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Symbolic Representations versus Embodiment: A Test Using Semantic Neighbours and Iconicity

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By

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A Test Using Semantic Neighbours and Iconicity

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ABSTRACT

According to the symbolic representation account, word meaning can be sufficiently captured by lexical co-occurrence models (Markman & Dietrich, 2000). In contrast, the embodied cognition account maintains that words are understood via simulated perceptual experiences (Barsalou, 1999). The Symbol Interdependency Hypothesis reconciles these different approaches by proposing that we use symbolic representation most of the time and embodied approaches when deeper processing is required (Louwerse, 2007). To test this hypothesis, a series of experiments manipulated symbolic and embodied factors in shallow and deep processing tasks. Concreteness was also manipulated because it is thought to interact with depth of processing. Overall, results support the Symbol Interdependency Hypothesis. Reaction times were shorter for shallow processing tasks, close semantic neighbours, and iconic word pairs. Moreover, only the embodied factor, and not the symbolic factor, played a role in the deep processing task.

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To Milad: “We must remember that tomorrow comes after the dark. So you will always be in my heart, with unconditional love” (Shakur, 1999).

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CHAPTER 1

REVIEW OF LITERATURE

Theory of Symbolic Representations

Understanding the mechanism through which humans obtain meaning from words has been a challenging pursuit for researchers in the area of psycholinguistics. Over the years, various theories have been proposed to explain how we process and understand words. A review of these theories and the associated empirical findings follows in order to set the stage for a series of experiments that will adjudicate among the theories.

Language comprehension has been explained through symbolic – also referred to as computational, linguistic, or amodal – theories (Markman & Dietrich, 2000). These theories maintain that words, considered to be an external medium, map onto internal symbolic representations of word meaning (Weiskopf, 2010). There is an arbitrary relationship between symbols and what they represent in the real world, and the meaning of a linguistic symbol is understood by how it is related to other linguistic symbols (Meteyard, Cuadrado, Bahrami, & Vigliocco, 2012). Thus, words are understood via rule-governed manipulation of symbols (Weiskopf, 2010). Notably, perceptual inputs are transduced into symbols so that the process of understanding words does not necessitate perceptual experience nor does it recruit the brain's sensorimotor system (Meteyard et al., 2012; Weiskopf, 2010). In other words, sophisticated capacities such as language comprehension are viewed as being different from lower level perceptual processes (Jirak, Menz, Buccino, Borghi, & Binkofski, 2010).

Collins and Quillian (1969) introduced a symbolic, hierarchical model of semantic knowledge in which concepts were represented as nodes, with general concepts (e.g., *animal*) located at the top of the hierarchy, and more specific concepts (e.g., *robin*) located at the bottom.

Collins and Loftus (1975) revised the earlier hierarchical model by introducing a spreading activation model wherein concept activation proceeds or spreads from the target concept to related concepts. Both the hierarchical and the spreading activation model assume localist representation such that each concept corresponds to a single node. On the other hand, in distributed representation models (Hinton, McClelland, & Rumelhart, 1986), concepts are represented as unique patterns of activation among common nodes. Distributed representation models also symbolize concepts through the activation of representations of the individual features of the concept. More recently, researchers from the symbolic orientation have aimed to capture the meaning of words by computationally studying word usage in large bodies of text. Computational analyses have been used to develop lexical co-occurrence models. One such co-occurrence database is the Hyperspace Analogue to Language (HAL; Lund & Burgess, 1996). In HAL, the different contexts in which a word appears in a large body of text are analyzed and meaning is derived from the number of times that certain pairs of words co-occur. Words are represented in the form of vectors in a high-dimensional semantic space. In this semantic space, word vectors with smaller distances between them are deemed to be more similar in meaning than word vectors located farther apart. Consistent with the symbolic view, the meaning of a word is obtained from its relationship to other words as opposed to the referent of the word. For example, the word *flower* is understood because it is related to other words such as *plant*, *garden*, and *nature*. These latter words are considered to be the semantic neighbours of *flower*.

Other lexical co-occurrence databases include Latent Semantic Analysis (LSA; Landauer & Dumais, 1997), Bound Encoding of the Aggregate Language Environment (BEAGLE; Jones & Mewhort, 2007), Latent Dirichlet Allocation (LDA; Blei, Ng, & Jordan, 2003), Topic Model (Griffiths, Steyvers, & Tenenbaum, 2007), and High Dimensional Explorer (HiDEx; Shaoul &

Westbury, 2006). Although there are subtle differences among databases, the overarching commonality is that word meaning is derived through an analysis of the words that a target word associates with at either the sentence level or in some larger context.

Co-occurrence in both HAL and LSA is influenced by word frequency. This is unfortunate because it makes the metrics derived from those databases less useful in psycholinguistic experiments because frequency is a confound. Durda and Buchanan (2008) were able to remove the influence of word frequency and introduced an adaptation of HAL called WINDSORS (Windsor Improved Norms of Distance and Similarity of Representations of Semantics).

Research on Symbolic Representations

Lexical co-occurrence models produce results that correlate with human performance on various psycholinguistic tasks. Lund and Burgess (1996) used HAL to demonstrate that distances between vectors could explain human reaction times on a single-word priming experiment. Burgess and Lund (1997) also used HAL to demonstrate that vectors could distinguish between semantic and grammatical concepts. Burgess and Conley (1998) showed that HAL could distinguish between proper names, famous proper names, and common nouns. Research with patients has revealed that semantic density, as determined by HAL, plays a role in the type of semantic errors produced by those with deep dyslexia (Buchanan, Burgess, & Lund, 1996). LSA was shown to both contain spatial knowledge and have the ability to temporally order units of time, days of the week, and months of the year (Louwerse, Cai, Hu, Ventura, & Jeuniaux, 2006). LSA performed analogously to non-native English speakers on a synonym selection task of the Test of English as a Foreign Language (Landauer & Dumais, 1997). LSA was able to pick up on changes in content within a text and predict the effect of text coherence on comprehension

(Foltz, Kintsch, & Landauer, 1998). LSA was also able to mimic experimental findings concerning human metaphor comprehension (Kintsch, 2000). Louwerse and Connell (2011) demonstrated that word co-occurrences could be used to categorize words into their perceptual modalities. Louwerse (2008) found that iconic word pairs (e.g., *attic-basement*) were more frequent than reverse-iconic word pairs (e.g., *basement-attic*), accounting for shorter human reaction times during semantic judgments of iconic word pairs compared to reverse-iconic word pairs. Durda et al. (2009) showed that co-occurrence rankings included featural information such that there could be a reliable mapping from co-occurrence vectors to featural information.

To summarize, symbolic views of word meaning understand meaning as being derived from the linguistic context in which the word occurs. A number of databases have been introduced over the years and they differ with respect to how the linguistic units are assumed to be represented but in all cases the representations are, in some way, a reflection of the linguistic context.

Theory of Embodiment

Symbolic theories can be contrasted with embodied theories, also known as perceptual or modal theories. Historically, this debate between as conventionalism and naturalism traces back to Plato's *Cratylus* (Fowler, 1921). Embodied theories maintain that language comprehension is grounded in sensorimotor interactions with the environment. In contrast to the symbolic view, real world perceptual experiences as opposed to symbolic representation form the basis of understanding words. When words are encountered, a mental simulation occurs and that indirect experience aids comprehension. Glenberg and Robertson (1999) proposed the Indexical Hypothesis which states that sentences are understood by simulating the actions that underlie them. Unlike symbolic theories, which separate language comprehension and lower level perceptual processes, embodiment theories postulate that both are intertwined. Barsalou (1999), in his Perceptual Symbols Systems theory, states that during direct perceptual experience, sensorimotor regions of the brain are activated in a bottom-up fashion. Perceptual symbols, or representations of the experience, then become encoded in the brain. Later, sensorimotor regions of the brain are partially reactivated in a top-down manner in the absence of direct perceptual experience. Returning to the *flower* example from above, the embodied theory would suggest that we understand this word not only by its relationship to other words, but through our experience of touching and smelling flowers, whereas from a co-occurrence perspective, one need not have actual experience with a flower to understand that it may have a pleasant odour.

Research on Embodiment

Numerous studies have provided support for the embodied view of language. At the level of individual words, researchers have found a Body-Object Interaction (BOI) Effect (Siakaluk, Pexman, Aguilera, Owen, & Sears, 2008). Words with a high BOI, that is, words representing entities with which the body can physically interact with ease, lead to shorter reaction times on lexical and phonological decision tasks when compared to words with a low BOI.

At the level of sentences, Glenberg and Kaschak (2002) found an interaction between performing an action and sentence comprehension; they called this interaction the Action-Sentence Compatibility Effect (ACE). In their study, participants were asked to judge the sensibility of sentences describing both the transfer of concrete objects (e.g., *Andy delivered the pizza to you; you delivered the pizza to Andy*) and the transfer of abstract information (e.g., *Liz gave you the news; you gave Liz the news*). Participants responded by either pressing a button close to them, or far away from them. Results indicated that for both concrete and abstract sentences, sensibility judgments were faster when the action in the sentence matched the action required for responding, that is, if participants were judging the sensibility of a sentence that had to do with giving away something, then their judgment was faster if the button that they were required to press in order to respond was located far away from them. In a follow-up study, Glenberg et al. (2008) found activation of the corticospinal motor pathways to the hand muscles when reading both the concrete and abstract transfer sentences. Other studies have demonstrated the ACE when a physical movement such as turning a knob in a clockwise direction interferes with participants' understanding of sentences describing an opposite movement (e.g., *Eric turned down the volume*) (Zwaan & Taylor, 2006). The ACE has also been studied in the context of conceptual metaphors where orientational literal sentences (e.g., *she climbed up the hill*), metaphors (e.g., *she climbed up in the company*), and abstract sentences with similar meaning to the metaphors (e.g., *she succeeded in the company*) all elicit faster hand motion responses when the direction implied in the sentence matches the direction of hand movement (Santana & de Vega, 2011). Moreover, asking participants to move their hands in an upward direction while reading sentences compatible with 'more' is easier than asking participants to move their hands downwards (Guan, Meng, Yao, & Glenberg, 2013). Remarkably, the ACE is not limited to actual physical movement, but also occurs with imagined physical movement (Wilson & Gibbs, 2007).

In addition to the ACE, iconicity findings have been used to argue for the embodied view of language. Iconicity refers to whether the relative positions of words on a computer screen match the relative positions of their referents (Zwaan & Yaxley, 2003a). In general, language comprehension is facilitated when words are spatially presented in a manner that reflects their meaning. Setic and Domijan (2007) asked participants to judge whether the word displayed on a computer screen was an animal that either could or could not fly. Critically, the word was displayed in either the upper or lower part of the screen relative to a fixation point. Reaction times for names of flying animals were shorter when they were displayed in the upper part and names of non-flying animals were judged faster when they were displayed in the lower part. These results were replicated when the words for animals were replaced with non-living things typically associated with either upper or lower space. Similarly, Estes, Verges, and Barsalou (2008) found that words representing objects associated with high or low space stalled subsequent identification of unrelated visual targets presented in the object's typical location. Zwaan and Yaxley (2003b) demonstrated the iconicity effect with word pairs. Participants saw word pairs either in an iconic relationship (e.g., the word *attic* presented above the word *basement*) or in a reverse-iconic relationship (e.g., the word *basement* presented above the word *attic*) and were asked to indicate whether the two words were semantically related. Results revealed that reaction times were shorter when word pairs were displayed in an iconic relationship compared to when word pairs were displayed in a reverse-iconic relationship. This iconicity effect disappeared when the word pairs were presented horizontally. Zwaan and Yaxley (2003a) also showed that whether the iconicity effect appeared or disappeared depended on which visual field the word pairs were presented in, thus implicating hemispheric differences. Dunn, Kamide, and Scheepers (2014) used an auditory lexical decision task to demonstrate the facilitation of saccades to spatially congruent locations. For example, after hearing the word *moon* participants were quicker to look up than down. Like the ACE, the iconicity effect occurs with both concrete and abstract stimuli. Research has shown that when participants are asked to make evaluations of words presented on a computer screen, evaluations of positive words are faster when the words are displayed at the top of the screen, whereas evaluations of negative words are faster when the words are displayed at the bottom of the screen. Moreover, positive evaluations tend to activate higher areas of the visual field and negative evaluations activate lower areas of the visual field (Meier & Robinson, 2004). An ERP experiment demonstrated that the processing of affective words produced spatial information which subsequently influenced performance on a spatial cue detection task (Xie, Wang, & Chang, 2014).

