires the participant to report whether they had seen the stimuli in the studied list or not. On the other hand, the recall task requires generating the previously studied stimuli. Generating a word may seem to be more demanding and thus, can benefit from the utilization of contextual or associative information. Because the tested words and their presentation rate can be controlled the recognition task is more guided compared to the recall task. Recall, however, sets participants freer, enabling the analysis of the underlying memory system. Both tasks can be tested in various time scales, such as testing immediately after studying the list or delaying the test phase using a demanding distractor task.

1.1. Laws of Episodic Memory

A recall task may take several forms; participants may be asked to recall items freely in any order they want, free recall, in the order of study, serial recall, or probed to specific items in the list, probed recall. Because the free recall task is the least manipulative laboratory test for memory (Figure 1, see the different types of free recall tasks), it reveals the nature of the human memory mechanism with two robust effects as recency and contiguity. When participants are asked to immediately recall the words from the list they studied a couple of seconds ago, they first tend to retrieve the last 3 or 4 words they studied: namely the recency effect (Figure 2). Similarly, the probability of recalled words coming from temporally nearby positions is quite high; namely the contiguity effect (Figure 3). When a distractor task was added between the study and test phases, the recency effect is diminished while the contiguity effect remains intact. A distractor task can also be added between each item of the study list, so both contiguity and recency effects can still be observed in the test. Two main classes of memory models were proposed to account for the aforementioned effects, namely dual store and single store memory models. Dual store memory models assume that memory system consists of "short-term store" (STS) with limited capacity and "long-term store" (LTS) with unlimited capacity. Some accounts such as Lehman and Malmberg (2013)'s Buffer model, short-term store is an active control process which is termed as a control process model. On the other hand, single store memory models assume that memory system should not be divided, instead, they use context and temporal associations both in encoding and retrieval processes. They proposed that the studied items are encoded with their contexts and retrieved by using the contextual information as a cue.

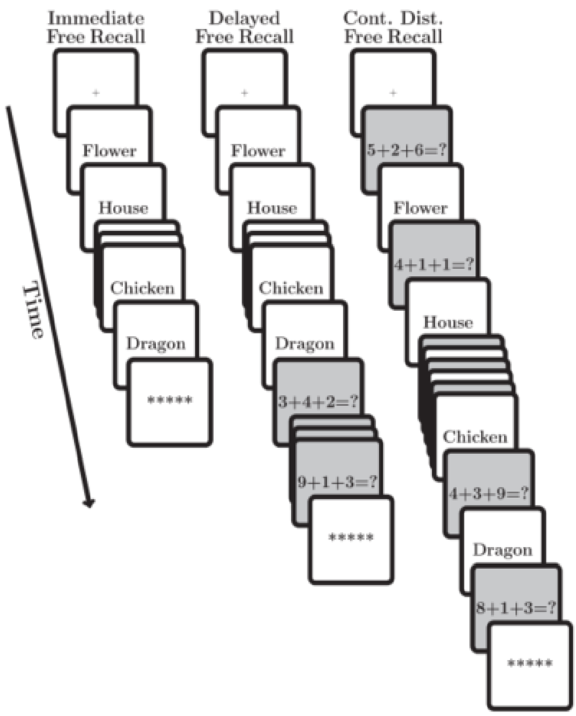

Figure 1. Demonstration of immediate, delayed, and continuous distractor recall tasks. Adopted from Sederberg et al. (2008).

1.1.1. Recency and Contiguity Effects

According to the law of recency, recently experienced events are easier to be retrieved, and forgetting starts immediately after experiencing the event. The recency effect can be observed in the probability of first recall within the list items in a free recall task. Murdock (1962) calculated recall probabilities of words depending on their serial positions in the list using different list lengths in an immediate free recall (Figure 2). Dual store models naturally account for this finding due to direct read-out from STS (Atkinson & Shiffrin, 1968; Lehman & Malmberg, 2013; Raaijmakers & Shiffrin, 1981). Single store models suggest that the similarity of study and test contexts results in recency effect (Howard & Kahana, 2002).

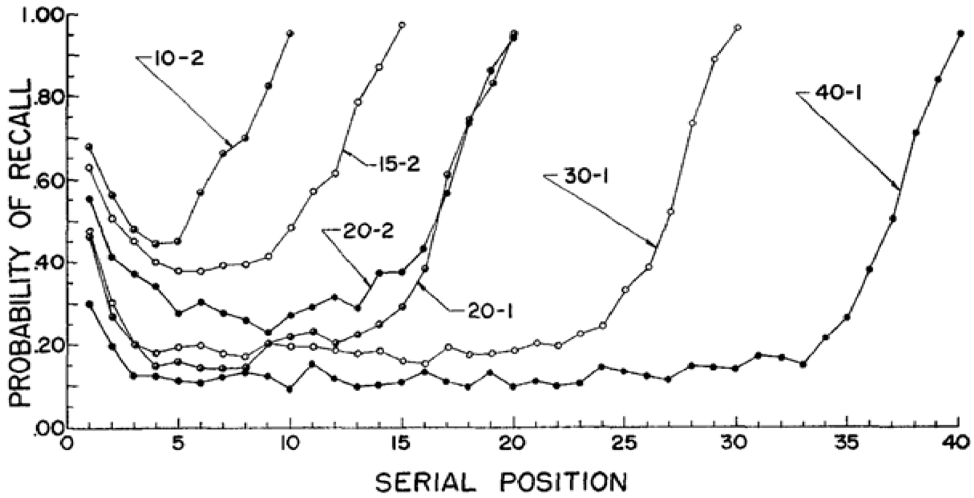

Figure 2. Serial Position Curve of lists of 10, 15, 20, 30, and 40 items. The second number next to the list length demonstrates 1- and 2-seconds presentation duration. Primacy and recency effects can be observed in various list-length. Adopted from Murdock (1962).

According to the law of contiguity, events that occur in close temporal proximity become associated. The law implies that the items studied in nearby list positions are naturally close in temporal proximity and will be retrieved successively when participants are asked to freely recall the study list. Kahana (1996) analyzed the free recall patterns and quantified the conditional response probabilities as a function of serial position in the study list (lag-CRP). Lag-CRP is the probability of recalling an item from serial position i+1, given that participant did initial recall from serial position i. Lag is the difference between the study positions of the successively recalled items in the study list (j-i). A monotonic decrease in the probability of recalling an item as its absolute lag increases can be seen in Figure 3. In addition, he demonstrated that the following item is more likely to be recalled than the preceding item, which is the forward asymmetry in the contiguity effect. In dual store models, contiguity arises with the co-occurrence of items in the STS, while in TCM, the overlapping encoding contexts of neighbor items arises the contiguity effect.

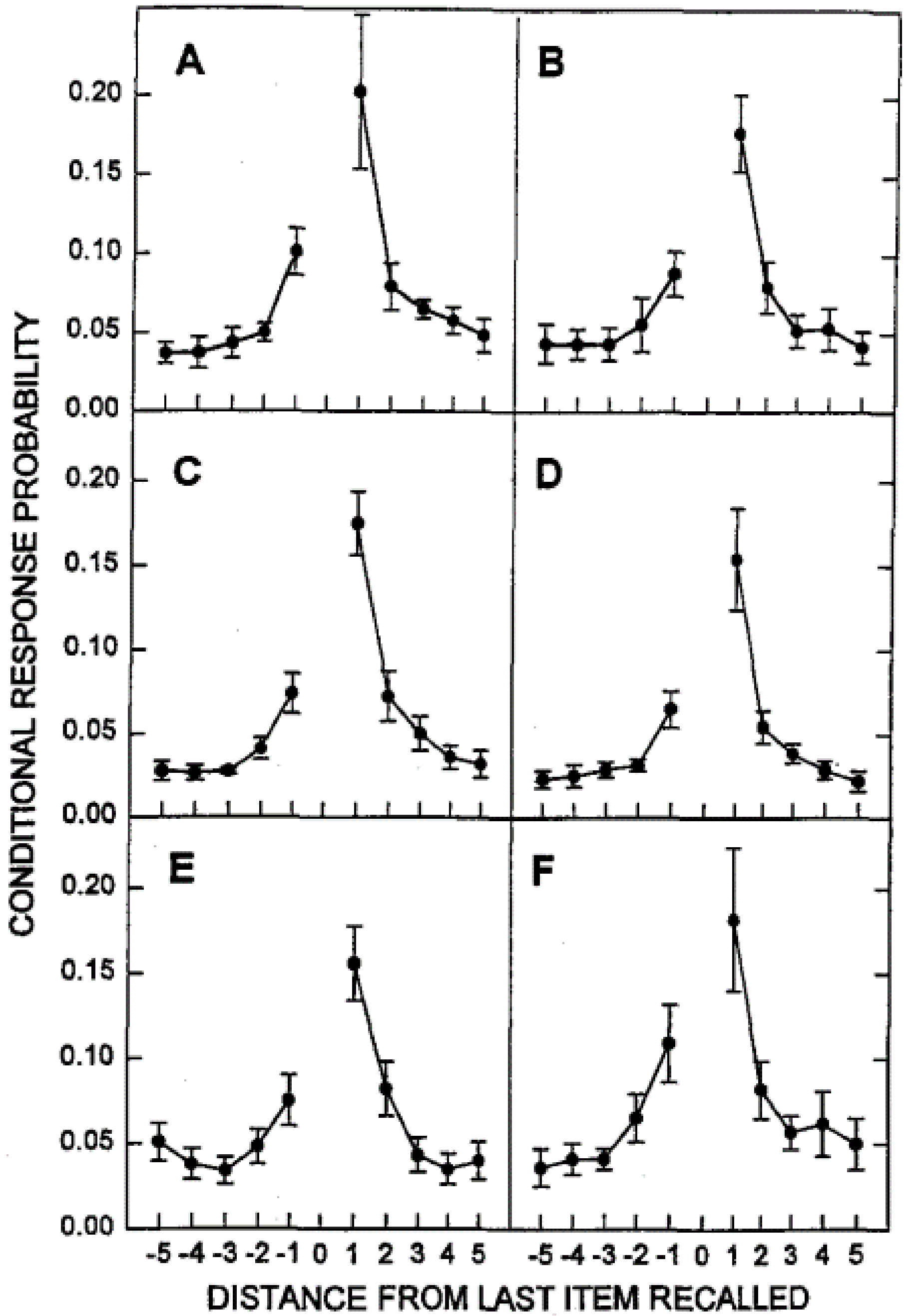

Figure 3. Lag-CRP analysis for studies of Murdock and Okada (1970) and Murdock and Metcalfe (1978) varying in different list-length, modality of stimulus, and presentation rates. Adopted from Kahana (1996).

As mentioned earlier, strong recency and contiguity effects are observed in immediate free recall (Kahana, 1996; Murdock, 1962). However, in delayed free recall, recency is diminished (Glanzer & Cunitz, 1966; Howard & Kahana, 1999; Postman & Phillips, 1965), whereas contiguity remains intact (Howard & Kahana, 1999), which dual store accounts naturally account for. When Howard and Kahana

(1999) applied continuous distractor to free recall, the recall pattern became similar to immediate free recall. The long-term recency (Bjork & Whitten, 1974) and the contiguity effect indicated that items are not required to be in immediately adjacent positions to become associated with each other. The long-term recency and the contiguity effects challenged the dual store account. Because if a distractor task empties the STS to rule out recency when a continuous distractor is put between list items, the items cannot co-occur in the STS during the study. So, the long-term recency and the contiguity effects should not have been observed according to the initial version of the dual store models, while the contextual coding models can naturally explain the findings (Sederberg et al., 2008). Further, Howard et al. (2008) demonstrated the recency and contiguity effects in longer time scales using a surprise final free recall test after studying and recalling 48 lists. They reported similar functional forms in both recency and contiguity effects. However, asymmetry in long-term contiguity was not observed, although it was seen in delayed and continuous distractor free recall tests. (Kahana et al., 2008).

Kahana and Caplan (2002) conducted a probed recall task in which participants studied lists of 10 triples and probed by single and compound cues in the test session. Both cue types (e.g., AB?, A?-, A-?) revealed forward recall advantage (than backward cues, e.g. ?BC, ?B-, ?-C) in mean accuracy and RT. Caplan et al. (2006) continued to use triples as an intermediate between pairs and lists. They used a successive testing paradigm to compare the correlation of forward and backward probes of triples. In successive testing, each pair is tested twice in two test sessions (A-B pair was tested by ?-B in Test1 and A-? in Test2), half of the pairs are tested in the same direction, and the other half is tested in the opposite direction as the study session. Symmetric mean accuracy and RT in pairs, along with the symmetric mean performance in pairs and triples, were found; however, forward and backward correlation in triples were weaker than in pairs.

In addition to recalling the target item correctly, erroneous recalls may exhibit the underlying associative processes. Intrusions in cued, serial, and probed recall indicate long-range associations among studied items. Forward asymmetry was observed in intrusions of serial recall (Haberlandt et al., 2005) as in responses of free recall. Woodward Jr and Murdock (1968) probed some items in the lists, intrusions showed a forward asymmetry. In probed recall task, within-list intrusions revealed forward asymmetry (Kahana & Caplan, 2002). When subjects fail to recall a target item in the triples, they tend to erroneously recall items following the cue block than items preceding it. In addition, intrusions tend to come from adjacent triples compared to remote ones within the same list. The intrusion analysis from Caplan et al.'s study demonstrated an adjacent pair (and triple) advantage in within-list intrusions but without a forward asymmetry (2006). Davis et al. (2008) conducted the cued recall task which does not require encoding associations other than association within pairs. The intrusion pattern across pairs demonstrated a forward advantage for the nearby pairs over remote ones (Figure 4).

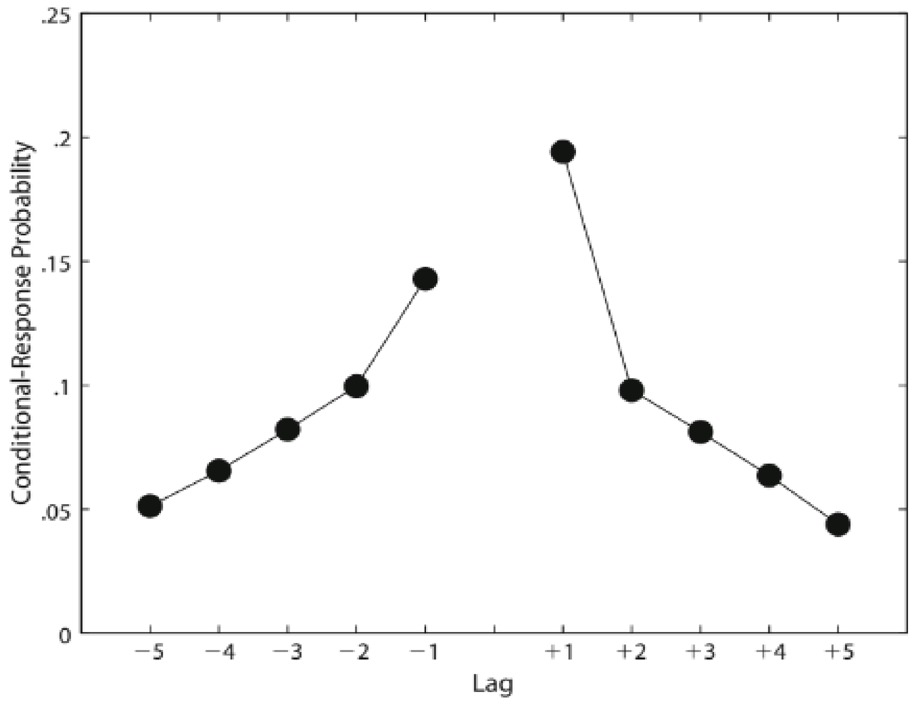

Figure 4. The probability of intrusions in cued-recall coming from the other pairs depending on their lags. Adopted from Davis et al. (2008).

Kılıç et al. (2013) further the developed probed recall task to investigate the underlying mechanisms of the contiguity effect. Participants were presented with multiple lists of words in the study session and asked to rate the studied word's abstractness and concreteness. In the test phase, they saw a randomly selected probe word from the random list. Later, they were asked to rate how sure they were of seeing the probe word from 1 to 9; after rating, they generated another word from the list that probe was presented in. Researchers broke the traditional study-test cycle to indicate that the contiguity effect was not a mere result of successive study and test sessions. The recalls were grouped as those recalled from the same list as the probe word, that is, within-list contiguity (short-term contiguity), and recalls from the other lists, that is, between-list contiguity (long-term contiguity). That allowed Kılıç et al. to investigate the short and long-term contiguity effects in a controlled manner.

1.2. Episodic Associations

As laboratory findings of law of recency and contiguity indicates, episodic experience is featured by its serial order or sequence of events. People tend to remember events interconnected by time or by their order; for instance, thunder always follows lightning, or a phone number is composed of a series of digits. Based on their list length, memory for pairs and memory for more than two items may be divided. The reason behind forming an association between two events is not clear, whether it is due to temporal co-occurrence (Kahana et al., 2008), holistic association (Madan et al., 2010), or a mere combination of two events (Hockley & Cristi, 1996). As mentioned above, memory for lists is usually tested by serial recall, free recall, and recognition tasks, whereas memory for associative pairs is tested by cued recall and associative recognition tasks. The association of serial events could be retrieved by their initial direction (forward association) or reverse direction (backward association).

Episodic associations had long been studied as the ability to encode the relation between two items. In the associative recognition task, participants need to judge their memories for prior occurrences in the presence of target items. When a list of word pairs is studied, such as A_1 - B_1, A_2 - B_2 the link between the pairs can be tested with the recognition task by simply presenting the A_1-B_1, intact, or A_1–B_2 rearranged pair, and asked whether the participant had seen the pair together in the study phase. In the cued recall task, one of the pair items is provided as a cue for retrieval of the other item in the pair A_1 is provided as a cue and B_1 is required to be retrieved.

The direction of memory for serial order has been intensively debated. The independent association hypothesis (IAH) (Ebbinghaus, 1885; Wolford, 1971) proposes that forward and backward associative strengths are independent and separately modifiable in which forward associations (A-B) are better remembered than backward associations (B-A) (Kahana, 2002). In contrast, Gestalt psychologists proposed the associative symmetry hypothesis (ASH) (Asch & Ebenholtz, 1962; Kohler, 1947) that the item A and B in paired associates are encoded as a single unit resulting in the same association strength.

The mean accuracy performance (Caplan et al., 2006; Murdock, 1966) and response times (Thomas et al., 2003) of forward and backward recalls were used to compare IAH and ASH. Additionally, in the successive testing paradigm, forward and backward recalls demonstrated a high correlation (Caplan, 2005; Caplan et al., 2006; Kahana, 2002; Madan et al., 2010; Sommer et al., 2007). ASH requires a perfect correlation for every paired associate, A-B; the probability of recalling B given A perfectly predicts the probability of recalling A given B, whereas IAH is quite flexible (Kahana, 2002). Another strong support for associative symmetry in paired associates comes from the intrusions in a cued recall task that were not found to be biased toward one member of the pair (Davis et al., 2008).

Thomas et al. (2003) conducted a serial recall experiment with lists of 4, 5, and 6 words. They concluded that regardless of list length, accuracy was higher, and RTs were shorter in forward serial recall compared to the backward serial recall. However, Dougherty et al. (2022) reported no difference in overall accuracy except when conditionalized the prior recall. Kahana (1996) demonstrated a forward bias that involves twofold likelihood to recall the successive word rather than the preceding word after initial recall. Therefore, serial lists tend to be retrieved with forward asymmetry and the tendency becomes clear when recall probability is conditionalized on the prior recall. In paired associates the studies using associative recognition tasks showed that forward pairs are recognized faster and more accurately than the backward pairs irrespective of simultaneous or sequential presentation (Yang et al., 2013), under sentence encoding to boost relational encoding (Giovanello et al., 2009) or, under unitization task in which participants are asked to combine two words into a new concept (e.g., vegetable-bible) (Wiegand et al., 2010). Two studies that compared associative recognition with intact versus reversed probes by asking directional judgment that tests the order information within pairs also revealed that forward pairs were more accurately judged than backward pairs (Greene & Tussing, 2001; Kounios et al., 2003). In addition, two studies that used paired associates in free recall also supported forward asymmetry. In Mandler et al. (1981)'s study, participants studied lists of pair items and then were asked to report them in the same order when possible, which were remarkably accurate. Lehman and Malmberg (2013) carried out an experiment utilizing free recall task, where participants studied lists of pair items, and the results showed a strong tendency to first output the penultimate item.

Although cued recall tasks produce symmetric performance, asymmetry can be observed under certain conditions: when pair items come from different stimulus pools such as adjective and noun (Bartling & Thompson, 1977; Lockhart, 1969), concrete and abstract nouns (Lockhart, 1969), imageability (Madan et al., 2010), word frequency (Criss et al., 2011; Madan et al., 2010), and semantic relation (Popov et al., 2019). These experiments also showed that when item properties are equal, pure pairs, mean accuracy for forward and backward recalls are symmetric.

To sum up, contiguity effect is a robust effect that is observed in immediate (Kahana, 1996; Murdock, 1962), delayed (Howard & Kahana, 1999) and continuous distractor (Howard & Kahana, 1999) free recall, as well as recognition (Averell et al., 2016; Schwartz et al., 2005). It can be observed in various time scales; however forward asymmetry is less clear (Healey et al., 2019). Two studies to observe long-term contiguity effect tested participants with a surprise final free recall did not find asymmetry across lists (Howard et al., 2008; Unsworth, 2008). Kılıç et al. (2013) conducted the probed recall task, in which participants successively studied 6 lists of 21 words, later probed by one of the items in the list asking them to recall. They also did not report any asymmetry across-list transitions. Mack et al. (2017) asked participants to study one word in one hour using a smartphone application for a later free and serial recall in which contiguity and forward asymmetry was observed. However, Uitvlugt and Healey (2019) asked participants to recall news over 4 months and 2 years in separate experiments that reported different asymmetry findings. In addition, although the literature posits a forward advantage in the contiguity effect when memory for lists is tested with free or serial recall tasks in shorter time scales, task characteristics seem to modulate associative symmetry findings in pairs (Kahana, 2002; Yang et al., 2013). Forward asymmetry for pairs is observed in associative recognition, whereas cued recall reveals associative symmetry. Therefore, IAH is supported by studies that adopted associative recognition or list memory, whereas ASH is supported mainly by the studies that adopted cued recall tests.

