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Semantic and related types of priming as a context in word recognition

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In this paper written word context is being discussed, as well as its effect on word recognition time. To say that an item or word is recognized it must be identified as familiar. It is the only definition of recognition of our interest in this article. It should be noted, however, that recognition is not the only concept of interest for the researchers in the field. All the information that become available once the word is recognized may be important (words' meaning, is it a noun or a verb, singular or plural, how is it pronounced etc.). For the purposes of this paper, context is defined as "words that precede target word and affect its recognition time". This phenomenon is also known as priming. Priming as a research method is widely used in psychological and linguistics studies. We discuss on the concept of priming, what types of priming are identified in the literature and how they occur. Review of semantic, mediated, form-based and repetition type of priming is given, as well as what outcome they give in different types of tasks. Also, we give a short review of semantic priming models, and a description how semantic priming works. For this purpose, two of the most verified models have been described, and others were just briefly mentioned. Finally, most typical evidence from neuroimaging studies of semantic priming is offered.

Key words: priming, semantic priming, orthographic priming, context, word recognition, neighbourhood effect

What is the reason for study how context can affect word recognition? Let us put it this way, literacy is one of the most important things in today's society, but most of us take it for granted. This happens because once you have learnt to read it occurs automatically, with very little effort. Producing grammatically correct sentences that express your thinking is also given no attention, we all suppose that's the way thing should be. However, there are lots of people that have trouble reading, writing, understanding speech and all kind of problems concerning language. If there is a way to help them, or to better understand how just one aspect of language works, study of word recognition and factors that can affect it is justified.

One of the most important ideas in word recognition is that of priming. It involves presenting material before the word to which a response has to be made. Most common paradigm involves presenting one word prior to the target word to which participant is supposed to respond. The first word is called *prime*, and is usually presented for a very short period of time (in tens or hundreds of milliseconds), and the second word is called *target*, the one to which response has to be made. The time between prime presentation (onset) and the target presentation is called stimulus onset asynchrony, or SOA (Harley, 2005). Target word can be preceded by a sentence or a picture, and priming can also be auditory, as well. In this paper, however, we are focused on how (written) words prime words.

Priming

Priming refers to an increased sensitivity to certain stimuli due to prior experience. Because priming is believed to occur outside of conscious awareness, it differs from memory that relies on the direct retrieval of information. Direct retrieval utilizes explicit memory, while priming relies on implicit memory, and it is assumed to be an involuntary and perhaps unconscious phenomenon. Research has also shown that the effects of priming can impact the decision-making process (Jacoby, 1983). In other words, priming is the implicit memory effect in which exposure to a stimulus influences response to a subsequent stimulus. It can occur following perceptual, semantic or conceptual stimulus repetition.

Priming effect, in a form that identification of a word can be facilitated by prior exposure to a word related in

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meaning, has been known for over a century (Cattel 1888/1947; Harley, 2005). Mayer and Schvaneveldt (1971) provide one of the first recent demonstrations of what is one of the robust and important findings about word recognition. Using lexical decision task they demonstrated that word is recognized faster if it is immediately preceded by another word related in meaning.

Priming can affect word recognition in two different ways; it can speed up target word processing, or slow it down. If a prime is making word processing faster than it is called *facilitation*, and if it slows down the processing then it is considered to be *inhibition*. Whether the prime will affect target word in one of two ways depends on both word choices – prime and target word. And of course, it depends on what type of priming we want to use (see section below for information about types of priming). It is considered that if two words are connected in any way (orthographic, semantic etc.) it should have a facilitatory effect, and if they are not connected then the effect should be inhibitory (or there should be no effect at all). But this is far more complex issue as we will see in the rest of the paper. Furthermore, there are several models that give an explanation why things like inhibition or facilitation even occur.

Types of priming

Semantic priming

The most common type of priming in word recognition tasks is *semantic priming,* which is considered to be a type of *context effect* (Harley, 2005). The s*emantic* in *semantic priming* implies that priming is produced by true relations of meaning. This term dates back in seventies when Meyer and Schvaneveldt (1971) published their article in Journal of Experimental Psychology, entitled "*Facilitation in recognizing pair of words: Evidence of dependence between retrieval operations*." In that research, participants were asked to decide whether two simultaneously presented strings of letters were both words (e.g., table-grass) or not (e.g., marb-bread). Of the word-word pairs, half were semantically related (e.g., nurse-doctor) and half were not (e.g., bread-door). On the average, responses were 85 milliseconds (ms) faster to related pairs than to unrelated pairs. This phenomenon later came to be known as "semantic priming" (McNamara, 2005).

