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Understanding Vocabulary Learning and Teaching: Implications for Language Program Development

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Chapter 2
Supporting Your Brain Learning Words

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Introduction

As children, we pick up between 10 and 15 new words a day without explicit instruction. This seems to come naturally to us. However, later in life as adults, learning a new language—and particularly all that new vocabulary—can feel anything but instinctive. What changes when we grow up that seems to make this linguistic acquisition more difficult?

It helps to understand how language is processed in the brain. We have to distinguish between the language network and the limbic system, as well as analyze how they are formed and interact with one another. Once we understand this, we can make recommendations about how to effectively learn words as adults, although we must keep in mind that language learning is, after all, an individual effort and much depends on the learner's background and motivation. In psycholinguistic terms, this means that if the word to be learned is not attended to properly, it cannot be acquired.

This chapter presents information about the creation and maintenance of the language network and the limbic system, followed by a discussion of attentional resources. At the end of each section, implications for learning and teaching are outlined. The concluding section provides a number of recommendations for language program directors and materials developers when structuring a vocabulary learning program.

The Language Network

It is often assumed that language processing takes place in two areas of the brain: Broca's (responsible for speech production) and Wernicke's (responsible for speech comprehension). These are the areas in which phonemes—the smallest units of sound—and lexemes—the smallest units of meaning—are processed. In learning the vocabulary of a new language, an incoming word is compared to the existing inventory of phonemes and lexemes in order to be identified. If it cannot be identified, a new record of the word is created. When a word is activated to be used in speech, lexemes and phonemes from two or more languages are called up at the same time to then be processed in Broca's area.

We now know that Broca's and Wernicke's areas are part of a larger language network called the perisylvian cortex. The cortex connects Broca's and Wernicke's areas with the primary motor cortex, which coordinates the physical aspects of speaking, as well as with the auditory cortex that processes sound. In addition, the phonological loop, which consists of two subsystems—the rehearsal component and temporary storage—is integrated into the network. Although the rehearsal takes part in Broca's area by identifying phonemes, the temporary storage subsystem is not part of Broca's area. Rather, it is on the left side of the parietal lobe, where phonemes that cannot be immediately identified are temporarily stored (Baddeley, 2007). The network is built by forming connections; the more words are acquired, the more connections are formed. The same network is used when we learn our first language (L1) as children and when we learn another language as adults. As adults, we have to form connections once again, in order to acquire the words of a second language (L2) we are learning.

In analyzing the rehearsal process in the language network, studies in cognitive psychology have shown that in order to process words into long-term memory, it works well to use spacing techniques: that is, to repeat words within a certain time frame. These techniques are used in what is labeled "rote learning," which is an effective method for beginning learners (Barcroft, 2009; van Zeeland & Schmitt, 2013). Rote learning isolates words from context. However, from a pedagogical point of view, it is desirable that a learner be able to use a word in a given context (Nation, 2001). From a psycholinguistic point of view, rote learning is efficient because repetition fosters the "subvocal rehearsal process" (Ellis, 1995). (It is beyond the scope of this chapter to go into all the details of the over 300 studies that have been carried out in this area, but for an overview see Balota, Duchek, & Logan, 2007; Roediger & Karpicke, 2010.) The idea of spacing is based on the principle of giving the brain time to process the information by providing a pause or a distraction: words are presented, a pause or a distraction is inserted, the same words are presented again, another pause or distraction is inserted, the same words are presented again, and so on. A general distinction is made between two types of intervals: uniform (pauses are consistent in length) and expanded (pauses expand in length). Initially, studies were carried out on the same day; for example, using 30-minute intervals. However, Cull (2000) argued that intervals that are spread over multiple days more accurately reflect how a language learner progresses in a language class. Therefore, he carried out a series of studies using same-day intervals (one-day learning) as well as multiple-day intervals (multiple-day learning) in order to show that in one-day and multiple-day learning, both the uniform interval and the expanded interval lead to higher retention rates compared to the massed interval (no pauses or distractions are made). His results were later confirmed by another series of studies by Carpenter and DeLosch (2005). Schuetze (2015) took this experimental design further by carrying out several

retention tests to distinguish between short-term gains (test given the day after the last learning session) and long-term memory (test given four weeks after the last learning session). He showed that students (learning beginner German as an L2 at a West Coast university in North America) using the expanded interval when practicing five times in a 12-day period (practicing on days 1, 2, 4, and 8) performed better on the first test (one day after last learning session) than students who had practiced with the uniform interval in the same time period (practicing every two or three days). However, on the second test (given four weeks after the last learning session), although both groups of students did not remember as many words as they had on the first test, the ones who had used the uniform interval remembered more than those who had used the expanded interval. Another set of studies by Schuetze (2017) using a similar design showed that in order to improve retention rates, it is beneficial to increase the number of repetitions.