The underlying mechanisms of the contiguity effect are formulated differently in each model. In a larger perspective, the contiguity effect represents associations among items along with associations between items and context. As Healey et al. (2019) summarized contiguity generating mechanisms; associative chaining models link the neighbor items, positional coding models assumes items are associated with study positions, short-term memory models suggest co-occurrence of items in the short-term store, control process models use ad hoc encoding strategy according to task demands, the contextual coding models assume context similarity among successively studied items. To conclude, time scale similarity is an important finding that only contextual models can account for, while neither chaining, short-term memory, nor control processes can. Specifically, the chaining models and strategic control processes cannot naturally account for forward asymmetry. Control process models also fail to account for incidental learning and automaticity in the contiguity effect. Among many possible mechanisms that can explain the contiguity effect, the contextual models that define context based on temporal proximity provide an important theory.

While forward asymmetry was consistently found in serial lists, symmetric findings were reported in paired associates. Encoding of pairs were formulated by aforementioned models; for instance, TODAM was a chaining model which proposed pair learning by strengthening associations within pairs while weakening across pairs (Murdock & Franklin, 1984). Caplan (2005) attempted to unify associative chaining and positional coding models by introducing the isolation principle. According to his model, the association is encoded strongly within pairs but much weaker across pairs. Positional coding varies between pairs rather than within pairs. Pairs are “associatively” isolated from the rest of the list. In this way, the model can account for forward asymmetry in serial lists and associative symmetry in paired associates by having the same basic mechanisms for both. Nevertheless, more general models are required to explain laws of episodic memory; thus, this thesis discusses dual and single store memory models.

1.3. Dual Store Models

1.3.1. The SAM Model

The Search of associative memory (SAM) model is the developed version of Atkinson and Shiffrin's classical buffer model (Atkinson & Shiffrin, 1968). SAM model consists of two storage systems: short-term store (STS) with a limited storage capacity and an unlimited long-term store (LTS) (Raaijmakers & Shiffrin, 1981). As items are being studied, they first enter to STS until the registers are full; then, as new items continue to come, old ones in the registers are replaced randomly. In STS, there exists item-to-context and item-to-item associations. Items become associated with each other based on the amount of time they spend together in the STS. LTS can be considered as an associative matrix containing the values of all associations formed in STS, including pairwise associations. SAM model also gives flexibility to set associative weights independently.

1.3.2. The Buffer Model

Lehman and Malmberg (2013)'s Buffer model is a control process model with two storage units similar to the SAM model. Different from the SAM model, the buffer is not a simple, passive short-term store; on the contrary, it includes an active control process that works according to the subject's goals in a particular task. In the Buffer model, the representation of items is borrowed from the REM model (Shiffrin & Steyvers, 1997); an episodic image is stored for each item separately, which includes association between the studied item and the study context. Briefly, to achieve a desirable encoding strategy, items can be maintained through rehearsal or intentionally dropped from the buffer with the mechanism called compartmentalization. According to the model, items that are not needed to perform the current task can be dropped from the buffer intentionally, not probabilistically, which differs from the SAM model. In contrast, necessary items are maintained for further processing through rehearsal. The key feature of the buffer is having a limited capacity as in the SAM model. Therefore, different numbers of items can be rehearsed simultaneously depending on the task demands until reaching the buffer capacity.

Three types of information, namely information of item, interitem association, and item-to-context association, are encoded using the encoding resources of the buffer. Interitem association is formed by the co-occurrence of items in the buffer, while the item-to-context association is formed by the item occurring in the study context. Here, context features are encoded in a context vector which changes from trial to trial with a certain amount of probability; however, presentation of item does not cause a drift in the context as in TCM.

Retrieval in the Buffer model comprises a set of sampling and recovering operations as in the REM model. In free recall, the test context is used to initiate the sampling procedure, whose contents may again be influenced by task demands. Sampling is the procedure that probes the memory by measuring the match between the features of memory traces and the features of the cue. In immediate free recall, sampling starts with the buffer and then continues with the entire list. The next cue after the successfully retrieved item is the updated context with item and context features of the previously used context cue. Co-rehearsed items in the buffer will likely be sampled next, resulting in the contiguity effect. Model claims that long-term recency and contiguity need not result from the same mechanism. In continuous distractor tasks, buffer capacity is reduced due to distractor so that rehearsal is difficult. During retrieval, memory is probed similar to being recalled in delayed recall.

The model posits that when a list of single items is studied, each item is rehearsed sequentially. Each item’s trace includes its context highly similar to the prior item’s context. Additionally, co-rehearsed items are also associated with each other. With these assumptions in mind, the model accounts for asymmetry in the contiguity effect using the context assumption.

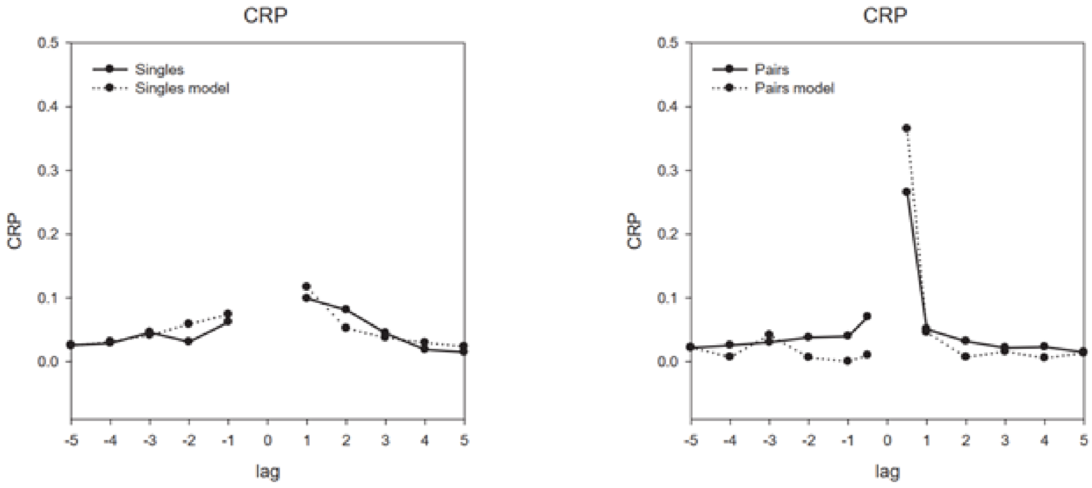

Figure 5. Lag-CRP analysis for single items and pairs. Experiment 4 from the Buffer model, immediate free recall of a list of pairs. The figure is adopted from Lehman and Malmberg (2013).

The model makes an explicit assumption for paired associates. The primary focus of a task with paired associates is to test how the association within pair items are formed. The model assumes that pairs are encoded as chunks with item-to-item and item-to-context associations. Associations among chunks are much weaker compared to within chunks; associations among chunks are formed only based on the similarity of their contexts they are presented in. Notice that the encoding mechanism of within and across pairs highly resembles Caplan (2005)'s formulation of the isolation principle. However, the Buffer model predicts an asymmetry within the pair because of the strong correlation between the context of the chunk and the first item. Thus, recall of the pairs begins with the first item. For instance, in immediate free recall, the first recall probability (FRP) is highest for the penultimate item (first item in the last pair). More importantly, in Experiment 4, they conducted an immediate free recall task with a list of pair items (Figure 5). According to their findings, the contiguity effect indicates a different pattern for pairs and single item lists. As seen in Figure 5, the model predicts that the pairs are more likely to make lag (chunk) +1 forward transition due to the chunks created by the compartmentalization process.

1.4.Contextual Coding Models

According to temporal context models, each studied item and the contextual features at the time of encoding are associated at the study session. During the test session, the current context is used as a retrieval cue for recently studied items (Bower, 1972; Howard & Kahana, 2002).

1.4.1. Temporal Context Model

Temporal Context Model (TCM) is a single store memory model developed to account for recency and contiguity effects without dividing the memory system into short-term and long-term stores. TCM assumes that associations are formed between item and context and the associations among items are caused by the shared context.

Context dynamics can be intuitively explained with an example; suppose that the participant studied the list school, boat, flower, shoe, dog, key. The assumption is that when a participant studies school item, information about school is activated. This information may include semantic information, school as a concept, imagery of one's primary school, specific memories about schools, or various school buildings that they have seen or been in. For simplicity, TCM assumes that the whole pre-experimental contextual representations of school are aggregated into a single vector representation like the state of the context vector, which is then added to the current state of the context. This school-related information updates the current context and pushes the internal context through high-dimensional space. The process is reiterated with each studied item with a certain amount of decay (Figure 6).

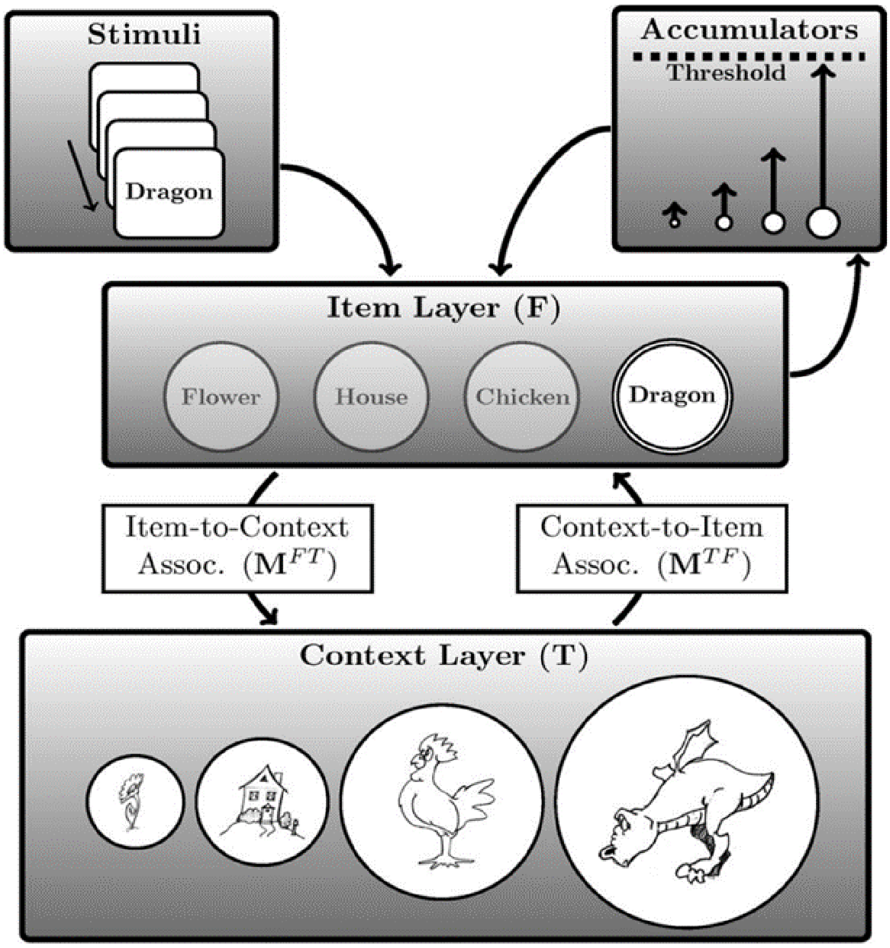

Figure 6. The figure demonstrates how TCM works (accumulator layer is added to an extended version of the model, TCM-A). The sizes of the circles illustrate the space the items have in the context layer. During the test, context is used as a cue for recall, which tends to be the last words due to the similarity of their contexts. Then, just-recalled word's context will also be retrieved and again will be used as a cue. The figure is adopted from Sederberg et al. (2008).

While pre-experimental context combines with the current context, item attributes are also associated with the state of context bidirectionally by creating context-to-item and item-to-context matrices in the associative neural network (Sederberg et al., 2008) (Figure 4). In this set of associations, when memory is cued with the current state of context, items associated with similar contexts become activated. When the subject is asked to initiate recall, time of test context is used as a retrieval cue activating items through context-to-item associations. Subjects naturally can generate one item at a time during the recall period. Therefore, competition occurs among leaky accumulators of items. Each item starts to accumulate strength with a certain amount of noise on the basis of activation by the cue. The first item that reaches the threshold is recalled, which is then re-presented to the network retrieving its state of study context. This newly retrieved context then serves as the new cue to continue to the recall process. In this way, TCM accounts for robust recency and contiguity effects in both short and longer time scales based on the same principle.

In immediate free recall, any visible cue exists, so it is assumed that the current test context is used as a cue to initiate recall. Because the context of the latest studied items has the most similar context to the test, the recency effect occurs. Additionally, distractors in TCM are modeled as random vectors that cause drift at some rate but do not induce modifications in associative matrices. Thus, the recency effect is eliminated due to the drift in the test context in the delayed recall task. In the continuous distractor case, however, a random vector of distractor locates in between each item, which creates a similar recency effect in the test phase. On the contrary to other accounts of the primacy effect such as the initial items spending more time in the buffer, TCM proposes that the novelty of beginning of list items attracts attention resulting in high probability of recalling earlier list items so does the opportunity to rehearse the items (Kahana, 2012). Lastly, TCM has a natural account for the contiguity effect and forward asymmetry. According to TCM, recalling an item brings its experimental and pre-experimental contexts, the latter being input to the context evolution equation at the moment that item is studied. Retrieved item's list context is an equally effective cue for both previous and subsequent list items. In contrast, the retrieved pre-experimental context of the recalled item is only integrated with the following item but not the preceding item. This creates a strong asymmetric cue favoring the following item transitions. Thus, forward asymmetry in the contiguity effect occurs (Kahana et al., 2008).

1.5. The Effect of Rehearsal Type

Relation between pair items can be endorsed using different orienting tasks. Sentence encoding requires participants overtly or covertly to generate one sentence using both items in the pair (Giovanello et al., 2009; Lehman & Malmberg, 2013); unitization is asking participants to integrate two items into a new concept (e.g., vegetable-bible) (Haskins et al., 2008; Wiegand et al., 2010), and imagining pair items together (McGee, 1980) have been used. In this study, 5 lists of pairs were presented to participants asking to overtly generate sentences using both words in the pair for a later probed recall task in which they needed to differentiate the lists they studied. In the sentence encoding procedure participants would focus on encoding pairs, so if contiguity effect is found, we can say incidental learning occurred (Healey, 2018). However, asking them to discriminate lists might lead them to develop strategy according to the task demands.

In addition, using pairs in a probed recall task was first in the literature, so it may operate as compound cuing. Kahana and Caplan (2002) reported forward asymmetry in compound cues in the probed recall study with triples. Lohnas and Kahana (2014) also reported a benefit for forward compound cues except for one condition in free recall. It is not clear whether pairs would result in compound cuing in this study. The memory performance can be compared with probed recall tasks with single items.

1.6. Aim of the Study

The aim of this thesis is to investigate the encoding mechanisms of pairs and single items using the probed recall task which was further developed by Kılıç et al. (2013). The difference between retrieval patterns of pairs and serial lists was demonstrated using the probed recall task in triples (Kahana & Caplan, 2002) and intrusions in the cued recall task (Davis et al., 2008). Therefore, the current aim is to test how associations between pairs induce retrieval of recent list pairs and which item of the recent pair will be recalled. If pairs are encoded holistically as suggested by Caplan (2005) who posits that pairs share single temporal context while neighboring pairs are associated with different temporal contexts, we can hypothesize that probing with a pair will result in a holistic retrieval. That is, when a pair is used as a probe the subject will be more likely to recall either of the items from a pair that was studied in a nearby position because pairs will be associated with a comparable context. Either item in the pair will be retrieved with equal likelihood due to a holistic association among the items in the pair. On the other hand, if pairs are not encoded holistically, probing memory with a pair may result in recalling the most recent item of the pair with greater probability. To summarize, a comparison between the temporal relationship among pairs and across pairs will provide the basics of the underlying mechanisms in episodic memory.

CHAPTER 2

EXPERIMENT

2.1. Preliminary Study: List Construction

2.1.1. Method

It is well known that semantic associations outperform the episodic associations (Howard et al., 2007); therefore, semantic relations are needed to be controlled to focus on the episodic relations in this study. However, conducting a Latent Semantic Analysis (LSA) (Landauer & Dumais, 1997) for Turkish was beyond the scope of this thesis in terms of time, resources, and the expertise, hence the words were taken from Kılıç et al. (2013) study in which LSA had been done using the SEMMOD package (Stone et al., 2008) to evaluate semantic similarity among words and translated into Turkish by Hazal Arpacı. Further, since this study was about word pairs, they were needed to be evaluated in terms of semantic relatedness.

All words were randomized, and 247 pairs were constructed randomly in MATLAB. Newly constructed pairs were transferred to Google forms to evaluate the semantic relatedness of each pair.

2.1.1.1. Participants

Data from 30 participants were collected with the snowball sampling method. 33% of participants were males, 67% were females. Participants were native Turkish speakers and aged between 21-35 (M = 25.03, SD = 3.12).

2.1.1.2. Materials

Google Forms was used to collect the data. 247 individual word-pairs were presented to the participants for rating on a scale from 1 (not related) to 10 (related).

2.1.1.3. Procedure

Ethical approval had been taken from the METU Ethical Committee in March 2022 for the main study and that has been used for this preliminary study. The Google Form link was sent to the potential participants through social networks. Participants were instructed to rate word-pairs according to their semantic relatedness. They evaluated 247 word-pair in total. Participants were asked to evaluate semantic relatedness of each pair with below question:

"Please rate the relatedness between two words from 1 to 10. 1 indicating not related, 10 indicating too related." ("Kelime çiftlerinin birbiriyle ne kadar ilgili olduğunu 1-10 arasında puanlamanızı istiyoruz. 1, kelimeler hiç alakalı değil demek, 10 ise kelimeler birbiriyle çok alakalı demektir.").

2.1.2. Results

Mean and standard deviation values was calculated for each pair. Then, the cutoff point to eliminate the word pair was determined exploratorily. The pairs whose mean rating was 5 and below were chosen to be in the study lists resulting in 204 word-pairs. Some of these pairs were unrelated such as karaciğer-torpido (liver-torpedo, M_{rel}=1.2, SD_{rel}=.55), some were more related such as madalya-uzunluk (medal-length, M_{rel}=4.63, SD_{rel} =2.6).

The remaining pairs were too related with each other such as kafiye-şiir (rhyme-poem, M_{rel}=8.79, SD_{rel}=2.82) or takım-tenis (team-tennis, M_{rel}=6.4 SD_{rel}=2.78). Therefore, pairs were broken, and individual words were randomized. The new pairs were constructed manually to be used as the new pairs in the test phase of the experiment. 10 of them were used in the practice session of the experiment. They were not used in the study phase.

2.2. Pilot Study

2.2.1. Method

A pilot study was run to test whether experiment is working on the PC in the lab and to see the preliminary results of the experiment. Since the total number of studied words were more than the experiment with the single words, the main question was whether participants can recall the words. The experiment code was written in MATLAB 2021b, Psychtoolbox-3.

2.2.1.1. Participants

10 participants participated in the experiment voluntarily. One participant was excluded because they misunderstood the experiment. Of the remaining 9 participants (M_{age}=23.2, SD_{age}=1.2), 88% were female, 11% were male, and all were right-handed, normal, or normal to normal vision.

2.2.1.2. Materials

The lists were constructed in the preliminary study using MATLAB and R software. The experimental code was prepared in MATLAB 2021b, Psychtoolbox-3 (Kleiner et al., 2007).

2.2.1.3. Design and Procedure

Ethical approval has been taken from the METU Ethical Committee. Participants came to the lab at the arranged time and signed a written consent to participate in the experiment. The experiment occurred in a sound-proof room; participants were first asked to read the instructions, and the experimenter verbally explained the procedure. They could ask every question in their mind in the preparation stage, but they were not allowed to ask questions once the experiment started.

