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Abstract and Concrete Concepts According to Word Association

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ABSTRACT

In psychology, the abstract/concrete distinction refers to a distinction among concepts, which is typically characterized as follows. Concrete concepts are those whose referents can be experienced through sensation/perception, such as *dog* or *pond*, whereas abstract concepts are those whose referents lack this attribute, such as *truth* (Wiemer-Hastings & Xu, 2005; Connell & Lynott, 2012; Brysbaert, Warriner, & Kuperman, 2014). This thesis describes and, using word association, tests several theories of conceptual representation motivated by the abstract/concrete distinction (or, where not motivated by it, with potential implications related to it). These include Dual Coding Theory (Paivio, 1986, 2007), Perceptual Symbol Systems (Barsalou, 1999, 2008), Language and Situated Simulations (Barsalou, Santos, Simmons, & Wilson, 2008), and Different Representational Frameworks (Crutch & Warrington, 2005, 2007, 2010). We find mixed support for Dual Coding Theory and Perceptual Symbol Systems, strong support for Language and Situated Simulations, and no support for Different Representational Frameworks.

Keywords**:** abstract and concrete concepts, dual coding, language, representation, simulation, word association

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LIST OF ABBREVIATIONS

DCT = Dual Coding Theory

PSS = Perceptual Symbol Systems

LASS = Language and Situated Simulations

DRF = Different Representational Frameworks

FSG = forward cue-to-target strength

CHAPTER 1
INTRODUCTION

1.1 THE ABSTRACT/CONCRETE DISTINCTION AND ITS VALUE

When philosophers discuss the abstract/concrete distinction, they refer typically to a distinction among objects or entities (Rosen, 2001). Where objects like dogs and ponds and trees are considered concrete, those like the letter 'A' and Shakespeare's 'Hamlet' are considered abstract. However, there is little consensus on what characterizes this distinction. While a common theme is that abstract objects lack key attributes possessed by concrete objects, just what these attributes are varies by account (e.g., mentality and sensibility, or spatiality and causal efficacy; Rosen, 2001). By contrast, psychology draws its abstract/concrete distinction not among objects, but concepts. Moreover, there is general agreement on how the distinction should be characterized. Concrete concepts are those whose referents can be experienced through sensation/perception[1], such as *dog* or *pond* or *tree*, whereas abstract concepts are those whose referents lack this attribute, such as *love* or *truth* (Paivio, Yuille, & Madigan, 1968; Wiemer-Hastings & Xu, 2005; Connell & Lynott, 2012; Brysbaert, Warriner, & Kuperman, 2014). Presumably, that this characterization has not proven contentious is because of the following set of circumstances: (1) the characterization is the basis for instructions used to obtain concept concreteness ratings (i.e., participants' assessments of how concrete or abstract a concept is; e.g., Brysbaert et al., 2014), (2) concept concreteness ratings are used as independent variables in studies that yield significant empirical findings, (3) these findings—besides being valuable to psychology in and of themselves—are relied upon by a number of influential psychological theories (Figure 1).

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[1] The word "perception" is here and elsewhere in this thesis taken to mean "nonverbal perception". This shortcut has become commonplace in the literature. However, it can be confusing in the context of a perceptual versus verbal system, as all verbal objects (e.g., words, phrases) inhere in perception. A similar point is made by Paivio, 2007 (p. 35, footnote 5).

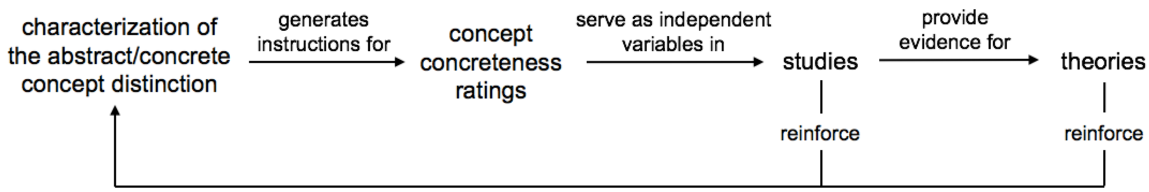

Figure 1. Psychology's characterization of the abstract/concrete distinction is the basis for instructions that are used to obtain *concept concreteness ratings*. Concept concreteness ratings serve as independent variables in studies yielding significant empirical findings. These findings—besides being valuable to psychology in and of themselves—are import for a number of influential psychological theories.

This thesis focuses on outlining and testing several theories of conceptual representation motivated by the abstract/concrete concept distinction. Some of these take the distinction literally, for example, by offering a view in which concrete, but not abstract, concepts are represented by sensory/perceptual experience (Paivio, 1986, 2007). Others take it less literally, for example, by suggesting that both abstract and concrete concepts are represented through sensory/perceptual experience albeit in differing manners that recapitulate the distinction (Barsalou, 1999, 2008).

1.2 THEORIES ADDRESSING THE DISTINCTION: A LITERATURE REVIEW

The theories covered are Dual Coding Theory (Paivio, 1986, 2007), Perceptual Symbol Systems (Barsalou, 1999, 2008), Language and Situated Simulations (Barsalou, Santos, Simmons & Wilson, 2008), and Different Representational Frameworks (Crutch & Warrington, 2005, 2007, 2010). Tenets and relevant studies for each are discussed in turn.

1.2.1 DUAL CODING THEORY (DCT)

Dual Coding Theory (Paivio, 1986, 2007) is characterized here as a theory of conceptual representation based on a series of nested ideas. The first and most general idea is that the mind contains *symbolic systems*, which are derived from, but functionally orthogonal to, sensorimotor systems (Table 1). Symbolic systems

Table 1. Orthogonal conceptual relations between symbolic systems and sensorimotor systems with examples of types of modality-specific information represented in each subsystem. Table and title recreated from Paivio (1986, p. 57, 2007, p. 36).

Sensorimotor systems	*Symbolic systems*	
	Verbal	Nonverbal
Visual	Visual words	Visual objects
Auditory	Auditory words	Environmental sounds
Haptic	Braille, handwriting	"Feel" of objects
Gustation	—	Taste memories
Olfaction	—	Smell memories
Emotion	—	Felt emotions

have the general attributes of systems—that is, they consist of parts forming a unitary whole—but deal specifically in mental representations*.* The second idea is that, among the various symbolic systems in the mind, two are fundamental in the sense that they are not also symbolic *sub*systems (Table 1). These are the nonverbal and verbal systems. According to Paivio (1986, 2007), the nonverbal and verbal systems exhibit key differences. The most central among these is that the nonverbal system processes "imagens" (fundamental units of nonverbal information, which include, for example, geometric forms, objects, or scenes), whereas the verbal system processes "logogens" (fundamental units of verbal information, which include, for example, words, stock phrases, or memorized poems). Another difference relates to their evolution and development. The nonverbal system is evolutionarily older than, and developmentally prior to, the verbal system, which might in fact depend on the nonverbal system for its evolution (2007, p. 279) and development (1986, p. 87-90). In the quote below, Paivio makes explicit the functionally independent nature of the two systems. Note, however, that while the two systems are separable, they maintain referential connections, and in fact it is because of these connections, rather than despite them, that they avoid being made into one larger system.

> A final question is whether it is also necessary to postulate an Aristotelian common sense that is completely amodal and capable of representing all sense modalities and accommodating the relation between nonverbal and verbal representations—a kind of interlingua that mediates transfer from

> one system to the other. Such a common representational system is precisely what propositional theorists propose, but dual coding theory incorporates a different view. The experiential derivation of the sensorimotor subsystems implies that they must be interconnected because of co-occurrences in experience and yet capable of functioning independently. The functional interconnections permit activation of one subsystem by another. The mediating interlingua is unnecessary and logically undesirable because it is unparsimonious and leads to an infinite regress of mediating interlingua (Paivio, 1986, p. 58).

The third idea—the first to address the abstract/concrete distinction—is that concrete concepts are represented in both the nonverbal and verbal system, whereas abstract concepts are represented only in the verbal system. It is at the level of this third idea that DCT gives rise to specific hypotheses.

One of these hypotheses is that, because concrete concepts are represented in two systems and abstract concepts in one, the former are processed more efficiently than the latter. Evidence of this "concreteness effect" is replete in the literature. Experiments using lexical decision (James, 1975; Bleasdale, 1987), recall (Paivio, Yuille, & Smythe, 1966; Romani, McAlpine, & Martin, 2007) and word naming (de Groot, 1989; Schwanenflugel & Stowe, 1989) have all demonstrated faster and/or more accurate processing for concrete than abstract concepts. However, despite the apparent ubiquity of the concreteness effect, there are reasons for doubt. First, experiments do not always reveal the concreteness effect (e.g., Experiments 3 and 4 in James, 1975; control conditions in Papagno, Fogliata, Catricalà, & Miniussi, 2009). Second, the concreteness effect might not be a concreteness effect per se. For example, Gernsbacher (1984) found that James' (1975) lexical decision advantage for concrete concepts could be accounted for using familiarity ratings (i.e., participants' assessments of how often they see, hear, or use a concept) in place of concreteness ratings. Comparably, Connell and Lynott (2012) found that ratings of perceptual strength (i.e., participants' assessments of the extent to which a concept is experienced through a given sense) are better predictors of lexical decision and word naming than are concreteness ratings. Third, a number of studies have demonstrated a reverse concreteness effect. For example, Pexman, Hargreaves, Edwards, Henry, and Goodyear (2007) found that participants were quicker to categorize abstract than concrete concepts as non-edible, and Kousta, Vigliocco, Vinson, Andrews, and Del Campo (2011) found that holding imageability and context availability constant led to faster lexical decisions for abstract than concrete concepts (which they ultimately attributed to greater emotional valence of abstract concepts).

