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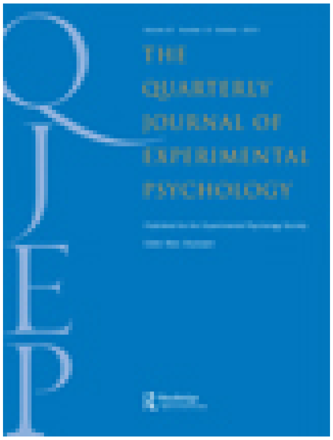

The Quarterly Journal of Experimental Psychology
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/pqje20

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Published online: 18 Nov 2014.

To cite this article: Alex Taikh, Ian S. Hargreaves, Melvin J. Yap & Penny M. Pexman (2014): Semantic classification of pictures and words, The Quarterly Journal of Experimental Psychology, DOI: 10.1080/17470218.2014.975728

To link to this article: http://dx.doi.org/10.1080/17470218.2014.975728

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THE QUARTERLY JOURNAL OF EXPERIMENTAL PSYCHOLOGY, 2014
http://dx.doi.org/10.1080/17470218.2014.975728

Semantic classification of pictures and words

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We provide new behavioural norms for semantic classification of pictures and words. The picture stimuli are 288 black and white line drawings from the International Picture Naming Project ([Székely, A., Jacobsen, T., D'Amico, S., Devescovi, A., Andonova, E., Herron, D., et al. (2004). A new on-line resource for psycholinguistic studies. *Journal of Memory & Language*, 51, 247–250]). We presented these pictures for classification in a living/nonliving decision, and in a separate version of the task presented the corresponding word labels for classification. We analyzed behavioural responses to a subset of the stimuli in order to explore questions about semantic processing. We found multiple semantic richness effects for both picture and word classification. Further, while lexical-level factors were related to semantic classification of words, they were not related to semantic classification of pictures. We argue that these results are consistent with privileged semantic access for pictures, and point to ways in which these data could be used to address other questions about picture processing and semantic memory.

Keywords: Picture classification; Semantic processing; Semantic memory; Semantic richness.

Over the past several decades, numerous studies have compared the processing of word and picture stimuli, often with the goal of testing theoretical claims about distinct semantic systems for words and pictures. While some have argued that there are separable semantic systems for the lexical and pictorial modalities (e.g., Paivio, 1991; Shallice, 1988), there are also theoretical claims that words and pictures access the same semantic system (e.g., Hogaboam & Pellegrino, 1978; Shelton & Caramazza, 1999). Indeed, there is electrophysiological evidence that the semantic system accessed by pictorial stimuli is very similar, if not identical, to the semantic system accessed by word stimuli. That is, in electrophysiological studies these two types of stimuli produce very similar patterns of neural response (Federmeier & Kutas, 2001; Ganis, Kutas, & Sereno, 1996). Similarly, Moore and Price (1999) reported considerable overlap in the brain regions activated by word and picture stimuli in a PET study, suggesting a common semantic system. At the same time, Moore and Price noted some differences; words were associated with greater activation than pictures in regions associated with phonological and lexical processing, while pictures were associated with greater activation than words in regions associated with semantic processing. Indeed, Catling and Johnston (2006) argued that one difference between word and picture processing is that the meaning of pictures can be accessed without necessarily requiring access to the depicted

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This work was supported by the Natural Sciences and Engineering Research Council (NSERC) of Canada under Discovery Grant # RGPIN 217309-2013 to PMP.

object's name (and associated phonological/orthographic information). Importantly, these are differences in the way in which words and pictures contact the semantic system, and not differences in the semantic representations of words and pictures per se. Similarly, Shelton and Caramazza (1999) argued that words and pictures have different relationships with semantic memory. Pictures have *privileged accessibility* to semantic memory, since they depict perceptual features and other aspects of meaning, whereas there is a nearly arbitrary relationship between words' physical presentation and meaning (Saussure, 1916). For instance, there is little about the form or sound of the word *rose* that conveys its meaning.

Studies of picture processing have tended to involve small numbers of items, and it seems likely that the debate over semantic processing of words and pictures could benefit from a larger-scale approach, such as that used in megastudies. Recently, the study of picture processing has been advanced by the creation of the International Picture Naming Project (IPNP; Székely et al., 2004). The project includes picture-naming norms for black and white line drawings of 520 objects and 275 actions, and provides naming latencies and accuracy rates in several languages (Bates et al., 2003; Székely et al., 2005). The work conducted using this database has helped to establish the factors that influence picture naming across languages and age groups. Certainly, picture naming requires access to meaning in order to derive the picture label, but task performance is also necessarily influenced by lexical and phonological factors. As such, picture naming offers limited insights for researchers interested in semantic memory. In order to advance our understanding of the semantic processing of pictures and words, one goal of the present study was to generate normative data for semantic classification of the IPNP pictures and also the corresponding word labels, and to make those data available to others.

Semantic richness

Many studies of semantic memory have capitalized on the fact that there is variability in the amount of information associated with different concepts. This variability can be defined in a number of different ways, as a function of the various descriptions of semantic memory that have been proposed. For instance, meaning can be derived from lexical co-occurrence information (the way words are used in language, e.g., Burgess & Lund, 2000; Landauer & Dumais, 1997), semantic features (basic attributes derived from experience with concepts, e.g., Jones, 1985; McRae, 2005; McRae, de Sa, & Seidenberg, 1997), or sensorimotor experience (grounded in perceptual representations acquired through experience with objects and situations, e.g., Barsalou, 1999; Pecher & Zwaan, 2005). Support for each of these frameworks has been provided by studies showing that each of these dimensions is related to lexical and semantic processing. That is, performance in visual word recognition tasks is faster for words that occur in the context of many other words (e.g., *bed*) than for words that share lexical contexts with few other words (e.g., *door*) (semantic neighbourhood effects; Buchanan, Westbury, & Burgess, 2001). Visual word recognition performance is also facilitated for words that generate many semantic features in feature listing tasks (e.g., *cougar*) compared to words that generate fewer semantic features in those tasks (e.g., *leopard*) (number of features effects; Grondin, Lupker, & McRae, 2009; Pexman, Holyk, & Monfils, 2003; Pexman, Lupker, & Hino, 2002).

