The Influence of Sentence Context on Reading Times for Abstract and Concrete Words

by

Rebecca Long Loomis
Class of 2010

A thesis submitted to the faculty of Wesleyan University in partial fulfillment of the requirements for the Degree of Bachelor of Arts with Departmental Honors in Psychology
Abstract

One variable that affects word processing is concreteness, the degree to which a word’s referent can be experienced by the senses. Concrete words tend to be processed more quickly than abstract words. The dual-coding theory states that processing is aided by image-based representations of words, whereas the context availability model holds that concrete words are processed more easily because they have stronger associated contextual information. This is the first study to test the context availability model by tracking eye movements in a reading task. Participants read abstract and concrete words in predictable and neutral sentences. The results showed a main effect of context and of concreteness. This finding contradicts the prediction of the context availability model that equivalent amounts of contextual information nullify the effect of concreteness. The results support the strategic imagery hypothesis, which states that imagery is used when it is helpful in completing a task.
The Influence of Sentence Context on Reading Times

for Abstract and Concrete Words

For humans, language is the medium through which we express our thoughts; we communicate our ideas about concepts and objects in the environment with words. It is not surprising, therefore, that the study of language is used to shed light on the ways in which representations and ideas are organized in the brain. In order to understand a written word, such as “book,” a reader must access ideas and knowledge related to “book” that are stored in her memory. If reading “book” takes significantly less time than reading another word, such as “cause,” we may infer from this difference that aspects of the word “book” make it easier to access in the mind than “cause.” In this way, studying the different factors that affect the way we read helps researchers understand the way we think.

There are many different variables that affect the rate at which people access, process, and read words. One such variable, which has received a great deal of research attention, is concreteness. Concreteness is the extent to which a word’s referent can be perceived by the senses. Words are typically classified as concrete, meaning that they have direct sensory referents, or abstract, meaning that they lack direct sensory referents (Schwanenflugel, Harnishfeger, & Stowe, 1988). The word “book,” which refers to an object that is tangible and can be easily pictured in one’s mind, is highly concrete. The abstract word “cause,” on the other hand, refers to a concept that is intangible and not easily pictured. Differences in the rate at which people read abstract and concrete words may suggest that abstract and concrete
concepts are stored in the mind in different ways, and this difference in turn may be studied to uncover more about language and human thought.

A large body of research suggests that lexical access (i.e., matching a word to its representation stored in the brain) and comprehension are easier for concrete words than for abstract words (e.g., Bleasdale, 1987; Juhasz & Rayner, 2003; Paivio, 1971). One study demonstrated that concrete words are read more quickly than abstract words by using eye movement methodology, in which the fixations and saccades (movements) of a reader’s eye are tracked as she reads (Juhasz & Rayner, 2003). Research has also shown that response times in naming (e.g., Schwanenflugel & Stowe, 1989) and recall tasks (e.g., Wattenmaker & Shoben, 1987) are shorter for concrete words than for abstract words when they are presented in neutral sentence or passage contexts. Furthermore, participants are able to think of word and image associates more quickly for concrete words than for abstract words (Paivio, 1966). This general phenomenon— that concrete words and concepts are processed more easily than abstract words and concepts— will be referred to as the concreteness effect throughout.

Theories of the Concreteness Effect

Pavio’s dual-coding theory explains the difference in processing times for abstract and concrete words by postulating two different systems of coding concepts in the mind: an imaginal system, in which concepts are stored as images, and a verbal system, in which concepts are stored as words (Paivio, 1971). Concrete words have the advantage of being encoded in both systems, while abstract words are only
encoded in the verbal system, due to their lack of imageability (i.e., they cannot be visualized). The word “book,” for example, would be encoded as a visual representation of a book in the imaginal system. The meaning of “book” and its semantic associates, such as “read,” would be encoded in the verbal system. An abstract word, such as “cause,” would only have a representation in the verbal system; it is quite difficult to think of an image that could represent “cause.” Retrieval of words that refer to concrete concepts is facilitated by the availability of two mental representations of the word. As a result, the dual-coding theory predicts that concrete words will be processed more quickly than abstract words whether presented alone, in sentence context, or in paragraph context.

The context availability model (e.g., Schwanenflugel & Shoben, 1983) accounts for the concreteness effect through an entirely different mechanism from the dual-coding theory. According to this model, lexical access and comprehension of words, sentences, and passages are aided by the presence of contextual information (see also Kieras, 1978; Schwanenflugel et al., 1988). This contextual information may come from the reader’s prior knowledge (e.g., the reader may automatically associate the context of reading with the word “book”) or from verbal context added to the material to be comprehended (e.g., a predictable sentence context, such as “she went to the library to check out a book”). The context availability model accounts for the concreteness effect with the observation that concrete words tend to have more inherent contextual information than abstract words, as in the example of “book” and “reading” described above. Thus, according to this model concrete words are easier to process because they have a greater amount of readily accessible associated
Sentence Context and Concreteness  6

contextual information, not because they have an additional imaginal representation in the brain.

Several mechanisms have been proposed to explain why abstract words tend to have less inherent context than concrete words. According to Kieras (1978), all types of knowledge are stored in one type of representation, which is referred to as a proposition. A proposition is made up of a concept and all of its related concepts, verbal or perceptual, which are interconnected in the mind. The propositions of words that have a large amount of inherent context are easier to access than the propositions of words that have a small amount of inherent context, because words with more inherent context have more connections with information that is permanently stored in the memory. Concrete words, which have more perceptual properties, have more associated information than abstract words. This theory, though dependent on the level of imagery associated with concrete concepts, is different from the dual-coding theory because it does not propose two separate coding systems.

Another explanation of the contextual differences between abstract and concrete words focuses on the number of associated contexts that abstract and concrete words tend to have and on the strength of the connection between each word and its associated context (e.g., Schwanenflugel & Shoben, 1983). This view states that abstract words are processed more slowly than concrete words because they tend to have a greater number of associated contexts, and consequently each context is weakly connected to the word. This becomes apparent when one attempts to list all possible contexts of an abstract word, such as “cause”: just cause, a lost cause, a cause celebre, the cause of a problem, of a victory, etc. Concrete words, on the other
hand, tend to have a smaller number of associated contexts. As a result, each context is more strongly associated to its concrete word, which makes each context easier to access. This view is supported by several studies in which participants were asked to rate abstract and concrete words on different measures of contextual information. These studies found that abstract words tend to appear in a greater diversity of contexts than concrete words (Schwanenflugel & Shoben, 1983), and that concrete words tend to have a stronger single associate than abstract words, which tend to have more numerous, weakly connected associates (Altarriba, Bauer, & Benvenuto, 1999).