A second hypothesis is that—because they inhere in different systems—the spatial distribution of neural activity differs during processing of abstract and concrete concepts (Holcomb, Kounios, Anderson, & West, 1999). Like the concreteness effect, this notion of "spatial distinctiveness" (Holcomb et al., 1999) receives strong support from the literature. For example, Kounios and Holcomb (1994) recorded event-related potentials (ERPs) while participants made lexical decisions on abstract and concrete concepts. Compared to abstract concepts, concrete concepts elicited more negative-going ERPs over the right hemisphere at 300-500 ms and 500-800 ms. Switching the task from lexical decision to concrete-abstract classification (i.e., 'is the concept concrete or abstract?') led to the same, but larger, effects. It also revealed greater repetition effects over the left hemisphere at 300-500 ms and 500-800 ms for abstract concepts, and over the right hemisphere at 500-800 ms for concrete concepts[2]. In a related study, Holcomb et al. (1999) recorded ERPs while participants read sentences whose terminal words varied in concreteness and congruency[3]. Compared to

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[2] Note that, besides demonstrating spatial distinctiveness, these findings confirm another postulate of DCT, which is that the nonverbal system is associated largely with the right and/or both hemispheres, and the verbal system with the left hemisphere (Paivio, 1986, p. 264; 2007, p. 133).

[3] Some examples from Holcomb et al. (1999):
Concrete congruent – Armed robbery implies that the thief used a *weapon.*
Concrete anomalous – Armed robbery implies that the thief used a *rose.*
Concrete neutral – They said it was because of the *rose.*
Abstract congruent – Lisa argued that this had not been the case in one single *instance.*
Abstract anomalous – Lisa argued that this had not been the case in one single *fun.*
Abstract neutral – They said it was because of *the fun.*

anomalous abstract words, anomalous concrete words elicited more negative-going ERPs over numerous, but especially anterolateral, sites at 300-500 ms and 500-800 ms. This was also the case for abstract versus concrete neutral words. Functional magnetic resonance imaging (fMRI) and repetitive transcranial magnetic stimulation (rTMS) offer still more evidence of spatial distinctiveness effects. Binder, Westbury, McKiernan, Possing, and Medler (2005) used fMRI to scan individuals' brains as they made lexical decisions on abstract and concrete concepts. Abstract concepts elicited greater activation in the left precentral gyrus, left inferior frontal gyrus and sulcus, and left superior temporal gyrus, whereas concrete concepts elicited greater activation in bilateral angular gyri, the right middle temporal gyrus, the left middle frontal gyrus, bilateral posterior cingulate gyri, and bilateral precunei. Papagno et al. (2009) applied rTMS to participants' scalps while they made lexical decisions on abstract and concrete concepts. Abstract concept decision accuracy was impaired by stimulating the left inferior frontal gyrus and left posterior-superior temporal gyrus, whereas concrete concept decision accuracy was impaired by stimulating the right posterior-superior temporal gyrus.

In summary, DCT (Paivio, 1986, 2007) is based on three nested ideas. The first idea is that the mind contains symbolic systems, which are derived from, but functionally orthogonal to, sensorimotor systems. The second idea is that, among the various symbolic systems in the mind, the verbal and nonverbal systems are fundamental. The third idea is that concrete concepts are represented in both the nonverbal and verbal system, whereas abstract concepts are represented only in the verbal system. It is at the level of this third idea that DCT gives rise to testable hypotheses, which include (1) concrete concepts being processed more efficiently than abstract concepts, and (2) differences in the spatial distribution of neural activity during processing of abstract and concrete concepts. Both hypotheses are supported by empirical evidence.

1.2.2 PERCEPTUAL SYMBOL SYSTEMS (PSS)

Perceptual Symbol Systems (Barsalou, 1999, 2008) proposes that during experience, the brain's modal systems—that is, systems responsible for sense-perception, action, and introspection—produce specific patterns of neural activity. Selective attention operates on these patterns to isolate important subsets from them. These subsets are extracted and stored in long-term memory as "perceptual symbols" (e.g., specific memories of *black*, *sweet,* or *paw*). Over time, related perceptual symbols congregate to form "frames". For example, specific memories of *black* may form a *black* frame, and specific memories of *muzzle, paw,* and *tail* may form a *dog* frame. The function of frames is to construct "simulations", which are top down activations of the brain's modal systems that reenact experiences toward some end. For example, when a dog is encountered and arm muscles need to be engaged to pet the dog, relevant frames (e.g., a *dog* frame) construct simulations consisting of sensorimotor system activation that reenacts the experience of petting. Taken together, frames and their simulations constitute "simulators", which are equivalent to concepts, and, in multitude, form a "situated simulation system". This simulation system is at the center of conceptual processing in both nonhumans and humans, and in the latter, is accompanied by a linguistic system which evolved from it as a means of controlling it.

Based on this description, it is clear that PSS shares features with DCT (see also Paivio, 2007, p. 118). For example, both posit sensorimotor/multimodal origins to conceptual processing, both incorporate separate systems for processing nonverbal/simulative and verbal/linguistic information, and both suggest that their nonverbal/simulation system serves as the evolutionary and developmental substrate for their verbal/linguistic system (Barsalou, 1999, p. 607; Paivio, 1986, p. 87-90, 2007, p. 279). But, considered more deeply, PSS and DCT are rather different. In DCT, information captured from the brain's modal systems is maintained as is in conceptual representations ("...DCT representations are isomorphic, holistic copies of modality-specific objects and events"; Paivio, 2007, p. 119). By contrast, in PSS, such information is readily parsed by selective attention and then integrated with other similar information before contributing to conceptual representations. Further, where both DCT's nonverbal and verbal systems partake in deep conceptual processing, PSS prioritizes in this regard its simulation system over what it sees as a more peripheral linguistic system (Barsalou, 2008, p. 622; see also upcoming discussion on Language and Situated Simulations).

Consequently, PSS makes different claims than does DCT about how abstract and concrete concepts are represented. Compared to DCT's asymmetrical representation across systems, PSS suggests that both types of concepts might be represented in a nonverbal/simulation system (Barsalou, 1999, 2008; Barsalou & Wiemer-Hastings, 2005). In that case, what distinguishes abstract from concrete concepts are different types of simulations (Barsalou & Wiemer-Hastings, 2005). Simulations related to abstract concepts might focus on introspective and setting/event properties of situations. For example, simulations related to 'true' might focus on "a speaker's claim, a listener's representation of the claim, and the listener's assessment of the claim" (Barsalou & Wiemer-Hastings, 2005, p .136). Simulations related to concrete concepts, on the other hand, might focus on critical objects and their properties[4]. For example, simulations related to 'dog' might focus on *paw* and *furry*. Consistent with these differences is the idea that abstract concept representations are more complex than concrete concept representations (Barsalou & Wiemer-Hastings, 2005).

Currently, the weight of evidence for PSS comes not from its predictions about the abstract/concrete distinction, but more general aspects of cognition and perception (see Barsalou, 2008, p. 623-631). However, evidence of the former type is accumulating. Barsalou and Wiemer-Hastings (2005) recorded participants as they verbally provided characteristics of three abstract concepts, three concrete concepts, and three concepts intermediate in concreteness for one minute. Recordings were transcribed and individual statements were

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[4] This claim is comparable to DCT's claim that some concrete concepts can be represented, at least partly, *as images* (Paivio, 2007, p. 120; Katz & Paivio, 1975).

assigned to one of five classes (and 45 subclasses): taxonomic, entity, introspective, setting/event, or miscellaneous. Assignment to the taxonomic class meant that the statement included a taxonomic relation to the concept, such as a subordinate (e.g., "seagulls" for the concept 'bird'). Assignment to the entity class meant that the statement described a property of a physical object, such as an external component (e.g., "beaks") or entity behavior (e.g., "chirping"). Assignment to the setting/event class meant that the statement described a property of a setting or event, such as a location (e.g., "(like) downtown areas"). Assignment to the introspective class meant that the statement described the mental state of an individual in a situation, such as an evaluation (e.g., "(can be like) annoying"). Assignment to the miscellaneous class meant that the statement was either a hesitation (e.g., "um") or a meta-comment (e.g., "and I think of") or that it repeated the concept or a previous statement. Analyses revealed that all three concept types focused on setting/event properties. However, in line with PSS, abstract concepts focused on setting/event and introspective properties more than did concrete concepts and concepts intermediate in concreteness. Furthermore, concrete concepts focused on entity properties more than did abstract concepts and concepts intermediate in concreteness. Finally, concepts intermediate in concreteness fell in between abstract and concrete concepts in their classes of focus. Wiemer-Hastings and Xu (2005) found comparable results in a similar study that used 18 abstract and 18 concrete concepts.