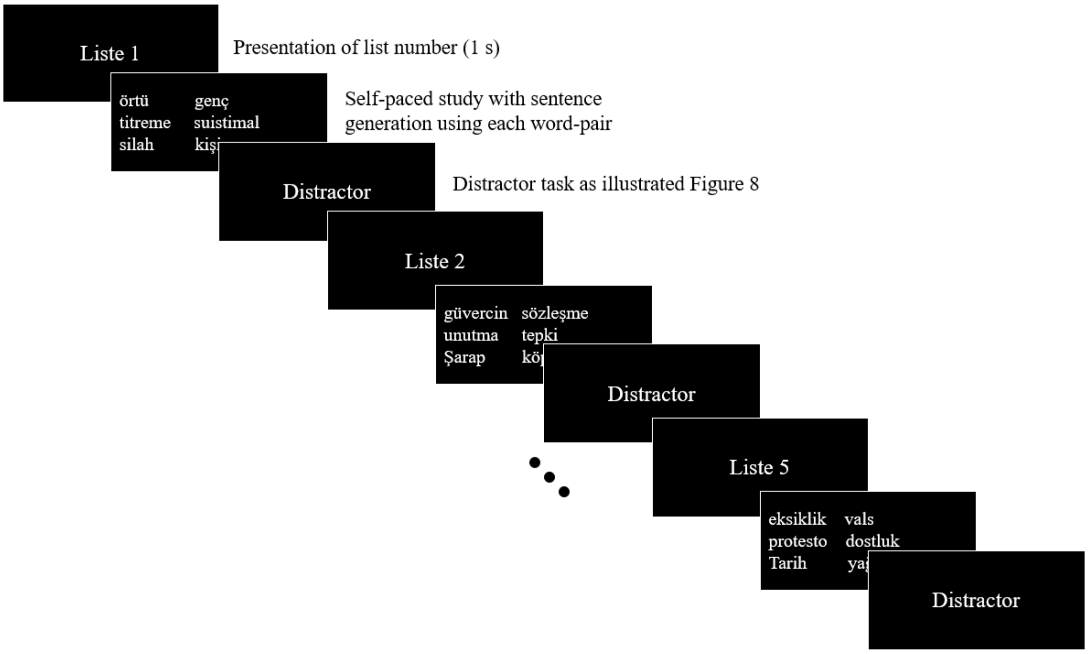

Figure 7. Example of study session

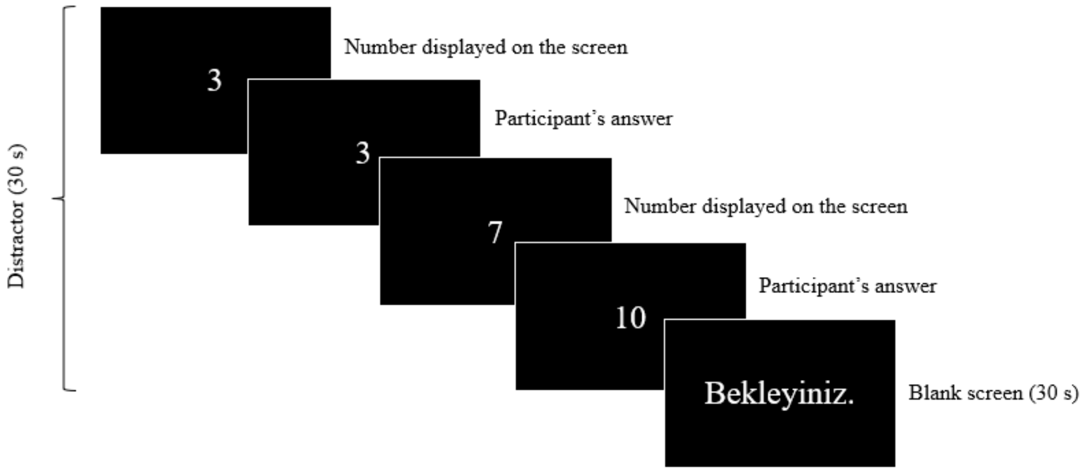

Figure 8. Example of distractor session

Participants completed two blocks of study and test. In each study block, as illustrated in Figure 7 participants were presented with five lists of 10 word-pairs resulting in studying 20 words per list. Pairs were presented simultaneously. As the pairs appeared on the screen, the participants engaged in an orienting task in which they generated sentences using the word pair out loud. There was no lower- or upper-time limit for study in each pair. After saying sentences aloud, they pressed the button "b" to continue with the next pair. Hence, the study time for each pair was self-paced without any limit. After studying each list, participants were given an arithmetic distractor task for 30 s. A break for 30 s followed the distractor task (Figure 8).

In each cycle, the test lists were constructed from 15 probe pairs from study lists and five new pairs. To eliminate concerns of primacy and recency, three probe pairs were selected from either 3-5-7th or 4-6-8th pairs of the lists. The probe pairs were presented randomly, such as one probe pair at a time. Participants were asked to make a recognition judgment. If their judgment was "yes", they were asked to generate another word from the same study list. There were no time restrictions for the responding in the recognition or recall tasks (Figure 9).

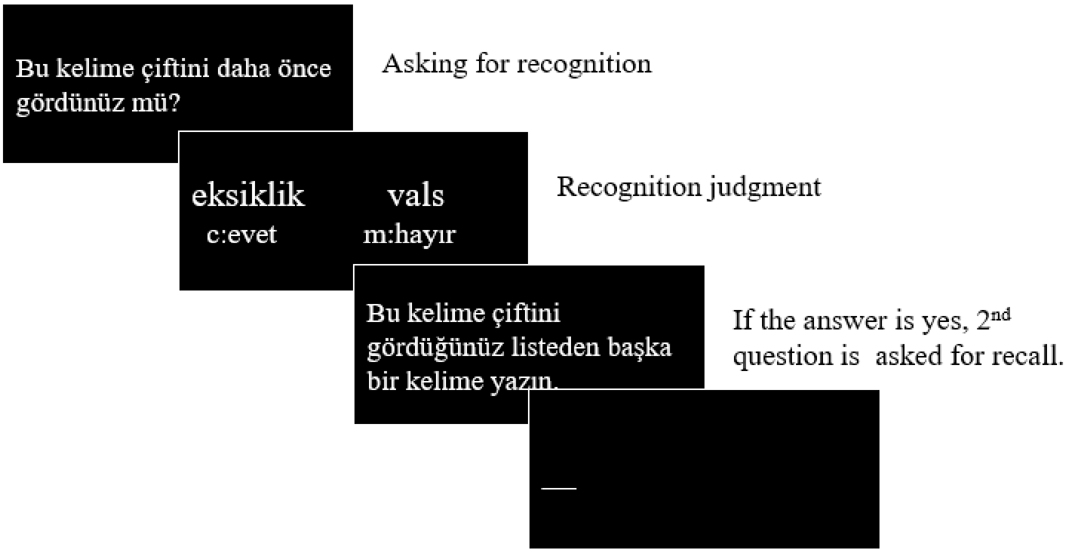

Figure 9. Example of test session

2.2.2. Results

30 true probe pairs, as 3 pairs per list, were presented for recognition judgment. There were 270 potential data points in which 185 responses were obtained (68.5%, $SD_{\text{performance}}$=14.7%) with the range of 50% (15/30) and 90% (27/30) from different participants. All participants correctly recognized the probe pairs 100% of the time and the proportion of recalling a word from the correct list was 22.5% (SD = .09%). A long-term recency effect between lists was observed (Figure 10). R (version 4.2.1)

(R Core Team, 2022) and Rstudio (version 2022.2.3.492) (RStudio Team, 2022) software with dplyr (Mailund, 2019) and tidyr (Wickham & Wickham, 2017) for data manipulation, lsr (Navarro & Navarro, 2021) for paired samples t-tests, ggplot2 (Wickham et al., 2016) for plotting were used in the thesis. In addition, JASP (Love et al., 2019) was used for Shapiro-Wilk and Wilcoxon rank tests.

Parametric and non-parametric tests were reported together since the data violated the normality assumption in some cases. Therefore, paired samples t-test was performed along with its non-parametric counterpart, Wilcoxon rank sum test. First, the Shapiro-Wilk test was conducted to test deviations from normality. In this test, a significant value demonstrates that the data is not normally distributed, so the data does not meet the normality assumption of parametric tests. Paired samples t-test compares the difference in means, the Wilcoxon rank sum test tests whether there is a difference in the rank total. The test ranks the differences and compares the positive and negative ranks, W value represents this difference between ranks. However, the sources do not provide a direct comparison of t and W values; therefore, p values and the effect sizes can be compared.

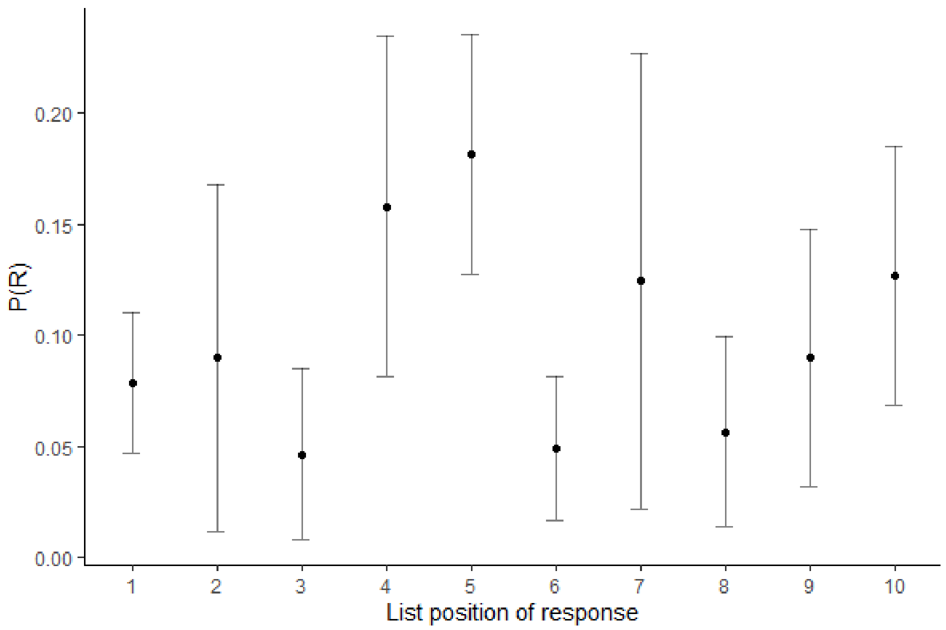

Figure 10. List position curve of response in the pilot study. Each data point represents recall probability of an item from the corresponding list. The error bars are 95% CI of the mean.

In addition, the left side of the Figure 11 illustrates the probability of recall as a function of serial position of the probe that demonstrates a slight advantage in the 8th probe. Right side illustrates the probability of recall as a function of serial position of response which indicates an approximately equal chance of each serial position.

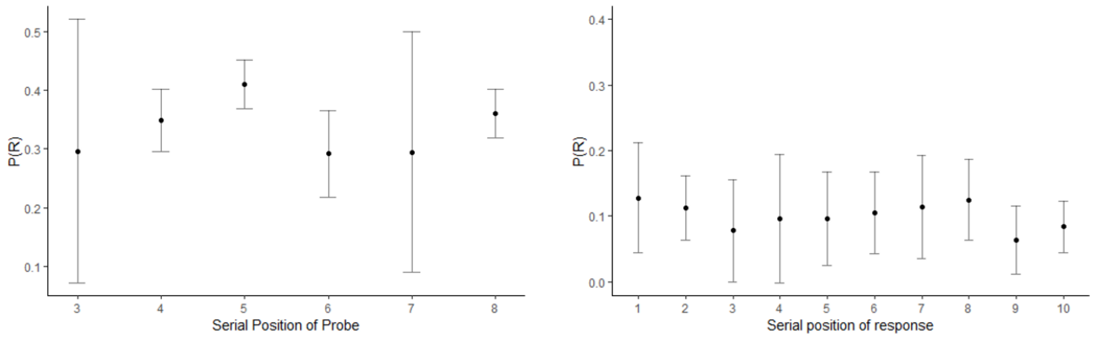

Figure 11. Serial position curve of probe pairs (left) and serial position curve of response (right) in the pilot study. Each data point represents the recall probability as a function of serial position of probe (left), and of response (right) within the list. The error bars are 95% CI of the mean.

The mean proportion of recalling the first word within the pair across all responses was 51.3% of the time (SE=4.94%) (Figure 12).

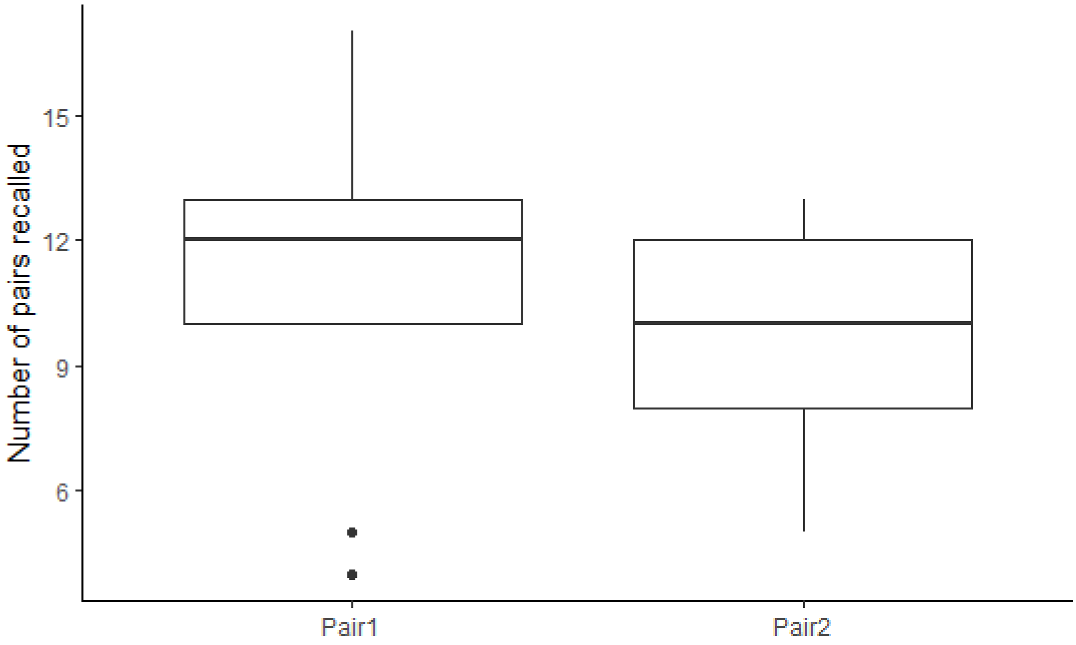

Figure 12. A boxplot of recalled items within the pair in pilot study

2.2.2.1. Data Organization

A MATLAB code has been written for data organization. First, the list, the study position in the list, and the position in the pair for each recalled word have been determined. The word lags (WL) and the list lags (LL) have been calculated for each participant. The WL was calculated as the study position of the word pair in which the recalled word was presented minus the study position of the probe pair. The same rule applies with the LL. Frequencies for specific WLs and LLs were calculated for each participant. For instance, if a participant recalls a word from the 6th pair in the list when they see the 4th pair as the probe, the word lag for the specific trial is WL+2. For within-list contiguity, only the data points where the probe list number and the response list number that were equal were taken into account. Due to small number of data points (22.5% of the whole data), the word lags were grouped as WL1,2,3 and WL5,6,7 to run the analyses.

Additionally, another MATLAB script was prepared to compute the conditioned response probabilities (CRP) of each word lag. The lag-CRP was calculated as the total number of responses observed with that lag divided by the total number of responses that could have been observed from that lag.

2.2.2.2. Within-List Contiguity Effect

To measure the short-term contiguity effect, responses from the same list as the probe words were analyzed. Since participants could recall from the correct list only 22.5% of the time, a small set of data points were available for this analysis. The analyses were performed by grouping word-lags 1,2,3 and 5,6,7 together due to this problem. Figure 13 demonstrates the conditional response probabilities (CRP) of each word lag. Lag is defined as the difference between the serial position of the probe pair and the response word's pair.

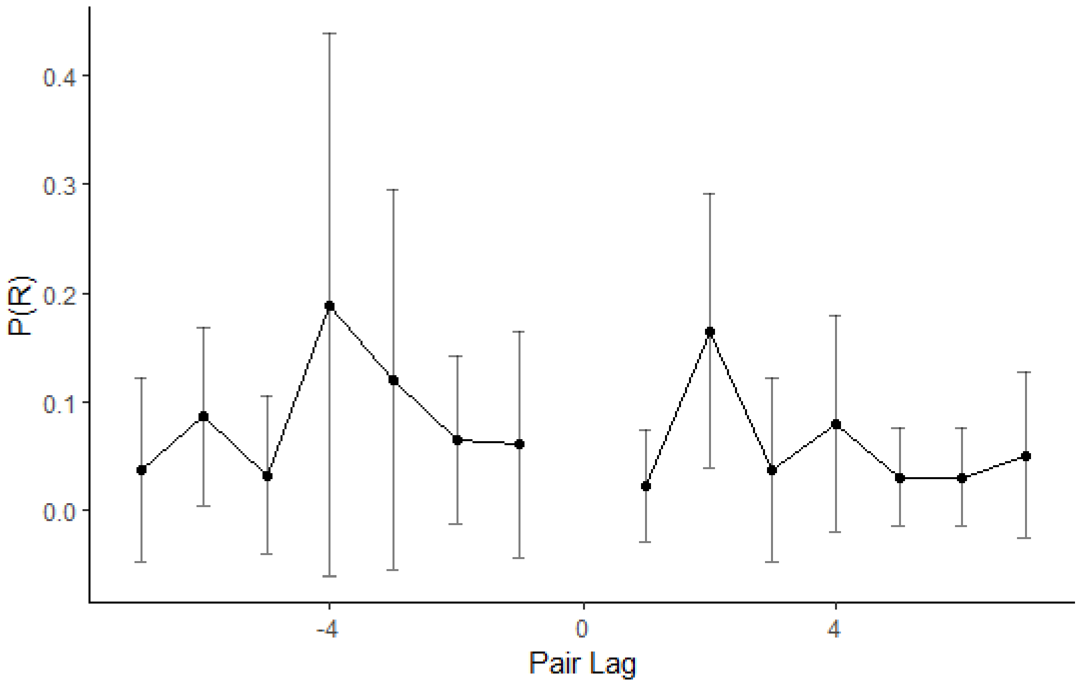

Figure 13. Lag-CRP plot for the within-list contiguity across pairs in pilot study. The error bars are 95% CI of the mean.

Shapiro-Wilk test did not indicate a violation of normality (*W*=.843, *p*=.062); however, Wilcoxon rank sum test was performed along with t-test. A paired samples t-test reported the pairs in the nearby positions, that is WLs 1,2,3, (*M*=2.22, *SD*=1.39) were not recalled more than the words in the distant positions to the probe pair, that is WLs 5,6,7, (*M*=1.44, *SD*=1.33), *t*(8)=1.67, *p*=.13, *d*=.56, *CI*=[-.29, 1.85] with the mean difference of .78. Wilcoxon rank test was not significant either (*W(*8)=13, *p*=.168, *r*=.733). Thus, within-list contiguity effect was not observed in this pilot study.

Another paired t-test analysis was conducted to test the asymmetry between positive and negative lags in recalled words, across pairs. Analysis was performed with WLs +1,+2,+3 and WLs -1,-2,-3 which indicated there is no significant difference between recalling subsequent (M=1.00, SD=1.00) and preceding pairs (M=1.22, SD=1.09), $t(8)$=-.42, p=.68, d=-.14, CI=[-1.42,.98]. Shapiro-Wilk test did not indicate a violation of normality (W=.951, p=.701) and Wilcoxon rank sum test did not reveal a significant asymmetry ($W(8)$=8.5, p=.75, r=-.19). The proportion of recalling the 1st item within pairs across within-list responses was 48.9% (SE=10.9%).

2.2.2.3. Between-List Contiguity Effect

The between-list contiguity effect was tested by grouping list-lags with LLs 1,2 and LLs 3,4. Figure 14 demonstrates conditional response probabilities of response words as a function of the list they come from.

Shapiro-Wilk test did not reveal a violation of normality (W=.93, p=.478). A paired samples t-test analysis was performed and the results indicated a significant difference between the lists that are closer to the correct list, meaning LLs 1,2 (M=11.89, SD=3.85), are recalled more than the lists that are distant from the correct list, meaning 3,4, (M=3.78, SD=1.48), $t(8)$=5.68, p<.001, d=1.89, CI=[4.82, 11.41] with the mean difference of 8.11. Even though there was no violation of normality, Wilcoxon rank sum test was performed, which is also significant ($W(8)$=45, p=.009). Thus, a between-list contiguity effect was observed.

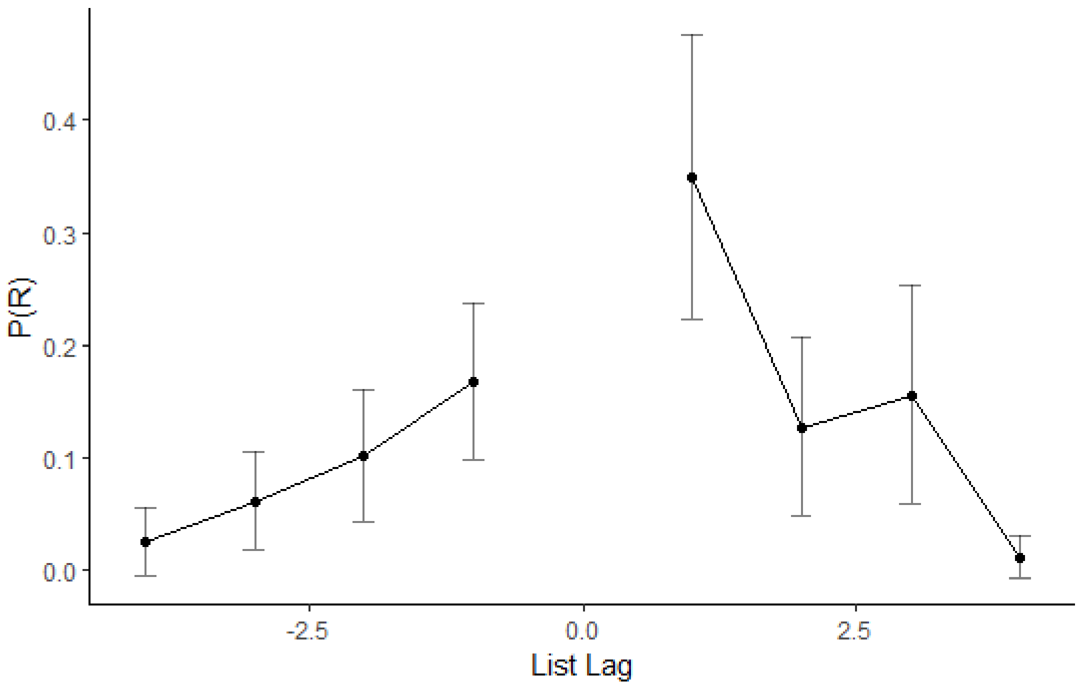

Figure 14. Lag-CRP plot for the between list contiguity effect in pilot study. The error bars are 95% CI of the mean.

Shapiro-Wilk test did not indicate a violation of normality (W=.923, p=.414). Another t-test was conducted to test asymmetry, again with grouped list lags between LLs +1,+2 and LLs -1,-2. A significant difference in recall performance was observed between positive lags (M=7.55, SD=2.92) and negative lags (M=4.33, SD=2.35), $t(8)$=2.66, p=.029, d=.887, CI=[.43,6.01] with the mean difference 3.22. Wilcoxon rank sum test also revealed a significant asymmetry ($W(8)$=32.5, p=.047, r=.806). The proportion of recalling the 1st item within pair across between-list responses was 51.2% (SE=6.48%).

List positions of responses are plotted in Figure 10, the figure demonstrates a list recency effect. Since distractor tasks were all the same after all lists, a long-term recency was observed in the pilot study.