*Measures of Contextual Information*

There are a variety of ways to measure and experimentally manipulate context. Context may be inherent in the reader’s prior knowledge of a word, as mentioned above. The context availability variable, which is often used as a measure of inherent context, represents how difficult or easy it is to think of a context in which a given word may appear (e.g., Schwanenflugel et al., 1988; Schwanenflugel & Shoben, 1983). Context availability values are obtained by subjective ratings; participants are asked to rate how easily they can think of a context for a given word (Schwanenflugel & Shoben, 1983). This variable is positively correlated with concreteness, which is consistent with the prediction of the context availability model that concrete words are more easily accessed due to a greater availability of inherent contextual information (Altarriba et al., 1999; Schwanenflugel et al., 1988).

Other word-level variables, in addition to context availability, have been used to measure context. As mentioned above, research has shown that concreteness and
context availability are correlated with subjective ratings of the number of different contexts a word is found in (Schwanenflugel & Shoben, 1983). The number of contexts a word is found in may also be measured objectively from a large body of written text, known as a corpus. Context variability, for example, is defined as the number of contexts in which words appear measured from a corpus of text documents covering a wide variety of topics such as health and business (Steyvers & Malmberg, 2003). Since each document deals with one specific subject, each is treated as a unique semantic context. Thus, a word’s context variability equals the number of corpus text documents the word is found in. The results of a recognition task, in which participants were shown a list of words and later asked to identify which words were on the original list from a new set of words, showed that word recognition was better for words found in few contexts (i.e., having low context variability) than for words found in many contexts (Steyvers & Malmberg, 2003). Although Steyvers and Malmberg did not expressly examine the relation between context variability and concreteness, their findings comport with the context availability model: abstract words should be more difficult to recognize than concrete words because they tend to appear in a greater variability of contexts.

An additional objective measure of context, called contextual distinctiveness, was proposed by McDonald and Shillcock (2001). Like context variability (Steyvers & Malmberg, 2003), contextual distinctiveness values are based on corpus information rather than subjective ratings. Contextual distinctiveness for a given target word represents the frequency distribution of contexts in which the word appears, with context defined as the words that occur immediately around the target.
Thus, contextual distinctiveness is a measure of how many different contexts a word appears in and how frequently it appears in each. McDonald and Shillcock use “run” and “amok” as examples of different levels of contextual distinctiveness: “run” may appear in written language with a wide variety of other words, but “amok” nearly always appears after “run.” Thus, “amok” has a high level of contextual distinctiveness and “run” has a low level of contextual distinctiveness. Contextual distinctiveness appears to be a practical measure of contextual information because it measures words in the same way that they are most often encountered in natural speech and reading—surrounded by other words. However, analyses run on contextual distinctiveness and the context availability variable found no correlation between the two, and contextual distinctiveness was only marginally correlated with concreteness (McDonald & Shillcock, 2001). Furthermore, because contextual distinctiveness is dependent upon the co-occurrence of words, it may not be applicable to studies in which words are presented in isolation (e.g., Schwanenflugel et al., 1988, exp. 1).

The amount of context associated with a given word is not limited to variables inherent in the word such as context availability, context variability and contextual distinctiveness. Context may be measured from the sentence or paragraph in which a word is found. The strength of the context provided by a sentence is typically measured by a cloze task, in which participants are given the beginning of a sentence and asked to indicate which word they think might come next. If a high percentage of participants indicate the same word, the sentence is regarded as a predictable context for this word. This type of context allows for the use of a greater variety of abstract and concrete words in studies examining the context availability model. A word’s
rated context availability and contextual distinctiveness cannot be changed, but a
predictable sentence context may be constructed for many words that have low
context availability or contextual distinctiveness. Furthermore, sentence context may
be manipulated so that the same word can be examined in both a predictable context
and a neutral (non-predictable) context.

The effects of sentence context on word processing are robust. The
predictability of a word affects early reading measures, such as first fixation duration
(the length of the reader’s first look at a word) and probability of skipping a word,
and has an impact on gaze duration (the total amount of time a reader spends looking
at a word before moving to the next word) and the probability of regressions (moving
the eyes back to a word after having left it) (Kliegl, Grabner, Rolfs, & Engbert, 2004;
Rayner, Ashby, Pollatsek, & Reichle, 2004; Rayner & Well, 1996). Specifically, first
fixation and gaze durations on predictable words are shorter, skipping is more
probable on predictable words, and regressions are more probable on unpredictable
words. As people read a sentence, they use context to predict which words might
logically come next in the sentence. When readers encounter an unexpected or
incongruous word, they read it more slowly than they would read an expected word
(Schwanenflugel & LaCount, 1988; Schwanenflugel & Shoben, 1985).

Evidence in Support of the Context Availability Model

A number of studies have found evidence in support of the context availability
model using a variety of tasks and measures of context. Schwanenflugel et al. (1988)
tested the context availability model using a lexical decision task, in which
participants were presented with a series of words and non-words (i.e., combinations of letters that have no meaning in English, such as “warad” and “tolfig”) and asked to indicate whether each was a word or not. Schwanenflugel et al. (1988) found equivalent response times for concrete and abstract words presented alone when rated context availability was controlled. When concreteness and context availability were confounded (i.e., the concrete word stimuli had higher context availability ratings than the abstract word stimuli), faster response times to concrete words were found. This study presents striking evidence in favor of the context availability model. It also provides an explanation for the concreteness effect found in past studies. Concrete words tend to have higher rated context availability than abstract words, so they will be processed more easily when context availability is not controlled.

In a separate experiment, Schwanenflugel et al. (1988) examined concrete and abstract words in sentence contexts using a lexical decision design in which the target concrete or abstract word was always the last word in the sentence. Participants were presented with the sentence up to the target word. After reading the sentence, they pressed a button to reveal the target word (or non-word) and indicated a lexical decision. According to the context availability model, sentence context will facilitate reaction times to words with low rated context availability to a larger extent than reaction times to words with high rated context availability. When a word already has high context availability, adding additional context does not greatly facilitate comprehension (Schwanenflugel & Shoben, 1983). The study by Schwanenflugel et al. was designed to examine the effect of sentence context on lexical decision response times to observe whether predictable sentence context would eliminate
differences in response times to concrete and abstract words. Schwanenflugel et al. also sought to determine whether response times to words low in rated context availability would gain greater facilitatory effects from sentence context than words high in rated context availability. Indeed, the results of the study showed that when equally predictable sentence contexts were provided there was no difference in response times to abstract and concrete words. The data also showed an interaction among concreteness, sentence context, and context availability. The presence of a predictable sentence context produced a greater facilitatory effect for abstract words than for concrete words when context availability was confounded with concreteness but not when context availability was controlled. These results support the context availability model by accounting for different response times to abstract and concrete words through differing levels of contextual information.