There is also evidence that word recognition is faster for words that refer to concepts that are easily imageable (e.g., *truck*) than for words that refer to concepts that are more difficult to image (e.g., *truth*) (imageability effects; e.g., Balota, Cortese, Sergent-Marshall, Spieler, & Yap, 2004). Similarly, words that refer to things with which the human body can easily interact (e.g., *mask*) tend to generate faster word recognition performance than do words that refer to things with which we can less easily interact (e.g., *ship*) (body-object-interaction effects; Hargreaves et al., 2012; Siakaluk, Pexman, Aguilera, Owen, & Sears, 2008; Siakaluk et al., 2008; Tousignant & Pexman, 2012). These have been referred to as *semantic richness effects* (for a review see Pexman,

2012) and are consistent with the principle that in general, when it comes to semantic activation in lexical processing, "more is better" (Balota, Ferraro, & Connor, 1991, p. 214).

One potential mechanism for richness effects was suggested by Plaut and Shallice (1993); the visual word recognition system settles more quickly into a stable pattern of activation for concepts with richer semantic representations. Similarly, in an fMRI study of semantic richness effects, Pexman, Hargreaves, Edwards, Henry, and Goodyear (2007) found that semantic decisions about relatively rich (i.e., high number of associates) concepts were associated with attenuated activation in a number of cortical regions linked to semantic processing (including left inferior frontal and inferior temporal gyri). While settling dynamics may provide a mechanism for richness effects, it is important to acknowledge that these simulations should not be taken as conclusive evidence that concepts with richer semantic representations are also accessed faster. Indeed, there is evidence that relative richness may influence decision-making mechanisms by contributing relatively more information towards a decision criterion. This would also account for the observation of faster processing for richer concepts (Kounios et al., 2009) but would not involve faster access to richer concepts.

Regardless of mechanism, it is clear that words vary in the richness of their meanings, and studies have shown that this variability in semantic richness has consequences for word recognition and for memory (Hargreaves, Pexman, Johnson, & Zdrazilova, 2012). In several recent studies, however, we have considered semantic richness effects in a more comprehensive way, by simultaneously examining their relative contributions to semantic processing. That is, we have simultaneously tested the effects of several richness dimensions on behavioural responses to a large set of words across a wide array of tasks that place different emphasis on meaning (Pexman, Hargreaves, Siakaluk, Bodner, & Pope, 2008; Yap, Pexman, Wellsby, Hargreaves, & Huff, 2012; Yap, Tan, Pexman, & Hargreaves, 2011). Results suggest that several of the richness dimensions have unique but overlapping relationships with lexical-semantic processing, and the implication is the best theoretical approach would be a model that incorporates multiple dimensions of semantic information.

This work on semantic richness effects has been made possible by large-scale studies that have been undertaken to establish norms for body-object interaction ratings (Bennett, Burnett, Siakaluk, & Pexman, 2011; Tillotson, Siakaluk, & Pexman, 2008), lexical co-occurrence metrics (Shaoul & Westbury, 2010), and feature listing (McRae, Cree, Seidenberg, & McNorgan, 2005). Many of these studies have involved the set of concrete concepts in the McRae et al. feature norms (e.g., Amsel, 2011; Amsel & Cree, 2013; Pexman et al., 2008; Yap et al., 2011, 2012). While much has been learned from these efforts, new dimensions of semantic richness have recently been described in additional norming studies, and it is important that the effects of these new variables be compared to those of existing richness dimensions in order that we further expand our understanding of semantic memory. For instance, Hoffman, Lambon Ralph, and Rogers (2013) used latent semantic analysis to establish the semantic similarity of linguistic contexts in a large text corpus. They then quantified the extent to which the contexts a given word was used in were dissimilar, and called this dimension semantic diversity. Higher semantic diversity values indicate words used in more dissimilar contexts. Further, Amsel, Urbach, and Kutas (2012) collected ratings for multiple sensorimotor attributes and derived two primary dimensions which, they argued, seemed to reflect information relevant to survival; avoiding death and locating nourishment. Concepts with higher values on these dimensions are associated with relatively more of each kind of information.

A second goal of the present study was to incorporate these new dimensions in a multidimensional examination of semantic richness effects, and to further distinguish effects of semantic richness by examining the effects in picture classification, which should increase the variance explained by semantic factors and decrease the variance explained by lexical factors (compared to classification of word stimuli). For the classification task, we chose the decision category living/nonliving. This is a broad, inclusive category that allows us to present many items for classification. Some previous studies of picture classification used multiple superordinate categories, presenting the category name with each target to be classified, and asked participants to judge whether the target picture matched the specified category (Potter & Faulconer, 1975; Potter, So, Von Eckardt, & Feldman, 1984). Other studies used single, small superordinate categories (Chainay & Humphreys, 2002; Yoon & Humphreys, 2007). The problem with this approach, for our purposes, is that the use of small superordinate categories creates strong effects of typicality that could mask other semantic influences.

