Strength of Perceptual Experience Predicts Word Processing Performance Better than Concreteness or Imageability

Louise Connell (louise.connell@manchester.ac.uk)
School of Psychological Sciences, University of Manchester
Oxford Road, Manchester M13 9PL, UK

Dermot Lynott (dermot.lynott@manchester.ac.uk)
Decision and Cognitive Sciences Research Centre, Manchester Business School, University of Manchester
Booth Street West, Manchester M15 6PB, UK

Abstract

Abstract concepts are traditionally thought to differ from concrete concepts by their lack of perceptual information, which causes them to be processed more slowly and inaccurately than perceptually-based concrete concepts. We examined this assumption by comparing concreteness and imageability norms to a set of perceptual strength norms in five separate modalities: sound, taste, touch, smell and vision. Results showed that that concreteness and imageability do not actually reflect the perceptual basis of concepts: concreteness ratings appear to be based on two different intersecting decision criteria, and imageability ratings are visually biased. Analysis of lexical decision and word naming performance showed that maximum perceptual strength (i.e., strength in the dominant perceptual modality) consistently outperformed both concreteness and imageability in accounting for variance in response latency and accuracy. We conclude that so-called concreteness effects in word processing emerge from the perceptual strength of a concept's representation and discuss the implications for theories of conceptual representation.

Keywords: abstract concepts; imageability; concreteness effects; perceptual strength; lexical decision; word naming

Introduction

What exactly constitutes an abstract concept? Traditionally, abstract words such as *truth* or *impossible* are assumed to refer to things that are not perceptually experienced, while concrete words such as *chair* or *turquoise* are assumed to refer to perceptible, material entities. A long history of research has examined processing differences between such abstract and concrete concepts. In particular, concreteness effects refer to a behavioral advantage for words that refer to concrete concepts, which are processed more quickly and accurately than abstract concepts in tasks such as lexical decision and word naming (e.g., Binder et al., 2005; James, 1975; Kroll & Merves, 1986; Schwanenflugel, Harnishfeger & Stowe, 1988; Schwanenflugel & Stowe, 1989).

A number of different theories have been proposed to account for concreteness effects in word processing performance. Dual coding theory (Paivio, 1986, 2007) holds that both concrete and abstract concepts have a verbal code representation, but that concrete concepts alone also have a nonverbal, perceptual code that "gives rise to conscious (reportable) imagery when activated" (Paivio, 2007, p. 39). Abstract words are slower to process because they can only be imaged indirectly, via related concrete words. Context availability theory (Schwanenflugel & Shoben, 1983; Schwanenflugel et al., 1988) instead argues that the type of information is less important than the quantity, and that concrete concepts are strongly linked to a narrow range of supporting contexts in memory whereas abstract concepts are weakly linked to a wide range. People are slower to process abstract words because they find it more difficult to retrieve associated contextual information. More recently, situated simulation views of conceptual representation (Barsalou & Wiemer-Hastings, 2005; Barsalou, Santos, Simmons & Wilson, 2008; see also Kousta, Vigliocco, Campo, Vinson & Andrews, 2011) have drawn together several aspects of both dual coding and context availability theories. Concrete concepts are represented in a narrow range of situations that focus on perceptual and motor information, while abstract concepts have a wide range of situations that focus on social, introspective and affective information. Abstract words are slower to process because people find it more difficult to access their situations.

However, despite their reputation as a textbook effect, concreteness effects do not always reliably emerge in semantic processing. Null effects are rarely publishable, but lack of concreteness effects in response times and error rates are not uncommon in cognitive neuroscience studies where significant findings on other measures are reported alongside null behavioral results (e.g., Fiebach & Friederici, 2003; Papagno, Fogliata, Catricalà & Miniussi, 2009; Sabsevitz, Medler, Seidenberg & Binder, 2005; Tyler, Russell, Fadili, Moss, 2001). Furthermore, reverse concreteness effects – a processing advantage for abstract concepts rather than concrete – have also been found in studies of healthy adult participants (e.g., Adelman, Brown & Quesada, 2006; Kousta et al., 2011). Such null and reversed concreteness effects are problematic for theories that claim fundamental representational differences between concrete and abstract concepts.

