Semantic Priming Study Suggests Concrete and Abstract Words have Qualitatively Similar Representational Systems

by

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Abstract
Despite the important role abstract concepts play in human life, the representational framework of abstract concepts has remained largely unexplored. The present study examined and compared abstract and concrete concept representation by way of a priming study. Specifically, this study tested the claim by Crutch and Warrington (2005) that concrete concepts are organized by a principle of similarity whereas abstract concepts are organized by a principle of association. A semantic priming task using semantically-similar but unassociated primes and associated but semantically-dissimilar primes for each target (e.g. mallet -> hammer; nail -> hammer) was used to test this claim. Analysis of variance and pairwise comparisons reveal no interaction between the main effect of priming and the concreteness of the target, suggesting that there is no qualitative difference in the representational systems of abstract and concrete words.
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1 Introduction

Despite the important role abstract concepts play in our lives and decision-making, there exists a dearth of knowledge regarding the words that represent them (Crutch & Warrington, 2005). The goal of this study is to extend our understanding of abstract concept representation by empirically testing the claim that abstract and concrete words are represented in qualitatively different representational systems (Crutch & Warrington, 2005).

Individual words vary on many dimensions (e.g. valence, meaningfulness) including the dimension on which this work will focus: the concrete vs abstract dimension. Concreteness refers to how directly the concept the word represents refers to sensory experience (Paivio, Yuille, & Magidan, 1968). Concepts that are rated high in concreteness are labeled “concrete” while concepts rated low in concreteness are labeled “abstract”. For example, the concept “fork” refers to visual, tactile, and perhaps even gustatory sensory experiences, and is therefore highly concrete; this is contrasted with a concept such as “justice”, which does not directly refer to any specific sensory experience, and is therefore very low in concreteness and is labeled “abstract”.

A number of experiments have contrasted behavioural responses to concrete versus abstract words, across an array of psychometrics including lexical decision (e.g., Bleasdale, 1987; Schwanenflugel & Shoben, 1983) and eye-fixation (e.g., Juhasz & Rayner, 2003). These studies have consistently discovered slower response times to abstract targets; in fact, this response time disparity was found to be so consistent and apparent that it prompted a stream of research dedicated to understanding the mechanisms responsible (see Paivio, 1991; Schwanenflugel & Shoben, 1983).

It is possible the difference in responses to abstract vs concrete concepts is due to either quantitative or qualitative differences in representation and processing. Quantitative explanations of the differences refer to differences in amount of processing power (where the definition of processing power differs by theory, e.g., amount of activation), whereas qualitative accounts focus on the type of processing (where the type again differs by theory, e.g., similarity vs. association).
Two now classic theories claim that there are quantitative differences in the representations of either concept-type: either that concrete concepts were represented in two coding streams whereas abstract concepts were represented in only one (Paivio, 1991); or that concrete concepts were experienced in a greater number of contexts, and therefore cause greater spreading activation (Schwanenflugel & Shoben, 1983). We can see that these theories are quantitative because they claim that the disparity in responses to concrete vs abstract words is due to a processing advantage gained by concrete words eliciting a quantitatively greater amount of activation in the system.

Paivio’s (1991) dual-coding theory proposes that concepts are represented in two different coding streams: one verbal and one non-verbal. These two streams are proposed to function independently, and thus, processing in either stream can have additive processing effects if they are both representing the same concept. That is, if a concept were to be represented in both, access to that concept would be facilitated by both streams. The exact mechanical explanation for why having multiple systems processing the same concept provides a processing advantage is unclear, however, I interpret this claim as being analogous to the advantage of having two power-lifters, as opposed to one, pushing activation of the representation above the threshold for response. Paivio proposes that concrete concepts can be represented in both streams, whereas abstract concepts can only be represented in the verbal stream; thus explaining the processing advantage seen for concrete concepts.

Kieras (1978) proposed that processing is heavily reliant on context availability, and Schwanenflugal and Shoben (1983) believed this could explain processing advantages seen for concrete words; due to it being easier to assign context to concrete words vs abstract words. This was tested and supported by a clever experiment where Schwanenflugel and Shoben used sentences to provide context for both concrete and abstract words. They found that, given equivalent contextual support, lexical decision times did not significantly differ between concrete and abstract targets. Therefore they concluded that concrete concepts reserve a processing advantage only because, in general, concrete concepts have more contextual information available.

In contrast to the above theories, Crutch & Warrington (2005) proposed that the differences in responses to abstract and concrete words can be attributed to each having qualitatively different
representation systems; namely, that concrete concepts are organized by semantic similarity, and that abstract concepts are organized by association. This was supported by their findings in a study involving a patient with semantic refractory access dysphasia; a disorder which is defined by the reduction in the ability to utilize the semantic access system following its activation. This patient experienced interference by associated words for abstract concepts (but not for concrete concepts) and by semantically similar words for concrete concepts (but not for abstract concepts) when the words were presented in an array.