The embodied view of language has also gained support from neuroimaging and patient investigations. Functional magnetic resonance imaging (fMRI) has been used to show that when participants listen to, read, or generate action-related words, the same regions of the brain are activated as if they were actually performing the action (Esopenko et al., 2012; Hauk, Johnsrude, & Pulvermuller, 2004; Tettamanti et al., 2005). Moreover, brain regions activated during the observation of hand, foot, and mouth actions are also activated when participants read sentences associated with these words (Aziz-Zadeh, Wilson, Rizzolatti, & Iacoboni, 2006). Boulenger, Hauk, and Pulvermuller (2009) also used fMRI and found that reading sentences – both literal and idiomatic – containing arm and leg related action words activated areas of the brain responsible for motor functioning. Notably, these studies have established that neural activation occurs somatotopically. Patient studies have provided support for embodiment by showing that an intact motor system is necessary for verb processing. Researchers have found selective impairments of verb processing in patients with motor neuron disease (Bak, O'Donovan, Xuereb, Boniface, & Hodges, 2001). Other researchers have failed to find a priming effect of verbs for patients with Parkinson disease off of their medication relative to Parkinson disease patients on medication and controls (Boulenger et al., 2008).

The Symbol Interdependency Hypothesis

While symbolic and embodied theories tend to be viewed as being at odds with one another, historical and recent attempts to reconcile these theories of language have been documented. Paivio's Dual Coding Theory (1986) advocated for separate cognitive subsystems for verbal and nonverbal information. Paivio (1986) described different types of processing including representational (direct activation of the verbal or non-verbal system), referential (activation of the verbal system by the non-verbal system or vice versa), and associative (activation of representations within the same verbal or nonverbal system). According to the Dual Coding Theory, depending on task requirements, one or multiple types of processing would be activated. More recently, Louwerse (2007) proposed the Symbol Interdependency Hypothesis, which argues that the linguistic system serves as a shortcut to the perceptual system. Symbols are grounded in embodied experiences; however, language comprehension for the most part uses symbolic representation and the embodied representations of words do not necessarily need to be accessed or fully activated. While embodied information enables a thorough understanding of words, symbolic information is adequate for providing most meaning. In addition to the Dual Coding Theory and the Symbol Interdependency Hypothesis, the Language and Situated Simulation theory (LASS; Barsalou, Santos, Simmons, & Wilson, 2008) proposes that language (symbolic factors) and situated simulation (embodied factors) both play a role in conceptual processing. The LASS theory incorporates a temporal component such that both symbolic and embodied factors are activated immediately, but symbolic activation reaches its peak earlier than embodied activation. Parallel to the claims of the Symbol Interdependency Hypothesis, symbolic factors are believed to be less precise than embodied factors, providing quick approximate representations, which the perceptual system then refines. The notion that symbolic factors tend to dominate early on in a language comprehension task has been linked to depth of processing. When symbolic processing is sufficient for obtaining meaning, the embodied system is not recruited. Therefore, symbolic factors are presumed to be most important for shallow tasks, with embodied factors coming into play for tasks involving deeper processing.

Indeed, Louwerse and Jeuniaux (2010) found that conceptual processing was both symbolic and embodied, with the relative influence of symbolic and embodied factors depending on depth of processing. In their study, participants were asked to make speeded judgments about semantic relatedness or iconicity for word pairs or pictures. The symbolic factor was operationalized as the degree to which stimuli were presented in the order in which they typically occur in language, and the embodied factor was operationalized as the extent to which stimulus pairs were presented in the spatial relationships in which they typically occur. An analysis of reaction times and error rates revealed that the symbolic factor dominated in the semantic relatedness task for word pairs (shallow processing) and the embodied factor dominated in the iconic judgment task for pictures (deep processing). Similarly, Hutchinson and Louwerse (2012) found that both symbolic and embodied factors were involved in conceptual metaphor comprehension, with the symbolic factor most salient for positive-negative word pairs presented horizontally, and the embodied factor most salient for positive-negative word pairs presented vertically.

The proposition of symbolic activation reaching an earlier peak has also received empirical support. In a modality-shifting experiment, Louwerse and Connell (2011) found that the effect of symbolic factors on reaction time preceded the effect of embodied factors. Fast responses were best explained by symbolic factors and slow responses by embodied factors, such that language statistics were used to make quick decisions and perceptual simulations were engaged for slower decisions. An fMRI experiment demonstrated that activations early on in a conceptual processing task matched activations that had occurred during a word association task, while activations late in conceptual processing matched activations that had occurred in a situation generation task (Simmons, Hamann, Harenski, Hu, & Barsalou, 2008). Similarly, an

EEG experiment revealed that while conceptual processing involved neural activation associated with both symbolic and embodied processing, effect sizes for symbolic areas were larger earlier on in a trial and effect sizes for perceptual areas were larger towards the end of a trial (Louwerse & Hutchinson, 2012).

The Present Study: Research Objectives

Louwerse and his colleagues have argued convincingly that symbolic and embodied theories are compatible and there is value in using both to address the question of how we obtain meaning from words. Whether the symbolic theory or the embodied theory has more explanatory power appears to depend on the depth of processing required for a particular task. Depth of processing, as mentioned here, refers to the psycholinguistic understanding of tasks measuring orthographic processes being regarded as shallow and tasks measuring semantics being regarded as deep. It is to be noted that the shallow versus deep terminology used in psycholinguistic research differs from that used in memory research. Symbolic factors such as lexical co-occurrence help explain performance on shallow tasks, and embodied factors such as iconicity help explain performance when deeper processing is involved. Research in support of the symbolic view has demonstrated that symbolic factors play a role in the processing of both concrete and abstract stimuli. Similarly, research in support of the embodied view has demonstrated that embodied factors play a role in the processing of both concrete and abstract stimuli. However, to my knowledge, no single study to date has compared the relative influence of symbolic and embodied factors on the processing of both concrete and abstract stimuli. Concrete words are typically processed faster than abstract words, i.e. the ‘concreteness effect’ (Paivio, 1991). The concreteness effect has been explained by Paivio’s (1971) Dual Coding Theory such that concrete words activate both the verbal and sensory systems, whereas abstract words only activate the verbal system. Therefore, concrete and abstract stimuli may differ with respect to depth of processing. I propose a series of experiments with the following major objective: to delineate the conditions (i.e. shallow or deep processing) under which symbolic and embodied factors are most salient for concrete versus abstract stimuli. Based on the Symbol Interdependency Hypothesis, it is predicted that the symbolic factor will be important for the shallow processing task and the embodied factor will be important for the deep processing task.

CHAPTER 2

DESIGN AND METHODOLOGY

Experiment 1

The purpose of Experiment 1 was to examine the role of symbolic and embodied factors in the shallow and deep processing of concrete and abstract stimuli.

Research Design

A 2x2x2x2 repeated measures within-subjects design, with semantic neighbours (close vs. distant), iconicity (iconic vs. reverse-iconic), task (shallow vs. deep), and concreteness (concrete vs. abstract) as within-subjects factors, was used.

Participants

34 University of Windsor undergraduate psychology students participated for partial course credit. This number exceeded the 13 participants suggested by a power analysis using a large effect size (partial $\eta^2 = .14$) and an alpha level of .05. All participants were at least 18 years of age, native English speakers, and had normal or corrected-to-normal vision.

Measures

The symbolic factor was operationalized through semantic neighbours using WINDSORS (Durda & Buchanan, 2008), a lexical co-occurrence database that controls for word frequency effects. Close semantic neighbours were operationalized as word pairs being less than 50 neighbours away from one another, and distant semantic neighbours were operationalized as word pairs being greater than 200 neighbours away from one another. The embodied factor was operationalized through iconicity, that is, whether word pairs were presented in the spatial relationships in which they typically occur. Shallow processing was operationalized as the semantic task where participants were asked to make judgments about the relatedness of word pairs. It should be noted that considering other common tasks used in psycholinguistic research such as the lexical decision task, the shallow task used in this study was relatively deep. Deep processing was operationalized as the iconic task where participants were asked to make judgments about the iconicity of word pairs. Concreteness was operationalized as word pairs representing physical objects, while abstractness was operationalized as word pairs representing intangible relationships.

The stimulus set was developed using WINDSORS (Durda & Buchanan, 2008). The stimuli were piloted on 14 University of Windsor graduate students and word pairs producing an error rate of greater than 25% were replaced. An ANOVA was conducted to ensure that the number of letters, number of syllables, orthographic frequencies (Durda & Buchanan, 2008) and age of acquisition (Kuperman, Stadthagen-Gonzalez, Brysbaert, 2012) for the word pairs showed no significant differences across conditions. Number of letters and syllables was the total number of letters and syllables in the word pair. Orthographic frequency was the mean orthographic frequency of the word pair. Finally, age of acquisition was the larger age associated with the word pair. For example, for the word pair *flower-vase*, the word *flower* is acquired at age 3.11 and the word *vase* is acquired at age 7.89, and thus the age of acquisition for the entire word pair was entered as 7.89. The means and standard deviations for these stimulus characteristics per condition are displayed in Table 1 below. Half of the target word pairs were close semantic neighbours and half were distant semantic neighbours. Moreover, half of the close and distant semantic neighbours were presented in an iconic relationship and half were presented in a reverse-iconic relationship. The stimulus set for the iconic task contained 20 concrete word pairs and 20 abstract word pairs. The stimulus set for the semantic task contained 20 concrete word pairs, 20 abstract word pairs, and 40 filler word pairs with no semantic relationship as determined by WINDSORS (Durda & Buchanan, 2008). The latter were added to the semantic task because all target word pairs were semantically related and without unrelated fillers the task would not have made sense. The 40 target word pairs in each task were randomly presented from a pool of 80 target word pairs so that the same target word pairs would not always be presented for the same task. The full stimulus set is presented in Appendix A.

