Title
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Is a *Diamond* More Elegant than a Diamond?: The Role of Sensory-Grounding in Conceptual Content

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Abstract

It has recently been suggested that much of the research in embodied cognition can be explained by a "disembodied" account in which conceptual and cognitive processes perform their computations in a modular fashion and the sensory and motor associations that show up in embodiment experiments may arise merely from spreading activation from the cognitive module to the sensory and motor systems (Mahon & Caramazza, 2008). In such a model, the cognitive module processes its information and accesses its representations exactly the same way as it always would have, and the embodiment effects are essentially epiphenomenal. We test this idea by manipulating the sensory aspects of the perceptual input that triggers the activation of a concept. Throughout the history of conceptual representation research, feature lists of concepts have been treated as a method for accessing the semantic content of those conceptual representations. When there are sensory differences in the font of the written word that triggers accessing of a concept, does the concept get accessed in a different way? Are different conceptual features more prominent than others? We find a series of conceptual features that are more prominent when the concept is presented in one font versus the other. Continuations of this research project involve reaction-time priming experiments to see if these differential access effects happen at the timescale of hundreds of milliseconds. Our results are discussed in the context of competing or compatible accounts of embodied and symbolic cognitive processes.

Keywords: language, embodied cognition, conceptual representation, psycholinguistics

Introduction

Converging evidence in the field of embodied cognition suggests that low-level perceptual processes, such as auditory and visual processing, are activated immediately and automatically during higher-level tasks, such as language and conceptual processing (Barsalou 1999; Bergen, Lindsay, Matlock, & Narayanan 2007; Calvo-Merino, Grezes, Glaser, Passingham, & Haggard 2006; Thelen & Smith 1994; Zwaan 2004). There remains debate, however, about the directness of this interaction. For instance, traditional cognitive science predominantly responds to findings in embodied cognition by suggesting that the core of the phenomenon is a symbolic representation and that after this process becomes active, the activation merely spreads to sensory and motor associations (Mahon & Caramazza, 2008). This view then implies that sensorimotor groundings are peripheral, not central, to conceptual representations. Furthermore, they argue that embodied cognition could only be plausible in regard to concrete concepts, since for abstract concepts such as "justice", it can be difficult to identify sensory and motor information that grounds it to the world.

However, concepts are not spontaneously activated from inside. Activating concepts, like *flower*, typically requires the environment to deliver a sensory stimulus to the observer. This stimulus will unavoidably have idiosyncratic sensory properties that must be completely discarded in order for the exact same symbolic concept (of *flower*) to get activated in exactly the same way every time one sees a flower or hears the word "flower". The case is the same for concepts such as "justice". Whether reading the word, hearing the word, or thinking the word, there is a contextual situation made up of sensory information that brought the concept to mind.

Moreover, evidence suggests that participants do not summarily discard such idiosyncratic information, as is seen in the phonemic categorical perception literature. For over a decade, the evidence indicated that the process of phoneme discrimination was discretely categorical (Liberman, Harris, Kinney, & Lane, 1961). Take for example the categorical perception of the phonemes "pah" and "bah". These two phonemes differ only on the dimension of voice onset time (VOT): if VOT is between 0 and 30 ms, then the sound is perceived as "pah", and if VOT is between 30 and 60 ms, the sound is perceived as "bah". When participants are asked to decide which of the two phonemes a sound is, this difference appears discretely divided at the 30 ms boundary.

More recently, further investigation of categorical perception has yielded more graded results. Just analyzing data from the endpoint of a response (such as accuracy) runs the risk of overlooking fine-grained details available before a response is fully executed (Abrams & Balota, 1991).

Therefore, by examining reaction times, the categorical perception effect may not be as discrete as outcome-based experiments suggest. When participants are asked to judge which of the two phonemes the sound is, reaction times reveal that the closer the stimulus's VOT is to the boundary between phonemes, the greater the increase in the corresponding reaction time (Pisoni & Tash, 1974). Although measurements of the overt response indicate that the decision is a categorical one, the reaction time data suggests that there is competition in the underlying system. Similarly, evidence from eye-tracking converges with the reaction time data and suggests that subtle variations of the two phonemes around the VOT boundary are not immediately discarded (McMurray & Spivey, 2000). Hence, idiosyncratic differences in incoming stimuli create competition that may result in reaction time differences.