One reason for inconsistencies in empirical tests of concreteness effects may be that the intuitive and theoretical assumption is valid (i.e., that concepts with perceptual information are faster to process), but that the typical basis for selecting experimental items (i.e., concreteness or imageability ratings) does not offer an accurate measure of the perceptual basis of concepts. Most researchers select items from published norms such as the MRC psycholinguistic database (available online at http://www.psy.uwa.edu.au/MRCDataBase/uwa_mrc.htm).

However, when we examined the original norming instructions used to collect these norms, we found it questionable that participants would have simultaneously considered their sensory experience across all modalities and then managed to aggregate this experience into a single, composite rating per word. Instructions for concreteness ratings, for example, define concrete words as referring to "objects, materials, or persons" and abstract words as referring to something that " cannot be experienced by the senses" (Paivio, Yuille & Madigan, 1968, p. 5). The resulting ratings, therefore, may reflect different decision criteria at the concrete and abstract ends of the scale, which is consistent with previous observations that the concreteness ratings scale has a bimodal distribution (e.g., Kousta et al., 2011). Imageability ratings are frequently used interchangeably with concreteness ratings (e.g., Binder et al., 2005; Sabsevitz et al., 2005) because of their high correlation and theoretical relationship in dual coding theory. Instructions for imageability ratings repeatedly refer to arousing a "mental image" (Paivio et al., 1968, p. 4), which is likely to lead naïve participants to focus on vision at the expense of other modalities. Both concreteness and imageability ratings could therefore add considerable noise to any dataset that assumed the ratings reflected a smooth continuum of perceptual experience across all modalities.

Our goals in the present paper were twofold. First, we aimed to establish whether concreteness and imageability norms actually reflect the degree with which concepts are perceptually experienced, as is commonly assumed. Second, we examined whether so-called concreteness effects in word processing are better predicted by concreteness/imageability ratings or by strength of perceptual experience. If the former, then forty years of empirical methodology have been validated but the reasons for null and reverse concreteness effects remain unclear. If the latter, then concreteness and imageability ratings are unsuitable for the tasks in which they are employed, and null and reverse concreteness effects are due to the unreliability of perceptual information in these ratings.

Experiment 1

Rather than ask participants to condense their estimations of sensory experience into a single concreteness or imageability rating, modality-specific norming asks people to rate how strongly they experience a variety of concepts using each perceptual modality in turn (i.e., auditory, gustatory, haptic, olfactory or visual: Lynott & Connell, 2009, in prep.; see also Connell & Lynott, 2010; Louwerse & Connell, 2011).

If concreteness and imageability are a fair reflection of the degree of perceptual information in a concept, then ratings of perceptual strength in all five modalities should be positively related to concreteness and imageability ratings, and these relationships should remain consistent across the rating scale. On the other hand, if we were correct in our hypothesis to the contrary, then we would expect some perceptual modalities to be neglected (i.e., no relationship) or even misinterpreted (i.e., negative relationship) in concreteness and imageability ratings. Specifically, concreteness norming instructions may have led to different decision criteria and therefore distinctly different modality profiles at each end of scale, whereas imageability instructions may have led to a predominantly visual bias.