Similar results in favor of the context availability model have been found in experiments using naming, meaningfulness judgment, and recall tasks. In a naming study, in which participants read a sentence and were asked to name the last word aloud, concrete and abstract words were named equally quickly when presented in predictable sentence contexts (Schwanenflugel & Stowe, 1989). A concreteness effect was observed when words were presented in neutral sentence contexts. The same result was found when participants were asked to judge whether abstract or concrete words were meaningful completions for sentences; there was no difference between responses to concrete and abstract words when the sentences were contextually predictable, but response times were faster for concrete words when sentences were contextually neutral (Schwanenflugel & Stowe, 1989).
Multiple studies have examined the context availability model on a different scale, looking at the effect of passage context on the processing of abstract and concrete sentences. In a recall task, for example, participants were given a four-sentence passage in which the sentences were either thematically related or completely unrelated to one another. Participants showed equal levels of recall for concrete and abstract sentences in the thematic condition, but recall was better for concrete sentences than for abstract sentences in the unrelated condition (Wattenmaker & Shoben, 1987). The effect of passage context type was examined in order to determine whether recall of sentences found in concrete passage contexts was superior to recall of sentences found in abstract passage contexts. The analysis showed that sentences were recalled equally well in both types of passage; thus, the results of the recall task could not be ascribed to a concreteness effect of passage type. Schwanenflugel and Shoben (1983) found similar results using a three-sentence passage context and measuring reading times for abstract and concrete sentences.

Studies that examine non-native language and cross-language lexical access have also provided supporting evidence for the context availability model. Native Dutch speakers who were proficient in English performed separate lexical decision tasks with English and Dutch words. In both languages, a concreteness effect was found only when context availability and concreteness were confounded, although this effect was attenuated in the task conducted in English (Van Hell & de Groot, 1998). Likewise, bilinguals translated abstract and concrete words at equal rates when the words were matched on context availability. Thus, a large body of evidence across multiple tasks demonstrates the central prediction of the context availability
model: concrete words are processed more quickly only when they have the advantage of superior contextual support relative to abstract words.

**Evidence Against the Context Availability Model**

In contrast with the above evidence, several studies have found concreteness effects that the context availability model cannot account for. Schwanenflugel, Akin, and Luh (1992) found superior recall for concrete words relative to abstract words matched on rated context availability, though the concreteness effect was smaller when context availability was controlled than when it was confounded with word concreteness. In two other recall tasks, concreteness effects were found when participants explicitly reported using imagery and when they were primed to use imagery to aid their recall (Schwanenflugel et al., 1992). These results were interpreted as supporting a strategic imagery hypothesis, which states that participants will use imagery when it is helpful in performing a certain task. This evidence does not completely support the dual-coding theory, because imagery was not automatically used in lexical access. The results also do not support the context availability model, which predicts that providing contextual information should eliminate the concreteness effect. Levi-Drori and Henik (2006) replicated the results of Schwanenflugel et al. (1988) and Van Hell and De Groot (1998) using a lexical decision task in Hebrew, providing evidence for the context availability model. However, when Levi-Drori and Henik further examined the concreteness effect in a second lexical decision task using three levels of rated context availability (low,
medium, and high), they found faster response times to concrete words than to abstract words in all three categories.

Levi-Drori and Henik (2006) also discussed the importance of controlling for the familiarity variable when examining context availability and concreteness. The familiarity variable represents the frequency with which a word occurs in daily language as measured by subjective ratings. Levi-Drori and Henik proposed that the results of the lexical decision studies conducted by Schwanenflugel et al. (1988) and Van Hell and De Groot (1998) may have been inaccurate because neither study controlled for familiarity ratings, which have a large effect on response times in lexical decision tasks. The concreteness effect found in Levi-Drori and Henik’s lexical decision task may be due in part to the fact that they controlled for familiarity. However, in a third lexical decision experiment, in which word stimuli were controlled for concreteness and familiarity, Levi-Drori and Henik found a significant effect of context availability. This result comports with analyses of other lexical decision task data, which found that context availability was a better predictor of response times than familiarity (Schwanenflugel et al., 1988).

A Comparison of Methods Used to Study Context and the Concreteness Effect

As described above, research findings on the effects of context and concreteness have come from a variety of tasks. Each of these tasks measures word processing in a slightly different way, and each has its flaws. Much of the supporting evidence for the context availability model comes from lexical decision and naming studies. Some research has shown that lexical decision, naming, and eye movement
studies are highly correlated with regard to their measurements of variables such as word frequency (i.e., the corpus-derived measure of how frequently a word appears in written text) (Schilling, Rayner, & Chumbley, 1998). Other studies, however, have shown disproportionate effects across these tasks. Balota and Chumbley (1984) found that the effect of word frequency was inflated in the lexical decision task relative to a category verification task and a pronunciation task. Furthermore, a lexical decision task that measured responses to concrete and abstract words found that the facilitatory effect of concreteness disappeared when the words were matched on neighborhood variables (Samson & Pillon, 2004). A word’s neighborhood is made up of all the words that can be formed by substituting any one letter in the original word (e.g., the neighbors of the word “cat” include “hat” and “car”). The words in a neighborhood are used to measure neighborhood density (the relative number of neighbors a word has) and neighbor frequency (whether a word has one or more neighbors that appear in written English more frequently than the word itself). When neighborhood density and frequency were controlled for, equivalent response times to concrete and abstract words were found. Samson and Pillon suggested that readers only use semantic information to make a lexical decision when they cannot make a decision by matching visual word information to word representations stored in their memories. Consequently, some lexical decisions are based purely on visual word information, and word meaning is not accessed. Lexical decision differs from natural reading in this respect, since accessing meaning is an integral component of reading.