Likewise, these effects do not disappear when the phoneme is embedded within a word. When the VOT of "pah" and "bah" phonemes is systematically varied within the words "pear" and "bear", eye movements vacillate between the two options as the VOT comes closer to the boundary (McMurray, Tanenhaus, & Aslin, 2002). Although participants ultimately make one response and click on one of the two available options, these eye-movements illustrate that the underlying process is sensitive to the competition between the two responses. Therefore, even in categorical speech perception, there is evidence that continuous variation in the speech signal is not immediately discarded (McMurray, Tanenhaus, Aslin, & Spivey, 2003), and in fact lingers long enough to affect spoken word recognition (McMurray et al, 2002).

A formal symbolic account of conceptual representation would suggest that concepts are stable representations that exist in long-term memory. This may be unlikely, since accessing a concept in different contexts allows for great variability. Because it is unlikely that we have a different stable concept for every contextual situation, we must then be accessing idiosyncratic feature combinations of concepts in different situations. Chairs are a great example of this. There are many types of chairs and often times contextual information carries the majority of the load in determining which chair features are accessed in a situation. For example, if someone is told to sit on a chair while visiting with a friend in the dining room, this person will recognize that a dining chair, with (most likely) four legs and a back, is what the friend is referring to. If, however, these friends are standing near a bar and the same sentence is uttered, the person will recognize that a bar stool is what is being referred to. As Barsalou (1993) states, "Accessibility appears to be the critical factor that underlies which features are retrieved from knowledge of a category to construct a concept on a particular occasion."

Barclay et al. (1974) examined how concepts are highly flexible in how they are accessed and interpreted. They showed that the optimal retrieval cues differed according to the context in which participants were given the word "piano". When the context involved moving the piano, the optimal cues were related to the weight of it, but when the context involved playing the piano, the optimal cues related to musical properties.

Barsalou, Solomon and Wu (1999) provided evidence that the way we access a concept does depend on the way in which it is accessed via our perceptual systems. For example, when participants are told to name features of an object such as a watermelon or half of a watermelon, their responses differ. Participants given the half watermelon example were more likely to list features characteristic of the inside of the watermelon. This is consistent with the idea that participants are mentally simulating an image of the object while asked to list the features. This suggests that the way in which an object is perceived has a strong impact on what aspects of that concept are accessed.

In our study, the idiosyncratic sensory properties of a stimulus are manipulated to investigate the impact of such differences on the activation of a concept. If idiosyncratic sensory properties are not discarded when reading a word that is intended to activate a concept, then systematic differences in either the features themselves or the ranking of these features can be expected. For example, think of the features that come to mind when you read the following word in Courier font: `Justice`. Now, when the only thing that has changed is the font (Edwardian Script), you may find a rather different set of features come to mind: *Justice*.

If the differences in the visual presentation of these two fonts are not discarded when activating a concept, the participants may be more likely to respond with punishment-related features, for example, for the Courier-font version and equality-related features for the Edwardian-font version. The Courier font may imbue the concept with a slight emphasis on its more concrete features and/or its more literal features, whereas the Edwardian font may imbue the concept with a slight emphasis on its more abstract features and/or its more idealistic or emotional features. We expect that some of these features evoked by our stimuli will show up more often in one font versus the other.

Methods

Participants

We collected data from 174 participants online using Amazon Mechanical Turk. Turk is becoming a favorable way to collect data from diverse participants quickly and has been found to produce data as reliable as those in traditional in-lab methods (Buhrmester, Kwang & Gosling, 2011). Participants ranged from 18 to 67 years of age and were reimbursed 20 cents to their Amazon account for completing the approximately 10 minute survey. We had to discard data from 24 of these participants due to unfinished surveys or participants attempting to complete the survey more than once.

Design, Stimuli, and Procedure

Participants were asked to complete a questionnaire consisting of fourteen words. In order to prevent participants

from employing strategies, the study was between subjects, and all of the words on each questionnaire were written in the same font. The two fonts used were Courier and Edwardian Script. There were 74 participants in the Courier condition and 76 participants in the Edwardian condition.

We selected stimuli that were expected to show systematic differences between the two font types. For example, words like "diamond", "dessert", or "engagement" might bring to mind fanciness or romance more strongly when viewed in the Edwardian font. Words like "justice", "service", or "duty" might bring to mind task or work force related features more strongly when viewed in the Courier font. Thus, we expected that some, but not all, of the features for each stimulus would be more frequently listed in one of the conditions. A full list of the stimuli in their respective fonts is shown in Table 1. The stimuli were randomized, so that any word order effects would be avoided.