Any proposed representational structure of concept representation should be able to account for behavioural data across all psychometrics. Priming is one such psychometric that has theoretical support for the insights its results give us into mental representation (e.g. Branigan, Pickering, Liversadge, Stewart, & Urbach, 1995; Rosch, 1975), and has been used to test theories of representation (e.g. Schawnflugel & Shoben, 1983, McRae & Boisvert, 1998). Therefore, theories of qualitatively different representation systems can be tested through a semantic priming study. If Crutch and Warrington (2005) are correct in their theory of concept organization, this difference may be apparent in differences in associative and similarity priming effects in concrete and abstract words. This study uses semantically similar (but un-associated) and associated (but semantically dissimilar) primes for a series of abstract and concrete concepts to look for systematic differences in priming effects that would be telling of a qualitatively difference in their principle of representation.

With the premise that abstract and concrete concepts do have the representational structure outlined by Crutch & Warrington (2005), I hypothesize that abstract words should receive either minimal or insignificant priming effects from similarity-priming, and greater or equivalent priming from association-priming in comparison to concrete words.
2 Method

2.1 Participants

Undergraduate student participants ($N = 150$, $M_{age}=18$, age range: 17-31) were recruited using The Academic Participation Scheduler (TAPS) at the University of Toronto Scarborough. Participants were screened for normal or corrected-to-normal vision and fluency in English (operationalized as 10 or more years of use as a first language) to ensure that they were able to complete the task, and were screen for handedness, as it is known to be an influential factor (Kaploun & Abeare, 2010) when using stimuli that is potentially lateralized (Wang, Conder, Blitzer, Shinkareva, 2010).

2.2 Experiment Design

A stimulus set was created consisting of 19 abstract and 19 concrete target words as well as a semantically-similar but unassociated prime, and an associated but semantically-dissimilar prime for each target (e.g. mallet -> hammer; nail -> hammer). Targets were chosen from Brysbaert, Warriner, & Kuperman’s Concreteness ratings for 40 thousand generally known English word lemmas (2013) with concrete words having a concreteness value between 4.5-5 and abstract words having a concreteness value <2. Associates were chosen from The University of South Florida free association, rhyme, and word fragment norms (Nelson, McEvoy, & Schreiber, 2004) with the strongest association that was not semantically similar chosen as the associate prime. Similar primes were found either from the Oxford thesaurus (Thesaurus, O.D., & Guide, 2010), for abstract words, or from the Semantic feature production norms for a large set of living and nonliving things (McRae, Cree, Seidenberg, & McNorgan, 2005) for concrete words, where the
most similar word, that had no associative value in the University of South Florida norms, was chosen. A list of 38 filler target words and an unrelated prime for each was also created. A baseline stimulus set was created consisting of all 76 target words without primes, and two experimental stimulus sets were created, counter-balanced so that each condition shows each target only once, and that across experimental conditions all prime-target pairs were shown. In order to avoid confounds presented by hemispheric differences in concept representation and in motor control, responses were recorded on a button box with one hand, and groups were counterbalanced so half of the participants used the index/middle finger for a yes/no response respectively and the other half used the index/middle finger5 for a no/yes response respectively. Thus, there are a total of 6 groups: a baseline and two experimental stimulus set exposures for each response type. Therefore, each group had 50% abstract targets and 50% concrete targets, and each priming group was exposed to 25% association pairs, 25% similar pairs, and 50% unrelated pairs to minimize the possibility that participants would use relatedness as a strategy to predict targets, and participants reported no use of strategies in debriefing. The experiment was designed on E-Prime 2.0. The participants completed the experiment on a Dell Dimension 1100 Desktop Computer using Windows XP, and a Sony Trinitron Multiscan G420 Monitor, with responses recorded by a Psychology Software Tools Serial Response Box, Model #: 200A.

2.3 Procedure

Participants were randomly assigned to one of the 6 groups. Each participant completed a consent form and a demographics survey. Each participant was then educated on the difference between abstract and concrete words and, after several practice trials with feedback, was presented with the list of stimuli and a semantic decision task (“Is the concept represented by the word on the screen concrete or abstract”). Prime presentation varied by group: Baseline trial
procedure included a fixation cross for 1500ms followed by a blank screen for 500ms, followed by the presentation of the target word, which remained on the screen until the participant responded. Experimental condition trial procedure included a fixation cross for 1500ms, followed by a blank screen for 500ms, followed by the presentation of the prime for 200ms, followed by a blank screen for 50ms, followed by the presentation of the target word, which remained on the screen until the participant responded. Participants were then debriefed and asked if they had used any specific strategies during the experiment.

3 Results

Data from participants with less than 70% overall accuracy were excluded (total excluded = 12(8%). Analysis focused on response time (RT) and accuracy, with RT analysis using only accurate responses. In the field, it is convention to eliminate participants, individual responses, and items which vary greater than 2.5 standard deviations from the overall mean; in this study, the within-group and within-item variability was so great that no participants, responses, or items were candidates for removal, despite differences as great as twice the overall mean. This study was designed for analysis to be focused on items. This is due to a combination of the imperative that the same participant does not see the same target twice to avoid identity priming (Malley & Strayer, 1995), and the effect lexical, emotional, and semantic properties of words have on response times (Benko, 2013). The influence of properties other than concreteness prompted this study’s design of using association-primes and similarity-primes to the same target word. Avoidance of identity priming prompted a study design where, within the experimental conditions, each participant was exposed to every target, but only one of the primes, balanced across groups. Further, because there was a prediction that no pure similarity priming would be
found in abstract words, a baseline condition (where no primes were presented) was completed by participants other than those in the experimental conditions. Thus, since it was not the case that each participant was exposed to every condition (no-prime, associate-prime, similar-prime), an item-analysis was most appropriate.