Finally, there is good reason to assume that semantic richness effects will be observed in a living/nonliving semantic classification task with pictures. In a recent study, Taylor, Devereux, Acres, Randall, and Tyler (2012) presented images for living/nonliving classification and reported an overall benefit of the number of features dimension. Notably, Taylor et al.'s images were not IPNP pictures, and their interest was in more fine-grained feature metrics; nonetheless, their finding is promising for our purposes.

EXPERIMENTAL STUDY

Method

Participants

Sixty-nine University of Calgary undergraduate psychology students (15 male; average age = 20.49 years) participated for partial course credit. Participants were randomly assigned to either the pictures ($n = 34$) or words condition ($n = 35$).

Stimuli and design

In selecting the stimuli for this study, we began by identifying those words in the McRae et al. (2005) norms for which there were corresponding pictures in the IPNP (Székely et al., 2004) object set. There were 244 such items, of which 82 represented living things, and 162 represented nonliving things. In order to better balance the numbers of living and nonliving items we selected an additional 45 pictures of living objects from the IPNP, for a total of 127 living things. As such, a total of 289 pictures were selected for the final item set, although only 288 were presented in the picture version of the classification task (the picture for *shell* was omitted due to a programming error). An additional 10 items were selected for the practice trials.

Visual and lexical variables. These included objective visual complexity of pictures (from the IPNP), and words' log frequency (logSUBTL-CD from Brysbaert & New, 2009), number of morphemes, and number of letters. In addition, in order to address the high correlations between words' orthographic (Coltheart, Davelaar, Jonasson, & Besner, 1977) and phonological (Yates, 2005) neighbourhood size ($r = .80$), and between orthographic (Yarkoni, Balota, & Yap, 2008) and phonological (Yap & Balota, 2009) Levenshtein distance (LD; $r = .92$), we used principal component analysis to reduce the two neighbourhood size measures and the two LD measures to a neighbourhood size (N) and LD component, respectively (see Yap et al., 2011, 2012).

Semantic variables. Imageability ratings were obtained from Cortese and Fugett (2004) and Schock, Cortese, and Khanna (2012). Body-object interaction (BOI) ratings were obtained from the Bennett et al. (2011) and Yap et al. (2012) norms. Number of features (NF) values were taken from the McRae norms. Average radius of co-occurrence (ARC) values were from Shaoul and Westbury (2010); words from denser semantic neighbourhoods have higher ARC values. Semantic diversity (SD) values were from Hoffman et al. (2013) and avoiding death (AD) and locating nourishment (LN) values were from Amsel et al. (2012).

Procedure

Participants were tested individually. All stimuli were presented on a 20″ monitor controlled by a desktop computer using E-Prime software (Schneider, Eschman, & Zuccolotto, 2001). Participants in the pictures and words conditions were instructed that they would see a series of pictures (or words) one at a time on the screen, and would have to decide whether each represents something living (by pressing the left button on the response box) or nonliving (by pressing the right button). Participants were informed that something was defined as living if it could independently grow or develop, and that people, animals, plants, fruits, and vegetables were considered living for the purposes of this experiment. Additionally, participants were instructed to respond as quickly and accurately as possible.

The experimenter remained in the testing room during the practice trials to ensure that the instructions were understood. The experimenter then left the room and the participants completed the remaining trials. Each trial began with a 500-ms fixation cross in the centre of the screen, followed by a 500-ms blank screen, followed by the target stimulus (words were presented in 18 pt. Courier New font). After participants responded living or nonliving via the response box, a 2000-ms blank screen was presented before the start of the next trial. During the practice trials, but not the experimental trials, "incorrect" appeared on the screen if the participants made the wrong semantic classification response. After half of the experimental trials were presented, participants were given a break, and resumed the experiment when ready by pressing a key on the response box. Items were presented in a different random order to each participant.

Results and discussion

We first computed mean classification responses for all 288 pictures, along with response data for the word condition, and these are presented in the Supplemental Material and are also available at http://psych.ucalgary.ca/languageprocessing/node/22. Next, we examined semantic richness effects in picture and word classification for the items for which we had complete data on all predictors. We excluded trials for which the response was incorrect (2.1% in the picture condition, 3.5% in the word condition). We also trimmed latency outliers, first by eliminating trials with response latencies faster than 200 ms or slower than 3000 ms, and second by removing trials that were more than 2.5 *SD* away from each participant's mean response latency (an additional 3.3% of trials in each task). We also excluded items with response accuracy of less than 70% in either the picture or word condition (3 items in the picture condition: *doll*, *cheese*, *asparagus*, and 3 items in the word condition: *shell*, *cheese*, and *bread*). Finally, nine of the items were semantically ambiguous in their word form (e.g., *bat*) and in the word version of the task were presented with a disambiguating cue (e.g., bat (animal)). We did not include these nine items in the analysis of either the picture or word conditions. As such, the final item sets for the analyses were comprised of 195 items in the pictures condition and 196 in the words condition. For these items, descriptive statistics are presented in Table 1 and intercorrelations between predictors and dependent measures are presented in Table 2. Standardized response latencies were used in the analyses since these minimize the influence of a participant's processing speed and variability (Faust, Balota, Spieler, & Ferraro, 1999).