Table 1

Means and Standard Deviations for Word Length, Syllables, Frequency, and Age of Acquisition (AoA) Per Condition in the Experiment 1 Stimulus Set

Condition	Word Length	Syllables	Frequency	AoA
Concrete				
Close-Iconic	11.8(2.25)	3.4(0.52)	28.38(34.99)	6.66(1.47)
Close-Reverse Iconic	13.9(2.85)	3.6(1.17)	32.56(36.74)	6.53(1.8)
Distant-Iconic	10.1(2.23)	2.8(0.92)	15.41(11.08)	7.22(2.28)
Distant-Reverse Iconic	11.3(1.64)	3(0.67)	54.29(113.6)	6.6(2.58)
Abstract				
Close-Iconic	11.4(2.76)	3.6(1.26)	113.68(188.7)	6.77(2.09)
Close-Reverse Iconic	11.1(3.7)	2.9(1.6)	318.07(468.61)	6.7(2.74)
Distant-Iconic	12.4(3.31)	4.2(1.62)	48.23(58.8)	8.37(1.52)
Distant-Reverse Iconic	12.3(4.42)	3.9(1.73)	302.4(556.51)	6.97(2.91)

Procedure

The experiment was run on a PC using the Windows XP operating system. The software program used to run the experiment was DirectRT (Jarvis, 2012), which enables the recording of response times with a timing resolution of 1 millisecond. Word pairs were presented in the middle of a black background with the first letter capitalized, size 24, bold-faced font with turquoise coloured letters. Each word pair appeared one at a time in random order, and the word pair remained on the screen until the participant gave their response by pressing either the “z” key or the “/” key. These response keys were covered with “Yes” and “No” stickers to simplify responding and they were counterbalanced across participants to avoid any confound of dominant hand responding. All participants completed both the semantic task and the iconic task and task order was counterbalanced across participants. Participants were provided with the following instructions for the semantic task:

> Please indicate as soon as possible whether the pair of words are related in meaning or not by pressing “Yes” = related and “No” = unrelated. Sometimes you will see opposites such as plus and minus and these are considered to be related. When word pairs are unrelated, they will not bear any obvious relationship to one another. You should not have to think of ways to relate the words. Your judgments should be intuitive. Since this is a reaction time experiment, we want you to work as fast as you can – but not at the expense of accuracy. You should use both index fingers to make your responses.

Participants were provided with the following instructions for the iconic task:

> Please indicate as soon as possible whether the spatial configuration of the pair of words is correct or incorrect by pressing “Yes” = correct and “No” = incorrect.
>
> Example #1:
>
> > Pot
> >
> > Plant
>
> The answer is incorrect.
>
> Example #2:
>
> > Doctor
> >
> > Patient
>
> The answer is correct.
>
> What we mean by spatial configuration is how you would expect to see the objects in real life. For example, when you think of a pot and a plant, you would expect to see the pot on the bottom, and the plant on the top. Because this example has the word pot on the top

and plant on the bottom, it is incorrect. In the second example, we are not talking about physical objects anymore, but about power. Doctors are typically considered to have more power compared to their patients. Because this example shows the word doctor on the top and patient on the bottom, it is correct. We are not asking you to make moral judgments, but how you would stereotypically expect it. We also expect happy concepts to be at the top and sad concepts to be at the bottom, so keep these relationships in mind when making your judgments. Since this is a reaction time experiment, we want you to work as fast as you can – but not at the expense of accuracy. You should use both index fingers to make your responses.

Data Cleaning Procedures

All incorrect responses were removed, resulting in the removal of 255 observations, or 9.37% of the data. Reaction times greater than 7000 milliseconds were regarded as invalid responses and 9 such reaction times (0.36% of the data) were removed prior to the outlier analysis to avoid inflating individual condition means. Within each of the conditions, reaction times greater or less than 2.5 standard deviations away from the mean were identified as outliers, resulting in the removal of 69 (32 from the semantic task and 37 from the iconic task) observations, or 2.81% of the remaining data. In total, 333 observations, or 12.24% of the original data set, were removed during data cleaning procedures. Participant mean response times, standard deviations and error rates per condition for the final data set are displayed in Table 2 for the semantic task and in Table 3 for the iconic task.

Table 2

Mean Reaction Times (RTs) (with Standard Deviations) and Average Error Rates Per Condition in the Experiment 1 Subject Analysis for the Semantic Task

Condition	Mean RT (msec)	Average Error Rate (%)
Concrete		
Close-Iconic	1193.56(365.76)	5.49
Close-Reverse Iconic	1189.6 (458.41)	7.06
Distant-Iconic	1254.76 (368.17)	7.45
Distant-Reverse Iconic	1221.82 (384.72)	11.37
Abstract		
Close-Iconic	940.39 (183.85)	1.57
Close-Reverse Iconic	1071.02 (363.91)	1.18
Distant-Iconic	1098.48 (306.73)	1.96
Distant-Reverse Iconic	1089.06 (269.74)	8.63

Table 3

Mean Reaction Times (RTs) (with Standard Deviations) and Average Error Rates Per Condition in the Experiment 1 Subject Analysis for the Iconic Task

Condition	Mean RT (msec)	Average Error Rate (%)
Concrete		
Close-Iconic	2029.14 (565.09)	6.27
Close-Reverse Iconic	2380.15 (814.75)	10.59
Distant-Iconic	2367.87 (717.06)	10.98
Distant-Reverse Iconic	2282.48 (651.10)	8.24
Abstract		
Close-Iconic	1439.43 (452.25)	0.78
Close-Reverse Iconic	1806.87 (560.89)	6.67
Distant-Iconic	1570.67 (356.15)	3.14
Distant-Reverse Iconic	1817.44 (556.12)	8.24

Results

Within each condition, correct responses were averaged and analyzed in a 2x2x2x2 repeated measures analysis of variance (ANOVA). As is standard for psycholinguistic research, both subject (*F*1) and item (*F*2) analyses will be reported. The assumptions of this statistical model were tested. The assumption of no significant outliers was met by removing any significant outliers prior to the statistical analyses. The Shapiro-Wilk test revealed that the assumption of normality was violated for 11 out of 16 cells. Given two levels of the within-subjects factors, the assumption of sphericity was met.

There was a main effect for task, with participants performing faster on the semantic task compared to the iconic task [$F_1(1, 33) = 164.46$, $p < .001$, partial $\eta^2 = .83$; $F_2(1, 9) = 1151.65$, $p < .001$, partial $\eta^2 = .99$]. There was a main effect for concreteness, with participants responding faster to abstract stimuli compared to concrete stimuli [$F_1(1, 33) = 174.96$, $p < .001$, partial $\eta^2 = .84$; $F_2(1, 9) = 73.09$, $p < .001$, partial $\eta^2 = .89$]. There was a main effect for iconicity, with participants responding faster to stimuli displayed in an iconic relationship versus a reverse-iconic relationship [$F_1(1, 33) = 11.54$, $p < .05$, partial $\eta^2 = .26$; $F_2(1, 9) = 13.83$, $p < .05$, partial $\eta^2 = .61$]. There was also a main effect for semantic neighbours, with participants responding faster to close semantic neighbours versus distant semantic neighbours [$F_1(1, 33) = 7.95$, $p < .05$, partial $\eta^2 = .19$; $F_2(1, 9) = 14.19$, $p < .05$, partial $\eta^2 = .61$]. For task and concreteness [$F_1(1, 33) = 28.46$, $p < .001$, partial $\eta^2 = .46$; $F_2(1, 9) = 55.26$, $p < .001$, partial $\eta^2 = .86$], follow-up t-tests indicated that in both the semantic task [$t_1(33) = -4.84$, $p < .001$] and in the iconic task [$t_1(33) = -9.64$, $p < .001$], abstract stimuli elicited shorter reaction times compared to concrete stimuli. There was an interaction between task and iconicity [$F_1(1, 33) = 11.82$, $p < .05$, partial $\eta^2 = .26$; $F_2(1, 9) = 15.02$, $p < .05$, partial $\eta^2 = .63$], with follow-up t-tests indicating that in the iconic task, iconic word pairs elicited shorter reaction times compared to reverse-iconic word pairs [$t_1(33) = -3.67$, $p < .05$], but in the semantic task, iconic word pairs did not elicit shorter reaction times compared to reverse-iconic word pairs [$t_1(33) = -0.87$, p=0.392]. There was no significant interaction between task and semantic neighbours. The results of the subject analysis are graphically displayed in Figure 1 below.

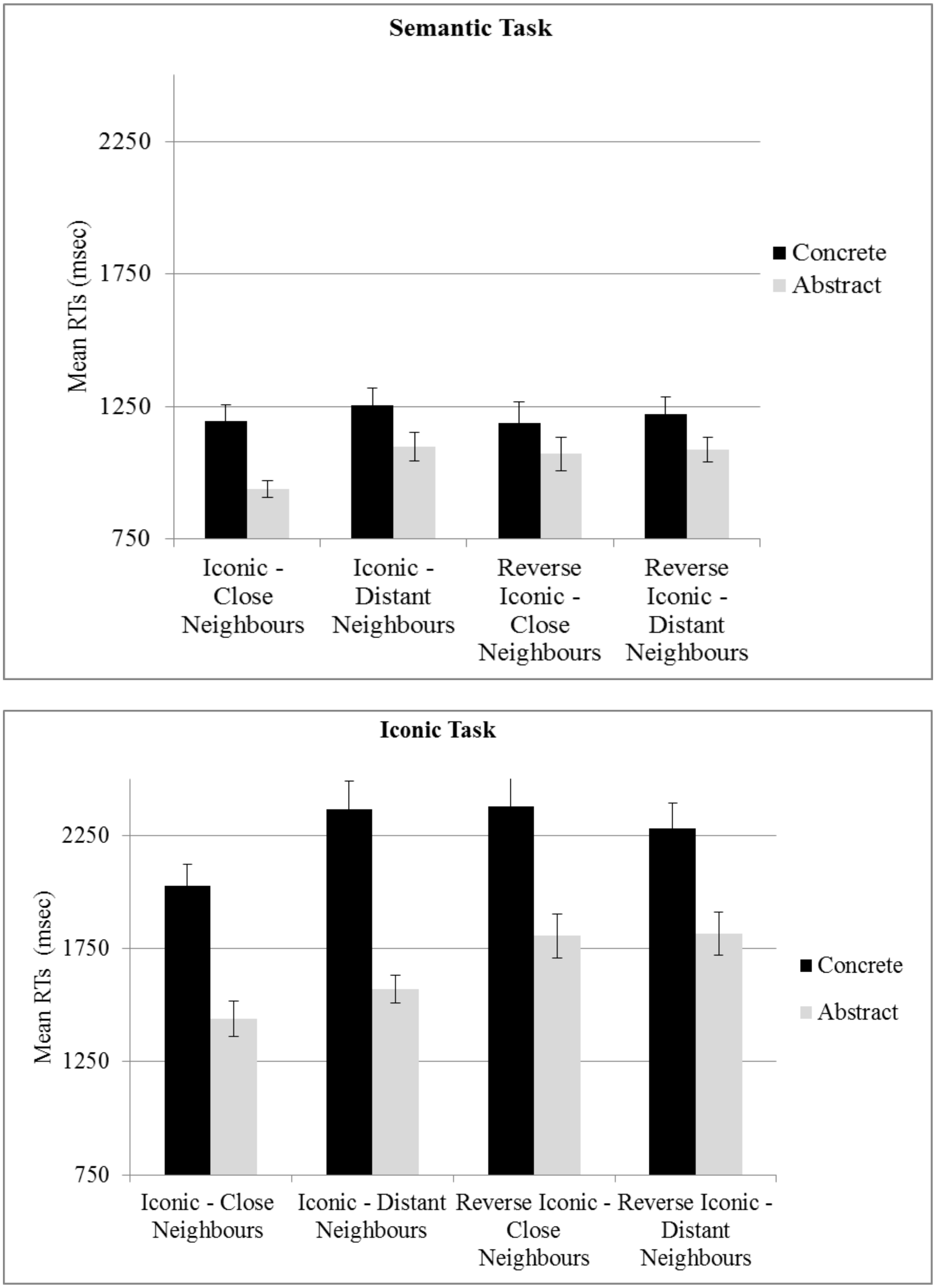

Figure 1. Mean RTs in Experiment 1 as a function of neighbours and iconicity in the subject analysis.