Another study providing evidence for PSS's claims about the abstract/concrete distinction—and one of particular relevance to this thesis because of its reliance on word association—was performed by Marques and Nunes (2012). In Experiment 1, *word association pairs* were selected from the University of South Florida free association norms (Nelson, McEvoy, & Schreiber, 1998; more on this in Section 2.2.1). Word association pairs are stimulus-response pairs (e.g., dog-paw) generated by presenting individuals with a stimulus word (e.g., dog) and instructing them to provide a response word (e.g., paw) (more on this in Sections 2.1 and 2.2.1). The particular word association pairs that were selected were the two most commonly produced pairs for each of 47 abstract and 47 concrete concepts (which served as stimulus words and were all nouns). Three independent coders assigned each word association pair to one of the following three classes based on the relationship of its stimulus and response words: linguistic, taxonomic, or object-situation. Assignment to the linguistic class meant that the response word was linguistically related to the stimulus word. For example, bee → hive, where the stimulus word and response word form a forward compound continuation. Assignment to the taxonomic class meant that the response word was taxonomically but not linguistically related to the stimulus word. For example, dog → animal, where the response word is a superordinate of the stimulus word. Assignment to the object-situation class meant that the response word was either a property or thematic/situational associate of the stimulus word that was not linguistically or taxonomically related to it. For example, bee → wings, where the response word is a property of the stimulus word. Furthermore, linguistic word association pairs were considered to come from a language-based system (akin to DCT's verbal system and PSS's linguistic system), and object-situation word association pairs were considered to come from a sensorimotor-based system (akin to DCT's verbal system and PSS's simulation system). Analyses of the codings revealed that object-situation word association pairs were produced with equal frequency for abstract and concrete concepts. Therefore, the authors concluded that abstract concepts are indeed represented in a sensorimotor-based (i.e., nonverbal/simulation) system—consistent with PSS, but not DCT. However, further analyses revealed that (1) linguistic word association pairs were produced more frequently for abstract than concrete concepts, and (2) linguistic word association pairs were produced more frequently than object-situation word association pairs for abstract concepts. Both of these findings clearly accord with DCT's claim about asymmetrical representation. All findings were replicated in Experiment 2, which used the same concepts (i.e., stimulus words) alongside newly collected response words.

While findings of the sort above are consistent with what PSS claims about abstract and concrete concept simulation, they provide no guarantee that simulation is in fact taking place. In theory, linguistic processing might be responsible for all or part of the observed results. This possibility is especially problematic for what PSS claims about abstract concepts, as there is little doubt that concrete concepts undergo nonlinguistic processing (the picture-word priming literature attests to this, e.g., Vanderwart, 1984). Accordingly, some recent studies have been aimed at examining the relationship between abstract concepts and nonlinguistic processing. For example, Wilson-Mendenhall, Simmons, Martin, and Barsalou (2013) had participants perform a concept-scene matching task involving abstract and concrete concepts while fMRI searched for activity in brain regions presumed responsible for nonlinguistic processing of those concepts. Such activity was indeed discovered for not only concrete but also abstract concepts. Another example comes from McRae, Nedjadrasul, Pau, Lo, and King (2017), who relied on picture-word and word-picture priming. In Experiment 1, participants made lexical decisions on abstract words that were preceded by either related or unrelated pictures of situations (e.g., 'share' preceded by a picture of two girls sharing a corn cob. Decision latencies for abstract words were shorter following related than unrelated pictures[5]. In the second experiment, participants made normalcy decisions (i.e., 'yes, normal' versus 'no, abnormal') to pictures depicting situations that were preceded by either related or unrelated words (e.g., two girls sharing a corn cob preceded by 'share'). Decision latencies for pictures depicting situations were shorter following related than unrelated abstract words. Presumably, because the individual elements appearing in the situation pictures (e.g., a corn cob) had no obvious semantic relations with the abstract words (e.g., 'share'), the results were not due to a mediation process (i.e., Paivio, 2007, p. 101-102) where, for example, abstract words (e.g., 'danger') activate concrete words (e.g., 'highway') that activate concrete nonverbal information (e.g., an image of a road sign) that leads to a response. Instead, it appears that abstract concepts are grounded directly in nonverbal information—consistent with PSS-style simulation.

[5] Note, this was the case when pictures were presented for 1000 but not 500 ms. The authors suggest that because pictures of situations are complex, time is required to process them.

In summary, PSS (Barsalou, 1999, 2008; Barsalou & Wiemer-Hastings, 2005) suggests that a simulation system is at the center of conceptual processing. Consequently, PSS makes different claims than does DCT about how abstract and concrete concepts are represented. Compared to DCT's asymmetrical representation across systems, PSS suggests that both types of concepts might be represented in a nonverbal/simulation system. In that case, what distinguishes abstract from concrete concepts are different types of simulations. Simulations related to abstract concepts might focus on introspective and setting/event properties of situations. In contrast, simulations related to concrete concepts might focus on critical objects and their properties. Empirical evidence supports (1) the existence of the simulation system, (2) the idea that the simulation system accounts for both abstract and concrete concepts, and (3) the idea that simulations related to abstract concepts focus on introspective and setting/event properties, whereas those related to concrete concepts focus on critical objects and their properties.

1.2.3 LANGUAGE AND SITUATED SIMULATIONS (LASS)

Language and Situated Simulations (Barsalou et al., 2008), rather than being a completely novel theory, extends PSS by explicating the role of the linguistic system. Note, however, that unlike PSS (and DCT and theories discussed later on), LASS is not directly motivated by the abstract/concrete distinction. We include it because of its connection to PSS and because it may have undiscovered implications related to the distinction (which we test). Borghi et al. (2017) make a similar observation:

> LASS theory is not specifically aimed at explaining abstract concepts. In principle, one could conclude from its principles that, while concrete concepts activate the simulation system, abstract concepts activate the linguistic one. However, this conclusion is not proposed by the LASS, even if [it] is consistent with its principles (Borghi et al., 2017, p. 275).

According to LASS, as a word is perceived (e.g., walnut), the linguistic system is activated in order to categorize the word's linguistic form (e.g., the auditory or visual instantiation of 'walnut'). As the linguistic form is categorized, it sets off a cascade of related and largely concurrent events. Depending on the task at hand, these may include simulation system activation intended to represent the linguistic form's deeper meaning (e.g., 'walnut' → someone cracking a walnut) as well as production of associated linguistic forms (e.g., 'walnut' → 'acorn'), which may *also* engage the simulation system (e.g., 'acorn' → a squirrel eating an acorn). There are two empirically important suggestions here. The first is that linguistic system activity peaks before simulation system activity when cues are words (Figure 2). This idea receives support from a study by Santos, Chaigneau, Simmons, and Barsalou (2011), which is discussed below. The second suggestion is that linguistic processing works on linguistic forms—e.g., spoken or written words—devoid of their perceptual referents, which are instead processed in the simulation system. In other words, linguistic processing is relatively superficial. Barsalou et al. (2008) point to work on lexical processing as evidence for this suggestion (p. 249-250). Note also that the description above concerns single word perception. When cues are phrases or sentences, the complexity of linguistic processing, simulations, and their interplay increases dramatically (Barsalou et al., 2008).

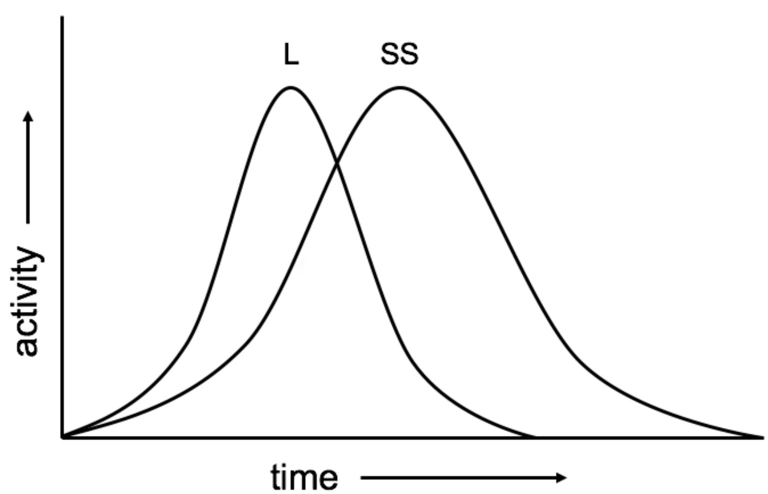

Figure 2. Linguistic system (L) activity precedes situated simulation system (SS) activity when conceptual processing is cued by words. Figure recreated from Barsalou et al. (2008, p. 248).