As illustrated in Table 2, frequency was correlated with several of the richness variables, particularly ARC ($r = .69$). This is consistent with previous studies; Hargreaves and Pexman (2012) reported a correlation between frequency and ARC of $r = .68$ for 25,463 words in the British Lexicon Project. Relationships between frequency and semantic richness reflect the fact that people tend to have more knowledge of, and experience with, concepts they encounter frequently. Although there were several significant correlations between the richness variables, most of the correlations were relatively modest (r less than .30). The exceptions were the correlations between ARC and imageability ($r = .38$) and SD ($r = .40$), and between imageability and NF ($r = .31$) and BOI and AD ($r = -.47$). Generally, the

Table 1. *Descriptive Statistics for Stimulus Characteristics and Behavioral Data*

	All items (n = *197)*		*Living* (n = *66)*		*Nonliving* (n = *131)*	
Variable	M	SD	M	SD	M	SD
Objective visual complexity for picture (kB)	16196.57	7997.20	17533.59	9608.06	15522.95	6993.03
Log word frequency (Brysbaert & New, 2009)	2.50	0.51	2.30	0.44	2.60	0.52
Number of morphemes	1.18	0.43	1.11	0.31	1.22	0.47
Word length (letters)	5.58	1.83	5.68	1.72	5.53	1.89
Orthographic neighbourhood size (ON, Coltheart et al., 1977)	4.45	5.39	3.76	5.32	4.79	5.41
Phonological neighbourhood size (PN, Yates, 2005)	9.16	10.18	8.08	10.69	9.71	9.90
Orthographic Levenshtein distance (OLD, Yarkoni et al., 2008)	2.05	0.87	2.16	0.81	1.99	0.89
Phonological Levenshtein distance (PLD, Yap & Balota, 2009)	1.92	0.96	2.04	0.88	1.86	1.00
Imageability	6.36	0.38	6.49	0.27	6.29	0.41
Body-object interaction (BOI, Bennett et al., 2011)	4.74	1.34	3.74	1.45	5.23	0.95
Average radius of co-occurrence (ARC, Shaoul & Westbury, 2010)	0.55	0.09	0.55	0.07	0.55	0.09
Number of features (NF, McRae et al., 2005)	12.97	2.99	14.00	2.89	12.45	2.91
Semantic diversity (SD, Hoffman et al., 2013)	1.49	0.22	1.48	0.23	1.50	0.22
Avoiding death (AD, Amsel et al., 2012)	0.06	1.06	0.40	1.19	−0.11	0.95
Locating nourishment (LN, Amsel et al., 2012)	−0.03	1.04	1.02	0.89	−0.57	0.60
Word classification latency	709.59	50.55	687.13	49.06	721.00	47.55
Word classification accuracy %	0.97	0.05	0.96	0.04	0.98	0.05
Picture classification latency	594.70	55.75	595.57	62.28	594.26	52.44
Picture classification accuracy %	0.98	0.07	0.97	0.07	0.99	0.07

correlations between the richness measures suggest that these dimensions, even SD, AD, and LN, which have not been included before, are not all tapping the same underlying construct.

Next, we conducted hierarchical regression analyses on standardized response latencies in the pictures condition and, separately, the words condition (there were too few response errors to warrant parallel analyses of those data). In both analyses, we entered visual and lexical variables in Step 1. We also included a variable labelled "response" in Step 1, which coded whether the item was to be classified as a living (1) or nonliving thing (0). The purpose of this variable was to capture variance that could be attributed to the two response options. Finally, we entered the semantic richness variables (imageability, BOI, ARC, NF, SD, AD and LN) in Step 2. Results of these analyses for the picture and word conditions are reported in Table 3, and include several notable findings.

As illustrated in Table 3, picture classification performance was not predicted by any of the visual and lexical variables (entered in Step 1), but the semantic variables (entered in Step 2) did explain significant variance in picture classification latency. In contrast, word classification was explained by word frequency. The absence of a word frequency effect in picture classification is quite striking, since one might expect that pictures of more familiar concepts would be recognized more quickly. This does not seem to be the case, and we return to this issue in the General Discussion. The pattern observed here, of null visual/lexical effects but significant semantic effects in picture classification, is consistent with claims that picture processing involves relatively extensive semantic processing and less reliance on lexical processing (Catling & Johnston, 2006; Gollan, Montoya, Fennema-Notestine, & Morris, 2005; Moore & Price, 1999). At the same time, the patterns of significant richness effects observed

Table 2. *Correlations Between Predictor Variables and Dependent Measures*

Variable	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*
1. Visual complexity	–																
2. Frequency	−.05	–															
3. Morphemes	.06	−.28**	–														
4. Length	.07	−.46**	.58**	–													
5. ON	−.09	.41**	−.30**	−.68**	–												
6. PN	−.16*	.40**	−.33**	−.67**	.80**	–											
7. OLD	.06	−.49**	.52**	.92**	−.69**	−.66**	–										
8. PLD	.11	−.47**	.54**	.87**	−.60**	−.66**	.92**	–									
9. Response	.12	−.27**	−.13	.04	−.09	−.08	.10	.09	–								
10. Imageability	.11	.36**	−.25**	−.23**	.14*	.19**	−.19**	−.22**	.25**	–							
11. BOI	−.26**	.40**	−.02	−.30**	.35**	.34**	−.29**	−.30**	−.52**	.07	–						
12. ARC	.12	.69**	−.37**	−.38**	.28**	.30**	−.38**	−.35**	−.01	.37**	.10	–					
13. NF	−.01	.22**	−.02	−.07	.08	.10	−.05	−.08	.24**	.30**	−.06	.16*	–				
14. SD	.05	.43**	−.24**	−.25**	.28**	.26**	−.28**	−.26**	−.03	.14	.02	.39**	.09	–			
15. AD	.17*	.00	−.03	.03	.00	−.02	.05	.05	.22**	.12	−.49**	.22**	.14	.06	–		
16. LN	.04	−.10	−.05	.09	−.04	−.06	.11	.11	.72**	.28**	−.23**	.02	.27**	−.07	.11	–	
17. Z Word RT	.00	−.24**	.19**	.17*	−.09	−.09	.13	.17*	−.33**	−.36**	.11	−.27**	−.27**	−.18**	−.21**	−.11	–
18. Z Picture RT	.02	−.09	−.04	.06	−.03	−.03	.05	.07	−.02	−.14*	.09	−.08	−.26**	−.14*	−.27**	.15*	.47**

Note: ON, orthographic neighbourhood; PN, phonological neighbourhood; OLD, orthographic Levenshtein distance; PLD, phonological Levenshtein distance; BOI, body-object interaction; ARC, average radius of co-occurrence; NF, number of features; SD, semantic diversity; AD, avoiding death; LN, locating nourishment; RT, response time. $^{*}p < .05$; $^{**}p < .01$.