Discussion

The results of Experiment 1 provide support for the Symbol Interdependency Hypothesis. Reaction times were shorter for the shallow processing task compared to the deep processing task, and the embodied factor only played a role in the deep processing task. Interestingly, abstract stimuli always led to shorter reaction times compared to concrete stimuli. While there was no significant difference between tasks based on semantic neighbours, it may be that the semantic relatedness task was not shallow enough. A limitation of this experiment was that given the number of conditions and the within-subjects design, only 5 stimulus pairs were presented in each condition. It would be worthwhile to replicate the results of Experiment 1 using a mixed within-between-subjects design where participants either complete the shallow task or the deep task, but not both. This would enable the presentation of 10 stimulus pairs per condition.

Experiment 2

The purpose of Experiment 2 was to replicate the results of Experiment 1 using a mixed within-between-subjects design.

Research Design

A mixed within-between-subjects design, with semantic neighbours (close vs. distant), iconicity (iconic vs. reverse-iconic), and concreteness (concrete vs. abstract) as within-subjects factors, and task (shallow vs. deep) as the between-subjects factor, was used.

Participants

90 (n=45 for semantic task and n=45 for iconic task) University of Windsor undergraduate psychology students participated for partial course credit. This number exceeded the 20 participants suggested by a power analysis using a large effect size (partial $\eta^2 = .14$) and

an alpha level of .05. All participants were at least 18 years of age, native English speakers, and had normal or corrected-to-normal vision.

Measures

The same concrete and abstract target word pairs that were used in Experiment 1 were used in Experiment 2. Given that all target word pairs were semantically related, an additional 40 new filler word pairs were added to the semantic task so that there would be an equal number of target and filler word pairs, and thus an equal number of 'Yes' and 'No' responses.

Procedure

Half of the participants were randomly assigned to the semantic task and half were randomly assigned to the iconic task. Aside from this difference the procedure for these tasks, including participant instructions, was identical to Experiment 1.

Data Cleaning Procedures

A minimum accuracy rate of 70% was used for both participants and words. This resulted in the removal of 1 participant as well as responses from 1 Distant-Iconic-Concrete word pair and 1 Distant-Reverse Iconic-Concrete word pair. The analyses were conducted on the remaining data.

All incorrect responses were removed, resulting in the removal of 684 observations, or 9.71% of the data. Reaction times greater than 9000 milliseconds were regarded as invalid responses and 3 such reaction times (0.047% of the data) were removed prior to the outlier analysis to avoid inflating individual condition means. Within each of the conditions, reaction times greater than 2.5 standard deviations from the mean were identified as outliers, resulting in the removal of 198 (89 from the semantic task and 109 from the iconic task) observations, or 3.12% of the remaining data. In total, 885 observations, or 12.75% of the data set, were removed during data cleaning procedures. Participant mean response times, standard deviations and error rates per condition for the final data set are displayed in Table 4 for the semantic task, and in Table 5 for the iconic task.

Table 4

Mean Reaction Times (RTs) (with Standard Deviations) and Average Error Rates Per Condition in the Experiment 2 Subject Analysis for the Semantic Task

Condition	Mean RT (msec)	Average Error Rate (%)
Concrete		
Close-Iconic	1139.34(208.85)	9.17
Close-Reverse Iconic	1155.23(225.29)	5.39
Distant-Iconic	1199.44(235.84)	15.01
Distant-Reverse Iconic	1236.87(283.10)	13.64
Abstract		
Close-Iconic	974.73(158.26)	4.78
Close-Reverse Iconic	1000.19(166.95)	1.61
Distant-Iconic	1102.05(215.79)	2.76
Distant-Reverse Iconic	1122.37(215.23)	7.31

Table 5

Mean Reaction Times (RTs) (with Standard Deviations) and Average Error Rates Per Condition in the Experiment 2 Subject Analysis for the Iconic Task

Condition	Mean RT (msec)	Average Error Rate (%)
Concrete		
Close-Iconic	2003.75(485.61)	6.89
Close-Reverse Iconic	2293.15(516.02)	15.73
Distant-Iconic	2181.39(569.23)	12.34
Distant-Reverse Iconic	2233.02(542.04)	14.29
Abstract		
Close-Iconic	1335.43(344.97)	3.06
Close-Reverse Iconic	1642.19(385.40)	10.19
Distant-Iconic	1561.22(421.02)	2.59
Distant-Reverse Iconic	1736.6(482.87)	8.73

Results

Within each condition, correct responses were averaged and analyzed in a mixed analysis of variance (ANOVA). As is standard for psycholinguistic research, both subject (*F*1) and item

(*F*2) analyses will be reported. The assumptions of this statistical model were tested. The assumption of no significant outliers was met by removing any significant outliers prior to the statistical analyses. The Shapiro-Wilk test revealed that the assumption of normality was violated for 4 out of 16 cells. However, skewness values did not exceed acceptable ranges for any of the cells and only one kurtosis value exceeded the acceptable range. Thus, the assumption of normality can be supported. Given two levels of the within-subjects factors, the assumption of sphericity was also met. Levene's test revealed that the assumption of homogeneity of variances was not met.

There was a main effect for task, with participants performing faster on the semantic task compared to the iconic task [$F_1(1, 87) = 119.99$, $p < .001$, partial $\eta^2 = .58$; $F_2(1, 16) = 416.76$, $p < .001$, partial $\eta^2 = .96$]. There was a main effect for concreteness, with participants responding faster to abstract stimuli compared to concrete stimuli [$F_1(1, 87) = 350.16$, $p < .001$, partial $\eta^2 = .80$; $F_2(1, 16) = 213.36$, $p < .001$, partial $\eta^2 = .93$]. There was a main effect for iconicity, with participants responding faster to stimuli displayed in an iconic relationship versus a reverse-iconic relationship [$F_1(1, 87) = 67.64$, $p < .001$, partial $\eta^2 = .44$; $F_2(1, 16) = 12.68$, $p < .05$, partial $\eta^2 = .44$]. There was also a main effect for semantic neighbours, with participants responding faster to close semantic neighbours versus distant semantic neighbours [$F_1(1, 87) = 61.84$, $p < .001$, partial $\eta^2 = .42$; $F_2(1, 16) = 14.51$, $p < .05$, partial $\eta^2 = .48$]. For task and concreteness [$F_1(1, 87) = 144.21$, $p < .001$, partial $\eta^2 = .62$; $F_2(1, 16) = 82.13$, $p < .001$, partial $\eta^2 = .84$], follow-up t-tests indicated that in both the semantic task [$t_1(44) = 10.19$, $p < .001$] and in the iconic task [$t_1(43) = 16.11$, $p < .001$], abstract stimuli elicited shorter reaction times compared to concrete stimuli. For task and iconicity [$F_1(1, 87) = 41.69$, $p < .001$, partial $\eta^2 = .32$; $F_2(1, 16) = 8.87$, $p < .05$, partial $\eta^2 = .36$], follow-up t-tests for the subject analysis indicated that in both the semantic task [$t_1(44) = -2.46$, $p < .05$] and in the iconic task [$t_1(43) = -7.79$, $p < .001$], iconic word pairs elicited shorter reaction times compared to reverse-iconic word pairs. However, follow-up t-tests for the item analysis indicated that in the iconic task, iconic word pairs elicited shorter reaction times compared to reverse-iconic word pairs [$t_2(8) = -3.58$, $p < .05$], but in the semantic task, iconic word pairs did not elicit shorter reaction times compared to reverse-iconic word pairs [$t_2(8) = -.71$, $p = .5$]. There was no significant interaction between task and semantic neighbours. The results of the subject analysis are graphically displayed in Figure 2 below.

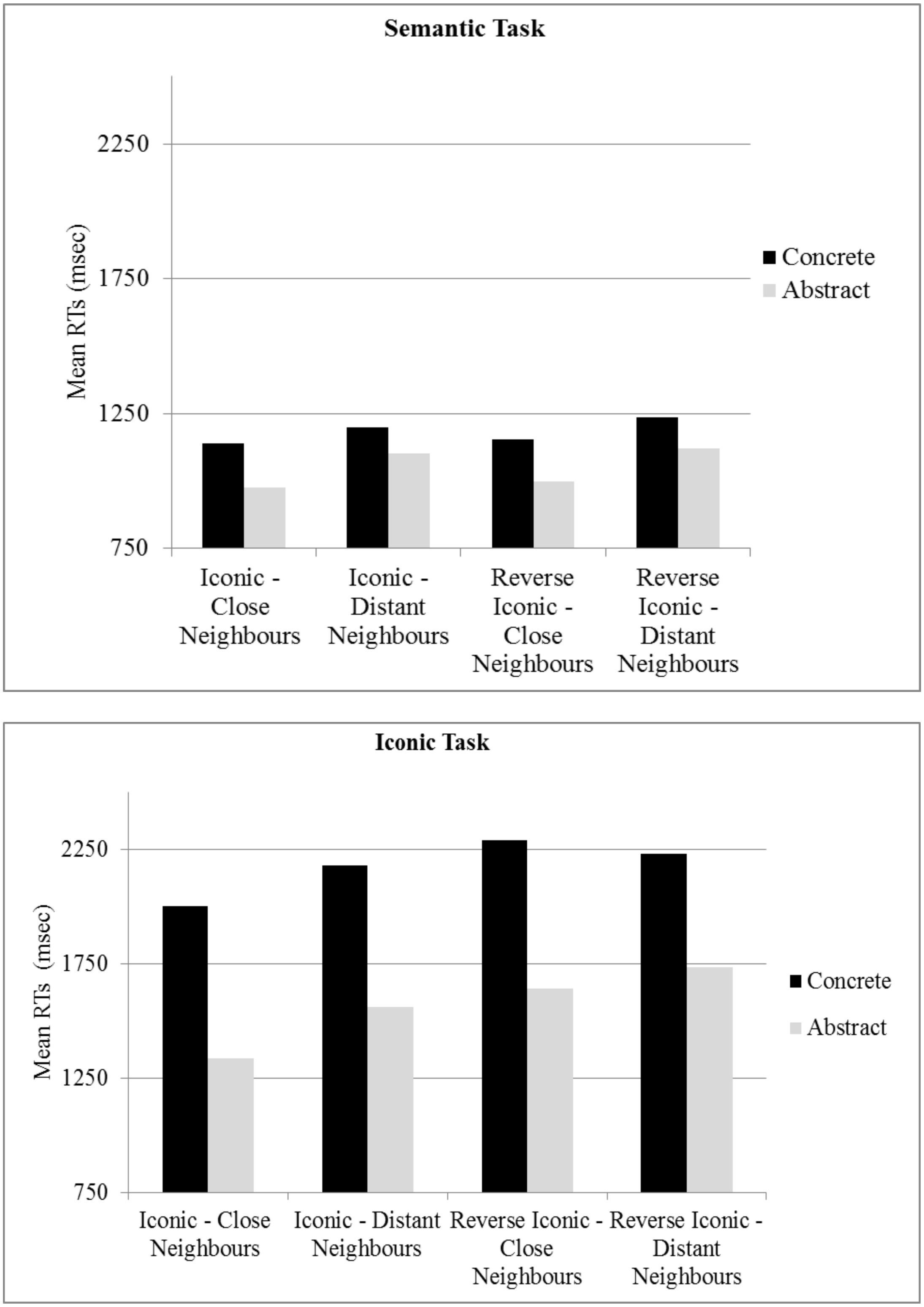

Figure 2. Mean RTs in Experiment 2 as a function of neighbours and iconicity in the subject analysis.

