INFLUENCE OF SEMANTIC PRIMING AND WORD FREQUENCY ON HOMOGRAPH PROCESSING

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Abstract: Semantic priming and word frequency effects have been actively researched to provide insights into the cognitive process, attention, memory, and applications in computational models for translation. This paper investigated the influence of semantic priming and word frequency on visual word recognition by native speakers of English. Three experiments were conducted to throw light on the mechanism of meaning activation based on how the homographs were processed in isolation and in contexts with semantic priming. The homographs used in the present study were ones with the same spellings, but with different pronunciation and meanings. Thus, the reading of the words would give clues to which meaning was activated. The findings suggest that the word frequency and personal familiarity have more influence on the choice of meaning activation of homographs than semantic priming.

Keywords: Semantic priming; word frequency; visual word recognition; homographs; meaning activation.

1. Introduction

Visual word recognition and processing is a fascinating research topic in psycholinguistics, cognitive science and language acquisition. It involves attentional and automatic processes. The former is slow, serial and sensitive to interference of the context while the latter is fast, parallel and not prone to interference from other tasks (Harvey, 1995). A number of models have been proposed to account for how we recognize and process visually presented words. The Search model claims that more frequent words are searched before low frequency words (Whaley, 1978; Carroll, 2004). This view is challenged by a number of researchers (eg: Gernsbacher, 1984; Lewellen, Goldinger, Pisoni, & Greene, 1993; Cordier, & Ny, 2005), who argues that familiarity, a personal frequency, plays a more central role in word processing than frequency. Visual word recognition is also influenced by semantic priming, which refers to the observation that a response to a target is faster when it follows a semantically-related prime (Chiappe, Smith, & Besner, 1996; Mattler, 2006; Black, et. al., 2013; Lam, Dijkstra, & Rueschemeyer, 2015; Schneider, 2016). For instance, the word *cat* will evoke a faster response when it precedes the word *tiger* since the two words are semantically similar. Sematic priming can be positive or negative. The positive priming speeds up processing while the negative priming slows down the speed of processing. Positive priming is caused by spreading activation, which means that the first stimulus activates parts of a particular representation or association in memory just before performing an action or task. The representation is already partially activated when the second stimulus appears.

Therefore, one needs less additional activation to become consciously aware of it (Reisberg, 2016). Negative priming is more complicated to explain as it is attributable to

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more than one process (Frings, Schneider, & Fox, 2015). It is an implicit memory effect in which prior exposure to a stimulus unfavorably influences the response to the same stimulus. To put it another way, the recognition of a word is speeded up when the word is semantically related to the ones that precede it. If there is a contradictory relationship between these words, inhibition occurs.

So far, no single model has been able to satisfactorily account for how we recognize and process visual words. Weak versions of these models seem to come into play. Thus, the mechanisms for mapping spelling to sound and spelling to meaning are far from perfectly understood and remain the object of active investigations (Yap & Balota, 2015; Yap, 2019). In addition to shedding light on reading, literacy, and language development, research on visual word recognition has enabled us to understand other cognitive domains, such as pattern recognition, attention, and memory. A good understanding of visual word recognition helps to propel advances in computational modeling and cognitive neuroscience. It also provides insights into us how reading should be taught and how reading disorders, such as acquired or developmental dyslexia, should be diagnosed and treated (Jacobs, & Ziegler, 2015; Nobre & Salles, 2016).

There are several methods of studying visual word recognition and processing, including braining scanning or imaging techniques, eye movements, tachistoscopic identification and measuring names, lexical decision, and categorization times (Lewellen et. al., 1993; Harley, 1995; Sereno & Rayner, 2003; Jacobs & Ziegler, ibid.). However, using homographs to look into the issue is hardly documented. This paper aims to shed more light on the mechanism of visual word recognition from a new angle. Using homographs, ie., words which have the same spellings but different pronunciations and meanings, I conducted experiments on how participants recognized the words in isolation, and with both positive priming and negative priming. Based on the pronunciation of the word, I could realize what meaning was activated. The results of the experiments can provide the answer to the question *Does semantic priming have stronger effect than frequency effect, or vice versa?* and test the hypothesis that *People tend to activate high-frequency words before less frequent words.*