2.2.3. Discussion

Within-list contiguity was not observed due to having a small number of participants in the pilot study and even a smaller number of data points for this condition. In addition, a forward asymmetry was not observed in within-list responses. However, between-list contiguity effect and the forward asymmetry was significant. The proportion of recalls from within pairs was around 50% with random fluctuations of the data across different conditions. Thus, the long-term contiguity effect was found along with a forward asymmetry while the proportion of the recalled items within the pair position was similar. Having more data points would reveal more robust findings in the experiment.

The reason behind conducting a pilot study was to understand how the experiment works due to its complex nature. Therefore, a practice session was decided to be added to the experiment based on participants' feedback. No recency effect was observed among within-list serial positions of the pairs; however, a long-term recency effect was found across lists due to the same duration of distractor task throughout the experiment. This distractor probably mimicked a recall pattern of the continuous distractor task. Additionally, 1 minute distractor (30 s mathematical calculation, 30 s blank screen) between each list was discussed as too long that prevent participants to recall from the right list, so it was reduced to 15 s of mathematical calculation and 15 s of blank screen. Also, the study session was totally self-paced which required a sentence production with each pair. It was observed that some participants spent too little time to study word pairs through the last lists. So, a minimum study duration for each pair was added for the experiment.

2.3. The Experiment

2.3.1. Method

The current thesis is registered in Open Science Framework. All materials are available at https://osf.io/da5zv/.

2.3.1.1. Participants

A power analysis was performed prior to experiment with G-Power software (Razali et al., 2011). The estimated sample size was 76 for the paired-samples t-test and for 0.99 power with two-tailed with .05 alpha and 0.5 DZ effect size.

85 participants participated in the experiment from Middle East Technical University for partial course credit or monetary compensation. 10 were excluded from the analysis, 3 could not report recall response due to MATLAB error, 2 could not

continue the experiment due to MATLAB crash, 2 left the experiment room during the experiment, 1 reported they had ADHD diagnosis, 1 informed they were foreign national, and 1 exceeded the average duration to complete the experiment by 2 standard deviations. Remaining 75 (M_{age}=22.04, SD_{age}=2.9) participants 70.7% of them were identifying themselves as women, 28% were as men, one participant was identifying their gender as other. All the participants were native Turkish speakers with normal or corrected to normal vision.

Additionally, due to a mistake in the data collection phase, first five participants were presented only one distractor after the 5^{th} (last) list; therefore, 2 sets of analyses were performed. They are excluded from the data for the main analyses, additional analyses can be found in the appendix.

2.3.1.2. Materials

The lists that were constructed in the preliminary study were used in this experiment. And the experimental code was the same as the pilot study with small additions.

2.3.1.3. Design and Procedure

Ethical approval had been taken from the METU Ethical Committee in March 2022. The experimental procedure was the same as the pilot study except from the change in distractor duration, minimum study duration for each pair, and adding a practice session. The distractor task consists of 15 s of arithmetic calculation and 15 s of blank screen. At the end of the 5th list distractor was added for two times to prevent long term recency effect that was observed in the pilot study. Minimum study duration for the pairs was determined to be 3 s based on the overall study reaction time in the pilot study, however, there was no maximum limit to study the word pairs, participants proceeded with their pace. Additionally, a practice session was added to the experiment after verbally delivering the instruction due to the hard nature of the experiment. During practice session, participants saw three lists with three word pairs in each list with distractor task in between. They were free to ask questions about the experimental procedure. After the practice, they were not allowed to leave the room or ask questions. Remaining steps were the same as the pilot study.

2.3.2. Results

7 responses with one-letter misspelling were corrected and response words were checked for correction in Turkish characters manually.

30 true probe pairs were presented for recognition judgment as in the pilot experiment. 1230 data points were acquired out of 2100 potential data points (58.57%, $SD_{performance}$=22.1%) with a range of .03% (1/30) to 93.3% (28/30). Proportion of recognizing the pairs correctly was 96.05% (28.81/30) and the percentage of recalling a word from the correct list was 31.05% (*SD*=20.5%). The same software was used for all the analyses. A long-term recency effect was observed even before the double distractor tasks were implemented (Figure 15).

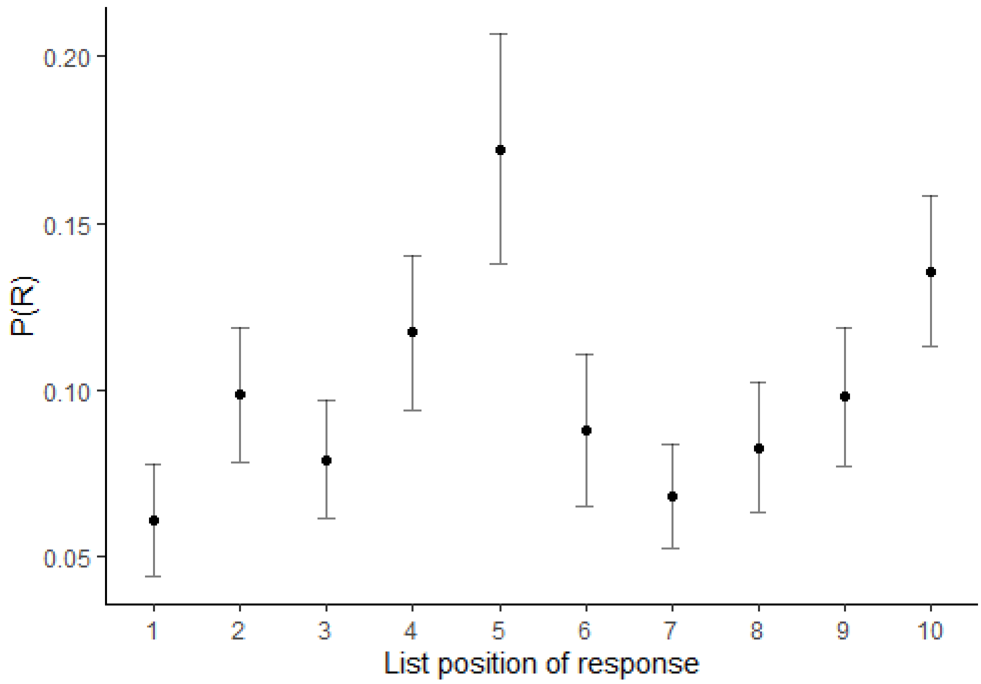

Figure 15. List position curve of response. Each data point represents recall probability of an item from the corresponding list. The error bars are 95% CI of the mean.

In addition, the left side of Figure 16 illustrates probability of recall as a function of the serial position of the probe which demonstrates a slight advantage for the 3rd and the 8th probe. The right side illustrates the probability of recall as a function of the serial position of response, which indicates a higher probability of recalling words from the middle pairs while the probability of recall slightly decreases towards the 10th pair.

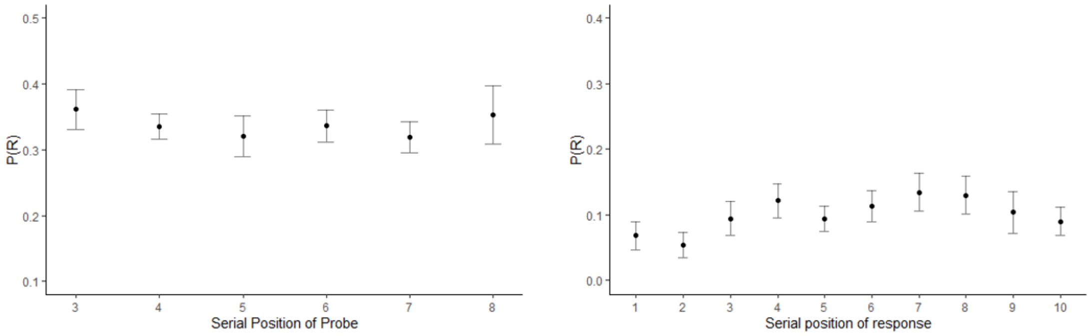

Figure 16. Serial position curve of probe pairs (left) and serial position curve of response (right) in the experiment. Each data point represents the recall probability as a function of serial position of probe (left), and of response (right) within the list. The error bars are 95% CI of the mean.

The mean proportion of recalling the first word within the pair across all responses was 55.2% (*SE*=1.97%) (Figure 17). However, sum of recalled items' positions within the pairs are approximately the same.

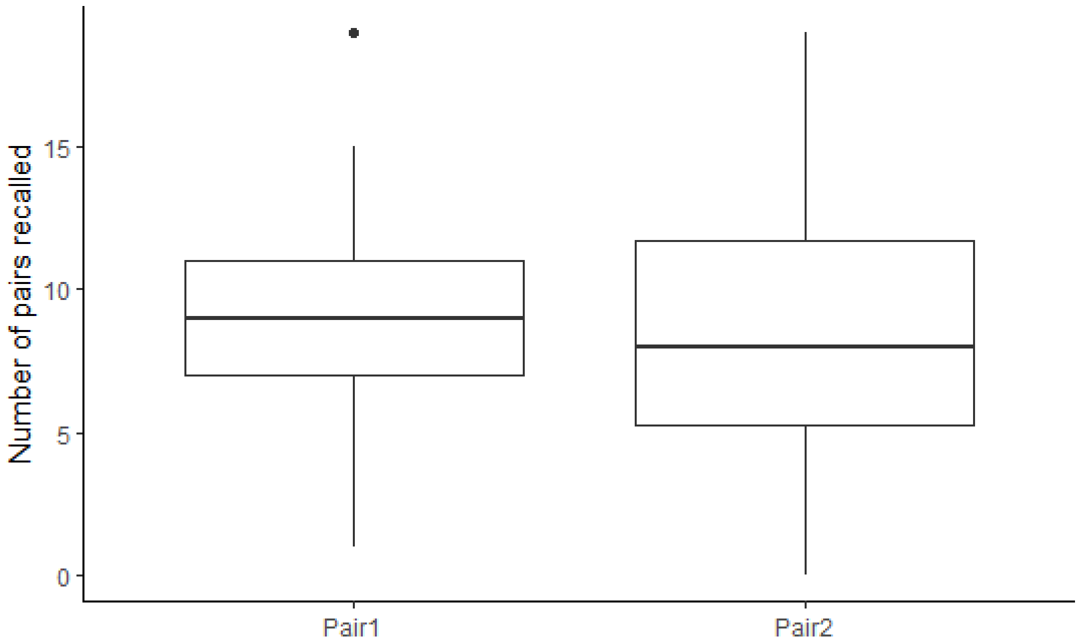

Figure 17. A boxplot of recalled items within the pair in the experiment

2.3.2.1. Data Organization

Data organization was the same with the pilot study.

2.3.2.2. Within-List Contiguity Effect

To measure the short-term contiguity effect, the responses from the same list as the probe pairs were analyzed. Since participants could recall words from the correct list only 31.05% (382/1230) of the time, only a small number of data points were available for this analysis. As in the pilot study, word-lags were grouped while testing the within-list contiguity effect. 2 participants could not recall any words from the right list, so data from 68 participants were analyzed. Figure 18 illustrates the conditional response probabilities (CRP) of each word lag.

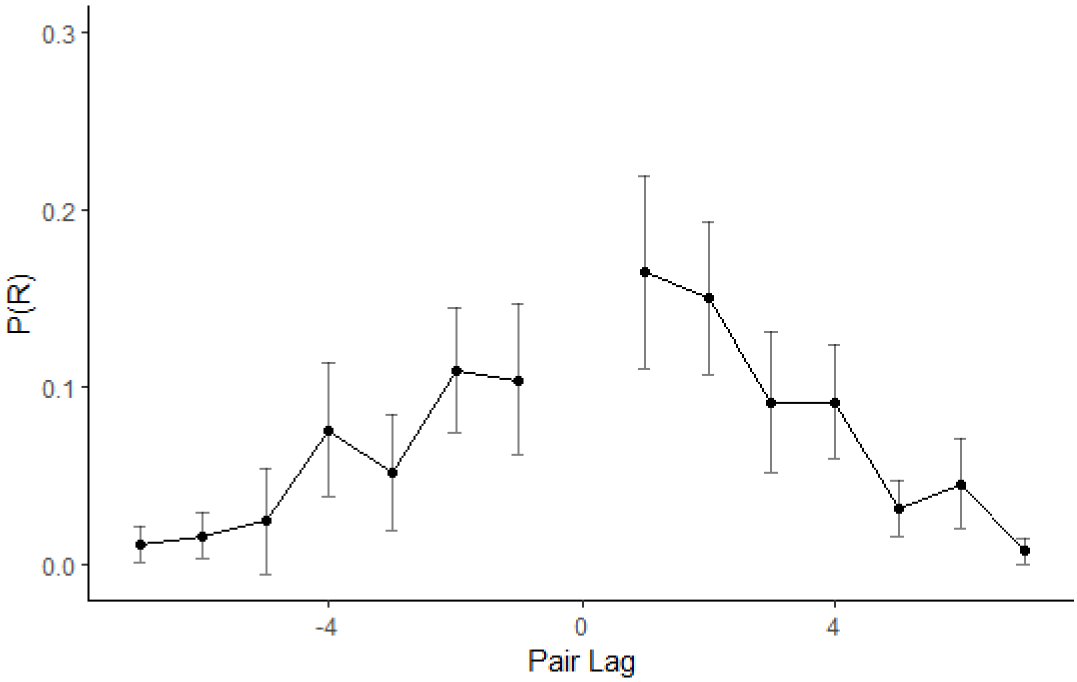

Figure 18. Lag-CRP plot for the within-list contiguity across pairs in the experiment. The error bars are 95% CI of the mean.

Prior to the analysis, Shapiro-Wilk test of normality was performed which indicated violation of the normality assumption (W=.794, p<.001). Therefore, Wilcoxon sign rank test was performed along with the paired samples t-test. The paired samples t-test demonstrated that responses came from the pairs in the nearby position to the probe. WLs 1,2,3 (*M*=3.81, *SD*=3.19) were recalled more than the pairs in the distant positions, WLs 5,6,7 (*M*=.81, *SD*=.996), *t(*67)=8.67, *p*<.001, *d*=1.05 , *CI*=[2.31, 3.69] with the mean difference of 2.92. Wilcoxon rank test also revealed a significant difference for the within-list contiguity effect *W(*67)=1995, *p*<.001, *r*=.979.

Another analysis was performed to test whether there is a forward asymmetry between positive and negative lags in recalled words across pairs. Since the Shapiro-Wilk test indicated a violation of normality (*W*=.835, *p*<.001), The Wilcoxon test was performed with paired samples t-test. Paired samples t-test did not report a significant difference between forward (*M*=2.07, *SD*=1.35) and backward (*M*=1.74, *SD*=2.22) lags (*t(*67)=1.53, *p*=.131, *d*=.185, *CI*=[-.104, .78]). However, the Wilcoxon rank sum test revealed a significant asymmetry (*W(*67)=419, *p*=.02, *r*=.367). The proportion of recalling the 1st item within pair across within-list responses was 56.2% (*SE*=3.45%).

2.3.2.3. Between-List Contiguity Effect

The between-list contiguity effect was tested by grouping list-lags as LLs 1,2 and LLs 3,4. Figure 19 illustrates the conditional response probabilities of responses as a function of list they come from. A long-term recency effect was observed (Figure 15).

Shapiro-Wilk test did not indicate a violation of normality assumption (*W*=.973, *p*=.139), but two tests were performed. First, a paired samples t-test was performed to test the contiguity effect which indicated that responses came from the nearby lists. More words were recalled from LLs 1,2, (*M*=8.63, *SD*=4.33) than the distant lists, LLs 3,4, (*M*=3.13, *SD*=2.35), *t(*69)=11.32, *p*<.001, *d*=1.35, *CI*=[4.53, 6.47] with the mean difference of 5.5. The Wilcoxon rank test also revealed a significant result, *W(*69)=2124.5, *p*<.001, *r*=.981. (Figure 19).

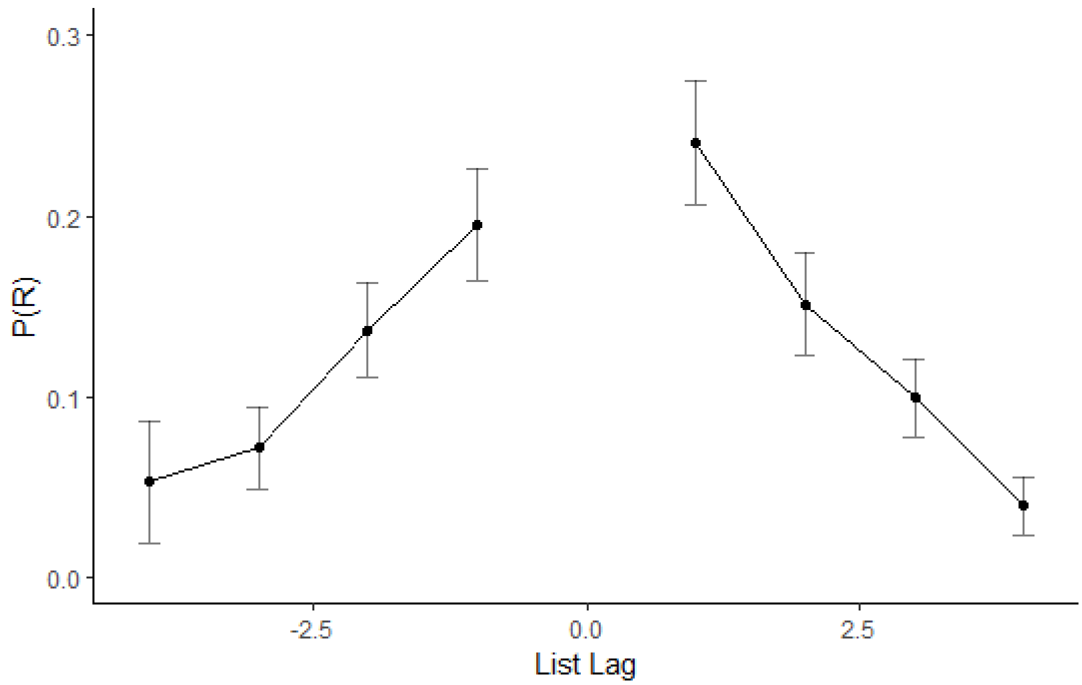

Figure 19. Lag-CRP plot for the between list contiguity effect in the experiment. The error bars are 95% CI of the mean.

Asymmetry was tested with another t-test and Wilcoxon test, since the normality assumption was violated (*W*=.958, *p*=.021). The paired samples t-test indicated that more responses came from positive lags (*M*=4.74, *SD*=2.92) than responses from negative lags (*M*=3.89, *SD*=2.34), *t*(69)=2.35, *p*=.021, *d*=.281, *CI*=[.131, 1.58] with the mean difference of .857. The Wilcoxon rank test also revealed a significant result, *W*(69)=1255.5, *p*=.025, *r*=.328. The proportion of recalling the first item within pair across between-list responses was 53.02% (*SE*=2.43%).

Table 1. Contingency Table for the Observed and Expected Frequencies

	Response list						
Probe list	1	2	3	4	5	Total	P(R)
Observed frequency							
1	56	37	27	49	37	206	0,17
2	39	56	41	47	37	220	0,19
3	31	44	58	45	58	236	0,20
4	34	44	32	62	77	249	0,21
5	17	28	33	43	150	271	0,23
Total	177	209	191	246	359	1.182	
P(R)	0,15	0,18	0,16	0,21	0,30		
Expected frequency							
1	31	36	33	43	63	206	0,17
2	33	39	36	46	67	220	0,19
3	35	42	38	49	72	236	0,20
4	37	44	40	52	76	249	0,21
5	41	48	44	56	82	271	0,23
Total	177	209	191	246	359	1.182	
P(R)	0,15	0,18	0,16	0,21	0,30		

Note: The frequencies are total number of responses collapsed across all responses of all participants. The rows indicate the responses given to probes from Lists 1 to 5. The columns indicate the number of responses from each list. The diagonal is the responses coming from the same list as the probe pair. The lower section demonstrates the expected frequencies which calculated by multiplying marginal probabilities with total number of responses for each cell. These values represent the expected frequencies if responses are independent from the probe pair. The observed frequencies across the diagonal are greater than expected frequencies in average which indicated responses were given as the same with probe list above chance. In addition, observed frequencies are lower than expected frequencies as list lag increases.

The table demonstrates the observed and expected frequencies of responses according to the list they come from and the list position of the probe. The responses on the diagonal represents the within-list responses, meaning that the probe and the response are coming from the same list. If participants performed perfectly, all the responses would be on the diagonal because they were asked to recall a word from the same list as the probe. The between-list contiguity effect can be observed in addition to Figure 19, as the study list becomes farther from the list of the probe number of responses decreases. Participants tended to provide a response to the probes coming from the later lists (i.e., the average in the first row of Table 1 is 17% while last row is 23%). Similarly, the responses displayed an across-list recency effect, responses came from the last list compared to the other lists (30%, 359/1182).

To control the list position effect, the observed response frequencies were compared with the expected frequencies. Expected frequencies refer to the expected performance if responses were independent of the probe word. The lower section of Table 1 demonstrates the expected frequency for each cell, which was calculated by multiplying marginal probabilities of the corresponding cell; that is, the expected frequency if the response list was independent of the probe list. A between-list contiguity effect would result in systematic deviation from expected frequencies. The ratio of observed frequencies to expected frequencies were used to quantify this deviation. For instance, the observed probability of recalling a word from List 1 given probed with a pair from List 1 was 0.272 [P(R1|P1) = 56/206]. The expected probability in the same condition is 0.149 [P(R1|P1) = 31/206]. The ratio of observed to expected probability is 1.83. A ratio that is greater than 1 indicates that participants recalled more words from that list than expected if responses were independent of the probe; a ratio lower than 1 means that the number of recalled words were less likely than expected. Table 2 demonstrates the ratios of observed and expected probabilities. The table here shows that when participants couldn't recall a word from the correct list, they tended to generate a word from nearby lists. That is, as we move from the diagonal of the table towards outer ends, ratios lower than 1. As in the Table 1 the diagonal shows the ratio of observed and expected probabilities that probe, and response belong to the same list which shows the probe's efficiency in returning to the correct list. In each row, the ratio decreases as the response list becomes farther from the probe list.