Discussion

The results of Experiment 2 provide further support for the Symbol Interdependency Hypothesis. Reaction times were shorter for the shallow processing task compared to the deep processing task, and in the item analysis, the embodied factor only played a role in the deep processing task. As in Experiment 1, abstract stimuli always led to shorter reaction times compared to concrete stimuli. While there was no difference in orthographic frequency across individual conditions, abstract word pairs were significantly more frequent than concrete word pairs, potentially explaining the shorter reaction times observed for abstract word pairs. Also, as in Experiment 1, there was no significant difference between tasks based on semantic neighbours. Given these findings, it would be worthwhile to replicate the results of Experiment 2 using a stimulus set that controls for orthographic frequency between concrete and abstract word pairs and to incorporate a task that is shallower than the semantic relatedness task.

Experiment 3

The purpose of Experiment 3 was to replicate the results of Experiment 1 and Experiment 2 using a stimulus set that controlled for extreme variations in orthographic frequency that may have influenced the results in the previous two experiments. Another purpose was to include a novel task designed to be shallower than the semantic relatedness task.

Research Design

A mixed within-between-subjects design, with semantic neighbours (close vs. distant), iconicity (iconic vs. reverse-iconic), and concreteness (concrete vs. abstract) as within-subjects factors, and task (very shallow vs. shallow vs. deep) as the between-subjects factor, was used.

Participants

58 (n=20 for semantic task, n=19 for iconic task, and n=19 for letter task; 14 males, 44 females; mean age = 21.4 years) University of Windsor undergraduate psychology students participated for partial course credit. This number exceeded the 27 participants suggested by a power analysis using a large effect size (partial $\eta^2 = .14$) and an alpha level of .05. All participants were at least 18 years of age, native English speakers, and had normal or corrected-to-normal vision.

Measures

The symbolic factor, the embodied factor, and concreteness were all operationalized the same way as in Experiment 1 and Experiment 2. The operationalization of depth of processing was different in Experiment 3 because a third task was included which was designed to be shallower than the semantic relatedness task, leading to 3 levels of depth of processing. Very shallow processing was operationalized as the letter task where participants were asked to make judgments about the number of letters in word pairs. Shallow processing was operationalized as the semantic task where participants were asked to make judgments about the relatedness of word pairs. Deep processing was operationalized as the iconic task where participants were asked to make judgments about the iconicity of word pairs.

The stimulus set was again developed using WINDSORS (Durda & Buchanan, 2008). The stimulus set from Experiment 1 and Experiment 2 was modified to replace target word pairs with combined orthographic frequency values of below 10 and above 200 and to replace target and filler word pairs that began with the same letter. An ANOVA was conducted to ensure that the target word pairs' orthographic frequencies showed no significant differences across conditions. Moreover, it was ensured that concrete and abstract word pairs did not differ significantly in orthographic frequency. The means and standard deviations for various stimulus characteristics per condition are displayed in Table 6 below. Half of the target word pairs were close semantic neighbours and half were distant semantic neighbours. Moreover, half of the close and distant semantic neighbours were presented in an iconic relationship and half were presented in a reverse-iconic relationship. The stimulus set for all three tasks contained 40 concrete word pairs and 40 abstract word pairs. The stimulus set for the semantic task had 80 filler word pairs and the stimulus set for the letter task had 18 filler word pairs. Both tasks had enough filler word pairs so that there would be an equal number of 'Yes' and 'No' responses. The full stimulus set is presented in Appendix B.

Table 6

Means and Standard Deviations for Word Length, Syllables, Frequency, and Age of Acquisition (AoA) Per Condition in the Experiment 3 Stimulus Set

Condition	Word Length	Syllables	Frequency	AoA
Concrete				
Close-Iconic	9.7(1.34)	2.7(0.48)	28.55(18.92)	6.29(1.69)
Close-Reverse Iconic	12.1(2.23)	2.9(0.99)	47.06(33.51)	6.01(1.47)
Distant-Iconic	9.6(2.01)	2.6(0.7)	42.87(24.41)	5.99(1.26)
Distant-Reverse Iconic	10.4(1.58)	3.1(0.88)	30.78(19.78)	7.25(2.33)
Abstract				
Close-Iconic	12.3(2.26)	4(0.94)	37.01(15.57)	8.43(2.23)
Close-Reverse Iconic	12(3.16)	3.2(1.4)	52.61(16.72)	6.94(1.68)
Distant-Iconic	12(3.43)	4(1.33)	41.22(20.28)	7.92(1.39)
Distant-Reverse Iconic	11.8(3.19)	3.5(1.65)	42.24(20.94)	8.33(1.97)

Procedure

Participants were randomly assigned to either the letter task, the semantic task, or the iconic task. The procedure for the semantic task and the iconic task, including participant instructions, was nearly identical to Experiment 1 and Experiment 2. The changes were that each task included a practice session with four trials and that word pairs were presented in all capital letters. Participants were provided with the following instructions for the letter task:

Please indicate as soon as possible whether the pair of words has the same number of letters or not by pressing “Yes” = same and “No” = different. Since this is a reaction time experiment, we want you to work as fast as you can – but not at the expense of accuracy. You should use both index fingers to make your responses. Hit the space bar to continue to the practice session.

Data Cleaning Procedures

A minimum accuracy rate of 70% was used for both participants and words. This resulted in the removal of 4 participants as well as responses from 1 Distant-Iconic-Concrete word pair, 1 Distant-Reverse Iconic-Concrete word pair, and 1 Close-Reverse Iconic-Concrete word pair. The analyses were conducted on the remaining data.

All incorrect responses were removed, resulting in the removal of 637 observations, or 14.7% of the remaining data. Reaction times greater than 9000 milliseconds were regarded as invalid responses and 12 such reaction times (0.32% of the data) were removed prior to the outlier analysis to avoid inflating individual condition means. Within each of the conditions, reaction times greater than 2.5 standard deviations away from the mean were identified as outliers, resulting in the removal of 125 (41 from the letter task, 42 from the semantic task, and 42 from the iconic task) observations, or 3.39% of the remaining data. In total, 774 observations, or 17.86% of the data set, were removed during data cleaning procedures. Participant mean response times, standard deviations and error rates per condition for the final data set are displayed in Table 7 for the letter task, Table 8 for the semantic task, and in Table 9 for the iconic task.

Table 7

Mean Reaction Times (RTs) (with Standard Deviations) and Average Error Rates Per Condition in the Experiment 3 Subject Analysis for the Letter Task

Condition	Mean RT (msec)	Average Error Rate (%)
Concrete		
Close-Iconic	1062.55 (300.69)	10.47
Close-Reverse Iconic	1150.25 (445.72)	14.56
Distant-Iconic	875.07 (211.18)	4.49
Distant-Reverse Iconic	1016.54 (355.05)	3.21
Abstract		
Close-Iconic	1247.16 (522.92)	19.77
Close-Reverse Iconic	1190.17 (453.79)	16.18
Distant-Iconic	870.54 (216.52)	8.05
Distant-Reverse Iconic	1084.01 (346.66)	16

Table 8

Mean Reaction Times (RTs) (with Standard Deviations) and Average Error Rates Per Condition in the Experiment 3 Subject Analysis for the Semantic Task

Condition	Mean RT (msec)	Average Error Rate (%)
Concrete		
Close-Iconic	1049.2 (191.59)	9.39
Close-Reverse Iconic	1028.46 (169.47)	7.93
Distant-Iconic	1205.77 (241.16)	22.56
Distant-Reverse Iconic	1170.43 (203.88)	17.9
Abstract		
Close-Iconic	1030.8 (193.04)	5.95
Close-Reverse Iconic	925.64 (134.14)	1.1
Distant-Iconic	1107.18 (210.12)	9.24
Distant-Reverse Iconic	1154.49 (223.45)	13.66

Table 9

Mean Reaction Times (RTs) (with Standard Deviations) and Average Error Rates Per Condition in the Experiment 3 Subject Analysis for the Iconic Task

Condition	Mean RT (msec)	Average Error Rate (%)
Concrete		
Close-Iconic	2322.32 (501.18)	11.25
Close-Reverse Iconic	2449.84(713.61)	13.5
Distant-Iconic	2285.3 (714.49)	7.04
Distant-Reverse Iconic	2602.2 (893.52)	22.82
Abstract		
Close-Iconic	1522.88 (422.64)	4.97
Close-Reverse Iconic	1702.64 (410.62)	5.56
Distant-Iconic	1588.47 (364.94)	1.86
Distant-Reverse Iconic	1943.33 (464.02)	9.94

Results

Within each condition, correct responses were averaged and analyzed in a mixed analysis of variance (ANOVA). As is standard for psycholinguistic research, both subject (*F*1) and item (*F*2) analyses will be reported. The assumptions of this statistical model were tested. The assumption of no significant outliers was met by removing any significant outliers prior to the statistical analyses. The Shapiro-Wilk test revealed that the assumption of normality was violated for 5 out of 24 cells. However, skewness values did not exceed acceptable ranges for any of the cells and only one kurtosis value exceeded the acceptable range. Thus, the assumption of normality can be supported. Given two levels of the within-subjects factors, the assumption of sphericity was also met. Levene's test revealed that the assumption of homogeneity of variances was not met. However, given that group sizes were equal and that the variance of the largest group was not greater than 4 times the variance of the smallest group, the statistical model is robust to a violation of this assumption.

There was a main effect of task [$F_1(2, 51) = 47.84$, $p < .001$, partial $\eta^2 = .65$; $F_2(2, 24) = 319.58$, $p < .001$, partial $\eta^2 = .96$]. Given unequal variances, Games-Howell was selected as a post hoc test, and this test indicated that the letter task was significantly different from the iconic task and that the iconic task was significantly different from the semantic task. However, the letter task was not significantly different from the semantic task. There was a main effect of semantic neighbours, with close semantic neighbours yielding shorter reaction times compared to distant semantic neighbours [$F_1(1, 51) = 55.41$, $p < .001$, partial $\eta^2 = .52$; $F_2(1, 24) = 23.59$, $p < .001$, partial $\eta^2 = .5$]. There was a main effect of iconicity, with iconic word pairs yielding shorter reaction times compared to reverse iconic word pairs [$F_1(1, 51) = 24.79$, $p < .001$, partial $\eta^2 = .33$; $F_2(1, 24) = 6.77$, $p < .05$, partial $\eta^2 = .22$]. There was no main effect of concreteness, unlike in previous experiments. There was an interaction between task and semantic neighbours [$F_1(2, 51) = 58.04$, $p < .001$, partial $\eta^2 = .7$; $F_2(2, 24) = 32.33$, $p < .001$, partial $\eta^2 = .73$], with follow-up t-tests indicating that, in the semantic task, close semantic neighbours elicited shorter reaction times compared to distant semantic neighbours [$t_1(18) = -7.57$, $p < .001$], but in the iconic task, close neighbours did not elicit shorter reaction times compared to distant neighbours [$t_1(16) = -1.53$, $p = .15$]. There was also an interaction in the subject analysis between task and iconicity [$F_1(2, 51) = 14.19$, $p < .001$, partial $\eta^2 = .36$], with follow-up t-tests indicating that, in the iconic task, iconic word pairs elicited shorter reaction times compared to reverse-iconic word pairs [$t_1(16) = -5.19$, $p < .001$], but in the semantic task, iconic word pairs did not elicit shorter reaction times compared to reverse-iconic word pairs [$t_1(18) = 1.35$, $p = .19$]. The results of the subject analysis are graphically displayed in Figure 3 below.