2. Method

The participants of the experiments include 45 native English-speaking Americans (24 males and 21 females). Native speakers of English were so chosen to ensure that they knew all the meaning and were consistent with the way of pronunciation of the homographs (see Appendices). Three experiments were conducted. The first experiment involved 14 participants (7 males and 7 females) who read the 5 words, namely *bow, tear, read, minute, does* in isolation. The purpose of this experiment was to cross-check with the dictionary entries to confirm which of the two meanings has higher frequency. For example, if a majority (or all) of participants read "tears" as /*ti∂z*/ rather than /*te∂z*/, then the word with pronunciation as /*ti∂z*/ has higher frequency than /*te∂z/.* The second experiment included 21 participants (10 females and 11 males) who read the words in the context shown in Appendix A, which biased the readers to the higher frequency. The third experiment involved 10 participants (6 males and 4 females) who read the excerpt which was modified as in Appendix B, which biased the readers to the lower frequency. However, I excluded one participant in the second group because she is a friend of mine, with whom I had had a discussion about homographs and she was well alert during experiment. My interview with her later revealed that when she encountered the word "*bow*", she realized she was reading the so-called garden path sentences, which she had learnt from a psycholiguistics lecture. She therefore slowed down her pace and looked ahead before reading the words. I considered her an exception and decided not to use her data.

Before they read the paragraph, I had them read this instruction "*The purpose of this reading extract is for an experiment on reading. Your assistance is highly appreciated. You can be confident that you will NOT be identified in any discussion of the data. Please read it out loud at your normal speed*". While they were reading these lines, they did not see the paragraph since it was covered with a sheet of paper. Then I uncovered the extract for them to read. The findings are presented in the following section.

3. Findings and discussion

The first basis to determine the frequency of a homograph is its order (hence transcription for pronunciation) in the dictionary entry. Before the experiment, I consulted two dictionaries: Longman dictionary of English language and culture (1998) and Oxford advanced learner's dictionary (2014). According to the orders of appearance in the dictionary entries, these homographs, namely *bow*, *tears*, *read*, *minute*, and *does* are considered to have the first meaning if they are pronounced as */bau/, /ti∂z/, /ri:d/, /min∂t/* and */dʌz/*. The other way of pronunciation, ie. */b∂u/, /te∂z/,/red/, /mainju:t/, /d∂uz/* is said to have the second meaning. In this context, the five words should carry the second meaning, and they have the second way of pronunciation. Intuitively, I assume that the first meaning is of higher frequency than the second meaning. Of these homographs, I did not know the second meaning of *doe /d∂u/*, which means a female deer, until I came across this excerpt. The results of the first and second experiments are presented in Table 1 below.

Table 1: *The homographs read in isolation and in the context that biases to the first meaning* **(**Experiments 1 and 2)

The homographs	Dictionary entry order	Reading in isolation (Total:14 readers)	Reading in context (Total:20 readers.)			
			Correct at first attempt	Incorrect at first attempt	Correct when re-reading	Occurrences of hesitation
Bow	1./bau/ 2. /b∂u/	/bau/ (4) /b∂u/ (10)	3	17	4	4
Tears	1. /ti∂z/ 2./te∂z/	/ti∂z/ (14)	0	20	2	6
Read	1./ri:d/ 2./red/	/ri:d/(14)	4	16	4	5
Minute	1./min∂t/ 2./mainju:t/	/min∂t/(14)	0	20	4	11
Does	1./dΛz/ 2./d∂uz/	/dΛz/(14)	9	11	2	6

As seen in Table 1, the dictionary entries favor my assumption except for */bau/*, which comes before /*b∂u/.* When reading these homographs in isolation, all of the participants activated the first meaning with an exception of 4 people (one male and three females) who read */bau/*. This might imply that /*b∂u/* and */bau/* have different personal frequencies. Surprisingly, of the 14 participants reading these words in isolation, only one female remarked (after finishing the reading) that there are two ways to read these words. When asked why she chose to read that way, she said those words were more common. The finding therefore seems to support the Search Model, which contends that more frequent words are searched before low frequency words (Carroll, 2004, p. 114). It is also evident that familiarity, which is a measure of personal frequency, plays an important role in word recognition. The participants who read "*bow*" as */bau/* might be more familiar with this meaning than the other sense /*b∂u*/, and vice versa.

Visual word processing is much more complicated in context since it is influenced by many factors. In the second experiment (see Appendix A), the three words *bow*, *tears* and *minute* have obvious semantic priming biasing to the first meaning while *read* and *does* do not have a clear prime. As shown in Table 1, a vast majority of the words were misread, indicating that the informants activated the wrong meaning. For "*bow*', 17 informants activated the second meaning. In this particular context, the readers were influenced by the negative semantic priming because the words *arrows* and *hunting* are right above the word *bow*. The word "*arrows*" and "*hunting*" led them to the garden path sentence (Frazier & Rayner, 1982), tricking them into activating "*bow*" as a type of weapon. Four people hesitated and corrected their pronunciation when encountering the phrase "*to a little girl*", which made them realize the garden path sentence phenomenon. The fact that three readers made it right at the beginning might have been attributable to the familiarity effect. As the finding of the first experiment shows, some people might have */bau/* in their high frequency store and this effect was stronger than the preceding semantic priming. Thus, they activated "*bow*' as an act of bending the body forward.