Method

Materials A total of 592 words were collated that represented the overlap of the relevant sets of norms, so each word had ratings of perceptual strength on five modalities as well as concreteness and imageability (see Table 1 for sample items). Perceptual strength norms came from Lynott and Connell (2009, in prep.), in which participants were asked to rate "to what extent do you experience WORD" (for nouns) or "to what extent do you experience something being WORD" (for adjectives) through each of the five senses (i.e., "by hearing", "by tasting", "by feeling through touch", "by smelling" and "by seeing"), using separate rating scales for each modality. Perceptual strength ratings therefore took the form of a 5-value vector per word, ranging from 0 (low strength) to 5 (high strength). Concreteness ratings were taken from the MRC psycholinguistic database for 522 words, with ratings for the remaining 70 words coming from Nelson, McEvoy and Schreiber (2004). Imageability ratings for 524 words also came from the MRC database, and were supplemented with ratings for a further 68 words from Clark and Paivio (2004). All concreteness and imageability ratings emerged from the same instructions as Paivio et al.'s (1968) original norms, and ranged from 100 (abstract or low-imageability) to 700 (concrete or high-imageability).

Design & Analysis We ran stepwise regression analyses with either concreteness or imageability rating as the dependent variable, and ratings of auditory, gustatory, haptic, olfactory and visual strength as competing predictors. For analysis of consistency across the scales, each dependent variable was split at its midpoint before

Table 1: Sample words, used in Experiments 1 and 2, for which perceptual strength ratings [0-5] match or mismatch ratings of concreteness and imageability [100-700].

	Perceptual strength						
Word	Auditory	Gustatory	Haptic	Olfactory	Visual	Concreteness	Imageability
soap	0.35	1.29	4.12	4.00	4.06	589	600
noisy	4.95	0.05	0.29	0.05	1.67	293	138
atom	1.00	0.63	0.94	0.50	1.38	481	499
republic	0.53	0.67	0.27	0.07	1.79	376	356

regression: concreteness ratings formed abstract (rating [100-400], N = 294) and concrete ([401-700], N = 298) groups, whereas imageability ratings formed low ([100-400], N = 167) and high ([401-700], N = 425) groups. A priori sensitivity analysis confirmed that the sample size of the smallest group (low-imageability words) was still large enough to capture even a low degree of fit (minimum R^2 = .074) in a five-predictor regression model at power of 0.8.

Results & Discussion

Concreteness Analysis showed clear dissociations between concreteness and modality-specific perceptual experience., with little consistency across abstract and concrete groups (see Figure 1). Abstract words' ratings were predicted by three of the five modalities, $F(3, 290) = 8.64$, $p < .0001$, $R^2 = .082$, but with a low degree of fit and inconsistency in the direction of the relationship: positively related to vision, and negatively to auditory and olfactory strength. In contrast, concrete words' ratings were predicted positively by olfactory and visual strength, $F(2, 295) = 33.52$, $p < .0001$, $R^2 = .185$, but these two perceptual modalities offered a higher degree of fit than the model for abstract words.

Most perceptual modalities therefore failed to retain a consistent relationship with concreteness across the scale (auditory, olfactory) or had no predictive value at all (gustatory, haptic). However, the most serious conflict concerned the inversion of the olfactory effect: more olfactory meant more abstract, but more olfactory also meant more concrete. Such inconsistency in behavior poses serious problems for the assumption that abstractness and concreteness represent two ends of the same continuum, and rather indicates that participants applied different decision criteria at the concrete and abstract ends of the norming scale. While perceptual strength can explain more than twice the concreteness variance in concrete words (19%) than it did in abstract words (8%), participants are clearly basing their concreteness rating on non-perceptual information. It therefore appears that participants in concreteness norming studies treated the scale as two intersecting continua, neither of which reliably reflects the extent of sensory experience.

Imageability Analysis of imageability showed a clear visual bias at the expense of other perceptual modalities (see Figure 2). Ratings of low-imageability words were predicted by two perceptual modalities: visual strength (positively) and olfactory strength (negatively), $F(2, 164) = 16.42$, $p < .0001$, $R^2 = .167$. High-imageability ratings, on the other hand, were related to three perceptual modalities with a similar degree of fit, $F(3, 421) = 36.32$, $p < .0001$, $R^2 = .206$: positively for both visual and olfactory information, and negatively for gustatory.