After clicking on a "show word" button, the word appeared on the screen. Participants were instructed to focus on the word until the answer boxes appeared, which occurred 200 ms later. They were told to then list the first four words that they thought of as associated to the target word, in the order that they thought of the words.

Table 1: Stimuli used in experiment

Courier		Edwardian	
Service	Patriot	*Service*	*Patriot*
Duty	Snow	*Duty*	*Snow*
Holidays	Wind	*Holidays*	*Wind*
Autumn	Glass	*Autumn*	*Glass*
Engagement	Diamond	*Engagement*	*Diamond*
Blue	Fire	*Blue*	*Fire*
Justice	Dessert	*Justice*	*Dessert*

Analysis

We performed analyses on overall frequency of the listed associations between conditions, as well as on list order. We extracted the five most frequently listed associates for each of the stimuli, as long as they were listed in the overall responses at least 20 times. For example, the five most frequently listed words for "autumn" were color-related (red or orange), cool or cold, leaves, fall, and season.

We performed a chi-square test on each of the word-associate pairs to see if the overall frequency of these differed between conditions. We performed this test on each of the associate-word pairs for each of the stimuli, resulting in 56 chi-square tests.

In order to examine list effects, each associate was given a rank order score for each participant. Associates listed first were given a score of 4, associates listed second were given a score of 3, associates listed third were given a score of 2, and associates listed fourth were given a score of 1. Those not listed at all were counted as 0s. Because of the non-normality of the data, we used nonparametric measures for list order analysis. We performed the Wilcoxon rank sum test with correction for ties on each of the word-associate pairs to see which pairs differed between conditions. The rank sum test used rank data to determine whether that associate has an overall higher rank order score in either condition. We performed this test on each of the associate-word pairs for each of the stimuli, resulting in 56 rank sum tests.

Many participants misunderstood "dessert" to be "desert", so we did not perform analyses on the data collected for that target word. Also, "glass" was troublesome – because of its polysemy, participants either treated it as a specific object (that we drink from) or as a material. In order to ensure that participants are accessing the same concept, we did not incorporate those into our analyses either.

Results

There were seven word-associate pairs found to significantly differ in their frequencies between conditions. For the word "diamond", the associate "necklace" occurred more often in the Edwardian condition ($\chi2 = 5.94$, $p < .05$), and the associate "hard" occurred more often in the Courier condition ($\chi2 = 3.93$, $p < .05$). For the word "justice", the associate "judge" occurred more often in the Edwardian condition ($\chi2 = 5.52$, $p < .05$), and the associate "police" occurred more often in the Courier condition ($\chi2 = 4.10$, $p < .05$). For the word "fire", the associate "smoke" occurred more often in the Courier condition ($\chi2 = 6.32$, $p < .05$). For the word "holidays", the associate "family" occurred more often in the Edwardian condition ($\chi2 = 4.40$, $p < .05$). For the word "service", the associate "work" occurred more often in the Courier condition ($\chi2 = 6.91$, $p < .01$). These results are shown in Table 2. Next we turned to list order effects.

Among those associates that were not found to be significantly different in their frequencies, two word-associate pairs showed a difference in rank order scores between conditions in the Wilcoxon rank sum test. "Holidays" elicited the associated word "gifts" which scored higher in the Edwardian condition (M=.500, SE=.051) than in the Courier condition (M=.203, SE=.080); $w = 2464.5$, $p < .05$. For the word "blue", the associate "water" scored higher in the Courier condition (M=.714, SE=.135) than in the Edwardian condition (M=.388, SE=.106); $w = 1066$, $p < .05$.

There were also many associated words elicited by the target words that showed little to no difference between conditions.

Table 2: Word-associate pairs found to be significantly different between conditions. * denotes $p < .05$ and ** denotes $p < .01$.