One can see that the effect might have some advantages for processing. Words are rarely seen or heard in isolation, also word related in meaning often co-occur in sentence. Hence, processing might be speeded up if words related to word you are currently reading are somehow made more easily available, as they are more likely to come next than random words.

Furthermore, it turns out that there are different types of semantic priming creating different effects. Still, they are all not equally successful in inducing priming. We can distinguish between two types of semantic priming – associative and non-associative semantic priming.

Associative priming refers to priming by associates which might or might not be related in meaning. What does this mean? Consider following example. If you have word association task, two words are considered to be associated if participant produces one in response to the other. This can be measured by word association norms such as those of Postman and Keppel (1970). Norms such as these list the frequency of responses to a number of words in responses to the instruction "Say the first word that comes to your mind when I say…chair" (Harley, 2005). In responses you may come across the words like "table", "sitting" etc., but sometimes there are responses that are not related in meaning, for example for word "hospital", you get "waiting".

Non-associative semantically related words are those that still have a relation in terms of meaning to the target, but that are not produced as associates. For example, take words "run" and "walk"; they are rarely produced as associates, but they are clearly associated in meaning. Both words refer to similar body movements. Or for example, "dolphin" and "cow". You can find semantic connection between those two words (both are mammals), but as said before they are not likely to be produced as associates.

The classic task for investigating semantic priming, besides *word association task*, is the *lexical decision task*. The stimuli consist of correctly spelled words and meaningless strings of letters called "non-words" (e.g., *tild*). On each trial of the experiment, a prime and a target are displayed on a computer screen. Participants are instructed to read the prime silently and then to decide whether the target is a word or non-word. The standard finding is that lexical decision responses are faster and more accurate when the target is semantically related to the prime (e.g., *cat-dog*) than when the target is semantically unrelated to the prime (e.g., *table-dog*). Another commonly used task is *naming* or *pronunciation*. In this task, participants are asked to read the target word aloud as rapidly as possible (non-words are typically not presented). Again, the common finding is that people can name the target word faster when it is primed by a semantically related word than when it is primed by a semantically unrelated word (McNamara, 2005).

Mediated priming

According to Harley (2005, p. 165) "Mediated priming is facilitation between pairs of words that are connected only through an intermediary (e.g. "dog" primes "cat" which primes "mouse")". However, evidence for this type of priming has not been found in all types of tasks, such as naming task, word association task, lexical decision etc. Mediated

priming is found to be more reliable in naming task than in lexical decision task (Balota & Lorch, 1986), but this is only the case if standard lexical decision task is used (where participants have to make decision on target word). If the task is changed, for example, that participants have to either "(a) make lexical decisions about the prime or target (McNamara & Altarriba, 1988) or (b) only make a response to word targets and not respond to non-word targets (den Heyer, Sullivan, & McPherson, 1987), mediated priming does occur in the lexical decision task" (Traxler & Gernsbacher, 2006, pg. 329). So, this makes us question why mediated priming is usually *not* found in lexical decision task. The reason is that participants normally speed up processing by using post-access checking, while naming task is less sensitive to post-access checking. This leads to conclusion that different tasks give different results, and researchers should construct experiments in respect to this finding.

Form-based priming

This phenomenon is also known as *orthographic priming*. The main feature of this kind of priming is that it relies on visual property of the word, that is – how word looks when written down. It is reasonable to suppose that if there is an overlap between physical forms of two words they can prime one another. Take for example words CHAIR and CHOIR or words STENCIL and PENCIL. However, form-based type of priming is very difficult to demonstrate, and depending on type of tasks and material in task this kind of priming can either facilitate or inhibit the word recognition.

Research paradigm involving masked orthographic priming was developed by Evett and Humphreys (1981). In this paradigm, two letter strings are briefly presented, both preceded and followed by pattern masks. Presented letter strings vary in relatedness, whether semantic, orthographic or phonological. Usually, (a) participants are not aware of presented stimuli, and (b) their response is faster on second word if that word in this case shares some orthographic features with the first word.

However, it has been shown (Humphreys, Besner, Quinlan, 1988) that form-based priming is only effective with primes masked at short stimulus on-set asynchronies (SOA) so that the prime is not consciously perceived. Further investigation showed that the efficacy of form-based primes depends on the exact makeup of the materials in the task (Forster & Veres, 1998). Form-based primes can even have inhibitory effect on target recognition, i.e. can slow down the recognition of target word (Colombo, 1986). One explanation of these findings is that visually similar words are in competition during recognition process so that in some circumstances similar-looking words inhibit each other.