For "*tears*", not single informant read it correctly at their first attempt. They all activated the first meaning when seeing the word. It should be noted that there were 6 hesitations, but only two of the informants re-read it as /te∂z/. They might have noticed the unusual use of the preposition "*in*" (*tears* ***in*** *her dress*) if "*tears*" was interpreted as liquid from the eye, hence hesitations. If "*tears*" meant liquid from the eye, the correct preposition should be "**on**", not "**in**". The reason why the four hesitating readers did not correct their pronunciation might lie in the fact that the word "*crying*" was within their perceptual span since it is right below "*tears*". They might have seen "*tears*" at the same time as they saw "*crying*", which triggered the semantic priming.

In comparison with "*bow*" and "*tears*", the number of correct readers of "*read*' is higher; however, the misreading group still outnumbers the correct readers. It is interesting to observe that all of the previous sentences are in the past tenses. If the "logical" priming had had an effect, the readers would all have activated the first meaning, ie., reading it as /*red/* instead of /*ri:d/*. Nonetheless, the 4 hesitations occurred only when the readers saw the phrase "*to the boy*". This finding tentatively implies that the frequency effect might be stronger than priming.

In a similar vein, no informant correctly read "*minute*" when encountering it. The hesitations occurred only when the readers saw the following line. Of the five homographs, the number of hesitations with "*minute*" is the highest (11). This is because the collocation of "*after a minute*" with "*but rapid examination of their weapons*" is very odd if "*minute*" is interpreted as "*a unit of time*". When reading the following line, they realized that they had activated the wrong meaning, hence mispronunciation. It is most noticeable that the number of correct readers of "*does*" is the highest (9/20). There are several possible explanations for this phenomenon. The previous sentence might have been semantic priming for "*does*". The logical sequence of tense might also have had an effect. After having been tricked four times, these readers might have become more cautious. Their reading speed slowed down toward the end of the extract. These aggregated effects might have been the reason why fewer participants misread "*does*'.

In summary, the findings of the second experiment show that reading is a complicated process which is affected by various factors. The hesitations seem to support the Serial processing model. The readers surveyed the surrounding words and made adjustments as they read on. However, automatic and parallel processing also seemed to have an important role in interpreting the words. Many of the readers did not modify their readings when they encountered the following segments which did not match the previous ones. They might have been influenced by the semantic priming and/or the frequency effects so strongly that they hardly noticed the mismatch of the homographs and the parts that followed. The second experiment, nevertheless, does not show which effect is stronger: word frequency or semantic priming. This question will be answered in the third experiment.

In the third experiment, some modifications were made. The sentences containing negative semantic primes "*arrows*" and "*hunting*" were replaced by other sentences which provide positive priming to the subsequent reading (see Appendix B), namely "*Henry, who was extremely respectful to women*" which clearly biases "*bow*" to the first meaning; "*A little girl who was coming out of a bush*" positively primes the second meaning of "*tears*" as "*bush*" is associated with "*thorns*", which might trigger the logical thought that her dress was torn by the thorns or plants in the bush; and *making* was inserted between a*fter* and *a minute* ("*after **making** a minute*"), which primes the second meaning as it is more logical to interpret "*minute*" as a unit of time in "*after a minute*" than in "*after **making** a minute*". The two words "*read*" and "*does*" were not changed because I wanted to see whether the participants in the third experiment still read the same way as those in the second experiment considering the same context for these two words. Thus, the major difference between the second and the third experiments is the positive semantic priming. The former biases the homographs to the first meaning while the later to the second. If similar results were found (i.e., the informants still activated the first meaning), it could be concluded that the frequency effect is stronger than the priming, and vice versa. The findings are presented in Table 2 below:

Table 2: *Semantic priming biases to the second meaning* (Experiment 3)

Homographs to be read Total: 10 readers	**Transcription and meaning**	**Correct at first attempt** (pronunciation of second meaning)	**Incorrect at first attempt** (pronunciation of second meaning)	**Correct when re-reading** (pronunciation of second meaning)	**Occurrences of hesitation**
Bow	1./bau/ 2. /b∂u/	6	4	2	5
Tears	1. /ti∂z/ 2./te∂z/	1	9	2	4
Read	1./ri:d/ 2./red/	3	7	1	3
Minute	1./min∂t/ 2./mainju:t/	2	8	2	4
Does	1./dΛz/ 2./d∂uz/	4	6	0	3