Table 2. Contingency Table for the Ratio of Observed and Expected Probabilities

	Response List				
Probe List	1	2	3	4	5
1	1,815	1,016	0,811	1,143	0,591
2	1,184	1,440	1,153	1,026	0,554
3	0,877	1,054	1,521	0,916	0,809
4	0,912	0,999	0,795	1,196	1,018
5	0,419	0,843	0,754	0,762	1,822

Note: The ratio of observed to expected probabilities are greater than 1 on the diagonal which quantifies participants returned to the same list as the probe pair.

2.3.2.4. Within-Pair Analysis

Recall asymmetry in pairs of all recalls were analyzed by comparing the proportion and the total number of recalls coming from the first pair and the second pair. The total number of recalls were analyzed in addition to proportions because proportion of recall of the first or second pair could be 100% even though participant recalled only one word in the whole experiment. Therefore, comparing both measures was necessary.

Data were not normally distributed, Shapiro-Wilk test indicated a violation (W=.901, p<.001). A paired samples t-test and the Wilcoxon rank test were performed to compare the recall proportions of the first and the second word in the pair. The proportions of the first word in the pair was recalled more (*M*=.553, *SD*=.165) than the second word in the pair (*M*=.447, *SD*=.165), *t*(69)=2.672, *p*=.009, *d*=.319. The Wilcoxon rank test was not significant, *W*(69)=1233.5, *p*=.072, *r*=.263. However, when the total number of recalls of the first word (*M*=9.157, *SD*=3.549) to the second (*M*=8.414, *SD*=.4.525) compared, Shapiro-Wilk test did not reveal a violation of normality assumption (*W*=.972, *p*=.118) both tests were conducted. According to both paired samples t-test (*t*(69)=1.32, *p*=.191, *d*=.158) and Wilcoxon rank test (*W*(69)=1132, *p*=.276, *r*=.159) were not reported significant difference between total number of recalls of the first or second word in the pair.

2.3.3. Discussion

Three changes were made in this experiment compared to the pilot experiment. First, addition of a practice session helped participants to understand the flow of the experiment better and allowed them to ask questions before beginning the experiment. Second, the double distractor was added at the end of study session before the test session to prevent the long-term recency effect. Third, the distractor duration was reduced from 30 s of mathematical calculation and 30 s of blank screen to 15 s calculation and 15 s blank screen which had a positive effect on the within-list recall performance. Thus, compared to the results of the pilot study, all changes were necessary.

Data were not normally distributed in some cases; therefore, parametric, and non-parametric tests were performed to be able to compare the findings. Contiguity effect was found both within and across lists. Findings from both analyses (including and excluding the first 5 participants) indicated a forward asymmetry across-lists in paired samples t-tests and Wilcoxon tests. However, Wilcoxon tests indicated a forward asymmetry whereas paired samples t-tests were not significant in within-list analyses. In addition, all findings except for one exhibited symmetric recall in pairs, thus we can conclude that pairs were recalled symmetrically in this experiment.

CHAPTER 3

GENERAL DISCUSSION

A preliminary study, one pilot study, and one experiment were conducted in the scope of the thesis. The preliminary study was conducted to choose the word pairs for the experiment. Words were translated into Turkish from Kılıç et al. (2013) study by Hazal Arpacı. Then, word pairs were randomly constructed and rated by human raters regarding their semantic relatedness. Study lists were constructed with the word-pairs whose mean semantic relation rating was less than 5 points. Hit rates were extremely high in the pilot study (100%) and in the experiment (96.05%); participants easily recognized the pair they studied. However, in the pilot study, the proportion of responses of all possible data points was 68.5%, with 22.5% recalling from the right list; in the experiment, total responses were 58.6% of all possible data points, with 31.9% recalling from the right list. The duration of distractor task was reduced, which increased the recall performance from the correct list. As the differences between expected and observed response frequencies showed, a long-term recency effect was observed despite having a double distractor task between study and test blocks. So, the probability of recalling a word from the last list was higher than all the previous lists. The probability of having response as a function of probe's serial position seemed to vary stochastically with a slight increase when participants were probed with the third and the eighth probes. The probability of recalling a word as a function of the pair's serial position within the list demonstrated no primacy or recency effect; on the contrary, the probability was slightly higher in the middle pairs.

First, all pairs were treated as one item to analyze across pair short-term and long-term contiguity effects. Short-term contiguity means observing the contiguity effect in shorter time scales, without a distractor task between studied items. Long-term contiguity is observed in longer time scales, usually when distractor tasks were included between items or even longer time scales. Since data were not normally distributed in some cases, the Wilcoxon rank test was performed along with paired samples t-test. Within-list contiguity was not significant in the pilot study, while it was found to be significant in the experiment. Between-list contiguity effect was significant in both pilot and experimental studies. Wilcoxon rank test indicated a forward asymmetry in the within-list contiguity effect while paired samples t-test did not. Both analyses were not significant in the pilot study. Forward asymmetry in between-list contiguity was found to be significant both in the pilot and in the experiment. Kılıç et al. (2013) reported both short and long-term contiguity effects but could not find a forward asymmetry. They also reported a long-term recency effect across-lists with 75 s of arithmetic task and 75 s blank screen and double distractor task before the test. Therefore, the across-pair within and between list contiguity findings replicated Kılıç et al. (2013) findings. Different from that forward asymmetry was observed within and between-list conditions, which were missing in Kılıç et al. study. Additionally, their study clearly indicated that using longer distractor tasks was not efficient in preventing robust long-term recency effect. Lastly, the intended effects were observed compared to Kılıç et al. (2013)'s study. First, this study was easier which can be seen in recall performances from the correct lists being 31.05% (*SD*=20.5%) in this study, compared to 18% (*SD*=9%) in theirs. Second, sentence encoding task might have causes deeper processing of items compared to abstract/concrete ratings. Alternatively, studying pairs might allowed participants to encode one item in the pair stronger which enabled to recognize or recall at least one of the pair items in the test.

The contiguity effect reflects the associative mechanisms in the memory system. It can be observed in the free recall and the recognition tasks and, most importantly, intrusions of serial and cued recall tasks. In shorter scales, the contiguity effect occurs automatically with a forward asymmetry. Various contiguity-generating mechanisms were proposed; however, automaticity and forward asymmetry of contiguity cannot be accounted for most of them. Time scale similarity is another robust feature of the contiguity effect that dual store memory models cannot explain. Despite being a dual-store account, control process models can account for the time scale similarity by suggesting that participants develop encoding strategies depending on the task demands. However, this assumption contradicts with automaticity of the contiguity effect. On the other hand, contextual coding models can naturally generate the contiguity effect with a forward asymmetry and time scale similarity in the contiguity effect using context assumptions.

In TCM, studied item causes a drift in the experimental context, so successively studied items have similar contexts. When one item is recalled or presented as a cue in the test session, its context becomes activated which naturally activates the context of nearby items. Also, since the pre-experimental context of an item is only associated with the forward item, forward asymmetry occurs. Therefore, TCM naturally accounts for automaticity, forward asymmetry, and time scale similarity in the contiguity effect. While the Buffer model is a control process model with limited capacity buffer that acts accordingly to the task demands via rehearsal and compartmentalization. According to the model, interitem associations are formed between items that co-occur in the buffer which also have similar contexts. Co-occurrence of items and their similar contextual information results in the contiguity effect. The model also posits that the current test context plays role in probing memory. However, as the other control process models, automaticity in contiguity effect and long-term effects challenges the Buffer model. To sum up, TCM has a clear view of the contiguity and the recency effects in all time scales compared to the Buffer model. However, this thesis aims to test pair and list memory in one task. The Buffer model was chosen to be compared with TCM because it has a specific prediction for encoding of pairs which TCM does not have.

Association among items was studied using paired associates, which raised whether pairs are encoded as a whole (ASH) or independently (IAH). Forward and backward asymmetry was investigated in cued recall using paired associates, which revealed symmetric findings, whereas forward asymmetry was consistently found in serial recall and associative recognition. Therefore, it was concluded that the asymmetry findings are modulated by tasks (Kahana, 2002; Yang et al., 2013). The differences in the asymmetry findings according to tasks may support the assumptions of control process models. Participants could be developing different encoding strategies in different tasks based on task demands.

The main research question of this thesis was whether the encoding dynamics of paired associates are different from the serial lists. However, single items and paired associates have been studied in different tasks in the literature; therefore, it is difficult to compare them. Only two free recall studies were conducted with paired associates, one supporting holistic association (Mandler et al., 1981) and the other supporting forward asymmetry (Lehman & Malmberg, 2013) in pairs. Therefore, we approached this problem using paired associates in a probed recall task. In this task, the traditional study and test cycle is broken, allowing to study short- and long-term effects together; additionally, combining the paired-associates paradigm with this task allowed the investigation of retrieval differences within and across-pair. The significance of the procedure is testing the pairs without giving either of them as a cue.

Encoding of pairs was investigated by comparing the proportion and the total number of recalls of the first and the second items in the pair. Proportions reflected participants' percentage of recalls of the first word and the second words in the pair which was fragile to low performers' proportions. So, paired samples t-test revealed significance in favor of forward asymmetry while Wilcoxon test was not significant when proportions were tested. In contrast, both tests on sum of recalls did not reveal any significance. Although it was not hypothesized, the proportions for pairs were calculated for within (56.2% for the first item) and between-list (53.02% for the first item) responses which showed no systematic difference. These findings align with Davis et al. (2008) findings of cued recall intrusions. Thus, symmetric retrieval was observed in pairs while forward asymmetry was observed in list recalls. Differential retrieval patterns for pairs and serial lists have been found in this thesis.

Participants engaged in sentence encoding while studying each pair, which encourages focusing on one pair at a time. Sentence encoding task was used to control possible encoding strategies and deep encoding of the pairs. Also, they were not instructed to preserve the order of the pairs in sentences. So, pair items were randomly used in the sentences, and word forms were used interchangeably to form the sentences, which might endorse the holistic association of pairs.

TCM does not have an explicit assumption for pair encoding, which is missing feature of the model. To my knowledge, this is the first time that TCM has been tested using paired associates. Across pair patterns in the thesis aligned with the findings of pair and triple intrusions (Caplan et al., 2006; Davis et al., 2008; Kahana & Caplan, 2002), and within-pair patterns aligned with cued recall studies (Caplan et al., 2006; Davis et al., 2008). We found symmetry in the retrieval of pairs which supported Caplan (2005)'s claim of shared context in pair encoding. On the other hand, the Buffer model makes explicit assumptions regarding pair encoding by differentiating buffer operations. Participants focus on pair learning by rehearsing, which reduces buffer capacity. Pairs are encoded as chunks; only one pair stay in the buffer, not allowing co-rehearsal of successive pairs. Associations within chunks are strongly correlated, but across chunks are minimal. The context of the chunk is correlated with the first item so that recall begins with the first item in the pair, resulting in forward asymmetry within pairs. Additionally, the model predicts a stronger forward asymmetry across-pair compared to single items.

3.1. Limitations

The most important limitation of this study was having small number of data points per participant (30). In the probed recall task, participants study multiple lists and tested by randomly selected probes from those lists; so only 15 responses to 5 lists of 10 pairs could have been obtained. In the current study, there were 2 cycles resulting in 30 possible data points per participant Moreover, since it is a hard task, participants gave a response around 58% of the time which means losing almost half of the data points. 31% of the obtained responses were coming from the right list.

The second limitation was not controlling the study words with Latent Semantic Analysis as it was initially intended. As mentioned, the first plan was to control semantic relation among the word using the LSA model (Landauer & Dumais, 1997) and SEMMOD package (Stone et al., 2008) as in the original study (Kılıç et al., 2013). Additionally, the word pool was too small to be properly randomized for each participant. Word pairs were further needed to be controlled in terms of word frequency and word forms of items, abstractness, concreteness, and imageability of items to randomize and construct pure pairs.

Another limitation was failing to strictly control the study and recall duration of each item. Only minimum study duration was controlled, which resulted in great deviations in experiment duration (*M*=34.84 min, *SD*=7.5 min). This variation can be one of the reasons for not seeing a statistically reliable result for asymmetry across time scales.

3.2. Future Research

Firstly, although this study has a small number of data points, the intended effects were observed. However, the performance varied greatly, so having more data points per participant would be beneficial to observe the effects robustly. Therefore, this study could be conducted in two sessions (4 cycles) resulting in 60 possible data points per participant. Moreover, some participants informed me that they changed the initial encoding strategy in the second cycle to perform better in the second cycle. They constructed a story for each list to discriminate better. So, if we have more study-test blocks in the experiment, we could observe the testing effect in the contiguity effect. In fact, Healey et al. (2019) reported that the contiguity effect increases with task experience. Also, another study can be conducted to test the effect of preserving the order of pairs in sentence encoding tasks on pair retrieval. In addition, since the number of data points per participant is small and data is not normal, Bayesian reanalysis could be performed with these data to examine the mean differences.

Secondly, intrusions were not analyzed in this study. Participants erroneously recalled words from the previous study block and practice session. They also recalled the same words over and over again. Thus, a future study might focus on the repetitions and intrusions.

Thirdly, semantic properties of words can be controlled to construct semantically unrelated word pairs. That study might be compared with this one to see whether words with human-raters and systematic selection. However, controlling only semantic relation is not sufficient for paired associates; so, word forms, abstractness, concreteness, and imageability of words should also be controlled.

The probed recall task originally conducted with single words using abstract/concrete judgment in the study session (Kılıç et al., 2013) which reported the contiguity effect in short and long terms, and long-term recency. In an unpublished thesis from our lab, contiguity effect replicated Kılıç's effects and found forward asymmetry using single words with pleasantness judgment in the study session (Arpacı, 2022). This study used sentence encoding for the pair items which resulted in a gap between single-item and pair-item probed recall tasks. To bridge the gap, pair-item probed recall task can be conducted with pleasantness judgment to test whether the effect will be observed.

Lastly, the probed recall task combines two main memory tasks: recognition and recall. Both recognition and recall tasks have distinct effects and theories in which memory models usually specialize in either recognition or recall. For instance, TCM (Howard & Kahana, 2002) and SAM (Raaijmakers & Shiffrin, 1981) were developed to explain the dynamics of recall, whereas REM (Shiffrin & Steyvers, 1997) accounts for the mechanisms behind recognition. Combining two tasks would enrich the literature by providing a clearer distinction between well-known effects and the probability of introducing new ones. For example, recognition performance was 96.05%, whereas recall performance was 58.57% in this study.

Further, the probed recall task was combined with paired associates enabling us to study them without giving either as a cue. This allowed us to study forward asymmetry in three conditions: in paired associates, short-term contiguity, and long-term contiguity. The Buffer model can account for probed recall task and forward asymmetry in contiguity in probed recall; yet the chunking mechanism might be updated. The mechanism assumes that context is correlated with the first item in the pair and starting recall with the first item in the pair. Nevertheless, we observed a symmetric retrieval in pairs, so adding the isolation principle would explain the findings (Caplan et al., 2006). Furthermore, TCM lacks an explicit pair assumption despite supporting the shared context assumption.

3.3. Conclusion

It was hypothesized that a contiguity effect with forward asymmetry would be found in within-and between list results along with symmetric performance of retrieval of pair items. All the effects were observed except forward asymmetry in within-list contiguity effect in the pilot study. The findings are built on the top of Kılıç et al. (2013)'s study illustrating that the contiguity and asymmetry can be observed in the probed recall task. Also, participants correctly recognized the probed pairs, yet could not recall as much.

This is the first time that pairs are studied without giving neither of them as a cue and showed associative symmetry. Therefore, these findings are important milestone for associative symmetry discussions. The probed recall task limits the recall patterns compared to free recall but sets participants free than the cued recall. So, it can serve as an intermediate between two tasks that allows to observe the retrieval dynamics of pair and serial lists together. Lastly, this thesis suggests modifications for the memory models for them to add predictions for paired associates in their models to develop broader understanding of human memory.

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APPENDICES

A. APPROVAL OF THE METU HUMAN SUBJECTS ETHICS COMMITTEE

UYGULAMALI ETİK ARAŞTIRMA MERKEZİ
APPLIED ETHICS RESEARCH CENTER

ORTA DOĞU TEKNİK ÜNİVERSİTESİ
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14 MART 2022

Konu : Değerlendirme Sonucu

Gönderen: ODTÜ İnsan Araştırmaları Etik Kurulu (İAEK)

İlgi : İnsan Araştırmaları Etik Kurulu Başvurusu

Sayın Aslı KILIÇ ÖZHAN

Danışmanlığını yürüttüğünüz Tuğba HATO'nun " Kelime Çiftlerinin Bellekte Kodlanma Dinamiklerinin Yoklayıcı Hatırlama Görevi ile İncelenmesi" başlıklı araştırmanız İnsan Araştırmaları Etik Kurulu tarafından uygun görülmüş ve **0164-ODTUİAEK-2022** protokol numarası ile onaylanmıştır.

Saygılarımızla bilgilerinize sunarız.

Prof.Dr. Mine MISIRLISOY
İAEK Başkan

B. INFORMED CONSENT FORM

ARAŞTIRMAYA GÖNÜLLÜ KATILIM FORMU

Bu araştırma ODTÜ Psikoloji Bölümü öğretim üyelerinden Doç. Dr. Aslı Kılıç Özhan danışmanlığında, Tuğba Hato'nun yüksek lisans tezi kapmamında yürütülmektedir. Bu form sizi araştırmanın koşulları hakkında bilgilendirmek için hazırlanmıştır.

Çalışmanın Amacı Nedir?

Bu çalışma yeni bilgiler öğrenirken belleğimize bu bilgileri nasıl kaydettiğimizi ve sonrasında nasıl hatırladığımızı araştırmaktadır.

Bize Nasıl Yardımcı Olmanızı İsteyeceğiz?

Araştırma ODTÜ Psikoloji Bölümü Bilişsel Psikoloji Laboratuvarı'nda yapılacaktır. Üniversite öğrencileri katılımcı olarak davet edilecek, katılmak isteyenler yaklaşık yarım saatlik bir laboratuvar seansına katılacaklardır. Çalışmada size kelimeler gösterilecektir ve daha sonra bu kelimeleri hatırlamanız istenecektir.

Katılımınızlar İlgili Bilmeniz Gerekenler:

Bu çalışma tamamen gönüllülük esasına dayalıdır. Herhangi bir yaptırıma veya cezaya maruz kalmadan çalışmaya katılmayı reddedebilir veya çalışmayı bırakabilirsiniz. Araştırma esnasında cevap vermek istemediğimiz sorular olursa boş bırakabilirsiniz.

Araştırmaya katılanlardan toplanan veri tamamen gizli tutulacak ve kimlik bilgileri ile herhangi bir şekilde eşleştirilmeyecektir. Katılımcıların isimleri bağımsız bir listede toplanacaktır. Ayrıca toplanan veriye sadece araştırmacılar ulaşabilecektir. Bu araştırmanın sonuçları bilimsel ve profesyonel yayınlarda veya eğitim amaçlı kullanılabilir, fakar katılımcıların kimliği gizli tutulacaktır.

Çalışmaya katılanlar bu duyurunun yapıldığı ders için puan alacaklardır. Alınacak puan dersin öğretim üyesi tarafından belirlenecektir.

Riskler:

Çalışma ile ilgili bilinen bir risk yoktur.

Araştırma ile ilgili daha fazla bilgi almak isterseniz:

Çalışmayla ilgili soru ve yorumlarınızı araştırmacıya hato.tugba@metu.edu.tr adresinden iletebilirsiniz.

Yukarıdaki bilgilieri okudum ve bu çalışmaya tamamen gönüllü olarak katılıyorum.

(Formu okuyup imzaladıktan sonra uygulayıcıya geri veriniz.)

İsim Soyisim Tarih İmza

B. THE INSTRUCTIONS OF THE EXPERIMENT

Çalışmamıza hoşgeldiniz. Deneyi doğru bir şekilde ilerletebilmeniz ve deney sırasında herhangi bir aksaklık yaşamamanız için yönergeyi dikkatli bir şekilde okumanız gerekiyor.

Çalışma yaklaşık 40 dk sürecek ve 2 bloktan oluşacaktır. Her blok ise 3 aşamadır: Çalışma, Aritmetik toplama ve Test aşamaları.

1. Çalışma aşaması: Bu aşamada 10 kelime çiftinden oluşan toplam 5 liste göreceksiniz. Bu kelimeleri mümkün olduğunca öğrenmeye çalışmanız beklenmektedir. Her çifti gördüğünüzde, kelimeleri kullanarak sesli şekilde bir cümle kurmanız beklenecek ve bu sırada ses kaydı alınacaktır. Ekrandaki çifti çalışmayı bitirdiğinizde "b" tuşuna basarak bir sonraki çifte geçebilirsiniz.

2. Aritmetik aşaması: Ekranın ortasında bir sayı göreceksiniz, ilk gördüğünüz sayıyı yazıp "enter" tuşuna basmanız gerekiyor. Sonra, gelen bir sonraki sayı ile gördüğünüz bir önceki sayıyı toplayarak ekrana yazıp tekrar "enter"a basacaksınız. Aritmetik aşaması sona erene kadar bu şekilde devam etmeniz gerekmektedir.

Her listeyi çalıştıktan sonra aritmetik toplama yapacaksınız ardından bir süre boş ekranla beraber bekleyeceksiniz.

3. Test aşaması: Gördüğünüz listelerin herhangi birinden size rastgele bir kelime çifti verilecek. Öncelikle bu çifti daha önce görüp görmediğinizi söylemeniz isteniyor. Eğer cevabınız EVETse "c" tuşuna, HAYIRsa "m" tuşuna basmalısınız. Ardından o kelime çiftini gördüğünüz listeden başka TEK bir kelime getirmenizi istiyoruz.

Herhangi bir sorunuz varsa deney başlamadan yürütücüye sorabilirsiniz, deney sırasında dışarı çıkmamalısınız. Eğer sorunuz yoksa boşluk tuşuna basarak başlayabilirsiniz.