For instructors, educating students about efficient vocabulary learning can go a long way. This entails informing students (here referring to those who are learning another language in the context of a North American postsecondary institution where a language class has three to five contact hours per week) that spreading out vocabulary learning over several days (uniform or expanded interval) is more beneficial than cramming (massed interval). If the goal is to acquire many words quickly, an expanded interval should be used. If the goal is to acquire words so that they are consolidated into long-term memory, a uniform interval is preferred. If there is time, a combination of the two is ideal: that is, starting with an expanded interval and then continuing with a uniform interval (Schuetze, 2017).

Finally, if we come back to the function of the phonological loop, several experiments dating back to the 1960s and 1970s have shown that longer words (Baddeley, Thomson, & Buchanan, 1975) and phonologically similar words (Baddeley, 1966a, 1966b) are difficult to process. Lexical errors and word associations in tip-of-the-tongue states, which are related phonologically to the target word, also demonstrate how similar-sounding words can interfere in L2 word learning and production (Ecke, 2001, 2015). Every phoneme has a memory trace, that is, a time limit for it to be identified in the phonological loop before the loop must make room for other phonemes that need to be processed. When rehearsing the many phonemes of a longer word, there might not be enough time for processing in the loop before all the phonemes are identified, whereas rehearsing the phonemes of similar-sounding words makes it difficult to discriminate them sufficiently in the time available. The last point refers to similar-sounding words in the same language.

The implication for learning is to avoid presenting learners with too many long words or similar-sounding words at a time. In L2 acquisition, a common practice for pronunciation exercises is to present rows of similar-sounding words. Although students can practice pronouncing vowels and consonants this way, they

will find it difficult to also acquire the meaning of the words that they are pronouncing. A more efficient method is to reduce the number of similar-sounding words. It is important to note that words that sound similar in two languages and have similar meanings, such as cognates, are exceptions because the new word is linked to a word that is already known in the learner's L1 (see Hall, 2002; Hall, Newbrand, Ecke, Sperr, Marchand, & Hayes, 2009).

There are other ways of learning words than rote learning. In fact, rote learning is often seen in conjunction with incidental learning. They are not mutually exclusive but are instead preferred at different levels of proficiency. Incidental learning assumes that students learn words by reading authentic texts because these texts provide a rich source of a language's vocabulary (Hulstijn, 1992). This method is often used once learners have reached an intermediate level of proficiency because it relies on the knowledge of a base vocabulary. However, the amount of reading that is required is high (Hulstijn, 2001; Schmidt, 2010; van Zeeland & Schmitt, 2013) and often beyond the scope of a second- or third-year language course. Nevertheless, students benefit from extensive reading if it can be accommodated into the curriculum. Ideally, although rote learning is an effective method at the beginner level, learners also practice some reading in first-year courses.

The Limbic System

The limbic system is another network in the brain. It connects the hippocampus (responsible for recording memories) with the amygdala (that processes emotions) and the entorhinal and perirhinal cortices that transmit information from the senses (Tranel & Damasio, 2002). The record of a word is created in the hippocampus: a protected region deep within the brain that, together with the amygdala and the two cortices, is apart of the temporal lobe. More specifically, this area is called the mesial temporal lobe. The hippocampus, the amygdala, and the cortices are represented on the left and right sides of the brain. The storage of words—more precisely, their lexemes—occurs in the nonmesial region, which is adjacent to the mesial region. This provides a safeguard: in case of damage to the hippocampus, words can still be recalled and used. However, it will be difficult to learn new words.