Table 3. *Results of Hierarchical Multiple Regression Analyses for Picture and Word Classification*

	Picture classification RT (n = *195)*						*Word classification RT* (n = *196)*					
Predictor variable	B	SEB	β	sr	ΔR^2	R^2	B	SEB	β	sr	ΔR^2	R^2
Step 1						.02						.24***
Response	−0.04	0.04	−.07	−.07			−0.21	0.03	−.43***	−.39		
Visual complexity	0.00	0.00	−.00	.00			0.00	0.00	.04	.04		
Frequency	−0.06	0.05	−.11	−.09			−0.16	0.03	−.37***	−.30		
Morphemes	−0.07	0.06	−.11	−.09			0.02	0.04	.03	.02		
Length	0.02	0.03	.12	.04			0.01	0.02	.06	.02		
N component	0.01	0.03	.02	.02			0.02	0.02	.09	.06		
LD component	−0.01	0.05	−.02	−.01			0.00	0.04	.01	.00		
Step 2					.21***	.23***					.11***	.36***
Imageability	−0.10	0.06	−.14†	−.11			−0.11	0.04	−.18*	−.15		
BOI	−0.02	0.02	−.10	−.06			−0.02	0.02	−.11	−.06		
ARC	0.29	0.31	.10	.06			0.03	0.24	.01	.01		
NF	−0.02	0.01	−.23**	−.20			−0.01	0.01	−.10	−.09		
SD	−0.14	0.09	−.12	−.10			−0.04	0.07	−.04	−.03		
AD	−0.07	0.02	−.29**	−.23			−0.03	0.02	−.14†	−.11		
LN	0.11	0.03	.44***	.28			0.10	0.02	.42***	.26		

Note: N, neighbourhood; LD, Levenshtein distance; BOI, body-object interaction; ARC, average radius of co-occurrence; NF, number of features; SD, semantic diversity; AD, avoiding death; LN, locating nourishment; RT, response time.
†$p < .08$; $^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$.

across the two tasks were quite similar, and thus provide little evidence that picture and word stimuli access different semantic memory systems.

The regression results also showed that the nature of the response (living vs. nonliving) was a significant predictor of response latencies in the word condition but not in the picture condition. The nature of this effect is made clear when one considers the mean response latencies for living and nonliving responses (see Table 1). In the pictures condition, mean responses for living and nonliving things were very similar ($M = 595.57$, $SD = 62.28$, and $M = 594.26$, $SD = 52.44$, respectively), whereas in the words condition, mean responses for living things ($M = 687.13$, $SD = 49.06$) were faster than responses for nonliving things ($M = 721.00$, $SD = 47.55$). We further explored the role of response category in additional regression analyses where we tested for interactions between response category and each of our predictors. Results showed one interaction in the pictures condition, where there was an interaction between response category and AD ($p < .001$): AD effects were not significant for nonliving things ($p = .45$) but were facilitatory for living things ($\beta = -.67$, $p < .001$). For the words condition there were two significant interactions, for response category with imageability ($p < .05$) and AD ($p < .05$). Imageability ($p = .29$) and AD ($p = .82$) effects were not significant for nonliving things, but were respectively facilitatory ($\beta = -.40$, $p < .001$) and borderline facilitatory ($\beta = -.32$, $p = .07$) for living things. These findings suggest that sensory and perceptual attributes might be emphasized when judging the meanings of living things, perhaps reflecting adaptations conferred by evolution, and consistent with the claims of Amsel et al. (2012) and Caramazza and Shelton (1998). In the General Discussion, we give more extensive consideration to the source of these differences.

The results also showed null effects of BOI in both picture and word classification. This result stands in contrast with the findings of Yap et al. (2012), where significant facilitatory BOI effects were observed in semantic classification (concrete/abstract decision) for word stimuli. The Yap et al.

study had nearly three times as many items in the analysis, however, so likely had more power to detect these effects. In addition, the nature of the judgments used in these two tasks (concrete/abstract vs. living/nonliving) may have played a role, as semantic classification responses vary as a function of the information that is diagnostic of the decision category (e.g., Hino, Pexman, & Lupker, 2006; Tousignant & Pexman, 2012).

Similarly, the Yap et al. study included a significant facilitatory NF effect for word stimuli in semantic classification, but in the present study the NF effect was significant only for pictures. The significant NF effect for picture classification observed in the present study replicates that reported by Taylor et al. (2012). Our interest here was in the overall NF effect, but others (e.g., Grondin et al., 2009) have argued that the facilitatory NF effect is driven by the number of shared features (NSF, the number of features that occur in more than one concept in the McRae norms). Indeed, Taylor et al. found that the presence of shared features facilitated living/nonliving responses to a set of pictures. In follow-up hierarchical regression analyses, we used the same predictors as those listed in Table 3 but we replaced NF with NSF. Results showed that that, like NF, NSF was a significant predictor of picture classification latencies ($\beta = -.17$, $p < .05$) but not word classification latencies ($\beta = -.11$, $p = .14$).