Another limitation of the lexical decision task became evident in a study on sentence constraint, which is the extent to which a sentence limits the reader’s
expectation of which word will come next (Schwanenflugel & Shoben, 1985). High-constraint sentences limit possible sentence completions to a much greater extent than low-constraint sentences. For example, the high-constraint sentence “Jane swept the floor with a…” has few logical completions; “broom” is almost certainly the word that a reader would expect to come next. On the other hand, the sentence “Jane opened the closet and took out the…” has many possible completions, only one of which is “broom.” As a result, readers tend to read expected completions of high-constraint sentences more quickly than they read logical completions of low-constraint sentences. The high-constraint sentence context primes readers to expect “broom,” for example, while the low-constraint sentence context does not. However, Schwanenflugel and Shoben found that they could alter the extent to which participants used the contextual cues of sentences in a lexical decision task by varying the proportion of trials in which sentence completions were expected or unexpected. When the frequency with which a participant read an unexpected completion to a sentence increased, the facilitatory effect of high-constraint sentence context decreased. Thus, participants used contextual cues to a lesser extent when they received a greater number of unexpected completions. This presents a problem for lexical decision tasks in which sentences are examined. Since any non-word completion to a sentence may be considered an unexpected completion, and participants encounter a number of non-words in any lexical decision study, participants may use contextual cues significantly less in a lexical decision sentence task than they do in natural reading.
A further disadvantage of the lexical decision and naming tasks used in previous experiments testing the context availability model is the extent to which they limited the reader’s use of parafoveal information. In reading, the main visual focus comes from the central part of the retina, known as the fovea. At the same time, some information can be gleaned from words that fall in the region outside the fovea, known as the parafovea. It has been demonstrated that context has an influence on parafoveal processing. One study manipulated the parafoveal preview of a word, so that it was either visually similar to or visually different from the actual word. The preview was displayed when the reader’s fovea was focused on the word to the left of the target word, and the display switched to the actual target word as the reader’s fovea moved to the target word. A visually similar preview had a greater facilitatory effect on reading for words that were highly predictable from the sentence context compared to words that were less predictable (Balota, Pollatsek, & Rayner, 1985). This finding demonstrates that the use of parafoveal information is an important component of sentence reading. Lexical decision and naming tasks used in previous studies separated the presentation of the sentence context and the target word, so that participants were unable to access target word information parafoveally (Schwanenflugel et al., 1988; Schwanenflugel & Stowe, 1989). Furthermore, one of these studies presented strings of X’s as neutral sentence contexts instead of presenting words in meaningful, non-predictive sentences (Schwanenflugel et al., 1988). This design created different demands for the predictable and neutral context conditions. The former required reading, and the latter did not.
The present study seeks to avoid the demands and confounding variables that are inherent in lexical decision and naming tasks by examining eye movements during reading. Two previous studies have examined the concreteness effect using eye movement methodology. Juhasz and Rayner (2003) found that three measures of reading time (first fixation duration, gaze duration, and total fixation duration) were shorter on concrete words than on abstract words presented in neutral sentence contexts. Dunabeitia, Aviles, Afonso, Scheepers, and Carreiras (2009) examined eye movements to pictures of the associates of concrete and abstract words using the visual-world paradigm. In this paradigm, sentences are read aloud to a participant while she looks at a display of four pictures. The results of this study showed that eye movements to pictures of associates were faster for abstract words than for concrete words. Dunabeitia et al. suggested that this evidence suggests the existence of qualitatively different representational frameworks for abstract and concrete words, wherein abstract words are organized with their verbal associates and concrete words are organized by semantic categories. This study provides an interesting example of the use of eye movements in measuring online processing of abstract and concrete concepts. No studies to date have used eye tracking to examine the effect of contextual support on processing times for abstract and concrete words.

The present study tests the context availability model using eye movements in a sentence-reading task. Concrete and abstract words were presented in sentences that were contextually predictive of the target word or contextually neutral. The context availability model predicts shorter reading times for concrete words compared to abstract words when they are presented without additional contextual information.
(i.e., in a neutral sentence context). The context availability model also predicts
equivalent reading times for abstract and concrete words presented in equally
predictable sentence contexts. Thus, if the context availability model is true, I expect
to find an interaction between context and concreteness to the effect that fixation
durations are shorter on concrete words than on abstract words in the neutral
condition, and fixation durations on concrete and abstract words are equal in the
predictable condition.
Method

Participants

Data sets from 45 undergraduate students of Wesleyan University were obtained for analysis. Participants received $7 or course credit. All participants were native speakers of English and had normal or corrected-to-normal vision.

Apparatus

Eye position and movements were recorded every millisecond by an Eyelink 1000 (SR Research, LTD) eye-tracker. A chin-rest and headrest were used to minimize head movement. Sentences were displayed on the center of a 20-inch ViewSonic CRT monitor computer screen in a single line of text in black Courier New 14 pt font against a white background. The computer screen was 83 cm away from the participant’s eye, at which distance 3.62 characters of text subtended 1 degree of visual angle. Participants read experimental stimuli with both eyes, but data were only collected from the right eye.

Materials

Forty word stimuli were selected based on their concreteness ratings in the MRC Psycholinguistic Database (Coltheart, 1981). Of the 40 words, 20 were classified as abstract, with a mean concreteness rating of 2.70 (range = 2.34 to 3) on a 1-7 scale. The other 20 words were classified as concrete, with a mean concreteness rating of 6.15 (range = 6.02 to 6.35). The concrete and abstract groups were matched on average word length, frequency of occurrence obtained from the Educator’s Word Frequency Guide (Zeno, Ivens, Hillard, & Duvvuri, 1995), age of acquisition, and sensory experience rating (for stimuli characteristics, see Table 1). Age of acquisition
and sensory experience ratings were collected from Wesleyan University undergraduates on a 1-7 scale. For age of acquisition, participants were asked to indicate the age at which they learned each word, with a rating of 1 indicating that a word had been learned between 0 and 2 years of age, and a rating of 7 indicating that a word had been learned at age 13 or older, with each rating in between representing an age range. For sensory experience rating, participants were asked to indicate how frequently they experienced a strong association of each word with a sensory experience, with 1 indicating that they never experienced such an association and 7 indicating that they often experienced such an association.

In addition, contextual distinctiveness (CD) ratings were collected for word stimuli from the Educator’s Word Frequency Guide (Zeno et al., 1995). However, abstract and concrete word stimuli were not matched on this variable, because the present study seeks to examine the effect of sentence context. In order to test the assertion of the context availability model that equally predictable sentence contexts will equalize processing times for abstract and concrete words, the word stimuli used should be confounded with respect to measures of contextual information such as CD (i.e., abstract word stimuli should be found in a greater variety of contexts than concrete word stimuli). For the concrete word stimuli used in the present study, the average CD rating was .66 (range = .33 to .95). For the abstract word stimuli, the average CD rating was .79 (range = .41 to .97). An independent samples t-test found the two CD ratings to be significantly different ($t(38) = -2.58, p < .05$).

Two sentences were created for each word stimulus: one contextually predictable sentence and one contextually neutral sentence (see Appendix for a
complete list of sentence stimuli). This yielded four experimental conditions: concrete-predictable, concrete-neutral, abstract-predictable, and abstract-neutral. Sentences were matched on character length. Mean lengths were as follows: concrete-predictable = 69.45 (range = 50 to 80); concrete-neutral = 70.95 (range = 60 to 80); abstract-predictable = 71.1 (range = 48 to 80); and abstract-neutral = 71.95 (range = 49 to 80). An independent samples t-test found no significant difference in length between abstract and concrete predictable sentences ($p > .5$) or between abstract and concrete neutral sentences ($p > .5$).

Forty-five filler sentences were written and included in the experiment in order to prevent participants from guessing the purpose of the study. Five practice sentences were also included. Each participant saw a total of 90 sentences, including all practice and filler sentences and 20 experimental sentences. In addition, 23 yes-or-no questions were written based on filler sentences in order to ensure that participants were reading the sentences for meaning.

Normative data

One hundred and twenty-five Wesleyan University undergraduates participated in normative studies measuring the predictability and goodness-of-fit of the experimental sentence stimuli. None of these students participated in the eye movement study.

Sentence predictability was measured using a cloze task. Participants were presented with the sentence stimulus up to the target abstract or concrete word (e.g., Noa’s obsession with acquiring more wealth is evidence of his ____) and asked to write down one word that could fit as the next word in the sentence. Sentences that
received more than 54% of target word responses were considered contextually predictable for the target word. In order to be considered contextually neutral, sentences had to receive 0 target word responses. The mean predictability for concrete-predictable sentences was 84.4% (range = 54.5% to 100%). The mean predictability for abstract-predictable sentences was 80.4% (range = 54.5% to 100%). An independent samples t-test was performed, and no significant difference was found in predictability between concrete-predictable and abstract-predictable sentences ($p > .25$).

