*Turkish Psychological Articles,* December 2020, *23*(46), 29-30 DOI: 10.31828/tpy1301996120201001m000023

# *Summary*
# A Review on Association Memory

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## Association Memory

Tulving (1985, 2002) defined episodic memory as the ability to remember personal events consciously, which includes temporal and spatial information. In episodic memory experiments, stimuli such as words, images, faces, sounds or fractals are studied for a subsequent test. In addition to item information, the associations formed among items are also important in understanding the mechanisms that underlie episodic memory. For example, the associations between items can be based on temporal proximity (Kahana, 2002), holistic (Madan, Glaholth, & Caplan, 2010) or independently formed (Hockley & Cristi, 1996). In short, understanding the mechanisms underlying the association memory is important for theoretical underpinnings.

### Association Memory Tasks

Two main tasks are used to measure association memory: cued recall and associative recognition. There are two types of cued recall: study-test method and anticipation method. In the study-test method, word pairs ($X_1$-$Y_1$, $X_2$-$Y_2$, $X_3$-$Y_3$, ... $X_n$-$Y_n$) are studied in a list and then one word is given as cue and its pair is asked ($X_1$-?, ?$_2$-$X_2$, $X_3$-?, ... $Y_n$-?, Ensor, Guitard, Bireta, Hockley, & Surprenant, 2019; Wilson, Kellen & Criss, 2019). In the forward recall condition, Xs are presented as cues the paired Ys are required while in the backward recall condition, Ys are presented as cues and the paired Xs are required to be generated. The aim of this task is to measure whether the associations formed symmetrically by comparing the correct recall performance across two conditions. On the other hand, in the anticipation method, participants are presented with a word and they are given time to anticipate the other associated word. The associated word is presented if participants fail to anticipate (Kahana, 2012). This method further allows to measure the associations that were formed semantically.

Associative recognition is another task that measures how well sole associative information is encoded and retrieved. Again, word pairs are ($X_1$-$Y_1$, $X_2$-$Y_2$, $X_3$-$Y_3$, ... $X_n$-$Y_n$) are studied and subsequently tested by recognizing whether the pairs are shown either in intact ($X_1$-$Y_1$) or rearranged ($X_2$-$Y_3$) pairs. Accordingly, this task allows researchers to measure the associative information of pairs by comparing accuracy of intact and rearranged pairs. Moreover, associative recognition task is also used to discriminate the effect of item and associative information on memory (e.g., Cox & Criss, 2017; Gronlund & Ratcliff, 1989; Jackson & Greene, 2017; Hockley, 1992; Hockley & Cristi, 1996; Nobel & Shiffrin, 2001; Osth & Fox, 2019).

In addition to presenting pairs of items, participants can study triplets (ABC) as Kahana and Caplan (2002) employed in a probed recall task. Later during test, one item cue (A?) or two item cues (AB?) are presented to elicit recall. These tasks are important for investigating whether pairs or triplets are forming symmetric and/or holistic associations or asymmetric and/or independent associations, which will be discussed further.

### The Difference Between Item and Associative Information

According to Murdock (1972) and Humphreys (1976, 1978), item information represents the existence of the stimuli and its content while association information represents the relationship among items and events. The difference between item and associative information has been investigated through item and associative recognition tasks.

Gronlund and Ratcliff (1989) investigated accumulation of information by employing the response deadline procedure. Their results suggested that the time required for giving the correct answer was slower for associative recognition test than item recognition test. Further, they showed that more intact pairs were recalled correctly than single items, suggesting that the intact pairs includ-

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ed more distinctive and thus, stronger traces than single items do. By using a similar procedure, Mohanty and Naveh-Benjamin (2018) concluded that response deadline affects association memory more than item memory. Additionally, McGee (1980) also provided evidence for the difference between item and associative information. According to those results, if words are studied individually, the performance is better in item recognition test than associative recognition test. On the other hand, if the words are studied as pairs, the performance is better in associative recognition test than item recognition test. All those results suggest that the procedure of encoding items and pairs are different from one another.