Word	Associate	Font Condition	Wilcoxon
Blue	Water	Courier	*
Holidays	Gifts	Edwardian	*

Word	Associate	Font Condition	Chi-Square
Justice	Police	Courier	*
Justice	Judge	Edwardian	*
Fire	Smoke	Courier	**
Holidays	Family	Edwardian	*
Service	Work	Courier	**
Diamond	Necklace	Edwardian	**
Diamond	Hard	Courier	*

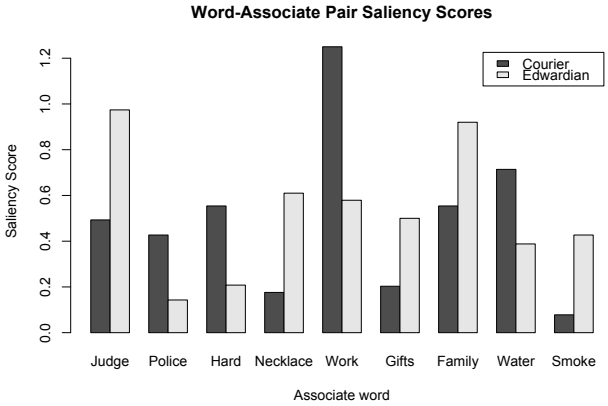

Figure 1: Bar chart of associations found to be significantly different between conditions

Discussion

For the word "diamond", the associate "necklace" scored higher in the Edwardian condition, while the associate "hard" scored higher in the Courier condition. This supports our earlier hypothesis that the Edwardian font might invoke more elegant features. We did not see a difference for the words "expensive", "ring", or "stone".

For the word "justice", the associate "judge" scored higher in the Edwardian condition and "police" scored higher in the Courier condition. In this case, it might be the case that the Edwardian font is calling to mind more authoritative aspects (judges have more authority than a police officer).

For the word "blue", the associate "water" scored higher in the Courier condition, while the associate "sad" approached significance in the direction of a higher score in the Edwardian condition. Perhaps there is more emotion associated with the Edwardian font in this case. This might also explain why "family" scored higher as an associate for "holidays" in the Edwardian condition.

For the word "service", the associate "work" scored higher in the Courier condition, which might indicate the more mundane features accessed in the Courier condition.

Our findings show that idiosyncratic sensory properties may significantly alter the way that meanings get accessed, suggesting that there may not be a context-free activation of a concept. The sensory associations that accompany a stimulus as it first gets processed by the perceptual system may play a significant role in shading the meanings of words and thus changing the way their concepts are activated in the first place. If this is the case, then the idea that sensorimotor grounding is nothing more than a secondary spreading of activation (Mahon & Caramazza, 2008) is unlikely.

Furthermore, the difference in responses observed for abstract concepts, such as "justice", addresses the concern that sensorimotor information is unable to make up such concepts. Even the activation of abstract concepts may be shaded by the sensory information present at the time of activation.

This experiment was a step toward exploring the relationship between sensory information and concepts and whether this relationship is at all separable. If it is not, then "disembodied" accounts of cognition should not be able to fully account for these phenomena.

Casasanto and Lupyan (in press) provide an alternative way of defining concepts by positing that all concepts are constructed ad hoc and are thus never exactly the same. The stability of concepts is only an illusion, and instead of thinking about these as concrete things represented in our minds, we should think about conceptualizing as a process that we do with our minds. If, as our data suggests, even the initial activation of a concept can be shaded by information present in the environment, then perhaps this is a better way of idealizing concepts.

Future experiments aim to explore our results using online measures. An ongoing second experiment will compare reaction times of responses to font-typical and font-atypical associations discovered in this experiment. Participants will either confirm or deny whether a word is an associate of one of the targets words used in the first experiment. If idiosyncratic differences in word presentation are not discarded, than we should see faster reaction times for the confirmation of font-typical association-target pairs than for font-atypical association-target pairs. Following that, there is possibility of using eye-tracking and/or mouse-tracking methodologies to further elucidate the results of the first experiments.

Additionally, there remains exploration to be done regarding which target-association pairs appear to show significant differences and which do not. Collecting additional data for different types of words can help to shed light on this question. For example, some concepts have a very specific sensory association because of previous experience, such as white and cold for snow. Other concepts have less restriction on sensory associations, such as a chair, which can be soft or hard and brown or pink. In addition, collecting words of different categories (nouns or adjectives) might provide further suggestions.

Finally, ongoing work using different fonts might elicit more dramatic differences. Because Courier is often used as a 'default' font, the words in the experiment are likely seen more often in Courier font than in Edwardian font. Additional versions of this study using only less commonly used fonts might invoke a stronger effect.

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