The amygdala plays a key role in the processing of emotions, which in turn play a role when recording information (Tranel & Damasio, 2002). If the senses are stimulated when a new word is encountered, the amygdala might tag the word in order to fast-track it (Amaral, Prince, Pitkanen, & Carmichael, 1992). Through the amygdala, a higher dose of a neurotransmitter is released, thereby processing the lexeme with heightened activation because the amygdala is connected not only to the entorhinal and perirhinal cortices that transmit sensory information but also to the basal forebrain (Amaral et al., 1992), which is connected to Broca's area. This heightened activation stimulates a memory trace—the duration of time

it takes a lexeme and the phonemes of a word to be processed before they decay. Most words decay in half a second, but the trace can be prolonged to last up to two seconds. With more stimulation, the likelihood of the lexeme to be matched to the phonemes increases. This happens with emotional words. For example, the probability of processing a word such as "hot" is higher compared to a word such as "hat," even though they are only differentiated by one letter. "Hot" has many potential emotional associations such as "hot weather," "hot car," or "hot coffee." The entorhinal and perirhinal cortices connect the hippocampus with sensory information from other brain regions in order to receive visual, auditory, and olfactory information (Gluck & Myers, 2001). When a word is retrieved, these brain areas are activated again. The retrieval of a word can be triggered by emotions. If a word cannot be recalled immediately, the amygdala can be activated by stimulating the senses, which may in turn assist memory. This works well with words that are attached to an emotional situation or event. For example, imagine that you burned your tongue the first time you drank a coffee in Germany. You may then more easily recall the German word for "hot"—*heiß*!—due to the sensory and emotional experiences associated with the word.

A good strategy when learning a new language is therefore to stimulate the senses as much as possible. Because the perisylvian cortex and the limbic system interact with one another, any type of stimulation of the senses helps learning. For example, the look, feel, or taste of an object that has a name you have never heard before will assist in creating a record of the new word. Any type of situational learning is beneficial, for example, if you are learning Spanish and go to a Spanish restaurant. However, while you are there, you need to practice your Spanish and make an effort to speak the language. Otherwise, your hippocampus will not record as much as you hope.

Attention

Processing a word from first encounter to long-term memory takes place over several phases, and the phases overlap. During the first phase, the word needs to be attended to (Schmidt, 1995, 2001). Attention requires much energy and is linked to our ability to direct attention to an incoming word, to divide attention if there are several incoming words, and to switch attention if there is an unknown word (Baddeley, 2007). This is a complex process involving several areas in the frontal lobe, referred to as the central executive, that are associated with planning, organization, and decision making. Among other things, the executive control is linked to the learner's motivation and his or her familiarity or unfamiliarity with a word. If attended to, words are processed by the phonological loop that is part of the language faculty in the brain.

Our capacity to process information is limited. More attention placed on content often means that less attention is available to process form (Barcroft, 2002;

Robinson, 2003; Skehan, 2009; VanPatten, 1990, 2004). It can happen that a word is recalled quickly and is pronounced with the correct combination of a lexeme and its phonemes but with an incorrect grammatical morpheme. Skehan (2012) refers to this as a trade-off: if you focus on one aspect, the other aspects might be neglected. An example from the many language courses I have taught is that learners of German whose L1 is English often have difficulties with plural forms of nouns. When talking about movies, they recall the word *Film* (movie) and pronounce it correctly but use an incorrect plural such as *Filmen* instead of *Filme*. The reason for this has to do with the way morphemes are processed in speech production. A lexeme is recorded with morphological markers but not actual morphemes. These markers function as placeholders. They indicate what type of morpheme can be linked to the lexeme. The actual morpheme is attached to the lexeme later. By saying *Filmen* instead of *Filme*, the speech is not only inaccurate, but fluency is also compromised because the mistake has to be corrected, which takes time.

For language program directors, it would be helpful to select textbooks that have a sufficient number of activities for practicing word meaning. The type of activities should be a combination of target activities (rote learning) and reading (incidental learning). Unfortunately, in many textbooks, vocabulary is more of an afterthought; that is, words are introduced for the purpose of practicing grammar. Here lies the problem. For a learner, it can be challenging to decipher the grammatical form of a word that has just been encountered because the attentional resources are directed to either its form or its meaning. The same issue occurs when learners are asked to form a sentence with a word they have just seen or heard only once or twice. Fortunately, the past decade has seen a revived interest in vocabulary studies in research and teaching. An inspirational approach comes from Jamie Rankin at Princeton University, who developed a vocabulary-driven first-year curriculum called *der/die/das*. (See Rankin in Chapter 6).