C. EXAMPLE OF PRELIMINARY STUDY

Kelime çiftlerinin semantik ilişkisi

Bu çalışma ODTÜ Psikoloji bölümü bünyesinde Tuğba Hato'nun yüksek lisans tez deneyi için bir ön çalışmadır. Çalışmada gördüğünüz kelime çiftlerinin birbiriyle ne kadar ilgili olduğunu 1-10 arasında puanlamanızı istiyoruz. 1 kelimeler hiç alakalı değil demek, 10 ise kelimeler birbiriyle çok alakalı demektir.

Çalışma tahmini olarak 15 dk civarı sürecektir, lütfen cevaplarınızı tek seferde veriniz aksi halde form yarım kaydedecektir. Çalışmaya katıldığınız için teşekkür ederiz. Çalışmayla ilgili bir sorunuz olursa hato.tugba@metu.edu.tr adresinden sorularınızı sorabilirsiniz.

Not: Çalışma sırasında e-posta adresiniz ve kimliğinize dair hiçbir bilgi kaydedilmemektedir.

(1: kelimeler hiç alakalı değil,
10: kelimeler çok alakalı)

İlerleme durumunu kaydetmek için Google'da oturum açın Daha fazla bilgi

Yaşınız?

Yanıtınız

Cinsiyetiniz?

Yanıtınız

Şu anki eğitim düzeyiniz?

Yanıtınız

uçurtma - buhar

1	2	3	4	5	6	7	8	9	10
○	○	○	○	○	○	○	○	○	○

imrenme - amaç

1	2	3	4	5	6	7	8	9	10
○	○	○	○	○	○	○	○	○	○

ceza - metin

1	2	3	4	5	6	7	8	9	10
○	○	○	○	○	○	○	○	○	○

ekmek - yabancı

1	2	3	4	5	6	7	8	9	10
○	○	○	○	○	○	○	○	○	○

panorama - araç

1	2	3	4	5	6	7	8	9	10
○	○	○	○	○	○	○	○	○	○

D. SUMMARY OF PRELIMINARY STUDY RESULTS

	Mean	Std. Deviation	Minimum	Maximum
uçurtma - buhar	4.400	2.280	1.000	8.000
imrenme - amaç	4.550	2.481	1.000	10.000
ceza - metin	3.750	2.613	1.000	9.000
ekmek - yabancı	2.800	1.673	1.000	6.000
panorama - araç	2.850	2.346	1.000	8.000
öğretmen - saman	2.650	2.254	1.000	10.000
takım - tenis	6.550	2.328	2.000	10.000
kurucu - bilezik	2.684	2.083	1.000	8.000
bandaj - kalıtım	2.750	2.124	1.000	9.000
güvercin - katır	6.200	2.331	2.000	10.000
kiriş - melez	1.900	1.119	1.000	4.000
alıcı - mücevher	6.750	1.650	2.000	10.000
volkan - rapor	2.950	2.502	1.000	9.000
film - musibet	4.850	2.368	1.000	10.000
kaymak - kanca	1.700	1.129	1.000	5.000
unutma - medeniyet	5.800	2.821	1.000	10.000
jokey - kurum	5.000	2.769	1.000	9.000
kavram - tampon	3.000	1.919	1.000	7.000
konfor - faktör	4.450	3.086	1.000	10.000
kıvılcım - ilmik	3.100	2.573	1.000	8.000
veto - organ	3.700	3.326	1.000	10.000
küreselleşme - namaz	2.950	2.350	1.000	10.000
sembol - çıkıntı	3.550	2.089	1.000	7.000
bakımevi - lokomatif	2.450	1.932	1.000	7.000
sarma - evlilik	4.050	2.800	1.000	10.000
yalancı - besteci	3.750	2.381	1.000	8.000
turist - iğne	3.250	2.221	1.000	7.000
omurga - çekmece	2.600	2.062	1.000	8.000
litre - ideal	3.900	2.269	1.000	8.000
demir - sodyum	7.450	1.820	3.000	10.000
çeviklik - sivrisinek	6.750	2.633	2.000	10.000
işaret - bayram	3.800	2.726	1.000	9.000
bluz - ihmal	2.250	2.023	1.000	9.000
ekim - açlık	5.158	2.911	1.000	10.000
konuşmacı - tahribat	3.200	1.936	1.000	6.000
umursamak - stadyum	3.050	1.959	1.000	8.000
kaygı - malikâne	3.400	2.393	1.000	9.000

	Mean	Std. Deviation	Minimum	Maximum
yosun – trajedi	2.350	1.725	1.000	6.000
lale – başlangıç	3.650	2.758	1.000	10.000
kalkan – sicil	3.200	1.963	1.000	7.000
satıcı - küre	4.300	2.155	1.000	8.000
kereste - acele	2.600	1.930	1.000	7.000
baba - merkür	3.350	2.540	1.000	9.000
diken - kürek	2.650	1.461	1.000	6.000
savaş - radyo	7.600	2.349	2.000	10.000
kaydetme - ayna	3.200	1.963	1.000	7.000
veda - kılçık	2.550	2.282	1.000	9.000
alan - nöbet	5.600	2.563	1.000	10.000
gözlük - kaşık	2.900	1.971	1.000	7.000
bronz - program	2.900	2.100	1.000	8.000
dişçi - kahraman	4.500	2.395	1.000	10.000
kunduz - üzüm	2.550	1.877	1.000	7.000
pantolon - çığlık	2.200	1.881	1.000	7.000
bilek - balta	4.100	2.469	1.000	8.000
önemli - kenar	3.250	1.860	1.000	7.000
trans - damar	4.850	2.661	1.000	10.000
kalıp - klarnet	3.100	2.075	1.000	9.000
bitki - yerçekimi	6.000	2.362	2.000	10.000
tank - bayrak	7.050	2.139	3.000	10.000
netice - denek	5.950	2.982	1.000	10.000
gümbürtü - çözüm	2.850	1.981	1.000	7.000
inilti - çaydanlık	3.842	2.387	1.000	8.000
pamuk - eskiz	3.100	2.075	1.000	9.000
asit - fantezi	3.900	2.573	1.000	10.000
roman - pazarlık	5.000	2.362	1.000	9.000
öğrenci - leke	5.350	3.281	1.000	10.000
çerçeve - asbest	3.050	2.743	1.000	8.000
konyak - rozet	2.750	2.197	1.000	8.000
genç - jöle	7.350	2.277	2.000	10.000
keten - ipucu	2.750	1.773	1.000	8.000
inci - hareket	2.800	2.567	1.000	10.000
ülser - depozito	1.900	1.832	1.000	8.000
emek - balon	4.000	2.753	1.000	8.000
hesap - krom	2.500	1.987	1.000	7.000
tuşlamak - tosbağa	2.550	2.305	1.000	8.000
doruk - fragman	3.350	2.390	1.000	8.000
hortum - portre	2.500	1.906	1.000	8.000
yağmur - büküm	2.900	2.382	1.000	8.000
dökmek - biber	6.150	2.996	1.000	10.000
hardal - değer	3.250	2.511	1.000	10.000
zümrüt - zambak	4.895	2.885	1.000	10.000

	Mean	Std. Deviation	Minimum	Maximum
çiseleme - kafes	2.650	2.346	1.000	9.000
suistimal - iyimser	5.550	2.892	1.000	10.000
gram - rakip	2.450	2.038	1.000	7.000
bilim - kapsül	6.700	2.155	2.000	10.000
sünger - armut	3.200	2.913	1.000	8.000
saçmalık - tepsi	2.650	2.254	1.000	8.000
bebek - parça	3.800	2.375	1.000	9.000
koro - dostluk	6.050	2.605	1.000	10.000
köpek - tepki	6.200	2.687	1.000	10.000
battaniye - boğum	3.350	2.207	1.000	8.000
bilmece - mürettebat	2.300	1.895	1.000	7.000
sörf - hükümdar	2.100	1.971	1.000	8.000
basamak - teori	4.600	2.664	1.000	9.000
birim - servet	5.550	2.523	1.000	10.000
maaş - fitil	3.400	2.542	1.000	8.000
tükenme - husus	2.950	1.986	1.000	7.000
akciğer - kılıç	2.550	2.438	1.000	9.000
rüzgar - titreme	7.650	2.323	1.000	10.000
yaprak - sicim	3.800	2.567	1.000	10.000
bela - kilise	3.600	3.016	1.000	10.000
denge - boğaz	5.000	2.714	1.000	10.000
mine - kütüphane	2.450	2.038	1.000	8.000
tahta - bülbül	2.800	1.852	1.000	7.000
kabin - yılbaşı	3.250	2.633	1.000	8.000
yeğen - cıvata	1.900	1.373	1.000	5.000
duygu - bölüm	3.750	2.489	1.000	9.000
asıl - ekonomi	3.250	2.149	1.000	8.000
kese - yüksük	4.650	2.889	1.000	10.000
kadın - tren	3.650	2.540	1.000	10.000
sözleşme - tartışma	6.200	1.824	2.000	9.000
evren - yöntem	5.450	3.000	1.000	10.000
boyut - palyaço	2.950	2.328	1.000	9.000
sığır - hızlı	3.200	1.824	1.000	7.000
tuğla - kanıt	3.400	2.501	1.000	9.000
tapınak - krallık	7.100	2.900	1.000	10.000
kilometre - ıspanak	2.200	1.399	1.000	6.000
ördek - mahkeme	1.900	1.861	1.000	8.000
peri - alabalık	2.050	1.504	1.000	6.000
kitle - jargon	5.211	2.485	1.000	8.000
içgüdü - ilgisiz	3.750	2.359	1.000	9.000
örtü - şemsiye	5.300	2.342	2.000	9.000
kısrak - pişirmek	2.150	1.182	1.000	5.000
müzisyen - cinsiyet	3.750	2.314	1.000	8.000
yonca - yumruk	2.250	1.916	1.000	7.000

	Mean	Std. Deviation	Minimum	Maximum
sandalye - oyuk	3.550	2.874	1.000	10.000
alerji - örümcek	4.650	3.200	1.000	10.000
kanalizasyon - soruşturma	3.950	3.220	1.000	10.000
civa - kanun	3.150	2.739	1.000	10.000
çalılık - pembe	2.600	2.062	1.000	9.000
kinaye - tahıl	1.850	1.268	1.000	5.000
batı - özne	4.600	2.542	1.000	10.000
sinir - mağaza	3.550	2.762	1.000	9.000
kapasite - eksen	3.800	2.668	1.000	9.000
tamirci - ölçüm	6.650	2.681	1.000	10.000
protesto - oturum	5.368	2.290	1.000	10.000
rumuz - masraf	2.250	1.743	1.000	7.000
sıvı - ağaç	4.200	2.764	1.000	10.000
hanedan - ikametgâh	5.200	2.546	1.000	9.000
mineral - örnek	4.250	2.989	1.000	10.000
erkek - özveri	3.850	2.681	1.000	10.000
erik - bölge	3.950	2.460	1.000	10.000
hazine - karbon	3.050	2.188	1.000	7.000
uzay - yüzyıl	6.100	2.553	1.000	10.000
kaplumbağa - gelgit	4.550	2.964	1.000	10.000
endişe - sabır	6.300	2.386	3.000	10.000
labirent - serenat	2.350	2.183	1.000	7.000
kırıntı - fasulye	3.050	2.164	1.000	7.000
güve - yelek	4.737	3.124	1.000	10.000
seviye - heves	3.550	2.235	1.000	10.000
teyze - saygı	5.950	2.685	1.000	10.000
görünüm - afiş	6.000	2.810	1.000	10.000
plaj - nişasta	1.947	1.353	1.000	5.000
deniz - istilacı	4.550	2.911	1.000	10.000
söğüt - sanayi	2.550	2.114	1.000	9.000
çanta - hapis	2.950	2.328	1.000	10.000
rıhtım - mağara	4.100	2.827	1.000	10.000
beyefendi - müttefik	3.200	2.118	1.000	8.000
çekiç - cesaret	3.900	2.900	1.000	10.000
tayın - zehir	1.850	1.565	1.000	6.000
kaldıraç - havuz	3.900	2.360	1.000	9.000
ajans - yanık	1.842	1.537	1.000	6.000
acemi - tercih	3.700	2.577	1.000	10.000
yağma - güvenlik	5.750	2.881	1.000	10.000
çorap - boru	2.300	2.055	1.000	8.000
kapı - aktarma	4.550	2.856	1.000	10.000
engel - yılan	3.900	2.532	1.000	8.000
akademi - kabuk	3.350	2.852	1.000	10.000

	Mean	Std. Deviation	Minimum	Maximum
tripod - bağırış	1.550	1.146	1.000	5.000
amatör - mezar	2.300	2.055	1.000	8.000
taslak - manşet	3.950	2.328	1.000	8.000
haşere - porselen	1.900	1.774	1.000	8.000
güney - ödeme	1.550	1.395	1.000	6.000
baskı - silah	6.400	3.560	1.000	10.000
sömürge - damga	4.950	3.220	1.000	10.000
anten - atom	2.500	2.115	1.000	8.000
cami - mermi	2.900	2.125	1.000	8.000
soğukkanlılık - vekil	3.750	2.173	1.000	8.000
imam - bilgisayar	1.800	1.152	1.000	5.000
takdir - gölet	1.550	1.191	1.000	5.000
metal - kasaba	2.900	2.024	1.000	8.000
levrek - folklor	2.950	2.625	1.000	10.000
domuz - hece	1.550	1.146	1.000	4.000
ahmak - nesne	2.850	2.455	1.000	8.000
olay - çocuk	4.500	2.585	1.000	10.000
rekor - kriz	5.800	3.286	1.000	10.000
anket - donanım	3.900	2.511	1.000	9.000
macun - görev	2.150	1.755	1.000	6.000
destan - kalıntı	5.300	2.993	1.000	10.000
fiil - köstebek	2.600	2.234	1.000	8.000
flüt - tiftik	1.900	1.944	1.000	8.000
koyun - gövde	3.800	2.526	1.000	8.000
kola - bölünme	1.750	1.293	1.000	5.000
araba - gezegen	3.550	2.762	1.000	10.000
klor - tabak	2.650	2.134	1.000	7.000
ithalat - kırpmak	3.300	2.812	1.000	10.000
dalga - çoğunluk	2.750	1.803	1.000	7.000
eğim - okuma	4.300	3.310	1.000	10.000
kafiye - şiir	8.632	2.872	1.000	10.000
eldiven - koridor	1.900	1.651	1.000	8.000
yemek - şafak	3.000	2.362	1.000	10.000
cumhuriyet - ceviz	1.800	1.322	1.000	5.000
terzi - derece	3.100	2.315	1.000	8.000
felç - belge	3.895	2.685	1.000	9.000
sempati - yular	2.250	2.149	1.000	10.000
keman - tost	1.500	1.395	1.000	7.000
adaş - ürün	1.650	1.089	1.000	4.000
benzetme - efsane	4.700	2.080	1.000	9.000
tema - konu	7.700	2.755	1.000	10.000
limon - aspirin	4.200	2.505	1.000	9.000
alay - rahim	1.900	2.337	1.000	10.000
kalabalık – mors	2.150	1.565	1.000	6.000

	Mean	Std. Deviation	Minimum	Maximum
biftek - yurt	2.300	2.080	1.000	8.000
ekşi - göbek	3.105	2.355	1.000	10.000
sonbahar - içecek	4.100	2.469	1.000	10.000
kuyruk - özel	2.950	2.481	1.000	8.000
dizgin - böcek	1.600	1.046	1.000	5.000
ayin - birey	4.100	2.634	1.000	10.000
tazı - daire	2.150	1.387	1.000	5.000
gemi - ozan	3.300	2.342	1.000	7.000
parlak - samimi	4.000	2.534	1.000	9.000
tekerlek - kurs	4.250	2.552	1.000	10.000
eksiklik - kişi	5.600	2.644	2.000	10.000
fikir - oluk	3.150	2.560	1.000	10.000
kraliçe - piyon	6.700	2.494	1.000	10.000
ortak - tütsü	2.400	1.789	1.000	7.000
havlama - rota	3.150	2.601	1.000	9.000
imparator - koloni	7.400	2.257	3.000	10.000
madalya - uzunluk	5.100	2.426	1.000	9.000
grup - cehennem	3.900	2.751	1.000	9.000
kemik - lağım	2.895	2.558	1.000	9.000
mısır - conta	2.000	1.947	1.000	8.000
melodi - vals	7.800	2.238	1.000	10.000
piyano - içerik	5.900	2.808	1.000	10.000
çorba - ekip	2.950	2.605	1.000	10.000
şarap - tarih	6.850	2.681	1.000	10.000
şurup - üçgen	1.850	1.496	1.000	7.000
filo - dürüstlük	2.800	2.067	1.000	7.000
miktar - orman	5.000	2.991	1.000	10.000
bakan - cüzdan	6.900	2.490	2.000	10.000
numara - kalp	3.400	2.624	1.000	9.000
menekşe - gelir	2.450	2.114	1.000	8.000

E. WORD PAIRS USED IN THE STUDY LISTS

grup	cehennem
güney	ödeme
labirent	serenat
menekşe	gelir
civa	kanun
karaciğer	torpido
acemi	tercih
dizgin	böcek
macun	görev
sünger	armut
bilmece	mürettebat
küreselleşme	namaz
film	musibet
beyefendi	müttefik
kuyruk	özel
lale	baslangıç
yalancı	besteci
kalkan	sicil
seviye	heves
benzetme	efsane
veda	kılçık
gemi	ozan
peri	alabalık
turist	iğne
tekerlek	kurs
amatör	mezar
güve	yelek
ülser	depozito
ceza	metin
yeğen	cıvata
imrenme	amaç
ekmek	yabancı
parlak	samimi
mısır	conta
kısrak	pişirmek
ahmak	nesne
cumhuriyet	ceviz
olay	çocuk

duygu	bölüm
sinir	mağaza
konfor	faktör
deniz	istilacı
sömürge	damga
tayin	zehir
kaymak	kanca
yemek	şafak
tuşlamak	tosbağa
eksi	göbek
kavram	tampon
saçmalık	tepsi
bilek	balta
cami	mermi
hanedan	ikametgâh
doruk	fragman
mineral	örnek
metal	kasaba
gözlük	kaşık
inci	hareket
sarma	evlilik
kiriş	melez
taslak	manşet
kitle	jargon
akademi	kabuk
levrek	folklor
tükenme	husus
terzi	derece
ördek	mahkeme
araba	gezegen
rıhtım	mağara
tebeşir	deve

F. DATA ANALYSIS WITHOUT EXCLUDING PARTICIPANTS

F.1. Results

30 true probe pairs were presented for recognition judgment as the pilot experiment. 1315 data points were acquired out of 2250 potential data points (58.4%, $SD_{performance}$=21.6%) with the range of .03% (1/30) to 93.3% (28/30). d' = .997, and the percentage of recalling a word from the correct list was 31.9% (*SD*=20.5%). The same software was used for all the analyses. A long-term recency effect was observed even though double distractor task was implemented (Figure 20).

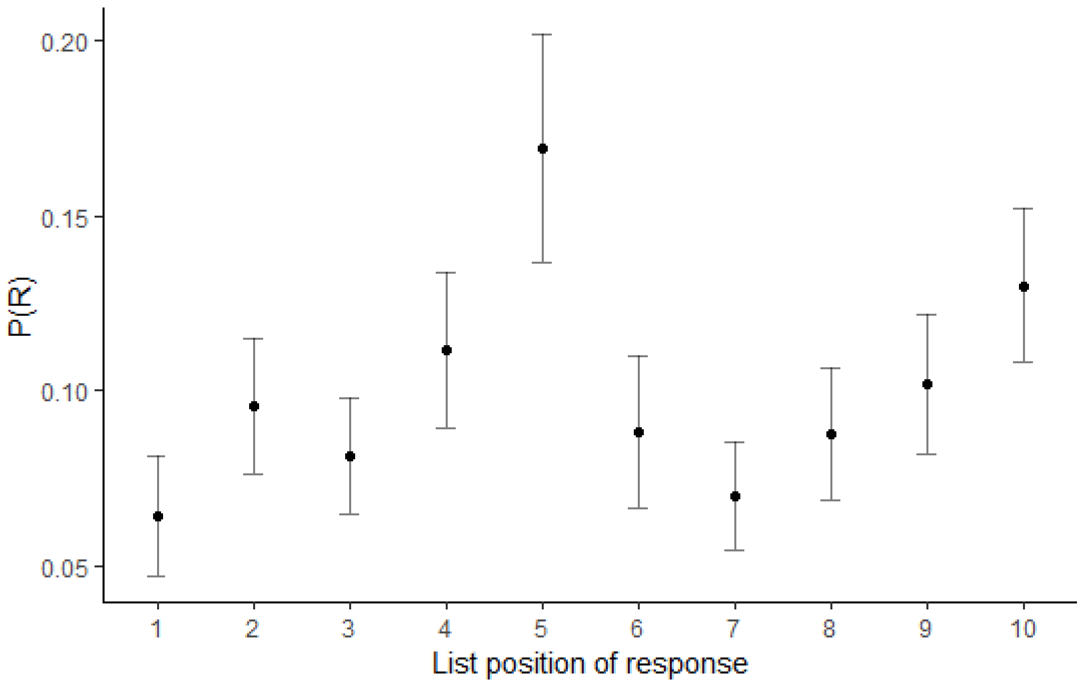

Figure 20. List position curve of response. The error bars are 95% CI of the mean.

In addition, the left side of Figure 21 illustrates probability of recall as a function of serial position of probe that demonstrates a slight advantage for 3rd and 8th probe.

Right side illustrates probability of recall as a function of serial position of response which indicates a higher probability of recalling words from the middle pairs while probability of recall slightly decreases towards to 10th pair.