Participants therefore tend to rely on visual experience when generating imageability ratings: visible things are highly imageable and invisible things are not. However, this focus on vision led other modalities to be neglected or misinterpreted. Neither auditory nor haptic experience was reflected at either end of the scale, and people tended to misconstrue olfactory information and ignore gustatory information for low-imageability concepts, yet follow olfactory strength while misinterpreting gustatory strength for high-imageability concepts. Results indicate that people do not find it equally easy to generate imagery across the range of modalities that constitute perceptual experience. Participants in imageability norming studies seem to have had difficulty in extending the meaning of "image" beyond its conventional interpretation as a visual impression.

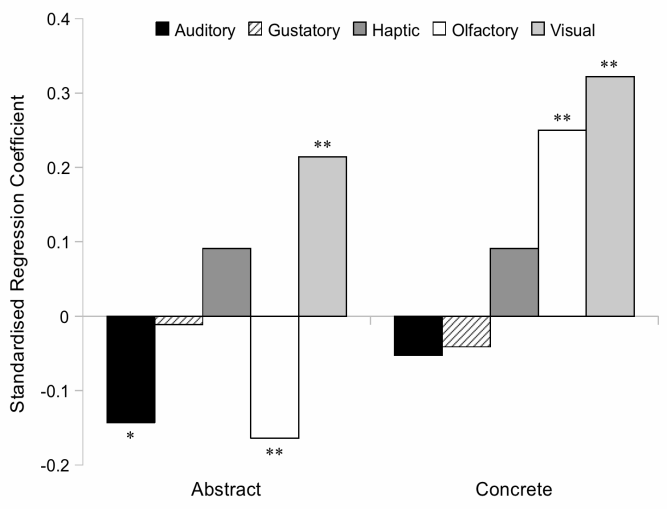

Figure 1: Modality predictors of concreteness ratings in Experiment 1 (* $p < .05$, ** $p < .01$).

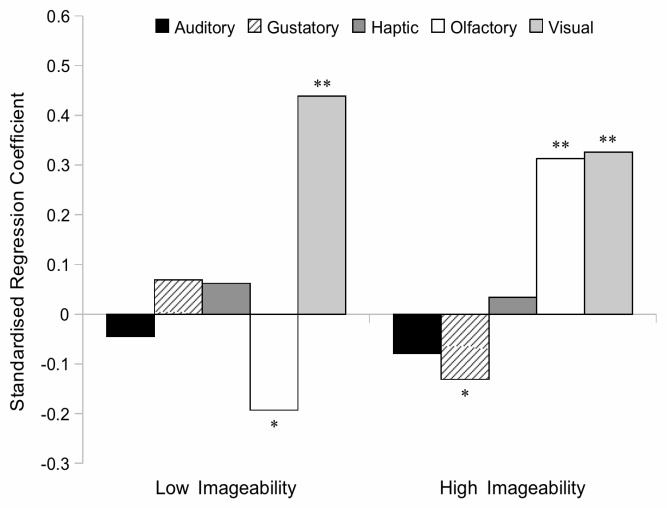

Figure 2: Modality predictors of imageability ratings in Experiment 1 (* $p < .05$, ** $p < .01$).

Experiment 2

Since neither concreteness nor imageability ratings reflect the full range of sensory experience, it raises the question of whether textbook concreteness effects in word processing are actually due to (a) the degree of perceptual information in each referent concept's representation, or (b) some other conceptually meaningful information that makes up most of

the variance in concreteness and imageability ratings. The present experiment aimed to resolve this question by comparing the unique predictive abilities of concreteness ratings, imageability ratings and perceptual strength in lexical decision and word naming performance.