Evidence for LASS comes mainly from Santos et al. (2011), and relates to its time course predictions. In Experiment 1, participants were shown stimulus words and asked to provide response words based on what came to mind (i.e., they performed word association—specifically, *continuous association*; more on this in Sections 2.1 and 2.2.1). For example, shown the word 'dog', they may have responded 'animal' then 'cat' then 'terrier'. Response words were recorded and then assigned to one of three classes (and ten subclasses) based on their relationship with their stimulus word: linguistic, taxonomic, or object-situation[6]. Assignment to the linguistic class meant that the response word was linguistically related to the stimulus word. For example, bee → hive, where the stimulus word and response word form a forward compound continuation. Assignment to the taxonomic class meant that the response word was taxonomically, but not linguistically, related to the stimulus word. For example, dog → animal, where the response word is a superordinate of the stimulus word. Assignment to the object-situation class meant that the response word was either a property or situational associate of the stimulus word that was not linguistically or taxonomically related to it. For example, bee → wings, where the response word is a property of the stimulus word. Santos et al. analyzed response word positions (i.e., whether they were the first, second, third, etc. response word given) and response word classes. Linguistic response words (average response position of 1.61) preceded taxonomic response words (average response position of 2.03), which preceded object-situation response words (average response position of 2.47), verifying LASS's claim that linguistic system activity peaks prior to simulation system activity when cues are words. Worth noting is that taxonomic response words occupy a middle position between linguistic and object-situation response words. This implies that the linguistic and simulation system are co-responsible for them. In Experiment 2, participants performed a property generation task, which yielded results similar to Santos et al.'s Experiment 1.

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[6] This procedure was essentially the same as the earlier described procedure used by Marques and Nunes (2012). We choose to redescribe it here.

In summary, LASS (Barsalou et al., 2008) extends PSS by explicating the role of the linguistic system. In doing so, it makes two important suggestions. The first is that linguistic system activity peaks before simulation system activity when cues are words. The second is that the linguistic system works on linguistic forms devoid of their perceptual referents, which are instead processed in the simulation system. Both of these suggestions receive empirical support.

1.2.4 DIFFERENT REPRESENTATIONAL FRAMEWORKS (DRF)

Different Representational Frameworks (Crutch & Warrington, 2005, 2007, 2010) departs from the theories discussed so far in several ways. First, it is best characterized as a theory *about* abstract/concrete concept representation, rather than one that relies on abstract/concrete concept representation to substantiate more general claims about, for example, between-system (DCT) or within-system (PSS) mechanics of conceptual processing. Second, it proposes that different organizations—rather than distributions across systems (DCT) or simulations (PSS)—are what is responsible for differences in abstract and concrete concept representations. Specifically, whereas abstract concept representations are organized by semantic association, concrete ones are organized by semantic similarity. Third, it makes no assumptions about whether a single or multiple systems are involved in representing concepts; "in stipulating the importance of different types of representation, we have made no suggestion that these necessarily constitute separate systems" (Crutch & Warrington, 2010, p. 68). Fourth, it does not explicitly incorporate nonverbal/simulation-type and/or verbal/linguistic-type systems at all, although it does not rule them out (Crutch & Warrington, 2010):

> ...this hypothesis is not entirely incompatible with previous theories, particularly if, for example, the dual-coding theory's "verbal system" was reframed as an associative representational structure, and the sensory system was reframed as representations of similarity-based information (Crutch & Warrington, 2010, p. 47).

DRF's main claim is that "abstract words have a relatively greater dependence than concrete words upon representations of semantic association and that concrete words have a relatively greater dependence than abstract words upon representations of similarity-based information" (Crutch & Warrington, 2010, p. 47). Figure 3 depicts two possible relationships between concreteness and similarity/association consistent with this claim (Crutch & Warrington, 2010). In both cases, concreteness is positively correlated with semantic similarity, and negatively correlated with semantic association.

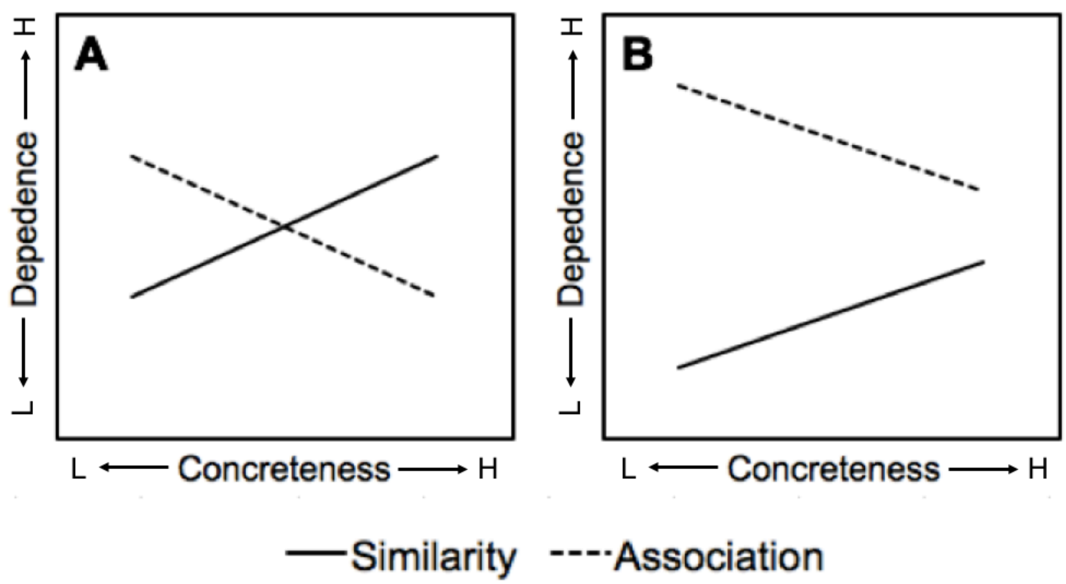

Figure 3. Two possible relationships between concreteness and semantic similarity/association consistent with DRF. Figure recreated from Crutch & Warrington (2010, p. 48).

Evidence for DRF comes largely from a series of neuropsychological studies by Crutch and Warrington. The first of these studies (Crutch & Warrington, 2005) utilized a semantic refractory access dysphasia patient on the premise that they would exhibit semantic interference effects due to a "sensitivity to the semantic relatedness of test stimuli" (Crutch & Warrington, 2005, p. 616). In Experiment 4 of the study, the patient was presented with arrays of (1A) semantically similar abstract words (e.g., array 1: boil, heat, cook, fry; array 2: look, peek, glance, see), (1B) controls produced by reorganizing words from across 1A arrays (e.g., array 1: boil, look, gale, clean; array 2: heat, peek, wind, eat), (2A) semantically similar concrete words (e.g., array 1: goose, crow, sparrow, pigeon; array 2:

cardigan, jacket, blouse, pullover), and (2B) controls produced by reorganizing words from across 2A arrays (e.g., array 1: goose, melon, pullover, biscuit; array 2: banana, cardigan, pizza, sparrow). As words from a given array were spoken by the experimenter, the patient was required to point to their written instantiations, until all words in the array had been spoken. Results revealed decreased correct responding for concrete, but not abstract, arrays as compared to controls, confirming one half of DRF's claim. Moreover, error rates increased with successive spoken words in all trials, implying a build-up of semantic interference. Experiment 5 used the same procedure as Experiment 4, except with test arrays organized by semantic association instead of semantic similarity, e.g., abstract: exercise, healthy, fitness, jogging; concrete: farm, cow, tractor, barn. Results revealed decreased correct responding for abstract, but not concrete, arrays compared to controls, confirming the other half of DRF's claim. A second neuropsychological study (Crutch & Warrington, 2007) tested a patient with deep-phonological dyslexia. Here, the patient was required to read arrays of concepts organized in a fashion similar to the previous study. Results again revealed an effect of semantic similarity upon processing of concrete, but not abstract, concepts, and an effect of semantic association upon processing of abstract, but not concrete, concepts. Notably, the effect here was a facilitation, rather than interference, effect. A third neuropsychological study (Crutch & Warrington, 2010) replicated the results from the previous two studies—i.e., interference during spoken word-written word matching and facilitation during word reading—with a global aphasic patient. DRF's claims have also been confirmed outside of neuropsychology. For example, using a visual world paradigm, Duñabeitia, Avilés, Afonso, Scheepers, and Carreiras (2009) found that abstract words draw more and quicker attention to pictures of semantically dissimilar associates (e.g., smell → picture of a nose) than do concrete words (e.g., crib → picture of a baby).

But despite the summarized findings, a number of studies have also failed to support DRF (e.g., Marques & Nunes, 2012; Zhang, Han, & Bi, 2013; Hill, Korhonen, & Bentz, 2014; Benko, 2015; Ferré, Guasch, García-Chico, & Sánchez-Casas, 2015). Among these, the aforementioned study by Marques and Nunes (2012) as well as a study by Hill et al. (2014)—because of their reliance on word association—are uniquely relevant to this thesis.