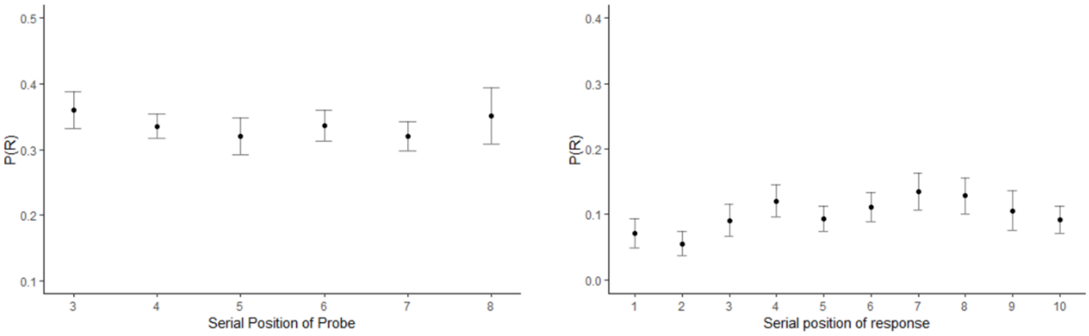

Figure 21. Serial position curve of probe pairs (left) and serial position curve of response (right) in the experiment. The error bars are 95% CI of the mean.

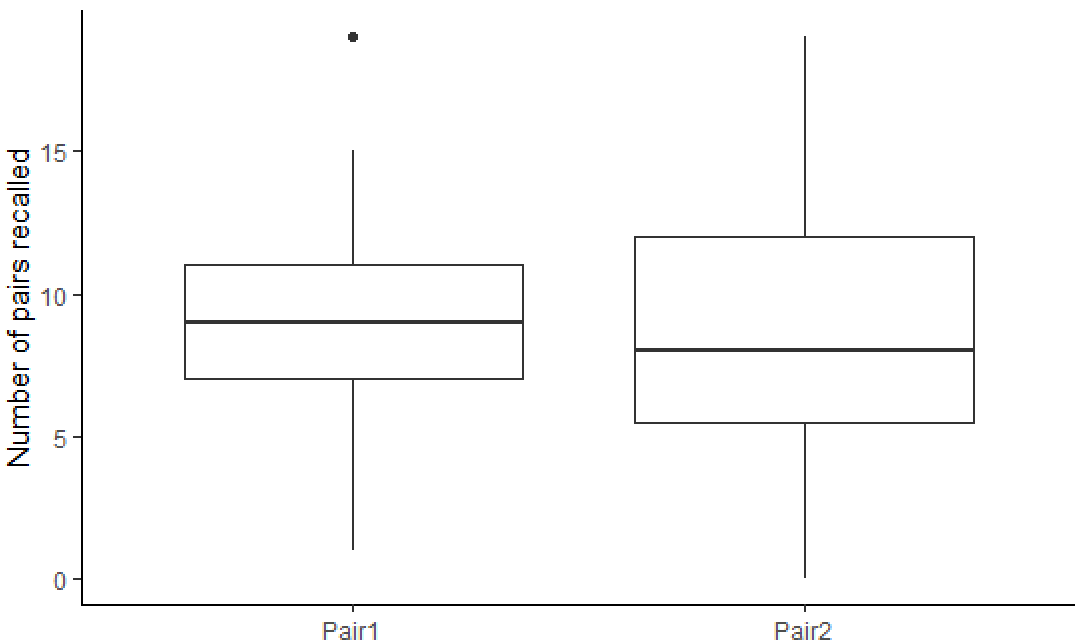

Figure 22. A boxplot of recalled items within the pair in the experiment with full data

The mean proportion of recalling the first word within the pair across all responses was 54.7% (*SE*=1.89%) (Figure 22). However, sum of recalled items' positions within the pairs are approximately the same.

F.1.1. Data Organization

Data organization was the same with the pilot study.

F.1.2. Within-List Contiguity Effect

To measure short-term contiguity effect, the responses from the same list as probe pairs were analyzed. Since participants could recall words from the correct list only 31.9% (413/1315) of the time, small number of data points were available for this analysis. As in the pilot study, word-lags were grouped while testing within-list contiguity effect. Figure 23 illustrates the conditional response probabilities (CRP) of each pair lag.

Prior to the analysis, Shapiro-Wilk test of normality was performed which indicated violation of normality assumption (W=.795, p<.001). Therefore, Wilcoxon rank test was performed along with the paired samples t-test. A paired samples t-test was conducted that demonstrated responses came from the pairs in the nearby position to the probe pairs, that is WLs 1,2,3 (M=3.77, SD=3.11) were recalled more than the pairs in the distant positions, that is WLs 5,6,7 (M=.85 , SD=1.07), $t(72)$=8.89, p<.001, d=1.04 , CI=[2.26, 3.57] with the mean difference of 2.92. Wilcoxon rank sum test also revealed a significant difference for within-list contiguity effect $W(72)$=2316, p<.001, r=.974. Thus, within-list contiguity effect was found.

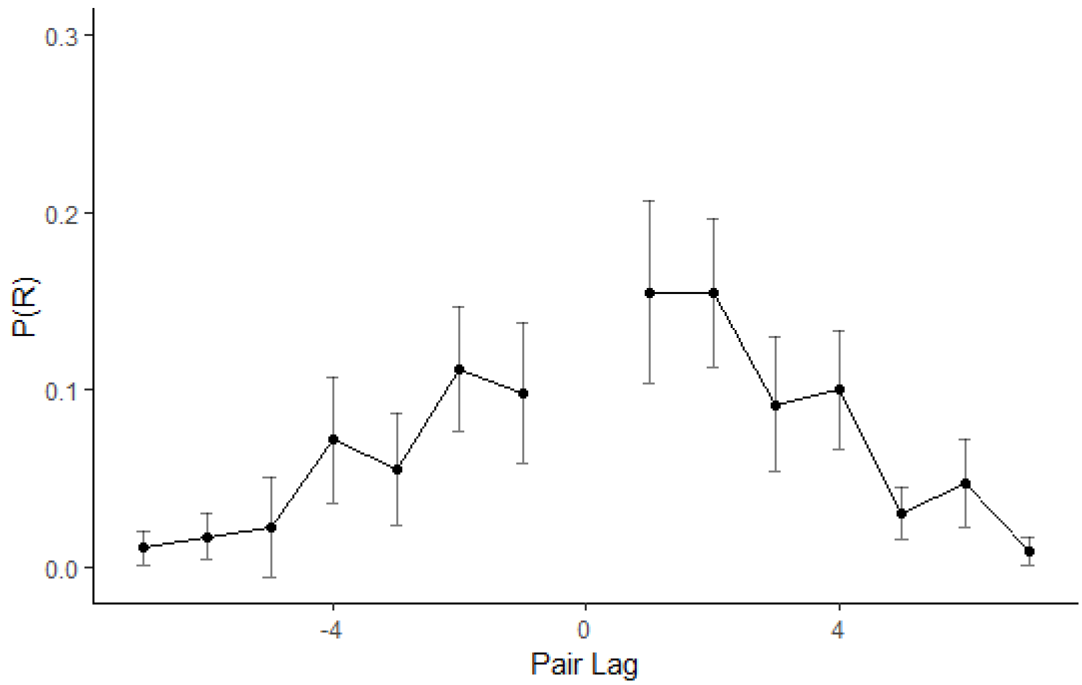

Figure 23. Lag-CRP plot for the within-list contiguity across pairs in the experiment. The error bars are 95% CI of the mean.

Another analysis was performed to test forward asymmetry between positive and negative lags in recalled words across pairs. Since Shapiro-Wilk test indicated violation of normality (W=.832, p<.001), Wilcoxon test was performed with paired samples t-test. Paired samples t-test was not reported a significant difference between backward (M=1.71, SD=2.16) and forward (M=2.055, SD=1.32) lags ($t(72)$=1.65, p=.10, d=.193, CI=[-.01, .76]). However, Wilcoxon rank sum test revealed a significant asymmetry ($W(72)$=954, p=.014, r=.385). The proportion of recalling the 1st item within pair across within-list responses was 55.4% (SE=3.26%).

F.1.3. Between-List Contiguity Effect

As the within-list contiguity effect, the between-list contiguity effect was tested with grouped list-lags with LLs 1,2 and LLs 3,4. Figure XX illustrates the conditional response probabilities of response words as a function of list they come from.

Shapiro-Wilk of normality test indicated a violation of normality (W=.945, p<.001). A paired samples t-test was performed to test whether nearby lists, that is LLs 1,2 (M=8.71, SD=4.23), was better recalled than distant lists, that is LLs 3,4 (M=2.99, SD=2.34), $t(74)$=12.32, p<.001, d=1.42, CI=[4.795, 6.645] with the mean difference of 5.72. Wilcoxon rank sum test also revealed a significant difference *W*=2464, *p*=<.001, *r*=.984. A long-term contiguity effect was found (Figure 24).

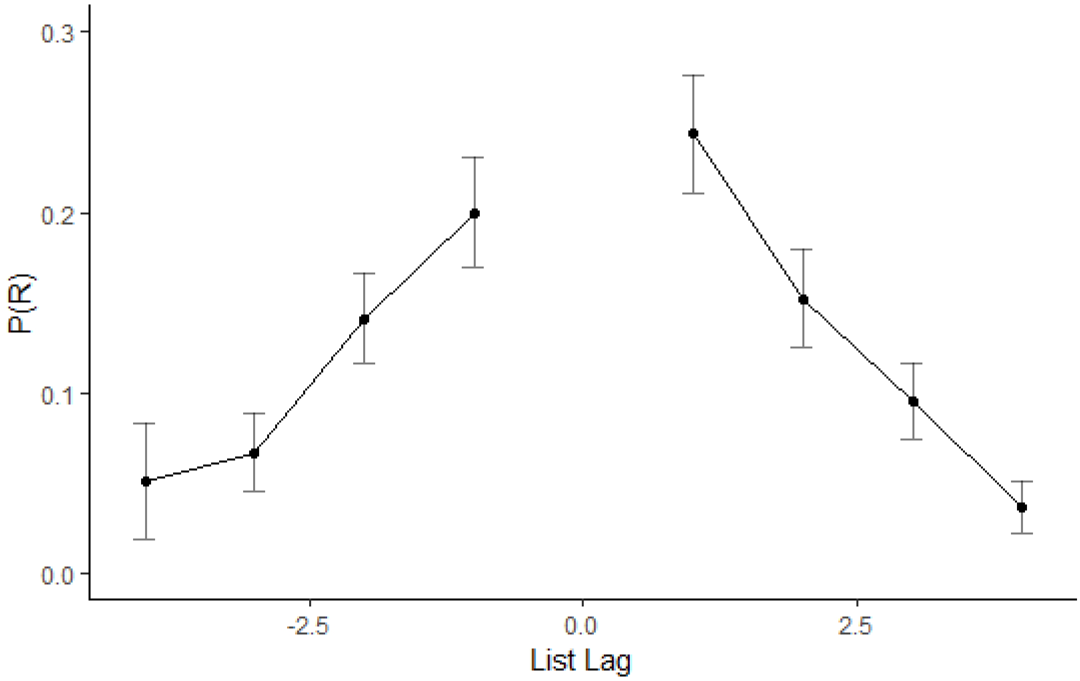

Figure 24. Lag-CRP plot for the between list contiguity effect in the experiment. The error bars are 95% CI of the mean.

A paired samples t-test was performed to test the asymmetry, whether forward lists, that is LLs 1,2, (*M*=4.73, *SD*=2.84) are better recalled than backward lists, that is LLs -1,-2 (*M*=3.97, *SD*=2.36), *t(*74)=2.134, *p*=.036, d=.246, *CI*=[0.016, .475] with the mean difference of .76. Wilcoxon rank sum test revealed a significant difference *W(*72)=1427.5, *p*=.038, *r*=.291. The proportion of recalling the first item within pair across between-list responses was 52.7% (*SE*=2.31%).

G. TURKISH SUMMARY / TÜRKÇE ÖZET

KELİME ÇİFTLERİNİN BELLEKTE KAYDEDİLME VE HATIRLANMA DİNAMİKLERİNİN YOKLAMALI HATIRLAMA TESTİYLE İNCELENMESİ

1. GİRİŞ

Tulving 1972 yılında olaysal belleği “zihinsel zaman yolculuğu” olarak açıklamış ve terimi literatüre kazandırmıştır. Olaysal bellek laboratuvarda katılımcılara uyaranları çalıştırıp tanıma (recognition) ya da çalıştıkları uyaranları hatırlama (recall) yaptırarak ölçülür.

Hatırlama testi serbest hatırlama, seri hatırlama ya da yoklamalı hatırlama olarak üçe ayrılabilir. Serbest hatırlama görevi kelime listesini çalıştıktan hemen sonra (immediate recall) yapıldığında hatırlama çalışılmış son 3 ya da 4 maddeyle başlar bu etkiye sonralık etkisi denir. Benzer şekilde birbirine yakın çalışılmış maddeler test esnasında da yakın sırayla hatırlanır, buna yakınlık etkisi denir. Hemen serbest hatırlamada iki etki de güçlü bir şekilde gözlenir ancak çalışma ve test arasına çeldirici bir görev eklendiğinde sonralık etkisi ortadan kalkar, yakınlık etkisi devam eder. Ayrıca, çalışma sırasında her maddenin arasına çeldirici eklendiğinde yine iki etkiyi de gözleriz, bu durumdaki etkilere uzun süreli yakınlık ve sonralık etkileri adı verilir. Kahana (1996) farklı çalışmalardaki serbest hatırlama örüntülerini inceleyerek yakınlık etkisini göstermiştir. Katılımcı i sırasındaki bir maddeyi hatırladığında i+1 maddesini hatırlama olasılığı yakınlık etkisidir. Aralık (lag) çalışma listesindeki maddelerin pozisyonları arasındaki farkı gösterir. Ek olarak, yakınlık etkisinde bir sonraki maddenin hatırlanma olasılığının bir öncekine göre daha fazla olduğu gözlenmiştir, buna ileriye dönük asimetri denir.

Yukarıda bahsedilen etkileri açıklamak amacıyla geliştirilen iki grup model vardır: çift depolu ve tek depolu bellek modelleri. Çift depolu modeller belleğin kısa süreli ve uzun süreli depolar olarak ikiye ayrıldığını öne sürerlerken tek depolu modeller belleğin tek parça olduğunu ve bağlamı kullanarak bilgilerin kaydedildiğini iddia etmişlerdir. Dolayısıyla uzun süreli sonralık ve yakınlık etkileri çift depolu modeller tarafından açıklanamazken tek depolu modeller doğal bir şekilde açıklayabilmiştir.

Howard & Kahana (1999) serbest hatırlama testi yapmış, yakınlık etkisi ve ileriye dönük asimetri bulmuştur. Ardından, Kahana & Caplan (2002) üçlü yoklayıcılı testi yapmıştır. Katılımcılara çalışma sırasında üçerli kelime grupları gösterilmiş ve test sırasında bir ya da iki kelimeyi yoklayıcı olarak sunarak o üçlüden kelime hatırlamalarını istenmiştir. Verilen cevaplarda yakınlık etkisi ve ileriye dönük asimetri gözlenmiştir. Bu bulgulara ek olarak, seri ve ipuçlu hatırlamalarda yapılan hatalar da yakınlık etkisi göstermektedir (Caplan ve ark., 2006; Haberlandt ve ark., 2005; Klein ve ark., 2005). Son olarak, Kılıç ve ark. (2013) yakınlık etkisini incelemek amacıyla yoklamalı hatırlama görevini geliştirmiştir. Bu çalışmada katılımcılar peş peşe her biri 21 kelimeden oluşan 6 liste çalışmış, test sırasında ise bu listelerden rastgele seçilmiş yoklayıcı kelimelerle tanıma testine tutulmuşlardır. Tanıma testi ardından yoklayıcıyı gördükleri listeden bir kelime hatırlayıp yazmaları istenmiştir. Çalışma geleneksel çalışma ve test döngüsünü kırarak yakınlık etkisinin farklı koşullarda da ortaya çıktığını göstermiştir.

1.1. Olaysal Çağrışımlar

Olaysal çağrışımlar literatürde iki madde arasındaki ilişkiyi test ederek çalışılmıştır. Bahsedilen ilişki, çağrışımsal tanıma ve ipuçlu hatırlama testleri ile test edilmiştir. Çağrışımsal tanıma A_1-B_1 şeklinde çalışılmış kelime çiftlerini test sırasında aynı (A_1-B_1) veya yeniden düzenlenmiş (A_1-B_2) olarak sunup katılımcıların ikisini beraber görüp görmediğini test eder. İpuçlu hatırlama ise maddelerden birini ipucu (A_1-?) olarak verip katılımcıdan diğerini hatırlamasını ister. Hatırlama yönü, bağımsız çağrışım (BÇH) (Wolford, 1971) ve simetrik çağrışım (SÇH) (Asch & Ebenholtz, 1962) hipotezleri tarafından tartışılmıştır. BÇH maddeler arasında ileriye ve geriye dönük iki ayrı çağrışım kurulduğu ve güçlerinin değişebileceğini iddia ederken SÇH maddelerin bir bütün olarak kaydedildiğini söyler. BÇH kelime çiftlerinin ileriye

dönük asimetriyle hatırlanabileceğini açıklayabilir ancak SÇH çiftlerin bir bütün olduğunu iddia ettiği için asimetriyi açıklayamaz.
Yukarıda bahsedildiği gibi kelime listelerinin hatırlanmasında yakınlık etkisi ve paralel olarak ileriye dönük bir asimetri gözlenir (Howerd & Kahana, 1999; Kahana, 1996; Thomas, 2003) ancak kelime çiftleri ipuçlu hatırlama ile test edildiğinde ileriye veya geriye dönük bir asimetri gözlenmemiştir (Caplan, 2006; Caplan ve ark., 2006; Madan, 2010; Sommer ve ark., 2007). Çağrışımsal tanıma testi yapıldığında kelime çiftlerinde ileriye dönük bir asimetri gözlenmiştir, bu bulgu kelime çiftlerindeki asimetri bulgularının uygulanan teste göre değiştiğini göstermiştir (Kahana, 2002; Yang ve ark., 2013). Dolayısıyla çağrışımsal tanıma testleri BÇH'yi desteklerken çağrışımsal hatırlama testleri SÇH'yi desteklemektedir.

Sözü edilen model grupları (çift ve tek depolu bellek modelleri) yakınlık etkisini farklı şekillerde açıklamışlardır ve her birinin güçlü ve zayıf yanları vardır.

1.2. Tampon Modeli

Çift depolu bellek modellerine bir örnek olan Tampon modeline (Lehman & Malmberg, 2013) göre tampon kısa süreli depo gibi pasif değil aksine verilen göreve göre strateji geliştiren aktif bir birimdir. Tamponun kaynakları kısıtlıdır, dolayısıyla her maddeyi bünyesinde barındıramaz. Göreve bağlı olarak ihtiyacı olan maddeleri tekrarlayarak (rehearsal) tutar, işe yaramayacak maddeleri ise kasti şekilde unutur (compartmentalization). Dolayısıyla tampon farklı durumlarda farklı sayıda maddeyi barındırabilir. Model, hemen ve geciktirilmiş serbest hatırlamada görülen sonralık etkilerini diğer çift depo modellerinde olduğu gibi tamponu boşaltmakla açıklar. Yakınlık etkisi ise tamponda maddelerin beraber bulunması ve arka arkaya çalışılan maddelerin benzer bağlamlara sahip olmasıyla açıklanır. Hatırlanan herhangi bir maddenin bağlamı da beraber hatırlanır bu yüzden birbirine yakın çalışılmış maddelerin arka arkaya hatırlanma olasılığı yüksektir. Ek olarak, model uzun süreli sonralık ve yakınlık etkilerinin kısa süreli etkilere göre farklı bir mekanizmadan kaynaklandığını savunur.

Modelin tez çalışmasına dahil edilme sebebi kelime çiftlerinin belleğe kaydedilmesi konusunda yaptığı yorumdur. Kelime çiftleri birer öbek olarak kaydedilir, her bir öbeğin bağlamı vardır. Bağlam öbekteki ilk kelimeye daha kuvvetli bağlanır, bu yüzden modele göre kelime çiftleri hatırlanmaya çiftteki ilk kelime ile başlanır. Dolayısıyla model kelime çiftlerinin hatırlanmasında ileriye dönük bir asimetri bekler.

1.3. Zamansal Bağlam Modeli (ZBM)

Zamansal Bağlam Modeli (ZBM) (Howard & Kahana, 2002) sonralık ve yakınlık etkilerini açıklamak üzere geliştirilmiş tek depolu bir bellek modelidir. ZBM'ye göre bellekte madde ve bağlamı ve maddelerin birbirleri arasında paylaşılan bağlam dolayısıyla çağrışımlar kurulur. Modelin işleyişi şu şekilde açıklanabilir: örneğin katılımcının sırayla okul, çiçek, köpek, anahtar kelimelerini çalıştığını varsayalım. Okul maddesini gördüğünde maddenin deney öncesi bağlamları bellekte aktive olur ve deney sırasındaki bağlamla eklenir, bu birleşme deney bağlamında bir kayma yaratır. Çalışılan her madde ile birlikte bu döngü tekrarlanır, yani deney bağlamı maddeleri gördükçe adım adım değişir. Birbirine yakın çalışılan maddelerin bağlamları birbirlerine benzerdir ve model yakınlık etkisini bu benzerlikle açıklar. Modele göre bir maddeyi hatırladığımızda maddenin bağlamı aktive olur, dolayısıyla yakınında çalışılmış diğer maddelerin bağlamları da aktive olmuş olur. Bir sonraki hatırlamanın aktive olmuş maddelerden biri olması beklenir. Ayrıca ilk hatırlanan maddenin deney öncesi bağlamı yalnızca sonraki maddeyle bağlanmış olduğu için yakınlık etkisinde ileriye dönük asimetri görülür. ZBM'ye göre katılımcılar çalışmanın hemen ardından test edildiklerinde son çalışılan birkaç maddenin bağlamı testin bağlamına çok benzediği için hatırlama son maddelerden başlar, sonralık etkisi gözlemlenir. Çalışma ve test arasında çeldirici konulduğunda ise bağlam değişmiş olduğu için sonralık etkisi ortadan kaybolur. Model aynı yaklaşımı kullanarak uzun süreli yakınlık ve sonralık etkilerini açıklar ve aynı mekanizmadan ortaya çıktığını iddia eder. Ancak ZBM'nin kelime çiftlerinin bellekte kaydedilmesi ve hatırlanması konusunda bir yorumu yoktur. Çiftlerin bütünsel olarak kaydedildiğini savunan SÇH'yi destekleyecek şekilde simetrik hatırlama olacağını iddia eder.