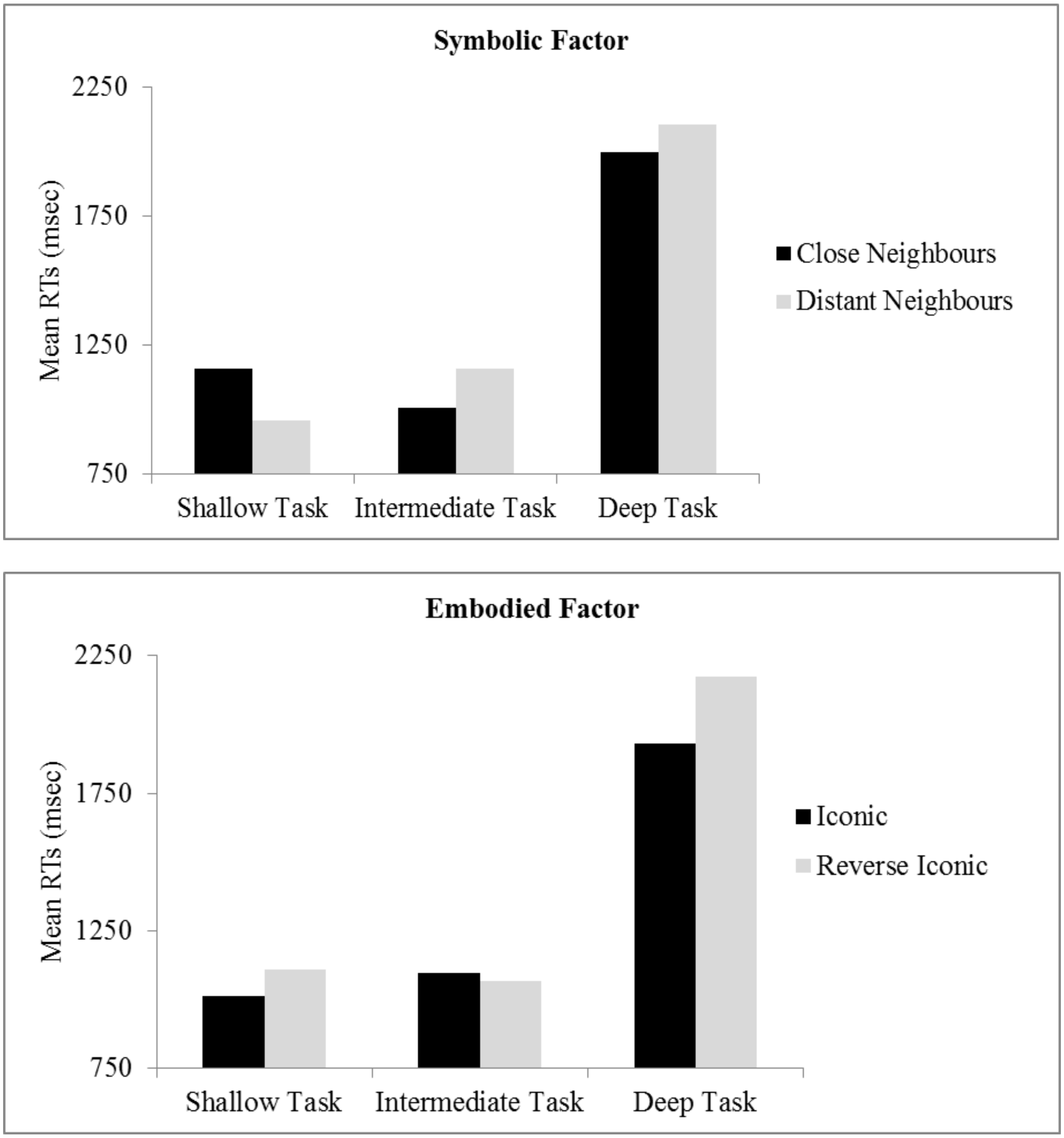

Figure 3. Mean RTs in Experiment 3 as a function of neighbours and iconicity in the subject analysis.

Discussion

The results of Experiment 3 again provide further support for the Symbol Interdependency Hypothesis. Reaction times were shorter for the very shallow processing task and the shallow processing task compared to the deep processing task and the embodied factor only played a role in the deep processing task. Unlike in Experiment 1 and Experiment 2, there was no effect of concreteness. Therefore, it can be concluded that the previous facilitation of reaction times by abstract stimuli may be explained by variations in orthographic frequency. With the addition of a shallower task, a significant difference between tasks was observed based on semantic neighbours. That is, in the semantic relatedness task, but not in the iconicity task, the symbolic factor played a role. The results from the new, most shallow, letter task were not consistent with the Symbol Interdependency Hypothesis such that reaction times were shorter for distant semantic neighbor word pairs and iconic word pairs. Considering continued support for the Symbol Interdependency Hypothesis across all experiments, the latter findings are more likely a result of the nature of the specific task. Participants were asked to determine whether word pairs had an equal number of letters. It is possible that participants were not counting the number of letters, and thus not reading the words, but rather visually determining if one word was longer in size than the other.

CHAPTER 3

CONCLUSIONS AND RECOMMENDATIONS

General Discussion

This study was conducted to reconcile symbolic approaches to language processing with embodied approaches to language processing. The Symbol Interdependency Hypothesis provided the impetus for this investigation. Previous research used the order in which words typically occur in language as a symbolic factor and iconicity as an embodied factor. The present study used a novel symbolic factor, where word pairs were either close or distant semantic neighbours, as determined by WINDSORS. Previous research did not compare concrete and abstract stimuli. Therefore, this study had 2 major objectives, to test the Symbol Interdependency Hypothesis using a novel symbolic factor and to explore the role of concrete and abstract stimuli.

Across all experiments, results demonstrated that reaction times were shorter for shallow processing tasks compared to deep processing tasks, reaction times were shorter for close semantic neighbour word pairs compared to distant semantic neighbour word pairs, and reaction times were shorter for iconic word pairs compared to reverse iconic word pairs. Reaction times were shorter for abstract word pairs compared to concrete word pairs in 2 of 3 experiments, but this effect disappeared in Experiment 3, in which stimuli were chosen to match orthographic frequency for concrete and abstract words.

Across all experiments, results also supported the Symbol Interdependency Hypothesis. The depth of processing required for a given task explained the extent to which symbolic or embodied factors were recruited. The symbolic factor, i.e. semantic neighbours, required less precise operations than the embodied factor, i.e. iconicity. The symbolic factor was recruited for the shallow processing task where participants determined whether word pairs were related in meaning or not. On the other hand, the embodied factor was recruited for the deep processing task where participants determined whether word pairs were shown in their appropriate spatial configuration or not. Results suggest that the embodied factor only played a role in the deep processing task. As the Symbol Interdependency Hypothesis predicted, we do not use embodied factors all the time, but only as needed with greater processing demands.

Future Directions

The present study supported the Symbol Interdependency Hypothesis using a novel symbolic factor, i.e. semantic neighbours from WINDSORS. This suggests that the results of the Louwerse and Jeuniaux (2010) study were not limited to the symbolic factor they used. Future research can extend these findings even further to other types of symbolic factors, such as different lexical co-occurrence models. Future research should continue to explore how concrete and abstract stimuli might influence depth of processing in the context of the Symbol Interdependency Hypothesis. Moreover, future research should incorporate a gradient of depth of processing tasks. The tasks used in the present study only serve as a starting point for the types of tasks that can be studied. The deep processing task used in the present study may have directly activated embodied representations because it required participants to attend to spatial relationships. It would be interesting to examine whether deep processing tasks that do not directly activate embodied representations e.g., a sentence comprehension task, would similarly recruit the embodied factor.

References

Aziz-Zadeh, L., Wilson, S. M., Rizzolatti, G., & Iacoboni, M. (2006). Congruent embodied representations for visually presented actions and linguistic phrases describing actions. *Current Biology, 16,* 1–6. doi:10.1016/j.cub.2006.07.060

Bak, T. H., O'Donovan, D. G., Xuereb, J. H., Boniface, S., & Hodges, J. R. (2001). Selective impairment of verb processing associated with pathological changes in Brodmann areas 44 and 45 in the motor neurone disease-dementia-aphasia syndrome. *Brain, 124*, 103-120. http://www.ncbi.nlm.nih.gov/pubmed/11133791

Barsalou, L. W. (1999). Perceptual symbol systems. *Behavioral and Brain Sciences, 22*, 577-660. http://www.ncbi.nlm.nih.gov/pubmed/11301525

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 (Eds.), *Symbols, embodiment, and meaning* (pp. 245–283). Oxford, England: Oxford University Press.

Blei, D., Ng, A., & Jordan, M. (2003). Latent Dirichlet allocation. Journal of Machine Learning Research, 3, 993–1022. https://www.cs.princeton.edu/~blei/papers/BleiNgJordan2003.pdf

Boulenger, V., Hauk, O., & Pulvermuller, F. (2009). Grasping ideas with the motor system: Semantic somatotopy in idiom comprehension. *Cerebral Cortex, 19*, 1905-1914. doi:10.1093/cercor/bhn217

Boulenger, V., Mechtouff, L., Thobois, S., Broussolle, E., Jeannerod , M., & Nazir, T. A. (2008). Word processing in Parkinson's disease is impaired for action verbs but not for concrete nouns. *Neuropsychologia, 46*(2), 743-756. doi:10.1016/j.neuropsychologia.2007.10.007

Buchanan, L., Burgess, C., & Lund, K. (1996). Overcrowding in semantic neighbourhoods: Modeling deep dyslexia. *Brain and Cognition, 32*, 111-114.

Burgess, C., & Conley, P. (1998). Representing proper names and objects in a common semantic space: A computational model. *Brain and Cognition*, *40,* 67-70. doi:10.1.1.8.3089

Burgess, C., & Lund, K. (1997). Modelling parsing constraints with high-dimensional context space. *Language and Cognitive Processes*, *12*(2/3), 177-210. doi:10.1080/016909697386844

Collins, A. M., & Loftus, E. F. (1975). A spreading-activation theory of semantic processing. *Psychological Review*, *82*(6), 407–428. doi:10.1037/0033-295X.82.6.407

Collins, A. M., & Quillian, M. R. (1969). Retrieval time from semantic memory. *Journal of Verbal Learning and Verbal Behavior*, *8,* 240–247. doi:10.1016/S0022-5371(69)80069-1

Dunn B. M., Kamide Y., & Scheepers C. (2014). Hearing “moon” and looking up: Word-related spatial associations facilitate saccades to congruent locations. *Paper presented at the 36th Annual Conference of the Cognitive Science Society.* Quebec City, Canada.