In Marques and Nunes' (2012) study, word association pairs were selected from the University of South Florida free association norms (Nelson et al., 1998). The particular word association pairs that were selected were the two most commonly produced pairs for each of 47 abstract and 47 concrete concepts (which served as stimulus words and were all nouns). Analyses performed on these pairs revealed that they more often exhibited semantic similarity (i.e., contained "synonyms, superordinates, category coordinates, and subordinates") when produced for abstract than concrete concepts, which is the exact opposite of what DRF predicts. Analyses also revealed that pairs more often exhibited semantic association (i.e., contained "thematic or situational associates and forward and backward completions") when produced for concrete than abstract concepts, again contradicting DRF. These results were replicated in a second experiment, which used the same concepts (i.e., stimulus words) alongside newly collected response words.

In Hill et al.'s (2014) study, word association pairs and their *forward association probabilities* were taken from the University of South Florida free association norms (Nelson et al., 1998). Forward association probabilities (also known as forward cue-to-target strengths) are probabilities of generating a given response word from a given stimulus word (more on this in Section 2.1). Each word association pair was assigned a score that reflected the semantic similarity of its stimulus and response words (based on their proximity in WordNet; Felbaum, 1998). A multiple regression with forward association probability as a dependent variable, and stimulus word concreteness rating, semantic similarity score, and their interaction as predictors was conducted to test the following DRF-inspired prediction:

> If concrete concepts are organized in the mind to a greater extent than abstract concepts according to similarity, then the associates of a given concrete concept should be more similar to that concept than the associates of a given abstract concept (Hill et al., 2014, p. 167-168).

What this prediction says, in other words, is that semantic similarity scores and forward association probabilities should pattern more similarly for a concrete stimulus word and its response words than for an abstract stimulus word and its response words.

Both semantic similarity and the interaction were significant positive predictors of forward association probability. However, because the interaction accounted for only a very minimal amount of variance in forward association probability over semantic similarity alone (i.e., less than 0.1%), the authors decided there was insufficient evidence for their prediction. That is, concrete concepts were not found to be more similar to their associates than abstract concepts.

In summary, DRF (Crutch & Warrington, 2005, 2007, 2010) departs from DCT and PSS in several ways. For example, it is best characterized as a theory *about* abstract/concrete concept representation, rather than one that relies on abstract/concrete concept representation to substantiate more general claims. DRF's main claim is that "abstract words have a relatively greater dependence than concrete words upon representations of semantic association and that concrete words have a relatively greater dependence than abstract words upon representations of similarity-based information" (Crutch & Warrington, 2010, p. 47). There exists empirical evidence both for and against this claim.

CHAPTER 2
USING WORD ASSOCIATION

2.1 WHY WE USE WORD ASSOCIATION

In word association, a stimulus word is presented to an individual who must then provide, based on what comes to mind, a response word (Jung, 1969; Nelson et al., 1998). For example, presented with 'walnut', an individual may respond 'acorn'. Because stimulus and response words are often conceptually—and not just associatively—related (McRae, Khalkhali, & Hare, 2012), word association may provide insight into how concepts are represented. Yet little work has drawn upon it in examining the abstract/concrete distinction.

The present study uses word association to test hypotheses related to the abstract/concrete distinction, each derived from one of the four theories discussed in Chapter 1. In doing so, it assumes—like the earlier discussed studies by Marques and Nunes (2012) and Hill et al. (2014)—that population-level word association statistics reflect how concepts are represented within individuals. It is unknown to what extent this assumption is justified, but word association statistics collected from populations have been found to correlate highly with those collected from individuals (Cofer, 1958).

2.2 HOW WE USE WORD ASSOCIATION

2.2.1 WORD ASSOCIATION PAIRS AND CONCEPTS

We relied on the University of South Florida Free Association norms (Nelson et al., 1998) for our word association data. The USF norms contain 5,019 stimulus words with roughly 750,000 associated response words. To obtain these data, over 6,000 participants performed a specific type of word association known as discrete association, which receives its name from the fact that participants provide only a single response word to each stimulus word (Nelson et al., 1998)[7]. In Nelson et al.'s (1998) discrete association task, participants were required to "write the first word that came to mind that was meaningfully related or strongly associated to the presented word".

The USF collection includes approximately thirty types of data, which are made available for all stimulus-response pairs—henceforth referred to as word association pairs—produced by at least two participants. The two-participant criterion was selected because idiosyncratic pairs are highly unreliable (Nelson et al., 1998). The present study uses the following five pieces of data: (1) *cue*[8], which refers to the stimulus word, e.g., walnut-acorn; (2) *target*, which refers to the response word, e.g., walnut-acorn; (3) *group size,* which refers to the number of participants presented with the stimulus word, e.g., 147 participants were shown walnut; (4) *forward cue-to-target strength (FSG)*, which refers to the quotient obtained from dividing the number of participants who produced the response word of the pair under consideration by its "group size", e.g., shown walnut, 2 (out of 147) participants wrote acorn, therefore the FSG of walnut-acorn is 2/147 = .014; and (5) *cue part-of-speech*, which refers to the dominant or only part of speech to which the stimulus word belongs, e.g., walnut is a noun.

We collected these data for 1764 word association pairs spanning 38 very abstract, 37 abstract, and 37 concrete concepts (i.e., cues; see Appendix A and B). The purpose of including two levels of abstract concepts was two-fold. First, we wanted to ensure adequate separation between abstract and concrete concepts, while at the same time covering a broad range of concreteness ratings. Had we included only an abstract and concrete group, we would risk missing an effect due to potentially inadequate separation between our abstract and concrete groups. Had we included only a very abstract and concrete group, we

[7] Discrete association is contrasted with continuous association, which has independent participants produce multiple responses to stimulus words (e.g., Santos et al., 2011). Continuous association can be problematic when subsequent responses are based on previous responses rather than on the stimulus word (i.e., "response chaining"; Nelson, McEvoy, & Dennis, 2000).

[8] "Cues" are cues to concepts. Therefore, we use the terms "cue" and "concept" interchangeably.

would be ignoring a large range of medium concreteness concepts. Second, we reasoned that we may gain insight into the *two-factor model of abstractness* (Wiemer-Hastings, Krug, & Xu, 2001), which says that:

> First, entities are abstract or concrete, depending on whether they are physical in nature (i.e., perceivable through vision, touch, etc.). Second, within these groups, abstractness varies according to more specific types of information (Wiemer-Hastings et al., 2001, p. 1134).

Evidence points to this model applying principally to abstract concepts, whose abstractness appears to vary according to introspective information (Wiemer-Hastings et al., 2001). That is, abstract concepts that are more abstract appear to be less constrained by introspective information.

To determine which specific concepts we would collect data for, we used two separate procedures; one for very abstract/abstract concepts and another for concrete concepts. Very abstract and abstract concepts began as a single group of concepts. These concepts were randomly selected from the USF database and then cross-referenced with Brysbaert et al. (2014) to ensure they had concreteness scores lower than 3.3 (out of max 5). We avoided concepts whose meanings we intuitively felt people might be unsure of. To create separate very abstract and abstract groups, we split the 75 concepts we collected based on their median concreteness score. This produced 38 very abstract concepts with concreteness scores from 1.25 to 2.13, and 37 abstract concepts with concreteness scores from 2.17 to 3.24.

Initially, we had planned to conduct supplementary analyses using the McRae, Cree, Seidenberg, and McNorgan norms (2005), and so our concrete concepts were chosen from across the various categories in those norms (e.g., animals, tools), with the constraint that they appear in the Nelson et al. (1998) norms. In one case, a plural form of a concept was selected from the McRae et al. (2005) norms but appeared only in its singular form in the Nelson et al. (1998) norms (i.e., boot). The concept was retained. This procedure worked out well as McRae et al. (2005) items tended to have high concreteness ratings, ensuring adequate separation from the abstract group. We collected a total of 34 concepts from the McRae et al. (2005) norms. To reach 37 concepts, three more were randomly selected from Nelson et al. (1998) and cross-referenced with Brysbaert et al. (2014) to ensure they had concreteness scores above 4 (max 5). Concreteness scores for our concrete concepts ranged from 4.11 to 5.00.

We compared our groups of concepts on several measures using univariate analyses with concept type (i.e., very abstract, abstract, and concrete) as a between-subjects factor. These included: group size, ln(frequency), familiarity ratings, and imageability ratings. A concept's group size refers to the number of participants that were presented with it in Nelson et al.'s (1998) word association norms. A concept's ln(frequency) refers to the natural logarithm of its number of occurrences in a given corpus—in this case, the $\text{SUBTLEX}_{\text{US}}$ corpus, which consists of 51 million words drawn from the subtitles of over 8000 movies and television shows (Brysbaert & New, 2009). A concept's familiarity refers to participants' assessments about how often it is seen, heard, or used (Gilhooly & Logie, 1980). Familiarity ratings were taken from the MRC psycholinguistic database (Coltheart, 1981). A concept's imageability refers to participants' assessments of the ease/difficulty with which the concept evokes a mental image such as a picture or sound (Paivio et al., 1968). Imageability ratings were taken from the MRC psycholinguistic database (Coltheart, 1981). Analyses of group size and ln(frequency) were based on all 112 concepts. Analyses of familiarity and imageability were based on the 106 and 107 concepts for which the MRC database contained familiarity and imageability ratings, respectively. Main effects indicating differences among concept types were found for ln(frequency), familiarity, and imageability, but not group size (Table 2).