Goodness-of-fit (GoF) norms were also collected in order to ensure that target words in the four conditions fit equally well in their respective sentences. Participants were presented with experimental sentence stimuli and asked to rate how well the target word fit in the sentence on a scale from 1-7, with 1 meaning that the word made no sense in the sentence and 7 meaning that the word fit very well in the sentence. The mean GoF for concrete-predictable sentences was 6.88 (range = 6.67 to 7). The mean GoF for concrete-neutral sentences was 6.48 (range = 5.4 to 7). The mean GoF for abstract-predictable sentences was 6.73 (range = 6 to 7), and the mean GoF for abstract-neutral sentences was 6.50 (range = 6 to 7). An independent-samples t-test found no significant difference in GoF between abstract and concrete predictable sentences ($p > .05$) or between abstract and concrete neutral sentences ($p > .5$).

Procedure

Participants were told that they would be participating in a study on reading in which their eye movements would be tracked. The heights of the chair and the
chinrest were adjusted for each participant, and participants were given a game controller to hold. The eye tracker was then calibrated for the participants’ eye movements. During the calibration, a series of small black circles with white dots in their centers appeared one at a time on the computer screen. The calibration occurred on a single line on the computer screen. Participants were instructed to look at the center of each circle until it disappeared. Calibrations had to have an average error of less than .4 degrees of visual angle and a maximum error of less than .5 degrees of visual angle in order to be accepted. After the calibration phase was completed under the appropriate error levels the experimental phase began.

Participants were instructed to look to a black box that appeared on the left side of the computer screen in order to trigger a sentence to appear. They then read the sentence silently to themselves. After reading the sentence, participants were instructed to look to a white paper square attached to the right side of the computer monitor and press a button on the game controller in order to make the sentence disappear and the next black box appear. After 25% of the sentences, a yes-or-no comprehension question was presented in the center of the screen. Participants were instructed to press the right hand button on the game controller to answer “yes” and the left hand button to answer “no.” The mean percentage of correct responses was 96% (range = 87% to 100%). After the five practice trials (one of which included a comprehension question) were completed, filler and experimental trials were presented in random order. Each participant saw only one sentence for each target concrete and abstract word. The sentences were divided equally into two conditions
so that each participant saw 10 concrete-predictable sentences, 10 concrete-neutral sentences, 10 abstract-predictable sentences, and 10 abstract-neutral sentences.

**Design and Data Analysis**

The seven measures analyzed were compared with 2 x 2 repeated measures analyses of variance (ANOVAs). The factors used were concreteness (concrete vs. abstract) and context (predictable vs. neutral). Analyses were performed by participants \( (F_1) \), in which measures were averaged across items, and by items \( (F_2) \), in which measures were averaged across participants. In the analyses by participants, concreteness and context were both treated as within-subjects factors. In the analyses by items, concreteness was considered a between-items factor, and context was considered a within-items factor.
Results

Experimental trials in which there was a track loss on the pre-target, target, or post-target word were excluded from analysis. As a result, 7.5% of the data from the 45 participants were discarded.

Four measures of eye fixation durations were analyzed: first fixation duration, the length of the first look at the target word; gaze duration, the sum of fixation durations on the target word during first pass reading (i.e., before the eyes moved from the target to another word); single fixation duration, the length of the first look at the target word in instances in which the target word was fixated only once; and total fixation duration, the complete length of time spent looking at the target word, including fixations after regressions. In addition, the probability of regressions out of the target word (i.e., moving to a word found earlier in the sentence from a fixation on the target word), the probability of regressions to the target word (i.e., moving back to the target word from a fixation on a word found later in the sentence), and the probability of skipping the target word were analyzed.

Among the experimental trials analyzed, the most common pattern of fixation was single fixation. In 69.33% of trials, the target word received a single fixation in first pass reading. In 24.55% of trials, the target word was not fixated (i.e., was skipped) in first pass reading. In 6.12% of trials the target word was fixated two or more times in first pass reading.

Mean durations for the four fixation duration measures are listed in Table 2. A repeated measures ANOVA indicated that there was a main effect of context for first fixation duration ($F_1(1, 44) = 12.12, p < .01; F_2(1, 38) = 11.69, p < .01$), gaze
duration \((F_1(1, 44) = 12.47, p < .01; F_2(1, 38) = 12.25, p < .01)\), single fixation duration \((F_1(1, 44) = 12.98, p < .01; F_2(1, 38) = 11.26, p < .01)\), and total fixation duration \((F_1(1, 44) = 6.45, p < .05; F_2(1, 38) = 5.73, p < .05)\). For all four measures, the effect was such that target words embedded in predictable sentence contexts were fixated for a shorter length of time than target words embedded in neutral sentence contexts.

The analysis also indicated that there was a significant main effect of concreteness for single fixation duration \((F_1(1, 44) = 5.87, p < .05; F_2(1, 38) = 4.36, p < .05)\), such that single fixation durations on concrete words were shorter than those on abstract words. There was a marginally significant main effect of concreteness for first fixation duration by participants \((F_1(1, 44) = 3.04, p = .09)\), which was not significant by items \((F_2(1, 38) = 2.21, p = .15)\). Likewise, the results showed a marginally significant main effect of concreteness for gaze duration by participants \((F_1(1, 44) = 3.14, p = .08)\), which was also not significant by items \((F_2(1, 38) = 1.13, p = .30)\). Both first fixation durations and gaze durations were shorter on concrete words than on abstract words. There was no significant main effect of concreteness for total fixation duration (all \(ps > .79\)). In addition, there were no significant context x concreteness interactions for any of the four measures of fixation duration (all \(ps > .27\)).

Regressions were conducted to analyze regressions out of the target word, regressions to the target word, and the probability of skipping the target word. No significant main effects or interactions were found for regressions out of the target word or for the probability of skipping the target word (all \(ps > .06\)).
The mean probabilities of regressions to the target word were 9.36 ($sd = 10.48$) in the concrete-predictable condition, 15.78 ($sd = 13.93$) in the concrete-neutral condition, 12.38 ($sd = 14.25$) in the abstract-predictable condition, and 9.71 ($sd = 10.45$) in the abstract-neutral condition. There was no significant main effect of context or of concreteness for regressions to the target word (all $ps > .24$). However, a significant context x concreteness interaction for regressions to the target word was found in the analysis by participants ($F_1(1, 44) = 7.39, p < .01$). The interaction was marginally significant by items ($F_2(1, 38) = 3.98, p = .05$). A paired-samples t-test was conducted in order to determine the nature of the interaction. The analysis showed a significant difference between regressions to concrete words in neutral sentence contexts and concrete words in predictable sentence contexts ($t_1(44) = -2.97, p < .01$). The interaction was such that regressions to concrete words were more likely in the neutral condition than in the predictable condition. In addition, a paired-samples t-test showed that regressions to concrete words in neutral contexts were significantly more likely than regressions to abstract words in neutral contexts ($t_1(44) = -2.40, p < .05$).
Discussion

The present study is the first to test the context availability model by examining eye movements in a sentence reading task. Data analysis in this study focused on three different effects: the effect of context, the effect of concreteness, and the interaction between context and concreteness. The results showed a main effect of context for all four measures of eye fixation durations considered. This finding further demonstrates the strong facilitatory effect of predictable sentence context on reading times that has been observed in a number of past studies (e.g., Rayner & Well, 1996). Past research and the present study have shown that words found in predictable sentence contexts are fixated for shorter periods of time than words found in neutral sentence contexts.