Durda, K., & Buchanan, L. (2008). WINDSORS: Windsor improved norms of distance and similarity of semantics. *Behavior Research Methods*, *40*(3), 705–712. doi:10.3758/BRM.40.3.705

Esopenko, C., Gould, L., Cummine, J., Sarty, G. E., Kuhlmann, & Borowsky, R. (2012). A neuroanatomical examination of embodied cognition: Semantic generation to action-related stimuli. *Frontiers in Human Neuroscience, 6*, 84. doi:10.3389/fnhum.2012.00084

Estes, Z., Verges, M., & Barsalou, L. W. (2008). Head up, foot down: Object words orient attention to the objects' typical location. *Psychological Science, 19*(2), 93-97. doi:10.1111/j.1467-9280.2008.02051.x.

Foltz, P. W., Kintsch, W. & Landauer, T. K. (1998). The measurement of textual coherence with Latent Semantic Analysis. *Discourse Processes, 25*(2/3), 285-307. doi:10.1.1.21.1029

Glenberg, A. M., & Kaschak, M. P. (2002). Grounding language in action. *Psychonomic Bulletin and Review, 9*, 558–565. http://www.ncbi.nlm.nih.gov/pubmed/12412897

Glenberg, A. M., & Robertson, D. A. (1999). Indexical understanding of instructions. *Discourse Processes, 28*, 1–26. doi:10.1080/01638539909545067

Glenberg, A. M., Sato, M., Cattaneo, L., Riggio, L., Palumbo, P., & Buccino, G. (2008). Processing abstract language modulates motor system activity. *The Quarterly Journal of Experimental Psychology, 61*(6), 905-919. doi:10.1080/17470210701625550

Griffiths, T. L., Steyvers, M., & Tenenbaum, J. B. (2007). Topics in semantic representation. *Psychological Review, 114*, 211-244. doi: 10.1037/0033-295X.114.2.211

Guan, C. Q., Meng, W., Yao, R., & Glenberg, A. M. (2013). The motor system contributes to comprehension of abstract language. *PLoS ONE, 8*(9): e75183. doi:10.1371/journal.pone.0075183

Hauk, O., Johnsrude, I., & Pulvermuller, F. (2004). Somatotopic representation of action words in human motor and premotor cortex. *Neuron, 41*, 301-307. doi: 10.1016/S0896-6273(03)00838-9

Hinton, G. E., McClelland, J. L., & Rumelhart, D. E. (1986). Distributed representations. In D. E. Rumelhart & J. L. McClelland (Eds.), *Parallel distributed processing: Explorations in the microstructure of cognition Vol. 1: Foundations* (pp. 77–109). Cambridge, MA: MIT Press.

Hutchinson, S., & Louwerse, M. M. (2012). The upbeat of language: Linguistic context and embodiment predict processing of valence words. In N. Miyake, D. Peebles, & R. P. Cooper (Eds.), *Proceedings of the 34th Annual Conference of the Cognitive Science Society* (pp. 1709-1714). Austin, TX: Cognitive Science Society.

Jarvis, B. G. (2012). DirectRT (Version 2012) [Computer Software]. New York, NY: Empirisoft Corporation.

Jirak, D., Menz, M. M., Buccino, G., Borghi, A. M., & Binkofski, F. (2010). Grasping language - a short story on embodiment. *Consciousness and Cognition*, *19*(3), 711-720. doi:10.1016/j.concog.2010.06.020

Jones, M. N., & Mewhort, D. J. K. (2007). Representing word meaning and order information in a composite holographic lexicon. *Psychological Review*, *114*(1), 1-37. doi:10.1037/0033-295X.114.1.1

Kintsch, W. (2000). Metaphor comprehension: A computational theory. *Psychonomic Bulletin and Review*, *7*(2), 257-266. http://www.ncbi.nlm.nih.gov/pubmed/10909133

Kuperman, V., Stadthagen-Gonzalez, H., & Brysbaert, M. (2012). Age-of-acquisition ratings for 30,000 English words. *Behavioural Research, 44*, 978-990. doi: 10.3758/s13428-012-0210-4

Landauer, T. K., & Dumais, S. T. (1997). A solution to Plato's problem: The latent semantic analysis theory of acquisition, induction, and representation of knowledge. *Psychological Review*, *104*(2), 211-240. doi:10.1.1.184.4759

Louwerse, M.M. (2007). Symbolic or embodied representations: A case for symbol interdependency. In T. Landauer, D. McNamara, S. Dennis, & W. Kintsch (Eds.), *Handbook of latent semantic analysis* (pp. 107-120). Mahwah, NJ: Erlbaum.

Louwerse, M. M. (2008). Embodied representations are encoded in language. *Psychonomic Bulletin and Review*, *15*, 838–844. doi:10.3758/PBR.15.4.838

Louwerse, M. M., Cai, Z., Hu, X., Ventura, M., & Jeuniaux, P. (2006). Cognitively inspired natural-language based knowledge representations: Further explorations of latent semantic analysis. *International Journal of Artificial Intelligence Tools*, *15*, 1021–1039. doi:10.1.1.99.2211

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. doi:10.1111/j.1551-6709.2010.01157.x

Louwerse, M. M., & Hutchinson, S. (2012). Neurological evidence linguistic processes precede perceptual simulation in conceptual processing. *Frontiers in Psychology, 3*, 385. doi:10.3389/fpsyg.2012.00385

Louwerse, M. M., & Jeuniaux, P. (2010). The linguistic and embodied nature of conceptual processing. *Cognition, 114*, 96–104. doi:10.1016/j.cognition.2009.09.002

Lund, K., & Burgess, C. (1996). Producing high-dimensional semantic spaces from lexical co-occurrence. *Behaviour Research Methods, Instruments, & Computers*, *28*(2), 203-208. doi:10.3758/BF03204766

Markman, A. B., & Dietrich, E. (2000). Extending the classical view of representation. *Trends in Cognitive Sciences, 4*, 470-475. http://philpapers.org/rec/MARETC

Meier, B. P., & Robinson, M. D. (2004). Why the sunny side is up: Associations between affect and vertical position. *Psychological Science, 15*(4), 243-247. doi:10.1111/j.0956-7976.2004.00659.x

Meteyard, L., Cuadrado, S. R., Bahrami, B., & Vigliocco, G. (2012). Coming of age: A review of embodiment and the neuroscience of semantics. *Cortex, 48,* 788-804. doi: 10.1016/j.cortex.2010.11.002

Paivio, A. (1986). *Mental representations: A dual coding approach.* Oxford, England: Oxford University Press.

Paivio, A. (1991). Dual coding theory: Retrospect and current status. *Canadian Journal of Psychology, 45,* 255-287. doi:10.1037/h0084295

Plato. Plato in Twelve Volumes, Vol. 12 translated by Harold N. Fowler. Cambridge, MA, Harvard University Press; London, William Heinemann Ltd. 1921.

Santana, E., & de Vega, M. (2011). Metaphors are embodied, and so are their literal counterparts. *Frontiers in Psychology, 2,* 90. doi:10.3389/fpsyg.2011.00090

Šetić, M., & Domijan, D. (2007). The influence of vertical spatial orientation on property verification. *Language and Cognitive Processes, 22*(2), 297-312. doi:10.1080/01690960600732430

Shaoul, C., & Westbury, C. (2006). Word frequency effects in highdimensional co-occurrence models: A new approach. *Behavior Research Methods, 38,* 190-195. doi: 10.3758/BRM.42.2.393

Siakaluk, P. D., Pexman, P. M., Aguilera, L., Owen, W. J., & Sears, C. (2008). Evidence for the activation of sensorimotor information during visual word recognition: The body–object interaction effect. *Cognition, 106*, 433-443. doi:10.1016/j.cognition.2006.12.011

Simmons, W. K., Hamann, S. B., Harenski, C. L., Hu, X. P., & Barsalou, L. W. (2008). fMRI evidence for word association and situated simulation in conceptual processing. *Journal of Physiology – Paris, 102*, 106–119. doi:10.1016/j.jphysparis.2008.03.014

Tettamanti, M., Buccino, G., Saccuman, M. C., Gallese, V., Danna, M., Scifo, P., … Perani, D.

(2005). Listening to action-related sentences activates fronto-parietal motor circuits. *Journal of Cognitive Neuroscience*, *17*(2), 273–281. http://www.ncbi.nlm.nih.gov/pubmed/15811239

Weiskopf, D. A. (2010). Embodied cognition and linguistic comprehension. *Studies in History and Philosophy of Science, 41*(3), 294-304. http://www.ncbi.nlm.nih.gov/pubmed/21466120

Wilson, N. L., & Gibbs, R.W. (2007). Real and imagined body movement primes metaphor comprehension. *Cognitive Science*, *31*, 721-731. doi:10.1080/15326900701399962

Xie, J., Wang, R., & Chang, S. (2014). The mechanism of valence-space metaphors: ERP evidence for affective word processing. *PLoS ONE 9*(6): e99479. doi:10. 1371/journal.pone.0099479

Zwaan, R. A., & Taylor, L. J. (2006). Seeing, acting, understanding: Motor resonance in language comprehension. *Journal of Experimental Psychology: General, 135*, 1–11. doi: 10.1.1.64.8506

Zwaan, R. A., & Yaxley, R. H. (2003a). Hemispheric differences in semantic-relatedness judgments. *Cognition*, *87*, 79-86. doi:10.1016/S0010-0277(02)00235-4

Zwaan, R. A., & Yaxley, R. H. (2003b). Spatial iconicity affects semantic-relatedness judgments. *Psychonomic Bulletin and Review, 10*(4), 954–958. http://www.ncbi.nlm.nih.gov/pubmed/15000544

APPENDICES

Appendix A

Target Word Pairs (with Semantic Neighbourhood Distance) Used in Experiments 1 and 2 with their Lengths (Len.), Syllables (Syll.), Frequencies (Freq.), and Age of Acquisition (AoA)

Condition	Word Pair	Len.	Syll.	Freq.	AoA
Concrete					
Close-Iconic	ATTIC(3) – BASEMENT(1)	13	4	7.35	6.74
	FLAME(10) – CANDLE(24)	11	3	26.98	6.25
	HIKER(7) – TRAIL(20)	10	3	32.06	8.50
	KNEE(2) – ANKLE(2)	9	3	18.30	4.89
	BRIDGE(8) – RIVER(5)	11	3	119.51	5.58
	CASTLE(42) – MOAT(14)	10	3	30.07	9.65
	FROSTING (14) – DOUGHNUT(30)	16	4	.53	5.42
	HEADLIGHT(8) – BUMPER(19)	15	4	.98	7.32
	LID(14) – CONTAINER(24)	12	4	6.83	6.50
	BUTTER (4) – BREAD(11)	11	3	41.20	5.78
Close-Reverse Iconic	MOUSTACHE(2) – BEARD(7)	14	3	17.69	5.40
	JOCKEY(38) – HORSE(49)	11	3	81.25	8.28
	PEDESTRIAN(3) – SIDEWALK(11)	18	6	4.08	9.75
	SWEATER(14) – PANTS(14)	12	3	6.37	5.22
	NOSE(8) – MOUTH(15)	9	2	103.47	3.58
	CHIMNEY(11) – FIREPLACE(3)	16	5	12.74	7.37
	TOMBSTONES(20) – COFFINS(13)	17	4	1.55	7.95
	TRAIN(22) – RAILROAD(49)	13	3	55.24	6.06
	SPRINKLES(17) – CUPCAKE(17)	16	4	.13	5.50
	SHOULDERS(8) – HIPS(6)	13	3	43.09	6.17
Distant-Iconic	ANTLER(419) – DEER(366)	10	3	9.60	6.39
	FOAM(3149) – BEER(3107)	8	2	19.98	6.15
	HOOD(1730) – ENGINE(2598)	10	3	25.65	6.28
	JAM(601) – TOAST(525)	8	2	9.05	6.56
	BOOT(797) – HEEL(866)	8	2	13.26	7.85
	FENDER(2583) – TIRE(1960)	10	4	4.14	8.50
	BRANCH(945) – ROOT(625)	10	2	38.18	5.94
	PENTHOUSE(387) – LOBBY(434)	14	4	3.97	13.11
	LAWNMOWER(411) – GRASS(357)	14	4		6.11
	BELT(1219) – JEANS(1477)	9	2	14.86	5.26
Distant-Reverse Iconic	BOUQUET(625) – VASE(509)	11	3	5.18	8.72
	HANDLE(933) – BUCKET(601)	12	4	26.23	6.30
	HEAD(1648) – FOOT(1295)	8	2	356.13	3.44
	SHEET(506) – MATTRESS(363)	13	3	19.90	5.33
	TEACUP(501) – COASTER(918)	13	4	.74	7.89
	FROTH(2078) – COFFEE(3271)	11	3	28.45	12.56
	CART(272) – WHEELS(284)	10	2	21.55	6.16
	SPRINKLER(663) – LAWN(771)	13	3	8.48	5.53