It has been documented that many factors can affect visual word recognition, like word frequency, length, familiarity, etc., but besides that, it matters what kind of prime precedes the target word. For example, some words have a large number of other words that look like them, whereas others do not. This is very important factor if you are about to use form-based priming in your research. All "look-alike" words to target word are so called *neighbours*. Different time necessary for word recognition that rises up from number of neighbours of one word is called *neighbourhood effect* (Grainger, O'Regan, Jacobs, & Segui, 1989).

Furthermore, in 1977 Coltheart, Daveaar, Jonasson and Besner proposed *N-statistics*; defined as number of words that can be created by changing just one letter of a target word. If a word has large N, then it is considered to have many orthographic neighbours, and *vice versa*, if a word has low N then it is considered to have very little orthographic neighbours. Neighbourhood size affects visual word recognition, although clear benefits are only found for low-frequency words (Andrews, 1989; Grainger, 1990), whether in naming task or lexical decision task. This means that facilitation provided by large number of neighbours is effective only for target words that have low frequency in language usage. Moreover, Grainger (1990) reported that response times to words are also sensitive to the frequency of the neighbourhood of the target words. When the frequency of the orthographic neighbours in lexical decision task was controlled, the size of the neighbourhood effect was reduced to that of naming task. Responses to target word that had high frequency neighbours were slowed down in the lexical decision task, and speeded up in naming task. Also, Grainger (1990) emphasized that in some previous papers target word frequency is often confused with neighbourhood frequency, and it should be handled with caution.

Repetition priming

This type of priming refers to technique of speeding up the recognition by method of word repetition. In repetition priming, prime and target represent the same word and are often separated by several other intervening items (Neely, 1991). Though the prime and target are semantically related in the repetition priming paradigm, any semantic priming that occurs can be contaminated by other types of priming produced by the shared graphemic or phonemic properties of the word (prime or target) (McNamara, 2005).

Main logic of this method is that once you have seen the word it is easier to recognize it when you see it again. This may seem to be so logical that does not even need to be tested. But numerous investigations on this subject showed that effects of repetition priming have been reported even several hours later.

Still another type of semantic priming should be mentioned, so called *threshold priming*. Since this is not a common type of priming it will not be discussed here. For additional information about this type of priming see McNamara (2005).

Models of semantic priming

Spreading activation models

Spreading activation model is one of two main theories of how priming occurs. This model was first built in a model of memory (Quillian, 1968); and had a couple of revisions (Collins & Loftus, 1975). Also, this type of model was proposed by Anderson (1976, 1983, 1993), and discussed by Posner and Snyder (1975) (McNamara, 2005). Although all this models differ from one another in some aspects, they share the main idea. All of them have a base in the following assumption: visual presentation of a word activates mental representation of the word. The activation spreads to related concepts, and also actives them, but a bit "slighter". For example, if the word "motorbike" is seen, the activation spreads to related concepts like "automobile" and activates it. If one word appears soon after another word in relation, it can be identified more quickly than when normally presented. Reason lies in previous partial activation of that nods.

Collins and Loftus' (1975) model of semantic processing distinguishes between two types of knowledge for a concepts; knowledge of their names and knowledge of the meaning of concepts. In their theory, conceptual network is organized according to semantic similarity. Even though this theory kept for a long time, the evidence was partly problematic for their model. Ratcliff and McKoon (1981) showed that different SOA between target and prime gives different results. Specifically, if the SOA was shorter than 100 ms no priming occurred. Moreover, Lorch (1982) obtained similar results for semantic priming in a naming task (McNamara, 2005).

Compound cue theory

In the article from 1981, Ratcliff & McKoon examined three spreading activation models for retrieval of information from memory: a model proposed by Quillian (1968), by Anderson (1976) in the areas of memory, language and thought, and model proposed by Collins and Loftus (1975) in area in semantic memory (Ratcliff & McKoon, 1981). Spreading activation usually carries two different assumptions; amount of activation arriving at any node is a decreasing function of the number of links (the distance) the activation has traversed; and activation takes some significant amount of time to spread between nodes. This period of time however varies from one researcher to another. To test those two assumptions, two experiments were performed in which facilitation as a function of time was measured for the target words in a linearly structured paragraph. A target word was primed either by a word near to the target in the paragraph structure or by a word far from the target. Results showed that facilitation begins at about the same time for the far and near conditions. These findings were inconsistent with spreading activation models.