The results also showed a significant main effect of concreteness for the single fixation duration measure and marginally significant main effects (by participants) of concreteness for the first fixation and gaze duration measures (which were not significant by items). The pattern for all three measures was such that fixations on concrete words were shorter than those on abstract words, demonstrating the facilitatory effect of concreteness on word processing that has been found in many past studies (e.g., Bleasdale, 1987). The marginally significant effect of concreteness on first fixation duration indicates that concreteness has an effect on the early stages of word processing. The effects observed for single fixation duration and gaze duration provide evidence that concreteness affects later processing as well; as noted above, gaze duration measures the entirety of the processing of a given word in first
pass reading, and single fixation duration measures the entirety of the processing of a
given word that is fixated only once.

The concreteness effect found in the present study is consistent with the
results of Juhasz and Rayner (2003), which is the only other study to examine the
concreteness variable using eye movement methodology. Juhasz and Rayner found
effects of concreteness for several fixation duration measures, which differed slightly
depending on which measure of word frequency they used in analyzing their data.
First, using the same word frequency ratings as the present study (Zeno et al., 1995),
Juhasz and Rayner found that gaze durations and total fixation durations on concrete
words were briefer than those on abstract words. They also analyzed their data by a
different measure of word frequency, obtained from Francis and Kucera (1982). In
this analysis, Juhasz and Rayner found a significant effect for the first fixation
duration measure in addition to the gaze duration and total fixation duration
measures. The results of the present study differ slightly from those of Juhasz and
Rayner; the present study did not find a significant effect of concreteness for total
fixation duration, and Juhasz and Rayner did not find a significant effect of
concreteness for single fixation duration. However, the findings are still consistent
with one another, because single fixation duration and total fixation duration both
measure the entirety of the processing of a given word. Concreteness effects were
found for measures that take into account whole-word processing in both studies.

The concreteness effect found in the present study provides evidence in
opposition to the context availability model. The context availability model states that
concrete words are processed more easily than abstract words because concrete words
tend to have more associated contextual information. According to the context availability model, contextual information, not sensory information, facilitates processing of concrete words relative to abstract words (Schwanenflugel et al., 1988). Thus, the context availability model predicts that concrete words should be processed more quickly than abstract words when additional contextual information is not provided (or when the context availability variable is not controlled for). When contextual information is controlled for—by providing equally predictable sentence contexts to abstract and concrete words, for example—the context availability model predicts that processing times should be equal for abstract and concrete words (Schwanenflugel et al., 1988). The present study presented abstract and concrete words in neutral and predictable sentence contexts. In both conditions, shorter fixation durations (i.e., faster reading times) were found on concrete words compared to abstract words. This finding directly contradicts the central prediction of the context availability model.

The results of the current study also showed an interaction between context and concreteness (which was significant by participants and marginally significant by items) for probability of regressions to the target word. Regressions generally indicate the need for further processing of a word. Thus, a word that is regressed to more frequently is generally more difficult to process (though it should be noted that regressions also serve to correct for motor errors such as inaccurate saccades) (Rayner, 1998). The interaction found in the present study showed that regressions to concrete words in neutral contexts were significantly more likely than regressions to abstract words in neutral contexts. This finding does not support the context
availability model. The context availability model states that abstract words found in neutral sentence contexts should be more difficult to process than concrete words found in neutral sentence contexts. Therefore, since regressions are indicative of processing difficulty, the context availability model would predict a greater probability of regressions to abstract words in neutral sentence contexts than to concrete words in neutral sentence contexts. The interaction found in the present study was unexpected, and the influence of concreteness and sentence context on the probability of regressions should be examined in closer detail in the future.

A Comparison with Past Studies

Overall, the results of the present study failed to replicate those of prior studies that examined the context availability model. As discussed in the Introduction, there are a number of methodological issues with lexical decision tasks, some of which are specifically relevant to the effects of the concreteness variable. For example, Samson and Pillon (2004) found that controlling for neighborhood density and neighbor frequency eliminated the facilitatory effect of concreteness on reaction times in a lexical decision task. The discrepancy between the present results and those of single-word lexical decision studies (e.g., Schwanenflugel et al., 1988, exp. 1; Van Hell & de Groot, 1998) is not wholly surprising given these methodological issues.

Nevertheless, I had expected the results of the present study to be consistent with prior research that examined the context availability model by varying sentence context predictability (Schwanenflugel et al., 1988, exp. 3; Schwanenflugel & Stowe, 1989). These studies presented target abstract and concrete words in sentences and used response times to lexical decision and naming tasks on the target words to
measure the effect of word concreteness. Like the present study, the experiments by Schwanenflugel et al. and Schwanenflugel and Stowe sought to determine whether contextual information from a predictable sentence could account for the facilitatory effect of concreteness on word processing. Unlike the present study, they found equivalent response times to abstract and concrete words in predictable sentence contexts.

In order to explain this discrepancy in results, it may be useful to examine the methodological differences between the past studies and the present one. In the present study, sentences appeared on the screen in their entirety all at once, allowing participants to read them in the way that people typically read written text. However, in the relevant experiments conducted by Schwanenflugel et al. (1988) and Schwanenflugel and Stowe (1989), the presentation of the target word was separated from the presentation of the sentence context by a 500-600 millisecond gap. This additional time may have given participants the chance to completely process the sentence context and form stronger, more specific predictions as to the identity of the target word before its presentation. In the present study, participants were given no such opportunity. Target words were presented in the center of the sentences, and there was no additional time to process the context separately from the target word.

This interpretation of the results of Schwanenflugel et al. (1988), experiment 3, and Schwanenflugel and Stowe (1989) yields two possible explanations for the relative uses of context and imagery in these studies. The first explanation holds that participants only used contextual information and not imaginal information. This explanation is consistent with the predictions of the context availability model. In this
case, the results of the present study differ from those of past research because of the lack of extra time to integrate contextual information. Thus, the results previously shown (e.g., Schwanenflugel et al., 1988, exp. 3) depended on the ability of the participant to fully process the sentence context and form strong predictions before encountering the target word.