The present analysis also included three new richness dimensions: SD, AD, and LN. We did not observe significant effects of SD in either picture or word classification. The AD and LN dimensions, however, produced significant (or marginally significant) effects in both picture and word classification. The AD effects were facilitatory, such that classification responses tended to be faster for concepts that were more strongly associated with avoiding danger. Surprisingly, the LN effects were inhibitory; slower classification responses for words that were more strongly associated with nourishment. High LN items tend to be foods, and it seemed possible that these were somewhat difficult for participants to classify as “living”. Indeed, in our experience, participants often require additional instruction in order to include concepts like fruits and vegetables in the “living” category, as “living” tends to more readily be associated with animate things. Thus, it seemed possible that the inhibitory effect of LN was an artefact of the category we chose for classification. To test this possibility and to more fully evaluate the influence of task demands on the effects observed, we conducted two more follow-up analyses on the same set of items for which we analyzed picture and word classification data, above ($n = 197$). In this case, we analyzed standardized lexical decision latencies from the English Lexicon Project (ELP) database (Balota et al., 2007), and unstandardized picture naming latencies from the IPNP (IPNP naming latencies were available unstandardized). Both picture naming and lexical decision involve semantic processing but do not require that participants think about a particular category of meaning. The results of these analyses are presented in Table 4.

As illustrated in Table 4, results for hierarchical regression analyses of IPNP picture naming latencies (using the same predictors as in Table 3) showed significant effects of frequency, imageability, and SD. These results stand in contrast to those for the present classification tasks, where SD did not emerge as a significant predictor. Results for the parallel analysis of the ELP lexical decision latencies for the same items showed significant effects of the lexical variables that tend to be important for LDT (frequency and LD), as well as significant facilitatory effects of ARC and marginally significant effects of BOI and LN. Importantly, the LN effect was facilitatory in this task whereas it was inhibitory in the classification tasks. Thus, under different task demands (those of lexical decision), the same items produced LN effects that were the more typical semantic richness effects, i.e., more is better.

Finally, to further explore the effects of the current predictors in lexical decision and semantic classification tasks, but for a larger set of items ($n = 414$), we conducted hierarchical regression analyses on standardized response latencies from the ELP and, separately, unstandardized semantic classification data from the Pexman et al. (2008) and Yap et al. (2011) studies (semantic

Table 4. *Results of Hierarchical Multiple Regression Analyses for IPNP Picture Naming and ELP Lexical Decision Latencies*

	IPNP picture naming RT						*ELP lexical decision RT*					
Predictor variable	B	SEB	β	sr	ΔR^2	R^2	B	SEB	β	sr	ΔR^2	R^2
Step 1						.22***						.61***
Response	−6.36	29.89	−.02	−.01			−0.08	0.02	−.17**	−.16		
Visual complexity	−0.00	0.00	−.06	−.06			0.00	0.00	−.03	−.03		
Frequency	−199.71	30.79	−.50***	−.42			−0.22	0.02	−.51***	−.42		
Morphemes	32.83	39.35	.07	.05			0.01	0.03	.02	.01		
Length	3.30	19.44	.03	.01			0.03	0.02	.21	.08		
N component	−8.83	19.51	−.04	−.03			0.01	0.02	.06	.04		
LD component	−42.85	34.89	−.21	−.08			0.06	0.03	.25*	.10		
Step 2					.16***	.38***					.03*	.64***
Imageability	−224.49	38.47	−.42***	−.34			−0.03	0.03	−.05	−.04		
BOI	−6.45	14.66	−.04	−.02			−0.02	0.01	−.13†	−.08		
ARC	−250.50	208.51	−.11	−.07			−0.40	0.18	−.16*	−.10		
NF	−4.64	4.46	−.07	−.06			0.00	0.00	.03	.03		
SD	−160.85	62.08	−.18**	−.15			−0.04	0.05	−.04	−.04		
AD	15.41	14.07	.08	.07			−0.01	0.01	−.06	−.05		
LN	6.88	18.17	.03	.01			−0.03	0.02	−.14+	−.08		

Note: $N = 197$. N, neighbourhood; LD, Levenshtein distance; BOI, body-object interaction; ARC, average radius of co-occurrence; NF, number of features; SD, semantic diversity; AD, avoiding death; LN, locating nourishment; RT, response time.
†$p < .08$; *$p < .05$, **$p < .01$; ***$p < .001$.

classification latencies in those studies were not standardized). In that semantic classification task, the decision category was concrete/abstract. Here we used the same predictors as in all of the previous analyses, except that we did not include the variables visual complexity (relevant to picture stimuli, and not available for all of the items in this analysis) and response (since all of the items in this semantic classification task got the same response: "concrete"). Results of these analyses for the ELP lexical decision and Yap et al. semantic classification data are reported in Table 5.

As illustrated in Table 5, and consistent with the findings of Yap et al. (2011) there tended to be more significant semantic richness effects in semantic classification than in lexical decision; imageability, BOI, NF, AD, and LN were all significant and facilitatory predictors of semantic classification latencies. The present results also show that LN is facilitatory in both lexical decision and semantic classification with the concrete/abstract decision category. As such, the trend toward a facilitatory effect of LN that was observed in analyses of ELP lexical decision latencies for the restricted item set, above, was significant here for a larger item set in both lexical decision and semantic classification latencies. Hence, it seems that it is not classification per se that produces the inhibitory effect of LN that was observed in the first analyses, for picture and word classification with the living/nonliving decision category. Rather, it is the particular category involved, and the information that is relevant to the living/nonliving distinction, that seems to generate the inhibitory LN effect.