When retrieval is considered, the rate of forgetting is also different for item information when compared with that for associative information. As Hockley (1992) suggested, the performance on item recognition test drops over time while the performance of associative recognition test is not affected.

Word frequency also affects item and associative information differently (Aue, Fontaine & Criss, 2018; Clark, 1992; Clark & Burchett, 1994; Clark & Shiffrin, 1992; Hockley, 1994). Clark and Burchett (1994) found that high frequent words increased cued recall and associative recognition performance while low frequent words increased item recognition test performance.

Finally, Hockley and Cristi (1996) showed that item and association focused encoding affects item and associative information differently. If participants studied words of pairs individually, their item recognition test performance was greater than their associative recognition performance. However, if participants studied words of pairs together, their item and associative recognition test performance did not differ. This means that item-focused study impaired associative information while association-focused study did not affect item information.

Overall, item and associative information is encoded differently, forgotten in different time durations, they are affected by word frequency level differently and their forgetting tendency is different from one another.

**Associative Information: How is It Encoded?**

There are three effective ways of encoding associative information (Kahana, 2012). The first one is forming one mental image with two items (Pavio, 1969). The second one is forming a sentence by using two items. The third effective way is using a mediator. The effectiveness level of each method depends on the items and people using them (Kahana, 2012).

Another factor supporting the learning of associative information is the testing itself. Testing on the pairs increases performance more than studying pairs (Ariel & Karpicke, 2017; Bjork, 1975; Carrier ve Pashler, 1992; Glover, 1989; Karpicke, 2017; Roediger ve Butler, 2011; Roediger & Karpicke, 2006). According to McDaniel, Kowitz and Dunay (1989), testing strengthens learning by causing elaboration and re-encoding of A-B relation.

**Symmetric Association and Independent Association Hypotheses**

In a cued recall task, for an X-Y pair, presenting X as cue and asking for Y as target means forward recall while presenting Y as cue and asking for X as target is referred to as backward recall. On the other hand, in an associative recognition task, if the pair is presented as X-Y order in the test, it is called as forward association while Y-X order is called as backward association. Moreover, in the free recall task, people's tendency to recall items in studied order is investigated. For example, when an item is recalled in a free recall task, if the subsequently recalled item is the following item in the study list, a forward recall was performed. If the preceding item in the study list is recalled, then a backward recall was performed. Contiguity effect shows a forward asymmetry suggesting that a forward recall is more probable than a backward recall.

Investigating the details of associative memory suggested two main hypotheses about symmetricity of associations. According to Independent Association Hypothesis (IHA), forward and backward recall is different from one another (Wolford, 1971; Kahana, 1996); performance on A-B association should be different from B-A association. In contrast to this hypothesis, Symmetric Association Hypothesis (SAH) argues that forward and backward associations are not different from one another and the associations are symmetric (Asch & Ebenholtz, 1962; Murdock, 1966; Kahana, 2002).

As literature suggests, whether associations are formed as holistic or independent of the nature of the task. If the task is a probed recall, a free recall, an associative recognition task and short lists with a length of 4-6 items, the results support IAH (Ebbinghaus, 1885/1913; Kahana, Howard, Zaromb, & Wingfield, 2002; Kahana, ve Caplan, 2002; Thomas, Milner, & Haberlandt, 2003). On the other hand, if the task is a cued recall task, performance on the forward and the backward recall was comparable and thus SAH is supported (Kahana, 2002; Murdock, 1965, 1966; Mandler, Rabinowitz, & Simon, 1961; Madan, Glaholt, & Caplan 2010; Sommer, Rose, &Büchel, 2007) with some exceptions (Caplan, Boulton & Gagne 2014; Popov, Zhang, Koch, Calloway, & Coutanche, 2019; Vaughn & Rawson, 2014).