A second explanation holds that participants in the prior studies did in fact use imaginal information in the processing of the concrete stimuli, which facilitated the processing of concrete words relative to abstract words. However, the facilitation was not apparent in the response time data of these studies. During the 500-600 millisecond gap, the sentence context could be fully processed and strong predictions about the target word could be made, which allowed the processing of the abstract words to “catch up” to the processing of the concrete words. Sentences with concrete words were presented with the same time gap, but they gained no additional advantage because processing can only be facilitated to a certain level in a certain amount of time. Thus, concrete and abstract words were facilitated to the same extent, as reflected in the equivalent response times found, but they were facilitated by different factors. Concrete words were aided by contextual information and imaginal information, while abstract words were aided by contextual information and the additional time given to consolidate it. The 500-600 millisecond gap and the corresponding additional processing of context effectively masked the concreteness effect in these studies. This explanation holds that participants used imaginal information to facilitate processing of concrete words in the previous studies and the present study.
Since both explanations described above are equally plausible from the behavioral data of Schwanenflugel et al. (1988), experiment 3, and Schwanenflugel and Stowe (1989), it is impossible to know whether or not participants used imaginal information in these experiments. However, the results of the present study are more consistent with the second explanation: that sentence context does not nullify the effect of concreteness. There are now two studies that have shown concreteness effects in sentence reading (the present study; Juhasz & Rayner, 2003), and it is unlikely that both found spurious effects of concreteness on fixation durations in reading. This pattern of reasoning leads to the conclusion that the concreteness effect was present in the prior studies, but it was masked by the time gap between the presentation of the context and the target words.

**Implications for the Context Availability Model and the Dual-Coding Theory**

Is all of the experimental evidence in favor of the context availability model a result of the use of tasks that mask the concreteness effect? It does not seem that this is the case. Despite the limitations of the prior studies that examined sentence context (e.g., Schwanenflugel & Stowe, 1989) and the limitations of those that used single-word lexical decision tasks (e.g., Van Hell & de Groot, 1998), there remains a body of experimental evidence in support of the context availability model that cannot be discounted by these issues. Wattenmaker and Shoben (1987), for example, found equivalent levels of recall for abstract and concrete sentences when they were presented in equally predictable passage contexts. Schwanenflugel and Shoben (1983) found a similar result when they examined reading times for abstract and concrete
sentences in passage contexts. Furthermore, the concreteness effect was nullified by contextual parity in a translation task performed by bilingual participants (Van Hell & de Groot, 1998). The wide variety of experimental evidence in support of the modulating effect of context on the concreteness effect provides a compelling reason not to dismiss the context availability model in its entirety.

Instead, it seems that a model that explains the concreteness effect while allowing for a strong influence of context would be the most parsimonious explanation for the body of evidence on the effects of concreteness and context in word processing, reading, and recall. In his 1986 work, *Mental Representations: A Dual Coding Approach*, Paivio updated his dual-coding theory (originally described in detail in *Imagery and Verbal Processes*, 1971). The base of the theory is unchanged: the human mind is still assumed to have two distinct representational systems, one image-based and one word-based. However, in his more recent work, Paivio states that the extent to which imagery is used in cognition depends on the task at hand. Intuitively, imagery is most useful and has the strongest effect when the task requires comprehension of concrete concepts and/or their spatial relations (Paivio, 1986).

Schwanenflugel et al. (1992) refer to this restatement of the dual-coding theory as the strategic imagery hypothesis, emphasizing the theory’s assertion that the imaginal representation of a word or concept is used when it is strategically helpful in performing a certain task. Schwanenflugel et al. conducted three recall tasks using abstract and concrete words that varied in rated context availability. In the first task, participants were shown a list of words and later asked to recall as many as they
could. In the second, participants were presented with the same recall task and were primed to use either imaginal information or contextual information to aid their recall. The third experiment also used the same recall task, with the addition that participants were asked to indicate which strategy they used to aid their recall (e.g., use of mental pictures, repetition, or context). The results of all three tasks provided evidence for the strategic imagery hypothesis. Some, but not all, of the participants used imagery to complete the tasks. Thus, this study did not entirely support the original dual-coding theory, which states that accessing word imagery is a necessary part of word processing. The results did not support the context availability model either, since controlling for the context availability ratings of the word stimuli did not entirely eliminate the concreteness effect (i.e., recall of concrete words was superior to that of abstract words). However, the results of Schwanenflugel et al. presented compelling evidence for the updated dual-coding theory/strategic imagery hypothesis.

The results of the present study suggest that sentence reading is another task in which the use of imagery is helpful. Upon consideration of the demands of sentence reading, this is not surprising. When trying to make sense of a sentence, a reader must bind a number of pieces of linguistic information (e.g., words and grammar) together to form a coherent whole. Forming an imaginal representation of a sentence would logically help a reader pull the different elements of the sentence into one idea. In the present study, participants were asked to read sentences and answer randomly presented comprehension questions about them. Creating a visual representation of a sentence, whether it contains an abstract or concrete target word, would be helpful to participants in completing this task.
Conclusions and Future Directions

The study of eye movements during natural reading provides important information about word processing and on-line context integration and avoids the confounding demands of the lexical decision and naming tasks. The present study has provided a valuable first look at the dual-coding theory and the context availability model using eye movements. Previous work has done much to clarify the relation between concreteness and context with regard to how we process written language. Future research using eye movements will certainly serve to further illuminate this relation.

It is important to note that the present study did not control for the context availability ratings of individual target words, though many prior studies on this topic have controlled for context availability ratings (e.g., Schwanenflugel et al., 1988). This does not detract from the value of the current findings, since the context availability model predicts that sentence context information should equalize processing of words that are unequal in their context availability ratings. As a result, the findings of the present study still do not support the context availability model. Even so, examining the impact of rated context availability on fixation durations in reading may help researchers further understand why contextual information nullifies the concreteness effect in some cases and not in others. In addition, the present study did not obtain imageability ratings (i.e., ratings of the extent to which a reader can picture the content of a sentence in her mind) for the sentences used. It is possible that the usefulness of imagery in reading depends on the imageability of the sentence at hand. This is especially relevant to examinations of the strategic imagery hypothesis.
Thus, it would be beneficial for future studies to compare the effect of concreteness on fixation durations across sentences of varying imageability.
References


Appendix

The predictable sentence context is listed first, and the neutral sentence context is listed second. Each participant saw only one sentence from each pair. The target words are in bold type for emphasis and were not presented in bold during the actual experiment.

Sentences with concrete words

At parties, college students will often consume too much alcohol and get sick. When she was visiting her father, Mia found a lot of alcohol in his pantry.

Every summer, we go to the beach to swim and lie in the sun. Danielle met her future husband at the beach during the summer.

The second string soccer players spent the game sitting on the bench watching. I brought my parents outside to see the new bench we had bought for our yard.

Andrea went to the library to check out a book about Greece. Andrea couldn't find the book that she was supposed to return to the library.

People who smoke have a higher risk of getting lung cancer than those who don't. Scott was overjoyed when he learned that his cancer was in remission.

The pirate ship fired a cannon at the unsuspecting cargo ship. At the museum, we saw an old cannon from the Revolutionary War.

The teacher wrote on the blackboard with chalk that made a screeching noise. The children drew pictures of farm animals with chalk on the sidewalk outside.