A comparison of the results of ELP analyses in Tables 4 and 5 (with smaller and larger item sets, respectively), shows that while ARC is a significant predictor of lexical decision latencies in the smaller item set it is not significant in the larger item set. Meanwhile, BOI and LN are not significant in the analysis of lexical decision latencies for the smaller item set but are significant in the analysis of the larger item set. These fluctuations reflect the fact that semantic richness effects vary not just with task demands but also with the particular item sets involved, since item sets vary in their

Table 5. *Results of Hierarchical Multiple Regression Analyses for ELP Lexical Decision Latencies and Yap et al. (2011) Semantic Classification Latencies*

	ELP lexical decision RT (n = 414)						*Yap et al. word classification RT (n = 414)*					
Predictor variable	B	SEB	β	sr	ΔR^2	R^2	B	SEB	β	sr	ΔR^2	R^2
Step 1						.58***						.20***
Frequency	−0.26	0.02	−.51***	−.46			−56.89	6.61	−.43***	−.38		
Morphemes	−0.04	0.02	−.06	−.05			4.08	8.03	.03	.02		
Length	0.04	0.01	.25**	.10			15.06	4.16	.41***	.16		
N component	0.02	0.01	.07	.05			2.83	4.66	.04	.03		
LD component	0.06	0.02	.22**	.09			−28.69	8.07	−.38***	−.16		
Step 2					.03**	.61***					.18***	.38***
Imageability	0.00	0.00	−.04	−.04			−0.38	0.08	−.21***	−.20		
BOI	−0.02	0.01	−.09*	−.07			−15.34	3.21	−.26***	−.19		
ARC	−0.16	0.13	−.06	−.04			28.05	42.78	.04	.03		
NF	−0.00	0.00	−.04	−.04			−3.46	0.93	−.16***	−.15		
SD	−0.06	0.04	−.05	−.05			−14.64	13.26	−.05	−.04		
AD	−0.01	0.01	−.04	−.04			−9.31	3.28	−.14**	−.11		
LN	−0.03	0.01	−.12**	−.11			−11.28	2.99	−.16***	−.15		

Note. N, neighbourhood; LD, Levenshtein distance; BOI, body-object interaction; ARC, average radius of co-occurrence; NF, number of features; SD, semantic diversity; AD, avoiding death; LN, locating nourishment; RT, response time.
$^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$.

distributions of values for different semantic richness dimensions and the relationships between dimensions, among other factors.

GENERAL DISCUSSION

The first goal of the present study was to address a gap in the megastudy literature by publishing normative behavioural data for the semantic classification of IPNP pictures. Numerous studies using words as stimuli have shown that task demands place important and informative constraints on the nature of processing, and as a result, on the role played by various visual, lexical, and semantic variables (e.g., Yap et al., 2012). By providing normative data for a semantic classification task using pictures under a relatively broad decision category (living/nonliving), the current database moves beyond the constraints imposed by picture naming. By shifting the emphasis to meaning, the semantic classification task offers us a more direct examination of any potential differences in how pictures and words make contact with meaning. In the context of a living/nonliving semantic classification task the results provide strong support for the idea that lexical-level variables (e.g., word frequency) play little role in the classification of pictures. This is consistent with the position that, compared to words, pictures have privileged access to semantic memory (Shelton & Caramazza, 1999). The present results also form an intriguing contrast with the results of the present analyses of IPNP naming latencies, which show a strong frequency effect in picture naming, consistent with the previous literature (e.g., Oldfield & Wingfield, 1965). Almeida and colleagues have suggested that frequency effects in picture naming reflect processing *beyond* initial picture processing and semantic identification stages, and are a signal of a separate lexical access stage (Almeida, Knobel, Finkbeiner, & Caramazza, 2007). Classifying pictures as living or nonliving could conceivably be completed without relying upon lexical access, which would account for the lack of significant frequency effects for picture classification in the current task. Since lexical access would be required when processing lexical stimuli, it would also account for the observation of significant frequency effects for words (that refer to the same referents as the pictures) when processed under the same decision criterion.

Additional support for the idea that pictures provide privileged access to meaning (Shelton & Caramazza, 1999) comes from the observation in the present study that semantic richness effects were more prevalent in the processing of pictures than of words, despite the fact that both sets of stimuli have the same referents. A wider array of semantic richness variables made significant contributions to picture processing than to word processing including number of features (NF; McRae et al., 2005), which was only significant for picture classification. In addition, there was evidence that picture classification may be less susceptible to response effects; that is, effects of the side of the decision to which a concept belongs. For word stimuli, living responses were faster than nonliving responses, while for picture stimuli, the living and nonliving response latencies were equivalent.

Semantic classification performance could be characterized using the diffusion model of two-choice reaction time tasks (e.g., Ratcliff, Gomez, & McKoon, 2004; Wagenmakers, van der Maas, & Grasman, 2007). By this framework, noisy information about a stimulus is accumulated over time. The decision is conceptualized as a random walk between two boundaries (here, the living thing boundary and the nonliving thing boundary). As evidence accumulates, progress is made through the decision space until a boundary is crossed and the stimulus is classified. The speed of evidence accumulation is captured by the drift rate, and drift rate varies as a function of the quality of information that can be extracted from the stimulus. For instance, in a lexical decision, the information provided by high frequency words is of higher quality than that of low frequency words (Ratcliff et al., 2004). In the context of semantic classification, higher quality stimuli would be those for which meaning information can more readily be accessed. Since pictures depict semantic information, we could assume that evidence accumulates quickly for pictures (steeper drift rate). For words, however, meaning is not depicted but rather must be derived from letter strings, and it seems that this leads to slower evidence accumulation. The notion that there are respective differences in the quality of information that pictures and words contribute towards a semantic classification decision could provide a framework for the idea of privileged semantic access for pictures.