	ICE-CREAM (370) – CONE(738)	12	3		4.67
	CANDLE(607) – CAKE(731)	10	3	22.01	5.37
Abstract					6.89
Close-Iconic	COACH(14) – PLAYER(22)	11	3	42.13	8.42
	JOY(29) – SORROW(8)	9	3	60.59	5.58
	STRONG(19) – WEAK(8)	10	2	130.81	5.94
	TEACHER(11) – STUDENT(6)	14	4	51.82	5.00
	ANGEL(15) – DEVIL(17)	10	4	40.73	8.11
	POSITIVE(2) – NEGATIVE(2)	16	6	41.44	3.55
	GOOD(32) – BAD(29)	7	2	643.53	10.33
	LANDLORD(4) – TENANT(3)	14	4	16.42	5.11
	HEAVEN(10) – HELL(16)	10	3	73.49	8.74
	VICTORY(2) – DEFEAT(3)	13	5	35.89	7.06
Close-Reverse Iconic	BRIGHT(26) – DIM(44)	9	2	65.40	8.05
	HOST(30) – GUEST(40)	9	1	34.90	4.55
	CLEAN(19) – DIRTY(46)	10	3	52.14	5.89
	LIFE(7) – DEATH(4)	9	2	581.15	12.53
	OPTIMIST(45) – PESSIMIST(10)	17	6	1.24	4.39
	FIRST(28) – LAST(15)	9	2	1023.03	8.90
	MARRIAGE(3) – DIVORCE(3)	15	4	53.87	4.15
	FAST(2) – SLOW(2)	8	2	81.92	7.68
	EXCITEMENT(48) – BOREDOM(13)	17	5	28.11	3.78
	MORE(9) – LESS(22)	8	2	1259.01	6.32
Distant-Iconic	RICH(886) – POOR(482)	8	2	200.09	7.50
	OWNER(1306) – PET(1035)	8	3	28.29	8.16
	SUCCEED(898) – FAIL(998)	11	3	33.98	7.61
	HEALTHY(1546) – SICK(1338)	11	3	51.09	7.84
	BOSS(938) – EMPLOYEE(736)	12	4	20.90	8.80
	ACHIEVEMENT(2088) – FAILURE(2343)	18	6	38.25	9.95
	CONFIDENT(525) – ARROGANT(295)	17	6	14.59	7.75
	CEO(1042) – SECRETARY (1187)	12	7		11.79
	TRAINER(674) – TRAINEE(651)	14	4	3.71	8.00
	GUARD(2095) – PRISONER(2495)	13	4	43.18	12.05
Distant-Reverse Iconic	THERAPIST(574) – CLIENT(1005)	15	5	17.80	8.28
	INTELLIGENT(1892) – STUPID(1167)	17	6	31.07	7.11
	GAIN(305) – LOSS(394)	8	2	68.13	5.05
	BEAUTIFUL(289) – UGLY(309)	13	5	103.27	4.35
	RIGHT(3131) – WRONG(2173)	10	2	488.31	4.00
	NICE(1216) – MEAN(1728)	8	2	228.17	9.28
	SELFLESS(1579) – GREEDY(1662)	14	4	3.65	2.72
	YES(338) – NO(1392)	5	2	1729.41	9.40
	MANAGER(498) – CASHIER(673)	14	6	51.86	7.45
	WHITE-COLLAR(2927) – HOMELESS(1314)	19	5		

Appendix B

Target Word Pairs (with Semantic Neighbourhood Distance) Used in Experiment 3 with their Lengths (Len.), Syllables (Syll.), Frequencies (Freq.), and Age of Acquisition (AoA)

Condition	Word Pair	Len.	Syll.	Freq.	AoA
Concrete					
Close-Iconic	NOSE(9) – TONGUE(22)	10	2	61.79	4.47
	FLAME(10) – CANDLE(24)	11	3	26.98	6.25
	HIKER(7) – TRAIL(20)	10	3	32.06	8.50
	KNEE(2) – ANKLE(2)	9	3	18.30	4.89
	BRIDGE(25) – LAKE(26)	10	2	61.34	5.58
	CASTLE(42) – MOAT(14)	10	3	30.07	9.65
	STOVE(3) – OVEN(3)	9	3	12.81	5.67
	SHOWER(5) – TUB(17)	9	3	11.92	4.72
	LID(4) – TRAY(3)	7	2	10.99	6.05
	LUNGS(32) – STOMACH(27)	12	3	19.27	7.16
Close-Reverse Iconic	MOUSTACHE(2) – BEARD(7)	14	3	17.69	5.40
	JOCKEY(38) – HORSE(49)	11	3	81.25	8.28
	JACKET(19) – TROUSERS(2)	14	4	21.62	7.89
	SHIRT(9) – PANTS(4)	10	2	22.00	3.53
	ROOF(20) – FLOOR(48)	9	2	94.35	5.00
	CHIMNEY(11) – FIREPLACE(3)	16	5	12.74	7.37
	MOUTH(25) – THROAT(11)	11	2	99.39	5.09
	TRAIN(22) – RAILROAD(49)	13	3	55.24	6.06
	JEANS(4) – SHOES(6)	10	2	23.29	5.26
	SHOULDERS(8) – HIPS(6)	13	3	43.09	6.17
Distant-Iconic	HORN(679) – TAIL(506)	8	2	33.52	4.84
	FOAM(3149) – BEER(3107)	8	2	19.98	6.15
	HOOD(1730) – ENGINE(2598)	10	3	25.65	6.28
	DESK(422) – CARPET(361)	10	3	34.11	6.05
	BOOT(797) – HEEL(866)	8	2	13.26	7.85
	SEAT(1881) – PEDALS(1879)	10	3	42.42	6.50
	BRANCH(945) – ROOT(625)	10	2	38.18	5.94
	AIRPLANE(2214) – CAR(2162)	11	3	81.03	3.94
	PAPER (3633) – CLIPBOARD(2801)	14	4	86.41	7.76
	HAT(904) – BELT(985)	7	2	54.14	4.62
Distant-Reverse Iconic	FLOWER(-) – VASE(374)	10	3	26.58	7.89
	HANDLE(933) – BUCKET(601)	12	4	26.23	6.30
	MODEL(2460) – RUNWAY(3040)	11	4	39.28	8.35
	SHEET(506) – MATTRESS(363)	13	3	19.90	5.33
	FERRY(935) – OCEAN(932)	10	4	23.42	8.00
	FROTH(2078) – COFFEE(3271)	11	3	28.45	12.56
	CART(272) – WHEELS(284)	10	2	21.55	6.16
	BALCONY(1388) – LAWN(1399)	11	4	13.55	8.10
	SKY(2112) – GRASS(2750)	8	2	83.85	4.17
	FLAG(665) – POLE(479)	8	2	24.97	5.63

Abstract					
Close-Iconic	COACH(14) – PLAYER(22)	11	3	42.13	6.89
	JOY(29) – SORROW(8)	9	3	60.59	8.42
	ABUNDANT(8) – SCARCE(7)	14	4	16.41	12.84
	TEACHER(11) – STUDENT(6)	14	4	51.82	5.94
	ANGEL(15) – DEVIL(17)	10	4	40.73	5.00
	POSITIVE(2) – NEGATIVE(2)	16	6	41.44	8.11
	ACCEPT(8) – REJECT(4)	12	4	47.41	9.53
	LANDLORD(4) – TENANT(3)	14	4	16.42	10.33
	LEND(4) – BORROW(2)	10	3	17.25	8.45
	VICTORY(2) – DEFEAT(3)	13	5	35.89	8.74
Close-Reverse Iconic	BRIGHT(26) – DIM(44)	9	2	65.40	7.06
	HOST(30) – GUEST(40)	9	1	34.90	8.05
	CLEAN(19) – DIRTY(46)	10	3	52.14	4.55
	AGREE(11) – DISAGREE(6)	13	5	39.86	8.37
	SAFETY(29) – DANGER(29)	12	4	72.18	5.84
	INCREASE(2) – DECREASE(5)	16	4	50.54	8.56
	MARRIAGE(3) – DIVORCE(3)	15	4	53.87	8.90
	FAST(2) – SLOW(2)	8	2	81.92	4.15
	EXCITEMENT(48) – BOREDOM(13)	17	5	28.11	7.68
	SMOOTH(2) – ROUGH(3)	11	2	47.22	6.21
Distant-Iconic	PEACE(258) – VIOLENCE(225)	13	4	81.90	6.39
	OWNER(1306) – PET(1035)	8	3	28.29	7.50
	SUCCEED(898) – FAIL(998)	11	3	33.98	8.16
	HEALTHY(1546) – SICK(1338)	11	3	51.09	7.61
	BOSS(938) – EMPLOYEE(736)	12	4	20.90	7.84
	ACHIEVEMENT(2088) – FAILURE(2343)	18	6	38.25	8.80
	CONFIDENT(525) – ARROGANT(295)	17	6	14.59	9.95
	FIX(324) – BREAK(555)	8	2	64.84	5.30
	ALLY(1373) – ENEMY(1519)	9	5	35.16	9.61
	GUARD(2095) – PRISONER(2495)	13	4	43.18	8.00
Distant-Reverse Iconic	THERAPIST(574) – CLIENT(1005)	15	5	17.80	12.05
	INTELLIGENT(1892) – STUPID(1167)	17	6	31.07	8.28
	GAIN(305) – LOSS(394)	8	2	68.13	7.11
	BLESS(522) – CURSE(992)	10	2	20.20	7.47
	BOLD(2797) – MEEK(1665)	8	2	17.40	9.70
	STRAIGHT(800) – CROOKED(1353)	15	3	64.70	6.80
	FRESH(2402) – STALE(1070)	10	2	51.82	7.61
	PURE(685) – TAINTED(478)	11	3	31.72	9.84
	MANAGER(498) – CASHIER(673)	14	6	51.86	9.40
	BEAUTY(1477) – UGLY(1094)	10	4	67.75	5.05

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