In this field, however, subject-analysis is the convention and a repeated measures within-subject analysis of variance (ANOVA) on all subjects in the experimental conditions revealed faster RTs for concrete words vs abstract words $F(1, 90) = 21.589, p < .05$, no difference in priming type $F(1, 90) = .780, p = .379$, and no interaction $F(1, 90) = .291, p = .591$. Repeated measures within-subjects ANOVA on all subjects in the experimental condition also revealed greater accuracy for concrete words vs abstract words $F(1, 90) = 37.661, p < .01$, no difference in priming type $F(1, 90) = .237, p = .628$, and no interaction $F(1, 90) = .477, p = .492$.

To complete the item analysis, average accuracy and response times for each target in each condition (baseline, similar-prime, associate-prime) were calculated. The omnibus repeated measures ANOVA on RT revealed no main effect of priming $F(2, 35) = 1.358, p = .264$, no interaction effect of priming $F(2,35) = .173, p = .841$, and revealed faster RTs to concrete words than abstract words $F(1, 36) = 7.59, p = < .05$. The omnibus repeated measures ANOVA on accuracy revealed no main effect of priming $F(2, 35) = .685, p = .507$, no interaction effect of priming $F(2, 35) = .748, p = .477$, and revealed greater accuracy for concrete words than abstract words $F(1, 36) = 8.93, p < .05$.

Analysis was then focused on effects of priming on accuracy and RT within each response-type. In the index/middle no/yes response group, repeated measures ANOVA on RT revealed no main effect of priming $F(2, 35) = .215, p = .807$, no interaction effect of priming $F(2, 35) = .313, p = .732$, and revealed faster RTs for concrete words $F(1, 36) = 8.953, p < .05$. Repeated measures ANOVA on accuracy revealed no main effect of priming $F(2, 35) = 1.403, p$
= .252, no interaction effect of priming $F(2, 35) = 2.7, p = .074$, and greater accuracy for concrete words $F(1, 36) = 7.314, p < .05$. In the index/middle yes/no response group, repeated measures ANOVA on RT revealed a main effect of priming $F(2, 35) = 4.578, p = .013$, no interaction effect of priming $F(2, 35) = .109, p = .897$, and revealed faster RTs for concrete words $F(1, 36) = 4.64, p < .05$; these results of this analysis are shown in Fig. 1. Repeated measures ANOVA on accuracy revealed no main effect of priming $F(2, 35) = .037, p = .964$, no interaction effect of priming $F(2, 35) = .724, p = .492$, and revealed greater accuracy for concrete words $F(1, 36) = 9.402, p < .05$.

![Fig. 1](image) Response times to Concrete and Abstract concepts by priming condition.

4 Discussion

The results of the index/middle yes/no group show a main effect of priming on RT, no effect of priming on accuracy, and no interaction between the effect of priming condition and concreteness. This would undermine the theory that each concept class is contained in qualitatively differing representational systems, as each concept class was affected by priming.
equivalently; however, given the following limitations, a follow-up study is suggested prior to coming to any strong conclusions. The difference in results for each response-type group speaks to the importance of controlling response-type compatibility in behavioural studies. The index/middle no/yes group may have experienced greater task difficulty due to a Simon Effect reflecting the consistency in which “yes” usually precedes “no” in left to right reading and speech in English. This response-type incompatibility may be the reason that expected main effects of priming were not present. Further limitations include the stimulus set design. Many lexical, semantic, and emotional properties of words are known to affect their response time and accuracy (Benko, 2013), and an ideal stimulus set would control for all relevant variables in both targets and their primes; unfortunately, due to the limited availability of dissimilar associates and unassociated similar words, this was not feasible. The requirement of finding associates that are dissimilar and similar words that are unassociated is also a very difficult process, as the two are often entangled (Fischler, 1977), and this requirement may lead to similar words not being similar enough, or associated words not having a strong enough association. A stimulus set which consists of a significantly larger number of prime-target pairs, where the lexical, semantic, and emotional values of each is documented, and an objective strength value of association and similarity is documented for each pair followed by a regression analysis; this would allow each of the word properties and similarity/association strength to vary along a scalar spectrum, which would overcome the difficulty of creating controlled categories, and allow for a more powerful study with a greater number of stimuli. Further, it is known that concreteness varies along a spectrum, and Crutch & Warrington (2005) proposed that the representation system varies accordingly, and using scalar concreteness levels would allow a testing of this claim as well.
In conclusion, although a dearth in the knowledge of abstract concept representation exists, so is there a dearth of databases and methodologies required to appropriately test such claims.
References


Appendices (if any)
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