If concreteness effects are due to the degree of perceptual information in each referent concept's representation, then perceptual strength should outperform concreteness and imageability in predicting latency and accuracy in word processing. In this case, we would expect perceptual strength to exhibit an independent effect in the presence of concreteness / imageability predictors, but not vice versa, because most of the variance in concreteness and imageability ratings reflects decision criteria that are unrelated to processing performance. On the other hand, if concreteness effects are actually due to some other non-perceptual representation that is captured by concreteness and imageability ratings, then they would maintain an independent effect even when perceptual strength has already been partialled out. In this sense, concreteness effects would subsume perceptibility effects, because the variance in concreteness and imageability ratings would reflect conceptually meaningful information in addition to perceptual differences.

Method

Materials The same set of 592 words from Experiment 1 was used in this study, along with lexical decision and naming data from the Elexicon database (Balota et al., 2007; available online at http://elexicon.wustl.edu), which also provided lexical characteristics for each word to act as independent regression variables (see below).

Design & Analysis Hierarchical regression analyses determined the proportion of variance each candidate rating could explain. The dependent variables were mean lexical decision and naming times for each word (M = 633 ms, SD = 64 ms; M = 622 ms, SD = 53 ms; respectively), and their accompanying mean accuracy rates (M = 96.6%, SD = 5.4%; M = 98.9%, SD = 3.3%). As well as raw RT in ms, we also analysed standardized RT based on the mean z-scores of the original participants in the Elexicon data, which offers a more reliable measure of latency by partialing out individual differences in overall speed and variability (Balota et al., 2007). As independent variables in all regressions, we used a basic model found by Brysbaert and New (2009) to provide the best fit for RT and accuracy: log contextual diversity, log^2 contextual diversity, number of letters in the word, and number of syllables in the word.

The independent (unique) effects of concreteness (M = 427, SD = 107) and imageability (M = 461, SD = 92) were ascertained by adding the relevant predictor to a model containing maximum perceptual strength[1] and examining whether it led to an increase in fit. The independent effect of perceptual strength (M = 3.78, SD = 0.75) was calculated twice: once by entering it in a model that already contained concreteness, and once by adding it to a model that contained imageability. The correlation between imageability and concreteness was high, r (590) = .828, p < .0001, and comparable to previous studies (e.g., r = .83 in Paivio et al., 1968). Maximum perceptual strength had a much weaker relationship with both concreteness, r(590) = .429, p < .0001, and imageability, r(590) = .502, p < .0001.

Results & Discussion

Only perceptual strength emerged as a unique predictor of variance in word processing (see Figure 3 and Table 2). When either concreteness or imageability had already been included in the model, perceptual strength still accounted for an extra proportion of variance in all measures except naming accuracy. Critically, the inverse was not true. When maximum perceptual strength was included as a predictor, there was no model where the addition of concreteness or imageability produced an increase in fit[2]. It is important to note that perceptual strength was in all cases acting in the expected direction (see Table 2): RT decreased and accuracy increased with higher perceptual strength. In other words, the independent predictive ability of perceptual strength never counteracted any facilitation by concreteness or imageability. Maximum perceptual strength thus captures meaningful information about conceptual structure that other ratings do not, and this information impacts directly on word processing performance.

One other striking difference emerged. Previous research has found that contextual diversity is inversely correlated with concreteness and imageability (i.e., abstract words appear in more diverse contexts than do concrete words: Schwanenflugel & Shoben, 1983; Schwanenflugel et al., 1988). Our data was consistent with this established pattern: zero-order correlations showed that concreteness was negatively related to log contextual diversity, r(590) = –.108, p = .009, though the weaker trend for imageability was not significant, r(590) = –.024, p = .560. Yet, in sharp contrast, perceptual strength was *positively* correlated with contextual diversity, r(590) = .117, p < .0001. That is, although concrete-rated words have a narrower variety of contexts than abstract-rated words, perceptually strong words have a *wider* variety than perceptually weak words. We return to this issue in the general discussion.

General Discussion

In the present paper, we show that concreteness and

[1] Maximum perceptual strength represents the highest rating in the concept's dominant modality, which analysis showed was the best method of compressing the five-value vector of perceptual strength into a single variable (necessary for equitable comparison with concreteness and imageability).