Less clear are the mechanisms that can account for the difference we observed in decision time for words that reference living versus nonliving things. One explanation assumes that the living thing boundary is reached more quickly than the nonliving thing boundary. This could be because concepts in the living thing category have more shared and fewer distinguishing features (Cree & McRae, 2003), and that where stimulus quality is relatively low, the presence of shared features provides higher quality information by indicating more coherent category membership. That is to say, where category members share more features, the presence of those features is diagnostic of category membership and typicality. Interestingly, in a diffusion model of semantic categorization, Vandekerckhove and colleagues observed that category typicality was the primary determinant of drift rate (Vandekerckhove, Verheyen, & Tuerlinckx, 2010).

One remaining question is why these relationships do not seem to hold when using pictures that depict the same things that the words refer to. Presumably, where stimulus quality is relatively high (e.g., when presenting pictures), individual features are simply depicted. This privileged access may reduce the relative role played by category coherence on decision latencies. Of course, these explanations are entirely post-hoc. Numerous representational differences can be attributed to "living" and to "nonliving" categories (Cree & McRae, 2003) and these differences could conceivably influence other parameters of the diffusion model, such as boundary separation or starting point. It is also important to acknowledge that semantic classification decisions are sensitive to participants' relative focus on the particular exemplar category selected (i.e., "living"). Tousignant and Pexman (2012) presented the same set of items under four sets of instructions: 1. *Is it an entity?*, 2. *Is it an action or an entity?*, 3. *Is it an entity or an action?*, and finally, *4. Is it an action?*. They only observed BOI effects when the decision made explicit reference to the category "entity", observing no BOI effects when the decision was framed in terms of "actions and non-actions". Additional evidence that the decision category shapes semantic processing comes from our analyses of the Yap et al. semantic classification data with word stimuli and the concrete/abstract decision category. In those data, LN had a facilitatory effect on classification latencies, but in our classification task with the living/nonliving decision category LN had an inhibitory effect on classification latencies. Similarly, the exemplar category "living" may modulate the information that participants view as diagnostic of category membership, leading to overall faster responses for positive verifications (i.e., living things). Where stimuli are pictures, privileged access may attenuate any benefit of being able to focus on a criterial set of exemplar features. What is clear from this discussion is that the influence of category on semantic classification latencies and how this interacts with modality (either picture or words) are topics that are worthy of further study.

Regardless of the direction of the effects, the fact that strong AD and LN effects were observed in the present semantic classification tasks indicates that participants access this information even when making quite simple semantic judgments about familiar concepts. This finding provides support for the importance of Amsel et al.'s (2012) sensory and perceptual attributes for semantic processing. These effects are also consistent with the notion that the structure of semantic memory reflects evolutionary pressures (Caramazza & Shelton, 1998). Caramazza and Shelton suggested that semantic organization might reflect adaptation for ready recognition of living things. While this proposal was not the focus of the present work, our results do provide evidence that dimensions related to survival could be important to meaning retrieval (Amsel et al., 2012).

Another goal of the present study was to conduct a multidimensional examination of semantic richness effects, and to further distinguish effects of semantic richness by examining these effects in a picture classification task. While previous studies have found evidence that semantic richness influences picture processing (e.g., Taylor et al., 2012), most investigations have relied on picture naming data (e.g., Bennett et al., 2011), and we are not aware of any studies that have examined the semantic classification of pictures while simultaneously including multiple semantic richness dimensions. Thus, we believe that the present study is the first to comprehensively examine a large number of richness effects in picture processing while holding important correlated factors constant.

One limitation of the present analyses was our lack of attention to dimensions that might capture some of the visual and structural variability that exists across picture stimuli. While we did include the objective visual complexity variable in our analyses, there is evidence that other variables, such as object contours and parts, are important to picture processing (Marques & Raposo, 2011; Marques, Raposo, & Almeida, 2013). In future research, it will be useful to derive these measures for all IPNP stimuli, and to integrate those with the classification norms we have generated here.

Another limitation of the present study was created by the necessity to select a decision category for the semantic classification task. A semantic classification task requires a decision category, and although we chose the broadest one possible for our stimuli, the choice of category shapes processing in the task (as discussed above). While the concrete/abstract decision category is arguably broader than living/nonliving, it is not viable with pictorial stimuli (i.e., how could one develop pictures of abstract things?). As such, it is important to keep in mind the task demands involved in this particular decision category when drawing conclusions from the results.

By utilizing IPNP stimuli, the present study makes an important methodological contribution to the existing IPNP database. At numerous points in our discussion, our interpretation of the results has remained consistent with the idea that naming and classification tasks place different demands on lexical and semantic processes. Specifically, naming places greater emphasis on lexical variables such as word frequency, whereas classification places greater emphasis on semantic variables. By providing classification data for a highly cited set of pictorial stimuli, we can increase the usefulness of this impressive database. We believe that differences in task demands are not only useful when interpreting the relative contribution of lexical and semantic variables within a modality (i.e., pictures or words), but can also be used to inform hypotheses about between-modality contrasts. By contributing a set of classification data for the same stimuli used in the IPNP norms we hope to provide other researchers with a useful resource for leveraging on these unique task demands in their own research.

Supplemental material

Supplemental content is available via the “Supplemental” tab on the article’s online page (http://dx.doi.org/10.1080/17470218.2014.975728)

Original manuscript received 22 January 2014
Accepted revision received 6 August 2014

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