1.4. Çalışmanın Amacı

Tezin amacı Kılıç ve ark. (2013)'nın geliştirdiği yoklamalı hatırlama görevinde kelime çiftlerini kullanarak çiftlerin bellekte nasıl kaydedildiğini ve geri çağırıldığını incelemektir. Literatürdeki çalışmalar kelime listelerinin ileriye dönük asimetriyle kelime çiftlerinin ise simetrik hatırlandığını göstermiştir. Bu çalışmada çiftteki kelimelerden herhangi birini ipucu olarak vermeden katılımcılardan çiftin bir elemanını hatırlamaları istenmiştir. Eğer kelime çiftleri Caplan (2006)'nın iddia ettiği gibi tek bir zamansal bağlamı, komşu çiftler farklı zamansal bağlamları paylaşıyorlarsa yoklayıcıya verilecek cevapların simetrik olacağını hipotez edebiliriz. Ancak kelime çiftleri bütün olarak kaydedilmiyorsa çiftin bir parçasının öbüründen daha fazla hatırlandığını gözlemleyebiliriz. Sonuç olarak, kelime çifti içinde ve çiftler arası hatırlanma örüntülerini karşılaştırmak olaysal belleğin temel sorularından birine cevap verecektir.

2. YÖNTEM

İlgili çalışma Açık Bilim Sistemi'ne (ABS) kaydedilmiştir ve bu linkten görüntülenebilir https://osf.io/da5zv/.

2.1. Katılımcılar

Deney öncesi yapılan istatistiksel güç analizine göre 76 katılımcı gerektiği hesaplanmıştır, deneye 85 kişi katılmış 7 kişi MATLAB programı hatası, 1 kişi anadili Türkçe olmaması ve 1 kişi ADHD tanısı, 1 kişi deneyi 2 standard sapma daha uzun sürede bitirmesi sebebiyle analize dahil edilmemiştir. Ayrıca veri toplama sürecinde oluşan bir hatadan ötürü 5 katılımcı çıkarılmış ve toplam 70 kişinin verisi ile analiz yapılmıştır.

2.2. Uyaranlar

Deneyde kullanılan kelimeler deney öncesi yapılan bir ön çalışmada Kılıç ve ark. (2013) çalışmasından alınarak Türkçe'ye çevrilmiş ve katılımcılara kelime çiftlerinin anlamsal yakınlığı oylatılmıştır. Anlamsal yakınlığı yarıdan az olanlar deneyde uyaran olarak kullanılmıştır.

2.3. Desen ve Prosedür

Deney 2 çalışma-test döngüsü ile oluşturulmuştur. Her döngüde katılımcılar 10 kelime çiftinden oluşan 5 çalışma listesi çalışmıştır, her liste arasında 15 sn çeldirici matematik işlemi 15 sn boş ekran görmüşlerdir. Ayrıca her kelime çiftini çalışırken iki kelimeyi de içeren bir cümleyi yüksek sesle kurmaları istenmiştir. Test öncesi çeldirici iki kere gösterilmiştir. Test sırasında 15 yoklama çifti ve 5 yeni çift tanıma testinde gösterilmiştir, yoklama çiftini tanırlarsa o çifti gördükleri listeyi akıllarına getirip o listeden yalnızca bir kelime hatırlamaları istenmiştir. Aynı döngü iki kere tekrarlanmıştır.

3. SONUÇLAR

3.1. Veri Düzenleme

Yazılan MATLAB koduyla hatırlanan kelimelerin ait olduğu çiftlerin liste içindeki çalışılma pozisyonu ve çift içindeki yeri belirlenmiştir. Kelime aralığı (KA) ve liste aralığı (LA) her katılımcı için hesaplanmıştır. Kelime aralığı yoklama çiftinin liste içinde çalışılma pozisyonundan hatırlanan kelimenin bulunduğu çiftin pozisyonunun çıkarılmasıyla bulunur. Liste aralığı da aynı kuralın listelere uygulanmasıyla hesaplanır. Mesela katılımcı 4. sırada çalışılmış yoklama çiftini gördüğünde 6. sıradan bir kelime hatırlıyorsa KA +2 olur. Toplamda az veri olduğu için aralıklar 1,2,3 ve 5,6,7 şeklinde gruplanarak analizler yapılmıştır.

Bir başka MATLAB koduyla her bir kelime aralığına karşılık gelen koşullu yanıt olasılığı (KYO) hesaplanmıştır. Her bir aralıktaki cevap sayısının o aralıkta verilebilecek tüm cevaplara bölünmesiyle KYO hesaplanmıştır.

3.2. Genel Sonuçlar

Yanlış yazılmış Türkçe karakterler ve tek harf yanlışları elle düzeltilmiştir.

Test sırasında 30 tane doğru yoklama çifti gösterilmiştir, eğer hepsine cevap sağlansaydı toplamda 2100 cevap olacakken 1230 cevap elde edilmiştir (58.57%, SS=22.1%). Yoklama çiftlerini tanıma oranı 96.05% ve doğru listeye dönme oranı 31.05%'dir. Listeler arası uzun süreli sonralık etkisi son listenin ardından iki kez çeldirici konulmasına rağmen görülmüştür. Analizler R (versiyon 4.2.1) (R Core Team, 2022) ve Rstudio (RStudio Team, 2022) kullanılarak yapılmıştır.

3.3. Liste İçi Yakınlık Etkisi

Kısa süreli yakınlık etkisini araştırmak için cevapların yoklayıcı çiftle aynı listeden geldiği durumlar analiz edilmiştir. Katılımcılar doğru listeye yalnızca %31.05 oranla dönebildikleri için bu analizi yaparken kelime aralıkları 1,2,3 ve 5,6,7 şeklinde gruplandı.

Shapiro-Wilk normallik testi (W=.794, p<.001) verinin normal dağılmadığını gösterdi. Bu yüzden Wilcoxon testi eşli t-test ile beraber rapor edildi. Eşli t-test yoklayıcıya yakın çiftlerin, KA 1,2,3 ,(M=3.81, SD=3.19) uzaktaki çiftlere, KA 5,6,7, (M=.81, SD=.996) göre daha çok hatırlandığını gösterdi, t(67)=8.67, p<.001, d=1.05 , CI=[2.31, 3.69]. Wilcoxon test de anlamlı bir yakınlık etkisi ortaya koydu (W(67)=1995, p<.001, r=.979). Sonuç olarak liste içi yakınlık etkisi bulundu.

İleriye dönük asimetriyi test etmek için artı ve eksi aralıklar aynı testler kullanılarak birbiriyle karşılaştırıldı. Burada da Shapiro-Wilk test (W=.835, p<.001) verinin normal dağılmadığını gösterdi. Eşli t-testi yoklayıcıdan sonraki (M=2.07, SD=1.35) ya da önceki (M=1.74, SD=2.22) aralıklarda anlamlı bir fark olmadığını gösterdi (t(67)=1.53, p=.131, d=.185, CI=[-.104, .78]). Ancak Wilcoxon testi anlamlı bir asimetri gösterdi (W(67)=419, p=.02, r=.367). Liste içi cevaplarda çift içindeki ilk kelimenin hatırlanma oranı 56.2% (SE=3.45%) oldu.

3.4. Listeler Arası Yakınlık Etkisi

Listeler arası yakınlık etkisi liste aralıklarını 1,2 ve 3,4, şeklinde gruplayarak analiz edilmiştir (Figür 19). Uzun süreli sonralık etkisi gözlenmiştir (Figür 15).

Shapiro-Wilk testi (W=.973, p=.139) verinin normal dağıldığını göstermiştir ancak sağlıklı karşılaştırabilmek adına iki test de yürütülmüştür. Eşli t-testi yoklayıcıya yakın listelerden, LA 1,2, (M=8.63, SD=4.33) gelen cevaplar ile uzak listelerden, LA 3,4, (M=3.13, SD=2.35) gelen cevaplar karşılaştırıldığında anlamlı bir fark göstermiştir ($t(69)=11.32$, $p<.001$, $d=1.35$, CI=[4.53, 6.47]). Benzer şekilde Wilcoxon testi de anlamlı fark rapor etmiştir (W(69)=2124.5, p<.001, r=.981).

İleriye dönük asimetri yine aynı testler kullanılarak test edilmiştir, Shapiro-Wilk testi normal dağılımın ihlal edildiğini (W=.958, $p=.021$) göstermiştir. Eşli t-testi artı aralıklardan ($M=4.74$, $SD=2.92$) gelen cevapların eksi aralıklardan ($M=3.89$, $SD=2.34$) gelen cevaplardan fazla olduğunu göstermiştir ($t(69)=2.35$, $p=.021$, $d=.281$, $CI=[.131, 1.58]$). Wilcoxon testi de anlamlı fark rapor etmiştir, W(69)=1255.5, p=.025, r=.328.

Ayrıca Tablo 1 gözlenen toplam cevapların, cevapların listesi ve yoklayıcının listesine göre frekanslarını göstermektedir. Tablonun üst kısmı gözlenen cevapları gösterirken alt kısmı eğer yoklayıcının bir etkisi olmasaydı beklenecek cevapların frekanslarını gösterir.

Örneğin yoklayıcı çifti Liste 1'den verildiği durumda cevabın Liste 1'den gelme olasılığı 0.272'tir [P(R1|P1) = 56/206]. Aynı koşulda beklenen olasılık ise 0.149'dur [P(R1|P1) = 31/206]. Gözlenen frekansın beklenen frekansa oranı 1.83'tür. Oranın 1'den büyük olması o listeden hatırlanan cevap sayısının yoklayıcının etkisi olmadığı beklenen durumdan fazla olduğunu, 1'den küçük olması da az olduğunu gösterir. Tablo 1 ve Tablo 2'deki köşegenler gözlenen cevap sayısının yoklayıcının etkisi olmadığı durumda beklenecek cevap sayısından ne denli farklı olduğunu göstermektedir. Ayrıca, son listeden hatırlanan toplam kelime sayısı herhangi bir listeden hatırlananların yaklaşık 2 katıdır, dolayısıyla uzun süreli sonralık etkisi bu deneyde gözlenmiştir denebilir.

3.5. Kelime Çiftlerinin Analizi

Kelime çiftlerindeki asimetri, çift içinde hatırlanan toplam birinci kelime ve ikinci kelimeden gelen cevap sayıları ve oranları eşli t-testi ve Wilcoxon testleriyle incelenmiştir. Oran kullanılarak yapılan analiz, düşük performans göstermesine rağmen az sayıda cevap verdiklerinden çiftlerden birini %100 hatırlamış gibi görünen katılımcılar olduğu için toplam cevap sayısı ile de analiz yapılmıştır.

Shapiro-Wilk testi verinin normal dağılmadığını göstermiştir (W=.901, p<.001). Oranlara eşli t-testi uygulandığında kelime çiftinin ilk kelimesi ($M=.553$, $SD=.165$)

ikinciye (*M*=.447, *SD*=.165) göre daha fazla hatırlandığını gösterilmiştir (*t*(69)=2.672, *p*=.009, *d*=.319). Ancak Wilcoxon test anlamlı bir fark bulmamıştır(*W*(69)=1233.5, *p*=.072, *r*=.263). Toplam cevaplar ile eşli t-testi yapıldığında çiftin ilk kelimesi (*M*=9.157, *SD*=3.549) ikinciden (*M*=8.414, *SD*=.4.525) anlamlı olarak ayrılmamıştır (*t*(69)=1.32, *p*=.191, *d*=.158). Wilcoxon testi de anlamlı fark sunmamıştır (*W*(69)=1132, *p*=.276, *r*=.159).

4. TARTIŞMA

Tez kapsamında bir ön çalışma, bir pilot deney ve bir deney yürütülmüştür. Deneyde kullanılacak kelimeler ön çalışmada katılımcılara oylatılarak seçilmiştir. Deney sırasında tanıma testine verilen doğru cevaplar çok yüksekken (%96.05) hatırlama testinde bu oran %58.6'ya düşmüştür. Verilen cevapların geldiği listeleri incelendiğinde uzun süreli sonralık etkisi gözlenmiştir ancak cevapların liste içindeki pozisyonlarından herhangi bir etki gözlenmemiştir.

İlk adımda kelime çiftleri birer madde gibi ele alınarak kısa süreli ve uzun süreli yakınlık etkisi analiz edilmiştir. Veri bazı koşullarda normal, diğerlerinde anormal olduğu için hem t-testi hem de Wilcoxon testi uygulanmıştır. Liste içi ve listeler arası yakınlık etkisi her iki testte de gözlenmiş ancak ileriye dönük asimetri liste içinde eşli t-testinde bulunamamış Wilcoxon testinde bulunmuştur. Listeler arası asimetri ise her iki testte de rapor edilmiştir. Kılıç ve ark. (2013) liste içi ve listeler arası yakınlık etkisini raporlamış ancak ileriye dönük bir asimetri gözleyememiştir. Ayrıca 75 sn matematik işlemi ve 75 sn boş ekrandan oluşan çeldiriciyi testten hemen önce iki kere yani 3 dk boyunca sunmalarına rağmen uzun süreli sonralık etkisini gözlemlemişlerdir. Yani çeldiricinin süresini uzatmak uzun süreli sonralık etkisini ortadan kaldıramamıştır. Bu tezde elde edilen bulgular araştırmacıların yakınlık etkisi bulgularını tekrarlamış ve üzerine asimetriyi de gözlemlemiştir. İstenilen etkilerin gözlemlenme sebebi deneyin kolaylaştırılmış olması ve çalışma sırasında cümle kurmanın maddeleri daha derin işlemeye yol açmış olması olabilir. Alternatif olarak katılımcılar çiftlerden birini daha iyi öğrenip test sırasında onu kullanarak toplamda daha iyi bir performans göstermiş olabilir.

Yakınlık etkisi bellekte kurulmuş çağrışımları ortaya koyar. Serbest hatırlama ve tanıma testlerinde ortaya çıkar ve daha da önemlisi katılımcıların yaptığı hatalı hatırlamalarda da yakınlık etkisi gözlemlenir. Etki otomatik olarak ve ileriye dönük asimetriyle ortaya çıkar, ayrıca zaman skalasının değişmesinden de etkilenmez.

ZBM'nin temelinde maddeler ve bağlamları arasında kuvvetli bir bağ kurulması vardır. Birbirine yakın olarak çalışılmış maddelerin bağlamları çok benzerdir ve herhangi bir madde hatırlandığında bağlamı da aktifleşir. Dolayısıyla hatırlanan maddenin yakınındaki maddelerin de bağlamları aktifleşmiş olur, model böylece yakınlık etkisini doğal biçimde açıklar. Ancak model kelime çiftlerinin kaydedilmesiyle alakalı özel bir yorum yapmaz. Bu yüzden tezde Tampon modeli de incelenmiştir. Tampon modelinde, tampon tekrar ve kasti unutma yaparak maddeleri görevin gereklerine göre işler. Tamponda beraber bulunan maddeler birbirleriyle bağ kurar. Ayrıca maddeler bağlamlarıyla kaydedilir ancak bağlam ZBM'deki gibi madde çalışıldıkça kaymaz. Benzer bağlam ve tamponda beraber bulunma yakınlık etkisini ortaya çıkarır. Tampon modelinin yakınlık etkisi konusunda ZBM kadar net bir yorumu olmamakla beraber kelime çiftleri konusunda özel bir yorumu vardır. Bu yüzden bu iki model karşılaştırılmıştır.

Literatürde olaysal çağrışım kelime çiftlerinin test edilmesiyle ölçülmüştür ve çiftlerin bir bütün olarak mı (SÇH) yoksa bağımsız mı (BÇH) kaydedildiği tartışılmıştır. Daha önce de bahsedildiği gibi çiftlerin simetrik listelerin ise asimetrik olarak hatırlandığı rapor edilmiştir. Ancak çiftler ve listeler ayrı görevlerle test edildiği için karşılaştırılmaları mümkün değildir. Bu yüzden bu tezde çiftler ve listeler birlikte çalışılmıştır.

Çiftlerin bellekteki kaydı çift içindeki ilk ve ikinci kelimelerin hatırlanma oranları ve toplam cevap sayılarını karşılaştırılarak test edilmiştir. Testler ilk ya da ikinci kelime lehine sonuçlanmadığından kelime çiftlerinin simetrik hatırlandığı sonucuna ulaşılmıştır. Ek olarak, katılımcıların çalışma sırasında çiftleri kullanarak cümle kurmaları çiftlerin bütünsel olarak kaydedilmesini desteklemiş olabilir.

ZBM kelime çiftleri için özel bir yorum yapmaz ancak ortak bağlam paylaşmaktan ötürü bütünsel kaydedilmelerini desteklemektedir (SÇH). Bildiğim kadarıyla bu tez çalışması ZBM'yi kelime çiftleriyle test eden ilk çalışmadır. Çiftler arası hatırlamalarda bulunan bulgular literatürle (Caplan ve ark., 2006; Davis ve ark., 2008; Kahana & Caplan, 2002) uyumludur ve çift içi hatırlama örüntüleri de ipuçlu hatırlama bulgularıyla (Caplan ve ark., 2006; Davis ve ark., 2008) benzerdir. Tampon modeli çiftlerin kaydında tamponun işleyişini değiştirerek nasıl hatırlanacağı konusunda tahminde bulunmuştur. Öbeğin bağlamı ilk kelimeye daha kuvvetli bağlandığı için çiftlerin hatırlanmasında ileriye dönük asimetri öngörmektedir. Ancak deneyde simetrik hatırlama görülmüştür.

4.1. Çalışmadaki Kısıtlar

Deneyde 2 çalışma-test döngüsünde kişi başı olası 30 veri noktası toplanacakken, yoklamalı hatırlama görevinin zorluğundan kaynaklı katılımcılar %58 civarında cevap verebilmiştir. Bu da elde edilebilecek verinin neredeyse yarısını kaybetmek anlamına gelmektedir.

Çalışmadaki ikinci kısıt ise kelimelerin başta planlandığı gibi Örtük Semantik Analiz (Landauer & Dumais, 1997) ile seçilememesidir. Kelimeler Kılıç ve ark. (2013) çalışmasından Türkçeye çevrilmiştir. Kelimelerin Türkçe'deki kullanım sıklıkları, soyut ya da somut olmaları veya hayal edilebilirlikleri kontrol edilememiştir. Bu yüzden kelime çiftleri içindeki kelimelerin özellikleri eşit olmayabilir ve katılımcıların performansları etkilenmiş olabilir.

Bir diğer kısıt ise deney sırasında çalışma ve test sürelerinin sınırlandırılmamasıdır. Deney süresinin katılımcılar arasında farkı büyüktür (M=34.84 dk, SD=7.5 dk) ve bu fark bellek çalışmasında önemli bir karıştırıcı etki olabilir.

4.2. Gelecek Çalışmalar

İstenen etkiler kişi başı elde edilen veri noktalarının sayısı az olmasına rağmen gözlenebildi ancak katılımcıların performansları değişiklik gösterdiği için kişi başı daha çok veri noktas elde etmek faydalı olabilir. Bu doğrultuda çalışma 2 oturum şeklinde yürütülürse hem katılımcı başına elde edilecek veri artmış olur hem de katılımcılar deneyim kazandıkça performans değişiklikleri incelenebilir. Ayrıca, bu çalışmada hatalı ve yinelenen hatırlamalar hesaba katılmamıştır. Başka bir çalışmada analiz edilmeleri faydalı olacaktır.

Kelimelerin anlamsal özellikleri kontrol edilip deney tekrarlanabilir böylece insanların oyladığı kelime listelerinden çıkan sonuçlarla sistematik olarak elde edilen sonuçlar karşılaştırılabilir.

Bu çalışmada yoklamalı hatırlama görevi kelime çiftleri kullanılarak yapıldı ancak orijinal çalışma çalışma listelerinde tek kelime kullanmış ve katılımcılara kelimelerin hoşluğunu oylatmıştır. Labımızda henüz yayınlanmamış bir tez de Kılıç ve ark. (2013)'ün bulgularını yine çalışma listelerinde tek kelime kullanarak ve kelimelerin hoşluğunu oylatarak tekrar etmiş, ayrıca ileriye dönük asimetri de gözlemlemiştir. Bu tezde kelime çiftleri katılımcılara cümle kurdurarak çalıştırılmış ve yine bahsedilen etkiler bulunmuştur. Ancak aynı anda hem tek kelimeden çift kelimeye geçmek hem de kelimeleri çalışma şeklini değiştirmek bahsedilen araştırmalar arasında bir açıklığa neden olmuştur. Bu açıklığı kapatmak için kelime çiftlerinin hoşlukları oylatılarak çalışma tekrar edilebilir ve böylece etkilerin cümle kurulması sebebiyle mi ortaya çıktığı test edilmiş olur.

4.3. Sonuç

Yakınlık etkisindeki ileriye dönük asimetrinin liste içi ve listeler arasında bulunacağı ve çift içi hatırlamaların simetrik olacağı hipotez edilmiştir. Bulgular Kılıç ve ark. (2013) çalışmasının üzerine inşa edilmiş ve hipotez edilen etkiler bulunmuştur.
Kelime çiftlerinin yoklamalı hatırlama göreviyle test edilmesi çiftlerden herhangi birini ipucu olarak vermeden test edebilmeyi sağlamıştır. Bu şekilde literatürde ilk kez aynı deney içinde çift-içi, kısa süreli yakınlık ve uzun süreli yakınlık etkilerindeki ileriye dönük asimetri test edilebilmiştir. Yoklamalı hatırlama görevi katılımcıyı ipuçlu hatırlamaya göre serbest bırakırken serbest hatırlamaya göre kısıtlar. Bu yüzden iki tür görev arasında bir köprü olarak kullanılabilir ve kelime çiftleriyle listelerin hatırlanmasını beraber test edebilir. Son olarak, bu tezde elde edilen bulguları daha iyi açıklamak için bahsedilen bellek modellerinde değişim yapmayı gerektirecektir.

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