[2] Our approach and findings thus differ considerably from those of Juhasz et al., (2011), who found that a sensory experience rating predicted lexical decision times after imageability was partialled out. However, they did not examine concreteness ratings or word naming times, their rating asked people to aggregate all sensory experience on a single scale (which our Experiment 1 indicates that people find very difficult) rather than collecting ratings on separate modalities, and they did not show which of imageability and their own rating had better predictive power.

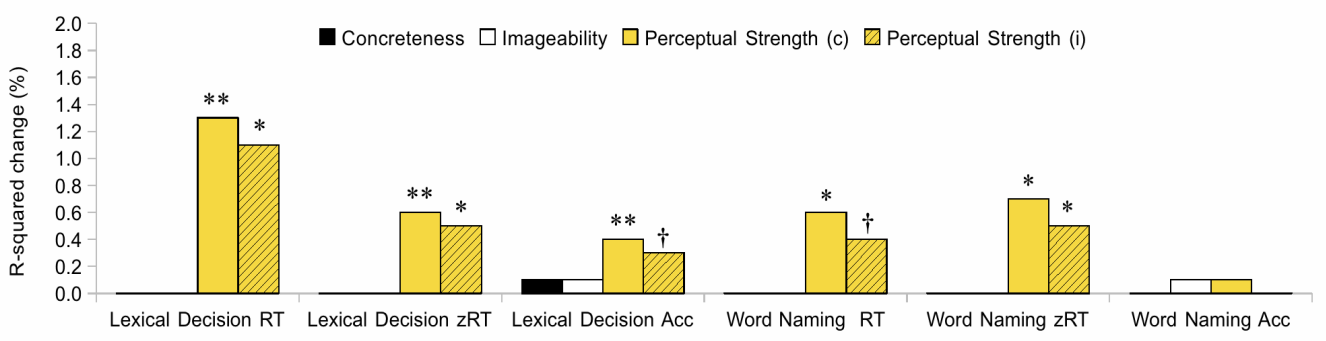

Figure 3: Independent (unique) effects of each predictor in Experiment 2, showing proportion of explained variance (R^2 change in %) of Elexicon reaction time and accuracy data, over and above that of perceptual strength, concreteness (c) or imageability (i) († $p < .1$, * $p < .05$, ** $p < .01$).

Table 2: Standardized regression coefficients for independent effects of each predictor over and above that of perceptual strength, concreteness (c) or imageability (i), in models of Elexicon reaction time and accuracy data in Experiment 2.

Predictor	Lexical Decision RT	Lexical Decision zRT	Lexical Decision Acc	Word Naming RT	Word Naming zRT	Word Naming Acc
Concreteness	– 0.016	– 0.004	– 0.031	+ 0.025	+ 0.002	– 0.023
Imageability	– 0.023	– 0.018	+ 0.036	– 0.013	– 0.024	+ 0.045
Perceptual strength (c)	– 0.132**	– 0.091**	+ 0.097**	– 0.089*	– 0.095*	+ 0.038
Perceptual strength (i)	– 0.127**	– 0.080*	+ 0.067†	– 0.072†	– 0.082*	+ 0.006

† p < .1, * p < .05, ** p < .01

imageability ratings do not accurately reflect the perceptual basis of concepts, and that concreteness effects in lexical decision and naming are better predicted by perceptual strength ratings than by concreteness or imageability ratings. These findings support the intuition that perceptual concepts are faster to process, and show that textbook concreteness effects in word processing are actually a function of the degree of perceptual information in each referent concept's representation. However, our results also suggest that concreteness and imageability ratings are unsuitable for the tasks in which they are employed, because most of their variance comes from non-perceptual decision criteria that is unrelated to word processing performance. Concreteness effects could therefore be better characterized as perceptibility effects, which can be sometimes nullified or inverted (e.g., Kousta et al., 2011; Papagno et al., 2009) when elicited from relatively noisy concreteness or imageability ratings.