Autumn is the season for drinking fresh apple cider and raking leaves. Brianna went to the coffee shop and had a hot cup of cider and a muffin.

This bread recipe requires that you knead the dough for ten minutes. At the supermarket, Consuela picked up some pre-made dough and sauce for pizza.
Leora wanted to make movies, so she majored in **film** at college.
On her way to the show, Leora realized she was out of **film** for her camera.

The little girl was lost among the trees in the dark **forest** behind her house.
Before dinner, we went for a long walk in the **forest** behind our house.

Windows are usually made of **glass**, which is why they break so easily.
Veronica gasped when she saw the **glass** in the windowpane shatter.

Excessive alcohol consumption can result in failure of the **liver** and kidneys.
The old man had to take medication for his **liver** after the operation.

My grandfather smokes tobacco from a wooden **pipe** after dinner.
Arnold was concerned when he found a **pipe** in his son's room.

I keep my grandmother's patchwork **quilt** on my bed.
When my grandmother died, she left me the **quilt** she had made.

As a sign of his love, Rob gave his girlfriend a single red **rose** in a vase.
Rob came home from school and handed his mother a **rose** that he had picked.

We keep our lawn mower and tools in a **shed** in the backyard.
Michelle asked her husband to go out to the **shed** and get her a shovel.

The sea captain's heart sank when he saw the pirate **ship** coming towards him.
The child sat in her room and played with the toy **ship** she got yesterday.

When Medusa looked at the warrior, he turned into **stone** and could not move.
Try as she might, she couldn’t move the large **stone** from the riverbed.

At the fancy restaurant, we ordered a bottle of red **wine** and some caviar.
During the flight, I watched a movie, drank a cup of **wine**, and ate some peanuts.
Sentences with abstract words

The dullness of the lecture subject made Jake yawn with boredom and disinterest. The graduate student wrote her paper about the effect of boredom on memory.

She donated money because she felt it was for a good cause and wanted to help. Nina's mother told her that she was not the cause of her son's problems.

The audience at the classical music concert was quiet and respectful. I saw several of my friends from high school at the concert last Saturday.

Though she was afraid, she mustered the courage to go bungee jumping. Sometimes it requires a great amount of courage to admit you were wrong.

Writing a good paper takes a lot of time and effort, but the result is worth it. When I look at Dali's paintings, I can see the effort he put into every detail.

Seeing his wife with another man, Josh turned green with envy and rage. Paula couldn’t help feeling a bit of envy when she saw her sister's new car.

Noa's obsession with acquiring more wealth is evidence of his greed and avarice. Ted believed that greed was the worst of the seven deadly sins.

He didn't know the answer, but he took a guess anyways. My friends and I each took a guess as to who would win the competition.

After she lied to her boyfriend, Beth had feelings of guilt and remorse. After the exam, Tony felt a strong sense of guilt because he had cheated.

To pledge that they didn't cheat, students sign a code of honor after a test. He said that it was a great honor to receive the Nobel Peace Prize.

During a brainstorming session, she got an idea for how to solve the problem. As soon as Tabitha got a new idea, she would write it down so as not to forget.
Winning the lottery is a matter of luck, not skill.
You need a good deal of luck to get noticed in the entertainment industry.

The wizard used magic to defeat the evil dragon.
The mother was worried that her son was obsessed with magic and wizards.

After sitting in traffic for hours, Ezra was in a bad mood and was late to work.
Researchers have found that a person's mood can change a lot in one day.

They ate all of the cake, so there is none left for you.
Bert went to the store and found none of the things he was looking for.

When his son scored the winning touchdown, the father felt great pride in him.
My friend Heather always takes pride in her work.

Going skydiving, he knew he was taking a risk, but the feeling was worth it.
Jonathan clearly understood the risk involved in skydiving, but he went anyways.

Katie broke up with her boyfriend after he betrayed her trust repeatedly.
When ten of my stocks crashed in one day, I lost all trust in my stock broker.

The mother admonished her daughter to always tell the truth in all situations.
The philosophy students discussed the meaning of truth and reality.

Before Maria blew out the birthday candles, she made a wish for a new car.
Dorothy knew that the chances were very slim that her wish would come true.
Footnotes

1 Seventy-two undergraduates participated in total. However, due to machine track losses on regions of interest, 45 data sets were suitable for analysis.

2 Word frequency is a measure of the number of occurrences of a given word per million words in written English text. The primary difference between the two word frequency ratings used by Juhasz and Rayner (2003) are the materials from which they are obtained: ratings from Zeno et al. (1995) are drawn from grade-level texts from Grade 1 through Grade 13+ and are viewed as cumulative (life-span) frequency measures, whereas Francis and Kucera’s (1982) ratings are taken from adult texts and are viewed as adult frequency measures.
Table 1

*Stimuli Characteristics*

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Concrete</th>
<th>Abstract</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concreteness</td>
<td>6.15*</td>
<td>2.70*</td>
</tr>
<tr>
<td>Length</td>
<td>4.90</td>
<td>5.05</td>
</tr>
<tr>
<td>Frequency</td>
<td>57.95</td>
<td>53.60</td>
</tr>
<tr>
<td>Age of Acquisition</td>
<td>3.60</td>
<td>3.64</td>
</tr>
<tr>
<td>Sensory Experience Rating</td>
<td>3.41</td>
<td>2.97</td>
</tr>
</tbody>
</table>

*Note.* Concreteness, age of acquisition, and sensory experience rating are mean rankings on a 7-point scale; frequencies (WFG) are in words per million. *significant difference (*p* < .001); there were no significant differences between the concrete and abstract groups for any other variable (all *ps* > .1).
Table 2

*Mean reading times averaged across items (msec)*

<table>
<thead>
<tr>
<th></th>
<th>Abstract</th>
<th>Concrete</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Predictable</td>
<td>Neutral</td>
</tr>
<tr>
<td>FF</td>
<td>214 (34)</td>
<td>229 (39)</td>
</tr>
<tr>
<td>GZ</td>
<td>226 (38)</td>
<td>248 (44)</td>
</tr>
<tr>
<td>SF</td>
<td>216 (36)</td>
<td>233 (42)</td>
</tr>
<tr>
<td>TF</td>
<td>256 (64)</td>
<td>267 (55)</td>
</tr>
</tbody>
</table>

*Note.* FF = first fixation duration, GZ = gaze duration, SF = single fixation duration, TF = total fixation duration. Standard deviations are indicated in parentheses.
Acknowledgements

First, I would like to thank my advisor, Barbara Juhasz, for her guidance on every step of this project. I could not have asked for a better advisor, and I will greatly miss working in the Eye Movement and Reading Laboratory.

Many thanks also go to my labmates: Leah Shesler for her help obtaining normative data; and Kacey Wochna, Joanna Dicke, and Alix Haber for their statistical and moral support. Thanks also to Rob Wohl for his proofreading and revising help.

Finally, I would like to express my deepest gratitude to the friends who supported me in this project and to my parents and sister for all of their help and guidance.