Table 2. Results from univariate analyses conducted on several measures related to our concepts

Effect	*df*	*F*	*p*
Group Size	2, 109	1.575	.212
ln(frequency)	2, 109	**10.968	.000
Familiarity	2, 103	**5.717	.004
Imageability	2, 104	**189.950	.000

Note. * = p < .05, ** = p < .01

The main effect of concept type on ln(frequency) was assessed with LSD tests. Concrete concepts (*M* = 6.297, *SE* = 1.398) were less frequent than very abstract concepts (*M* = 7.494, *SE* = 1.596), $p = .001$, and abstract concepts (*M* = 7.852, *SE* = 1.486), $p < .001$. Very abstract and abstract concepts did not differ, $p = .302$. We save the implications of these findings for the General Discussion.

The main effect of concept type on familiarity was also assessed with LSD tests. Concrete concepts (*M* = 531.147, *SE* = 49.047) were rated as less familiar than very abstract concepts (*M* = 550.541, *SE* = 29.064), $p = .028$, and abstract concepts (*M* = 560.514, *SE* = 28.994), $p = .001$. We save the implications of these findings for the General Discussion. However, note that the difference in familiarity between concrete concepts and the two sets of abstract concepts was small; approximately 20 to 30 on a 700-point scale. In addition, all three concepts types produced generally high ratings. In fact, the least familiar words used in our study were canoe and saxophone. Therefore, it appears that participants were quite familiar with all 112 concepts, as intended. Very abstract and abstract concepts did not differ in familiarity, $p = .251$.

The main effect of concept type on imageability was also assessed with LSD tests. Concrete concepts (*M* = 604.735, *SE* = 26.513) were rated as more imageable than both very abstract concepts (*M* = 341.946, *SE* = 58.676), $p < .001$, and abstract concepts (*M* = 398.694, *SE* = 79.110), $p < .001$. Furthermore, abstract concepts were rated as more imageable than very abstract concepts, $p < .001$. The main effect of concept type on imageability was expected because concreteness and imageability ratings tend to be correlated, as was the case with our data, r = .875, $p < .001$. In fact, both have been used in past research to distinguish between abstract and concrete concepts (e.g., Binder et al., 2005).

We also examined how parts of speech were distributed within our three concept types. Among our 38 very abstract concepts, 14 were nouns, 8 were verbs, and 16 were adjectives. Among our 37 abstract concepts, 15 were nouns, 8 were verbs, 13 were adjectives, and 1 was an adverb. Among our 37 concrete concepts, 36 were nouns and 1 was a verb. These distributions appear to mirror, at least roughly, natural distributions of parts of speech across levels of concreteness. We save the implications of these findings for the General Discussion.

2.2.2 CLASSES, SYSTEMS, AND TYPES OF RELATIONS

Using a scheme modified from Wu and Barsalou (2009; Appendix C), two independent coders assigned each word association pair to one of the following "classes" based on the relationship between its cue and target (see Appendix B): categorical, entity-based, introspective, lexical, or situational. The categorical class contained word association pairs in which targets were categorically related to the cue in various ways. This included, for example, superordinates as in 'drum-instrument', or categorical coordinates as in 'walnut-acorn'. The entity-based class contained pairs in which targets were concrete entity properties of cues. This included, for example, external surface properties as in 'bed-soft', or internal components as in 'apple-core'. The introspective class contained pairs in which targets were mental states related to cues. This included, for example, emotional states as in 'relief-happy', or evaluations as in 'challenge-difficult'. The lexical class contained pairs in which targets were purely lexical associates of cues. This included, for example, morphological associates as in 'luck-lucky', or forward compound continuations as in 'relief-fund'. Finally, the situational class contained pairs in which targets were related to cues through situations or types of events. This included, for example, actions as in 'crisis-cry', or people as in 'advice-mother'. Coders had the option of skipping word association pairs if they felt that the scheme did not accommodate them.

A third coder resolved discrepancies between the two initial coders, and provided class assignments for any word association pairs that were skipped. The third coder then reviewed all resolved assignments and made any changes that were considered necessary. Of the 1764 resolved assignments, 363 were changed before being finalized. In this way, assignments were ultimately up to the third coder's discretion, although they may have been inspired by the initial coders. We use classes primarily to test predictions based on PSS, which follows from earlier work having done so successfully in conjunction with both property generation (e.g., Barsalou & Wiemer-Hastings, 2005; Wiemer-Hastings & Xu, 2005) and word association (Marques & Nunes, 2012). Additionally, we use classes as shortcuts for assigning word association pairs to DCT and PSS/LASS systems, which we discuss next.

Each word association pair was assigned to the nonverbal/simulation system, verbal/linguistic system, or both. Note that DCT and PSS/LASS systems were combined because we assumed that the nonverbal and simulation systems as well as the verbal and linguistic systems would give rise to equivalent word association pairs. Marques and Nunes (2012) make a similar assumption when discussing their results (p. 1273). We feel this is a natural assumption, given that both the nonverbal and simulation systems process sensorimotor/perceptual information, and both the verbal and linguistic systems process language-based information.

Initially, assignments of word association pairs to systems were based on experimenter intuition about which systems were responsible for the production of their targets[9]. Because we assumed overlap between classes and systems, assignments were made using the following rules/shortcuts: (1) categorical word association pairs belong to the verbal/linguistic system, (2) entity-based word association pairs belong to the nonverbal/simulation system, (3) introspective word association pairs belong to the nonverbal/simulation system, (4) lexical word association pairs belong to the verbal/linguistic system, and (5) situational word association pairs belong to the nonverbal/simulation system. We later decided to generate a second, more empirical, set of assignments that considered Santos et al.'s (2011) finding in which taxonomic (i.e., categorical)

[9] When we say that a system is responsible for a target, we mean that it is the system primarily responsible for the choice of the target, not the last system to be active prior to the response. All targets, because they are words, must ultimately pass through the verbal/linguistic system. However, that does not mean that the verbal/linguistic system is always the main determinant of the target.

target positions on a continuous word association task fell halfway between linguistic (i.e., lexical) and object-situation (i.e., entity-based and situational) target positions. Here, assignments were made using these rules/shortcuts instead: (1) categorical word association pairs belong equally to both systems, (2) entity-based word association pairs belong to the nonverbal/simulation system, (3) introspective word association pairs belong to the nonverbal/simulation system, (4) lexical word association pairs belong to the verbal/linguistic system, and (5) situational word association pairs belong to the nonverbal/simulation system. We considered dropping our intuition-based assignments and analyzing only the more empirical Santos-based assignments. However, because the two sets differed in only one respect (i.e., how categorical word pairs were treated), they could be easily contrasted, and so we decided to analyze both. Therefore, we make a distinction between system^{santos} and system^{intuit}. We use systems to test predictions based on DCT, PSS, and LASS, which follows from earlier work having done so successfully (Marques and Nunes, 2012; Santos et al., 2011).

Finally, each word association pair was labeled according to the semantic relation of its cue and target (i.e., "type of relation"; see Appendix B) which could be either semantically similar (i.e., cues and targets have similar meanings), or semantically associated (i.e., cues and targets have different but associated meanings). These labels relied on the subclasses in the scheme modified from Wu and Barsalou (2009; see Appendix C). Inspired by Crutch and Warrington's (2005, 2007) stimuli, we labeled word association pairs with synonymous, similar, and coordinate cues and targets as semantically similar, and all other word association pairs as semantically associated. Note that, unlike Marques and Nunes (2012), we did not label pairs with subordinate or superordinate cues and targets as semantically similar. We felt that Crutch and Warrington's stimuli (2005, 2007) gave little indication to do so. We use types of relation to test predictions based on DRF, which follows from earlier work having done so successfully (e.g., Crutch & Warrington, 2005, 2007, 2010).

2.2.3 DEPENDENT VARIABLES

There were two main dependent variables in our study. The first was the number of unique word association pairs assigned to a given class, system, or type of relation, produced for a given concept, with the constraint that only pairs produced by at least two participants were considered. Two different procedures were used to obtain this variable depending on whether unique word association pairs under consideration were assigned to a given (1) class, system^{intuit}, or type of relation, or (2) system^{santos}. The procedure for obtaining numbers of unique word association pairs assigned to a given class, system^{intuit}, or type of relation produced for a given concept consisted simply of counting them. For example, there were eight unique word association pairs assigned to the categorical class (in short, eight unique categorical word association pairs) produced for 'walnut'. The procedure for obtaining numbers of unique word association pairs assigned to a given system^{santos} was more involved. First, we counted the number of unique non-categorical word association pairs assigned to a given system^{santos} produced for a given concept. For example, seven unique non-categorical word association pairs assigned to the nonverbal/simulation^{santos} system were produced for 'walnut'. Then, we counted the number of unique categorical word association pairs assigned to that same system^{santos} produced for that same concept, and divided this value by two (i.e., to reflect partial dependence on each system, as per section 2.2.2). For example, eight unique categorical word association pairs assigned to the nonverbal/simulation^{santos} system were produced for 'walnut', which divided by two, equals four such pairs. Finally, we summed the non-categorical and categorical pairs. For example, seven plus four equals eleven unique word association pairs assigned to nonverbal/simulation^{santos} system (in short, eleven unique nonverbal/simulation^{santos} word association pairs) produced for 'walnut'.