While the connection between concreteness effects and perceptual information might at first glance seem like old news (e.g., Barsalou & Wiemer-Hastings, 2005; Paivio, 1986, 2007), the present findings have some important ramifications for how such effects should be interpreted. Concreteness effects, by their very name, are assumed to result from an ontological difference between concrete and abstract concepts carrying through to a representational difference that affects speed and accuracy of processing. Labeling a word as “concrete” or “abstract” has an intuitive appeal, but we would argue that these terms lacked proper operationalization during norming and hence it is unclear exactly what information is captured by concreteness ratings. Of course, any set of ratings can only ever be an approximation of an underlying representation, and we are not suggesting that one should expect a perfect fit between concreteness ratings and behavioral effects. That said, the poor performance of concreteness ratings in the current data lies in sharp contrast to the robust performance of perceptual strength ratings. We suggest that the concrete / abstract ontological distinction must be disentangled from concreteness / imageability norms because empirical concreteness effects are not in themselves well predicted by concreteness / imageability.

Theoretically, the present results poses some problems for dual coding, context availability, and situated simulation explanations of concreteness effects. It is a central tenet of dual coding theory that highly perceptual concepts are those with the most direct connections between the verbal and nonverbal imagery codes, and people therefore find it difficult to generate perceptual imagery for words that lack these direct connections (Paivio, 1986, 2007). However, imageability (i.e., the ease of consciously generating imagery) is not well related to perceptual experience (Experiment 1), and its effects were entirely subsumed by larger effects of perceptual strength (Experiment 2). In other words, it is the extent of perceptual information in a concept's representation that matters to word processing, not the ease of generating imagery, which casts some doubt on the idea that processing delays for abstract concepts emerge from their lack of direct inter-system connections. Both context availability (Schwanenflugel & Shoben, 1983; Schwanenflugel et al., 1988) and situated simulation (Barsalou & Wiemer-Hastings, 2005; Barsalou et al., 2008)

views share the idea that abstract concepts are slowed in processing because they have a wider variety of potential situational contexts. This idea, however, is not borne out by our data. Strongly perceptual concepts (i.e., those that are generally assumed to be concrete, regardless of what concreteness ratings say) actually have greater contextual diversity than weakly perceptual concepts.

In sum, we believe that the operationalisation of abstract and concrete concepts deserves much closer scrutiny than it has received to date. Whether researchers want to investigate the ontological distinction between abstract and concrete concepts, or the variables that affect latency and accuracy in word processing, then they should reconsider the automatic tendency to reach for concreteness and imageability ratings that have little to do with the perceptual basis of concepts. Strength of perceptual experience has a powerful bearing on how people represent concepts during word processing, and these perceptibility effects are stronger than those elicited by concreteness or imageability.

References

Adelman, J. S., Brown, G. D. A., & Quesada, J. F. (2006). Contextual diversity, not word frequency, determines word-naming and lexical decision times. *Psychological Science, 17*, 814-823.

Balota, D. A., Yap, M. J., Cortese, M. J., Hutchison, K. I., Kessler, B., Loftis, B., … Treiman, R. (2007). The English Lexicon Project. *Behavior Research Methods, 39*, 445–459.

Barsalou, L. W., & Wiemer-Hastings, K. (2005). Situating abstract concepts. In D. Pecher & R. A. Zwaan, *Grounding cognition: The role of perception and action in memory, language, and thinking* (pp. 129– 163). Cambridge, UK: Cambridge University Press.

Barsalou, L. W., Santos, A., Simmons, W. K., & Wilson, C. D. (2008). Language and simulation in conceptual processing. In M. De Vega, A. M. Glenberg, & A. C. Graesser, A. (Eds.). *Symbols, embodiment, and meaning* (pp. 245-283). Oxford, UK: Oxford University Press.