In the late 80's two groups of researchers (Ratcliff & McKoon, 1988; Dosher & Rosedale, 1989) independently proposed compound-cue model of semantic priming. This involves the search of memory with a compound cue that contains both the prime and the target. This theory predicts that priming can only occur if two items are directly linked in memory (Harley, 2005). It therefore cannot account for mediated priming where two items that are not directly linked can be primed through an intermediary (McNamara, 1992, 1994). According to Nelly (1991), compound-cue modes have been categorized as "post-lexical" priming models, meaning that they account for priming with processes that occur after lexical access. These types of models have been criticized because they cannot explain priming in naming task (Neely, 1991).

Other models

There are of course several other models that attempt to give complete explanation why and how semantic priming occurs. Reason why they are placed in a separate part of this article is because they are adapted models of visual word recognition, i.e. models of reading in general; *Becker's verification model* (Becker, 1976; 1979), which is model of concepts representation; *Distributed network models* (McClelland & Rumelhart, 1986), and some *Multistage activation models* (e.g. Morton, 1969; McClelland & Rumelhart, 1981; Coltheart, Rastle, Perry, Langdon, and Ziegler's, 2001) that are actually a combination of two or more previously mentioned models. All this models are nicely described in McNamara's book (2005), and will not be described here. However, none of the existing models offer complete explanations for all types of priming. Some models are good at explaining one type of priming while others offer good explanation of type of task and so on. Reason for pointing out activation spread model and compound-cue model is that those two models were the most examined ones in the past, as well as because they contrast one another (Ratcliff & McKoon, 1992).

A brief overview of neuroimaging studies of semantic priming

Neuroimaging techniques were used in order to investigate brain activity during performing sematic priming related tasks.

One such study (Nobre, Allison & McCarthy, 1994) recorded event-related potentials (ERP) during semantic priming tasks with pairs of words. The results showed that evoked potentials have, so called, late component called N400 which was significantly related with semantic anomalies. It turned up that hippocampal region was a neural

generator of N400 potentials. Such potentials were present while processing unrelated word pairs, but were attenuated or absent with semantically related word pairs. This is classical "N400 priming effect" and it has also been reported by other researchers (e.g. Bentin, McCarthy & Wood 1985; Rugg, 1985). It seems that N400 priming effect is produced by processes that are involved in integrating semantic information into context. The easier it is for new information to be incorporated into immediate context, the smaller is the amplitude of the N400 component (McNamara, 2005).

It also seems that region of cortex called anterior cingulated cortex (ACC), placed on medial surface of frontal lobes, plays key role in semantic priming. Another neuroimaging study that used fMRI technique was carried out by Rossell, Bullmore, Williams, & David (2001). Four experiments, which included two un-primed lexical decision tasks and two semantic primed lexical decision tasks, were performed. Also, two of the semantic priming experiments used short and long SOA (stimulus onset time) in order to provoke automatic and controlled processing of semantic relations, respectively. Both, automatic and controlled semantic priming were critical for changes in activation of distinct parts of anterior cingulate cortex (ACC). Putamen and hippocampus both reacted differently to semantically related and unrelated words.

In another fMRI (e.g. Matsamuto, Haneda, Okada & Sadato, 2005; Rossell, Price & Nobre, 2003; Wilbe, Han, Spencer, Kubicki, Niznikiewicz, Jolesz, McCarley & Nestor, 2006) and PET studies (Mummery, Shallice & Price 1999) with semantic priming, changes in anterior cingulated cortex, and also, changes in various regions of temporal cortex and inferior frontal cortex activity have been found. Decreased activity was usually observed for semantically related pairs of words, relative to activity for semantically unrelated word pairs.

Conclusion

Semantic priming is a broad area of research, and here only the main forms, results and models concerning that phenomenon have been explained. Semantic priming is a simple demonstration of one of the most basic properties of cognitive systems; this refers to constantly relying on context in which the given information is being processed. According to definition alone, and given paradigm it can be seen that semantic priming is in the first place a context effect. That effect shows how primes, that are context words, can affect adjacent word recognition efficiency. By simply manipulating that context it can be demonstrated how visual word recognition can be either speeded up or slowed down. Semantic priming came to be used as a tool to investigate some aspects of perception and cognition, such as word recognition, sentence and discourse comprehension, and knowledge representation.

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