The second dependent variable was the proportion of participants who produced word association pairs assigned to a given class, system, or type of relation, for a given concept, with the constraint that only pairs produced by at least two participants were considered. As with the first dependent variable, two different procedures were used to obtain this variable depending on whether word association pairs under consideration were assigned to a given (1) class, system^{intuit}, or type of relation, or (2) system^{santos}. The procedure for obtaining the proportion of participants who produced word association pairs assigned to a given class, system^{intuit}, or type of relation, for a given concept, consisted of summing appropriate FSGs. For example, the three unique word association pairs assigned to the entity-based class produced for 'walnut' had FSGs of .02, .014, and .014 = .048, indicating that 4.8% of participants produced word association pairs assigned to the entity-based class for 'walnut' (in short, 4.8% of participants produced entity-based word association pairs for 'walnut'). The procedure for obtaining the proportion of participants who produced word association pairs assigned to a given system^{santos} for a given concept was more involved. First, we summed the FSGs of unique non-categorical word association pairs assigned to a given system^{santos} produced for a given concept. For example, .088 + .048 + .048 + .02 + .014 + .014 + .014 = .246 for the seven unique non-categorical word association pairs assigned to the nonverbal/simulation^{santos} system produced for 'walnut'. Then, we summed the FSGs of unique categorical word association pairs assigned to that same system^{santos} produced for that same concept, and divided this value by two (i.e., to reflect partial dependence on each system, as per section 2.2.2). For example, (.204 + .17 + .095 + .041 + .02 + .014 + .014 + .014) / 2 = .286 for the eight unique categorical word association pairs assigned to the nonverbal/simulation^{santos} system produced for 'walnut'. Finally, we summed the non-categorical and categorical summed FSGs. For example, .246 plus .286 equals .532, indicating that 53.2% of participants produced word association pairs assigned to the nonverbal/simulation^{santos} system for 'walnut' (in short, 53.2% of participants produced nonverbal/simulation^{santos} word association pairs for 'walnut').

Note that while we refer to our second dependent variable as "the proportion of participants...", it is more accurately an "estimation of the proportion of participants...". This is because it excludes FSGs for idiosyncratic word association pairs in its calculation, which if included may increase its value.

Admittedly, analyses conducted on proportions that consider FSGs of idiosyncratic word association pairs may offer different results than what we present. This is especially the case for analyses that compare across concept types, because proportions of participants who produced non-idiosyncratic word association pairs were, on average, smaller for very abstract (*M* = .745, *SE* = .011) and abstract (*M* = .766, *SE* = .015) concepts than for concrete concepts (*M* = .871, *SE* = .011).

We include both of these dependent variables, rather than one or the other, because it is unknown which is a more accurate approximation of conceptual representation (be that in general or with respect to a specific class, system, or type of relation). It is sensible to assume that a word association pair produced by a large number of participants lends greater insight into how a concept is represented than does a word association pair generated by only a few participants. However, there is no assurance that this is actually the case. Consider, for example, that fork is a more frequent target for knife than is cut. It is hard to imagine that a fork is more central to the meaning of knife than is the act of cutting. Deese (1965) provides relevant commentary (albeit in the context of data collected from continuous association tasks):

> ...the concept of associative strength seems misapplied to structures of meaning for individuals. Strength, or more precisely, frequency, has an important meaning when one considers populations of individuals and when one wishes to characterize the general meanings of words existing within that population. A meaning possessed by a single individual ought to have less influence in the description of the generalized meaning for the population than a meaning shared by a number of individuals. For a single individual, however, either a word is part of the associative meaning for another word or it is not. To be sure, meanings will fluctuate both systematically and quasi-randomly in time, but in the determination at any given time either a meaning is there or it is not (Deese, 1965, p. 175).

Finally, as a point of reference, we include figures that compare the average values of our dependent variables assigned to each class (Figure 4), system (Figure 5), and type of relation (Figure 6), for each concept type.

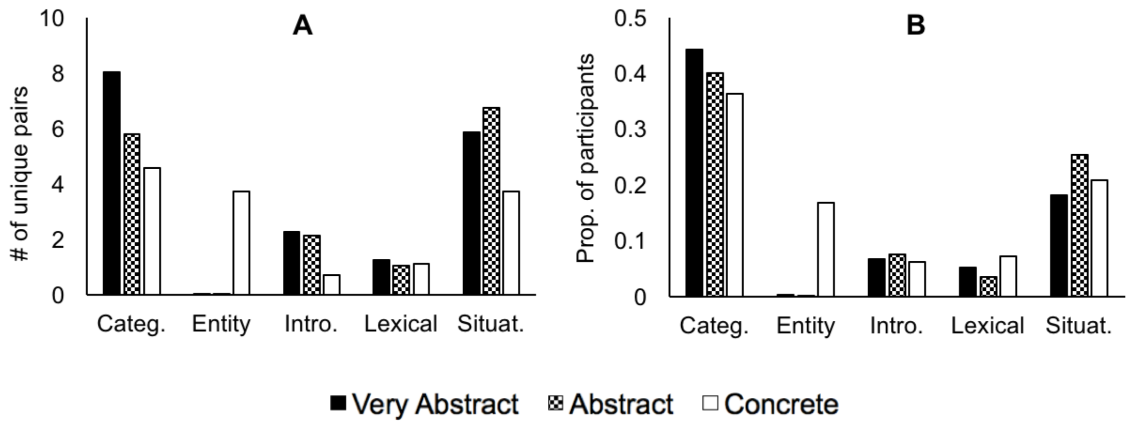

Figure 4. Average number of unique word association pairs produced for each class (Panel A) and average proportion of participants who produced word association pairs for each class (Panel B).

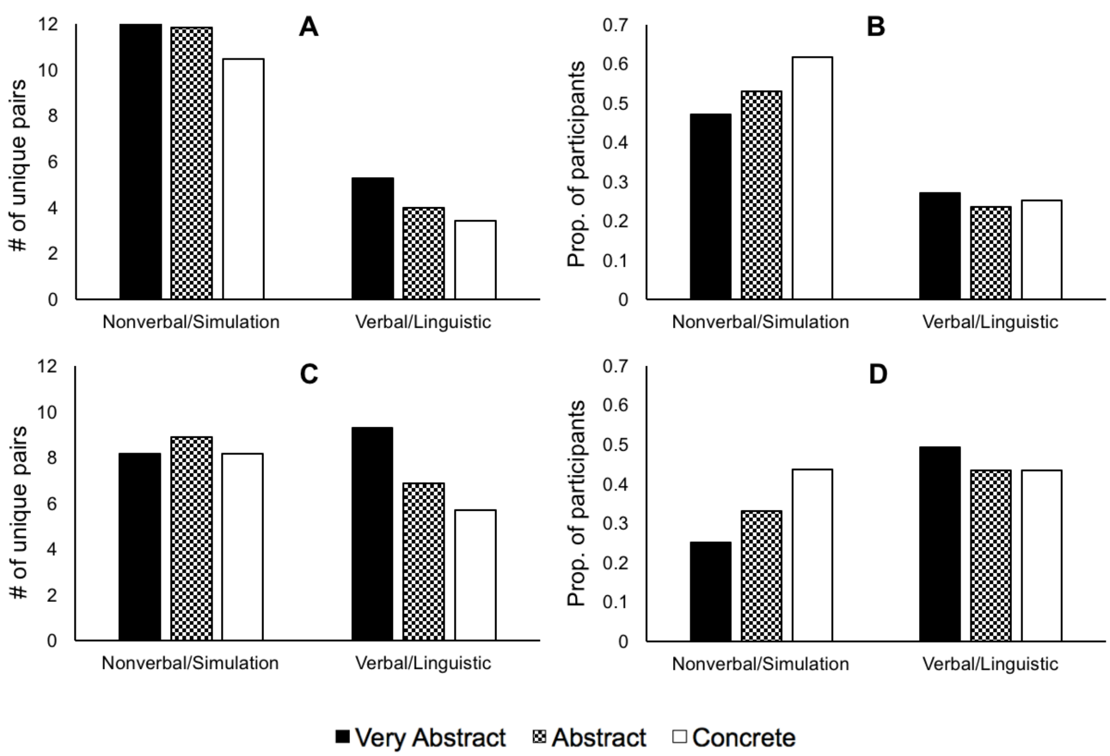

Figure 5. Average number of unique word association pairs produced by each system^{santos} (Panel A) and system^{intuit} (Panel C), and average proportion of participants who produced word association pairs using each system^{santos} (Panel B) and system^{intuit} (Panel D).