It is evident in Table 2 that except for "*bow*", the semantic priming had little effect on the activation of the other words. The number of misreaders is still higher than that of the correct readers. In comparison with the second experiment, more participants in the third experiment read "*bow*" correctly than those in the second (6 vs. 3, or 60% vs. 15%, respectively). The number of hesitations does not reflect the effect of frequency or priming since most of them hesitated only when they saw the following words, which means that they realized the mistakes only when they knew the following did not match the preceding. For other words, the number of correct readings was a little bit higher than that in the second experiment, but the misreaders still outnumber the correct counterparts. This suggests that the semantic priming had some effect on word activation but the frequency effect was the stronger. It should be noted that of the 10 informants in the third experiment, three of them misread all of the five words. One participant read all the words correctly but the pace was slower than the others. Seeing this, I asked him whether he looked ahead when reading the extract, he said he did look ahead after he encountered "*bow*", which made him realize the trick.

4. Conclusion

The aims of the experiments were to answer the questions whether people tend to activate higher frequency words before the less frequent words and find out whether frequency effect or semantic priming has stronger effect on word activation. The results suggest that semantic effect does have some influence on lexical decision but it is not as strong as the word frequency effect. When encountering homographs, people tend to activate the higher frequency sense first. The results concur with previous research which found the evidence that personal familiarity has stronger effects on visual word recognition than semantic priming (Perfetti, 2007). The findings also support recent studies, which found that word frequency and semantic priming interact and produce robust additive effects in lexical decision, with larger semantic priming effects for low-frequency targets than for high-frequency targets (Yap & Balota, 2007; Brysbaert, Madera & Keuleers, 2018). It is also implied that the process is dominantly driven by the top-down mechanism, i.e., personal schemata play an important role in interpreting visually presented words. The study makes a contribution to understanding the mechanism of for mapping the orthographical form to sound and meaning. In a broader sense, it may help provide an insight into the cognitive mechanism for reading comprehension and diagnosis of reading disorders. This research was carried out among native speakers of English. Further investigation can be conducted with learners of English to have more insightful understanding of how non-native English speakers recognize visual words with the influence of semantic priming as compared to word frequency.

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APPENDIX A *(for experiment 2)*

Jack's arrows were nearly gone so
he sat down and stopped hunting.
Then he saw Henry making a bow
to a little girl who was walking
towards him. The girl had tears
in her dress and was crying.
She gave Henry a note which he
brought over to the hunters. Read
to the boys, it caused great
excitement. Then, after a minute
but rapid examination of their
weapons, they ran down the valley
beside the little stream. Does
were standing at the edge of the
lake, making perfect targets.

APPENDIX B *(for experiment 3)*

Following the unusual footprints,
Jack and John lost sight of Henry,
who was extremely respectful to women.
Then they saw him making a bow
to a little girl who was coming out
of a bush. The girl had tears
in her dress and a piece of paper in her
hand. She gave Henry a note which he
brought over to the hunters. Read
to the boys, it caused great
excitement. Then, after making a minute
but rapid examination of their
weapons, they ran down the valley
beside the little stream. Does
were standing at the edge of the
lake, making perfect targets.

TÓM TẮT

ẢNH HƯỞNG CỦA KÍCH THÍCH NGỮ NGHĨA VÀ HIỆU ỨNG TẦN SUẤT TỪ ĐỐI VỚI VIỆC XỬ LÝ TỪ ĐỒNG HÌNH

Kích thích ngữ nghĩa và hiệu ứng tần suất từ là lĩnh vực nghiên cứu đang được quan tâm nhằm tìm hiểu cách thức não bộ xử lý thông tin trong quá trình tri nhận, ghi nhớ và ứng dụng trong mô hình điện toán về xử lý dịch thuật. Bài viết khảo sát ảnh hưởng của kích thích ngữ nghĩa và hiệu ứng tần suất từ đối với việc nhận dạng từ trong văn bản của người nói tiếng Anh bản ngữ. Ba thí nghiệm được tiến hành nhằm làm sáng tỏ cơ chế kích hoạt nghĩa dựa vào việc xử lý từ đồng hình xử lý độc lập và trong ngữ cảnh có kích thích ngữ nghĩa. Từ đồng hình sử dụng trong nghiên cứu này có cùng cách viết nhưng khác nhau về ngữ âm và ngữ nghĩa. Do vậy, việc đọc từ đồng hình sẽ cho biết nghĩa nào được kích hoạt. Kết quả nghiên cứu cho thấy tần suất từ và sự quen thuộc từ của cá nhân ảnh hướng lớn hơn kích thích ngữ nghĩa đối với quyết định kích hoạt ngữ nghĩa của từ đồng hình.

Từ khóa: Kích thích ngữ nghĩa; tần suất từ; nhận dạng từ dạng viết; từ đồng hình; kích hoạt nghĩa.