We need to consider that the kind of trade-off being made also depends on the speaker's level of proficiency as well as his or her individual speaking preferences (Cook & Singleton, 2014; Singleton, 1995, 2007). The learner has to decide what is more important: either to get the message across by quickly recalling words even if they are not in the correct grammatical form or to assemble a perfect sentence, which may take extra time. In addition, if the concept of a word a speaker wants to use is different in the language being learned than in his or her L1, the speaker has to decide if the word chosen expresses what he or she wants to say. Since the decision has to be made quickly (a word is processed in half a second or less), the question is whether this decision-making process happens subconsciously or consciously. Likely, the answer depends on the personality of the speaker because some people like to take their time to respond or explicitly ask for assistance ("What is that word I am looking for?"), while others utter a word even though it might not be the one they had been searching for.

A question often asked is "How many words should be learned in a day, a week, or over the course of a semester?" A survey by Schmitt (2008) showed that suggestions range from 3 to 20 repetitions. This depends very much on the number of contact hours a learner has when studying a language, his or her personal motivation, and opportunities to engage in the studied language outside the classroom. Further, it also depends on the context of processing (Hulstijn, 2001; Nation, 2009; Schmitt, 2008; Schuetze, 2017; Webb, 2005), that is, if the words learned are targeted (rote learning) or are learned in context (incidental learning). So when we think about how many words we can learn at a time, ultimately there is no definitive answer. A key to success, however, is to not learn large numbers of words at a time but instead to break them down into smaller portions and repeat them.

Another good strategy is to give the brain a rest between learning sessions. We know that during rapid eye movement sleep, the dorsolateral prefrontal region rests (Muzur, Pace-Schott, & Hobson, 2002), while the main part of the limbic system is quite active. We can deduce that when the executive control is resting no new information is attended to and consequently information that entered the brain before sleep is processed again. Since the hippocampus sits deep within the limbic system, it is possible that the record of a word is reviewed to some degree. In addition to reviewing, the brain might also sort out information it receives into what is considered important and what is considered unimportant, strengthen the important information, and link it to other previously existing information. In a study on memory, participants had to learn word pairs (Wilhelm, Diekelmann, Molzow, Ayoub, Mölle, & Born, 2011). Group one was told that they would be tested on the material sometime in the future. They were divided into three subgroups: one that was allowed to sleep after the learning phase was complete (the learning phase took place in the evening and testing was done the following morning), one that was not allowed to sleep and stayed awake by playing cards and watching movies, and one that was also not allowed to sleep, but the learning phase was in the morning and the testing was in the evening of the same day. Group two was not told that there would be a test. This group was divided into the three subgroups using the same criteria as for group one. Results showed that the two subgroups that were allowed to sleep outperformed the other subgroups when they had to recall the word pairs; and of those two, the subgroup that was told that there would be a test outperformed the subgroup that was not given that information.

The implications for curricular development are to teach languages over multiple days per week in order to give the brain some rest between each teaching unit. For example, if a course has five contact hours per week, ideally it should be scheduled five days a week for one hour at a time. Research on sleep also indicates the benefits of building in review sessions before a test as well as announcing tests and exams in advance.

Conclusion

In summary, processing words is not just a matter of language faculties but also of memory and the senses. The perisylvian cortex interacts with the limbic system. Although we all have the same hardware in our brain (the language faculties, the limbic system, the central executive), it is a matter of how we use it. Some learners will form more connections within a network, as well as between networks, than others. Still, there are some general guidelines that might assist when coordinating a language program.

First, given the way the language network processes words, the factor of repetition should not be underestimated. However, if words are repeated too many times, the learner's executive control will cease to divert attentional resources to that word. One has to find a balance between introducing new words and reviewing others that have been previously introduced. There are several programs that work on the principle of flashcards, such as Quizlet, Anki, or eyeVocab.

Second, given how the language network interacts with the limbic system, stimulation should likewise not be underestimated. This stimulation can come from something as simple as providing opportunities for students to talk to native speakers or organizing field trips.

Third, a driving motivational factor for learners is to go to the country where the language they are learning is predominantly spoken. A language program should offer a summer school with a full immersion experience in that country. A question often asked is at what proficiency level it is most beneficial to participate in such a program. Although this depends on the program, if one goes abroad during the first year of foreign language studies the experience can be frustrating because the number of connections that have been formed in the brain might not be high enough to accelerate one's growth through engagement in an immersive environment. It might be more beneficial to wait until one has reached an intermediate level of proficiency. Nonetheless, language learning is an individual effort and depends very much on the individual student.

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