Binder, J. R., Westbury, C. F., McKiernan, K. A., Possing, E. T., & Medler, D. A. (2005). Distinct brain systems for processing concrete and abstract words. *Journal of Cognitive Neuroscience, 17*, 905–917.

Brysbaert, M., & New, B. (2009). Moving beyond Ku era and Francis: A critical evaluation of current word frequency norms and the introduction of a new and improved word frequency measure for American English. *Behavior Research Methods, 41*, 977-990.

Clark, J. M., & Paivio, A. (2004). Extensions of the Paivio, Yuille, and Madigan (1968) norms. *Behavior Research Methods, 36*, 371–383.

Connell, L., & Lynott, D. (2010). Look but don't touch: tactile disadvantage in processing modality-specific words. *Cognition, 115*, 1-9.

Fiebach, C. J., & Friederici, A. D. (2004). Processing concrete words: fMRI evidence against a specific right-hemisphere involvement. *Neuropsychologia, 42*, 62–70.

James, C. T. (1975). The role of semantic information in lexical decisions. *Journal of Experimental Psychology: Human Perception and Performance, 1*, 130–136.

Juhasz, B. J., Yap, M. J. Dicke, J., Taylor, S. C., & Gullick, M. M. (2011). Tangible words are recognized faster: The grounding of meaning in sensory and perceptual systems. *Quarterly Journal of Experimental Psychology, 64*, 1683-1691.

Kousta, S. T., Vigliocco, G., Vinson, D. P., Andrews, M, & Del Campo, E. (2011). The representation of abstract words: Why emotion matters. *Journal of Experimental Psychology: General, 140*, 14-34.

Kroll, J., & Merves, J. S. (1986). Lexical access for concrete and abstract words. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 12*, 92–107.

Louwerse, M. M., & Connell, L. (2011). A taste of words: Linguistic context and perceptual simulation predict the modality of words. *Cognitive Science, 35*, 381-398.

Lynott, D., & Connell, L. (2009). Modality exclusivity norms for 423 object properties. *Behavior Research Methods, 41*, 558-564.

Lynott, D., & Connell, L. (in prep.). Why noun concepts are more multimodal than adjective concepts: Modality exclusivity norms for objects. *Manuscript in preparation*.

Nelson, D. L., McEvoy, C. L., & Schreiber, T. A. (2004). The University of South Florida word association, rhyme, and word fragment norms. *Behavior Research Methods, Instruments, & Computers, 36*, 402–407.

Paivio, A. (1986). *Mental representations: A dual coding approac*h. Oxford, UK: Oxford University Press.

Paivio, A. (2007). *Mind and its evolution: A dual coding theoretical approach*. Mahwah, NJ: Erlbaum.

Paivio, A., Yuille, J. C., & Madigan, S. A. (1968). Concreteness, imagery, and meaningfulness values for 925 nouns. *Journal of Experimental Psychology, 76*(1, Pt. 2), 1-25.

Papagno, C., Capasso, R., Zerboni, H., & Miceli, G. (2007). A reverse concreteness effect in a subject with semantic dementia. *Brain and Language, 103*, 90–91.

Sabsevitz, D. S., Medler, D. A., Seidenberg, M., & Binder, J. R. (2005). Modulation of the semantic system by word imageability. *Neuroimage, 27*, 188–200.

Schwanenflugel, P. J., Harnishfeger, K. K., & Stowe, R. W. (1988). Context availability and lexical decisions for abstract and concrete words. *Journal of Memory and Language, 27*, 499–520.

Schwanenflugel, P. J., & Shoben, E. J. (1983). Differential context effects in the comprehension of abstract and concrete verbal materials. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 9*, 82–102.

Schwanenflugel, P. J., & Stowe, R. W. (1989). Context availability and the processing of abstract and concrete words in sentences. *Reading Research Quarterly, 24*, 114–126.

Tyler, L. K., Russell, R., Fadili, J., & Moss, H. E. (2001). The neural representation of nouns and verbs: PET studies. *Brain, 124,* 1619 –1634.