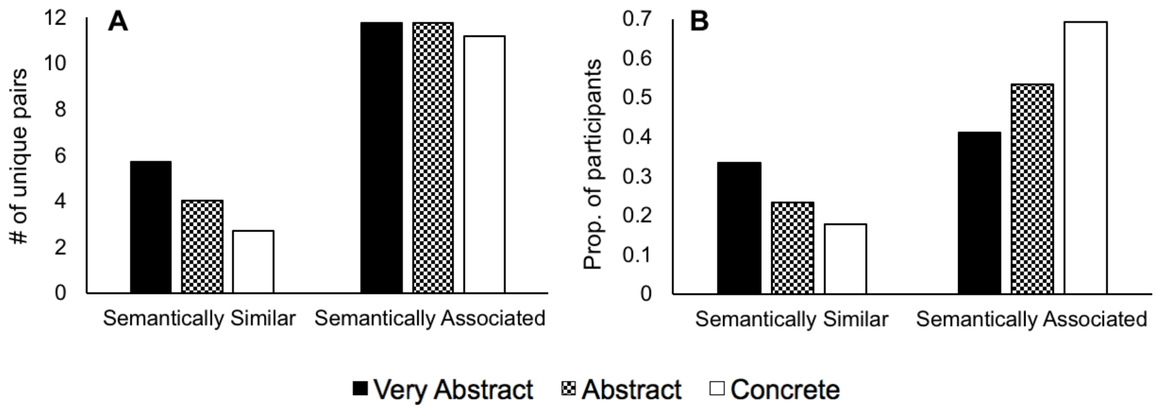

Figure 6. Average number of unique word association pairs produced containing each type of relation (Panel A) and average proportion of participants who produced word association pairs containing each type of relation (Panel B).

CHAPTER 3
TESTING THE THEORIES

3.1 TESTING DUAL CODING THEORY (DCT)

3.1.1 HYPOTHESES AND PREDICTIONS

Dual Coding Theory (Paivio, 1986, 2007) argues that abstract concepts are represented in the verbal but not the nonverbal system, whereas concrete concepts are represented in both. Based on this idea, we generated the predictions shown in Table 3, which are repeated using systems^{santos} (P1-P8) and systems^{intuit} (P9-P16). These particular predictions were generated because they represent the simplest predictions that follow logically from DCT. We avoided, for example, the prediction that "larger numbers of unique verbal/linguistic word association pairs were produced for very abstract than concrete concepts" because, despite its simplicity, it does not follow logically from DCT[10].

Table 3. Predictions based on DCT (P1-P16)

Prediction #	*Prediction*
P1, P9	Larger numbers of unique nonverbal/simulation word association pairs were produced for concrete than very abstract concepts.
P2, P10	Larger numbers of unique nonverbal/simulation word association pairs were produced for concrete than abstract concepts.
P3, P11	Larger numbers of unique verbal/linguistic than nonverbal/simulation word association pairs were produced for very abstract concepts.
P4, P12	Larger numbers of unique verbal/linguistic than nonverbal/simulation word association pairs were produced for abstract concepts.
P5, P13	Larger proportions of participants produced nonverbal/simulation word association pairs for concrete than very abstract concepts.
P6, P14	Larger proportions of participants produced nonverbal/simulation word association pairs for concrete than abstract concepts.
P7, P15	Larger proportions of participants produced verbal/linguistic than nonverbal/simulation word association pairs for very abstract concepts.
P8, P16	Larger proportions of participants produced verbal/linguistic than nonverbal/simulation word association pairs for abstract concepts.

[10] DCT's hypotheses do not imply that abstract concepts receive greater representation in the verbal system than do concrete concepts—only that they receive greater representation in the verbal system *relative to the nonverbal system* than do concrete concepts.

3.1.2 ANALYSES AND RESULTS

A 3 (concept type: very abstract, abstract, concrete) x 2 (system^{santos}: nonverbal/simulation^{santos}, verbal/linguistic^{santos}) repeated measures ANOVA was conducted using numbers of unique system^{santos} word association pairs produced. Unrelated to our predictions, we found main effects of system^{santos}, *F*(1, 109) = 314.830, *p* < .001. and concept type, *F*(2, 109) = 5.393, *p* = .006. The main effect of system^{santos} was due to larger numbers of unique nonverbal/simulation^{santos} (*M* = 11.509) than verbal/linguistic^{santos} (*M* = 4.241) pairs produced. The main effect of concept type was due to larger numbers of unique pairs produced per system for very abstract concepts (*M* = 8.737) than concrete concepts (*M* = 6.959), TUKEY HSD: *p* < .01. Related to our predictions, we failed to find a system^{santos} x concept type interaction, *F*(2, 109) = 0.486, *p* = .616. This interaction would have signaled the possibility that different numbers of unique nonverbal/simulation^{santos} pairs were produced between at least two concept types, consistent with predictions 1 and 2. It would also have signaled the possibility that different numbers of unique nonverbal/simulation^{santos} and verbal/linguistic^{santos} pairs were produced within at least one concept type, consistent with predictions 3 and 4. Predictions 1-4 were, therefore, unconfirmed.

A 3 (concept type) x 2 (system^{santos}) repeated measures ANOVA was conducted using proportions of participants who produced system^{santos} word association pairs. Unrelated to our predictions, we found main effects of system^{santos}, *F*(1, 109) = 176.728, *p* < .001, and concept type, *F*(2, 109) = 30.389, *p* < .001. The main effect of system^{santos} was due to larger proportions of participants producing nonverbal/simulation^{santos} (*M* = .540) than verbal/linguistic^{santos} (*M* = .254) pairs. The main effect of concept type was due to larger proportions of participants producing pairs per system for concrete concepts (*M* = .436) than very abstract concepts (*M* = .373), TUKEY HSD: *p* < .01, as well as abstract concepts (*M* = .383), TUKEY HSD: *p* < .01. Related to our predictions, we found a system^{santos} x concept type interaction, *F*(2, 109) = 4.961, *p* = .009. This interaction signaled the possibility that proportions of participants who produced nonverbal/simulation^{santos} pairs differed between at least two concept types, consistent with predictions 5 and 6. It also signaled the possibility that proportions of participants who produced nonverbal/simulation^{santos} and verbal/linguistic^{santos} pairs differed within at least one concept type, consistent with predictions 7 and 8. Accordingly, TUKEY tests were conducted on the interaction. Predictions 5 and 6 were confirmed. Larger proportions of participants produced nonverbal/simulation^{santos} pairs for concrete concepts ($M = .618$) than for both very abstract concepts ($M = .473$), TUKEY HSD: $p < .01$, and abstract concepts ($M = .530$), TUKEY HSD: $p < .01$. Predictions 7 and 8, however, were unconfirmed. In fact, larger proportions of participants produced nonverbal/simulation^{santos} than verbal/linguistic^{santos} pairs for very abstract concepts ($M = .473$ versus $M = .272$), TUKEY HSD: $p < .01$, as well as abstract concepts ($M = .530$ versus $M = .236$), TUKEY HSD: $p < .01$.

A 3 (concept type) x 2 (system^{intuit}) repeated measures ANOVA was conducted using numbers of unique system^{intuit} word association pairs produced. Unrelated to our predictions, we found a main effect of system^{intuit}, $F(1, 109) = 4.258$, $p = .041$, as well as a previously seen main effect of concept type. The main effect of system^{intuit} was due to larger numbers of unique nonverbal/simulation^{intuit} ($M = 8.429$) than verbal/linguistic^{intuit} ($M = 7.321$) pairs. Related to our predictions, we found a system^{intuit} x concept type interaction, $F(2, 109) = 4.265$, $p = .016$. This interaction signaled the possibility that different numbers of unique nonverbal/simulation^{intuit} word association pairs were produced between at least two concept types, consistent with predictions 9 and 10. It also signaled the possibility that different numbers of unique nonverbal/simulation^{intuit} and verbal/linguistic^{intuit} word association pairs were produced within at least one concept type, consistent with predictions 11 and 12. Accordingly, TUKEY tests were conducted on the interaction. Predictions 9 and 10 were unconfirmed. It was not the case that larger numbers of unique nonverbal/simulation^{intuit} word association pairs were produced for concrete concepts ($M = 8.189$) than for very abstract concepts ($M = 8.184$) or abstract concepts ($M = 8.919$). Predictions 11 and 12 were also unconfirmed. It was not the case that larger numbers of unique verbal/linguistic^{intuit} than nonverbal/simulation^{intuit} word association pairs were produced for very abstract concepts (*M* = 9.289 versus *M* = 8.184) or abstract concepts (*M* = 6.892 versus *M* = 8.919).

A 3 (concept type) x 2 (system^{intuit}) repeated measures ANOVA was conducted using proportions of participants who produced system^{intuit} word association pairs. Unrelated to our predictions, we found a main effect of system^{intuit}, *F*(1, 109) = 8.980, *p* = .003, as well as a previously seen main effect of concept type. The main effect of system^{intuit} was due to larger proportions of participants producing nonverbal/simulation^{intuit} (*M* = .455) than verbal/linguistic^{intuit} (*M* = .339) word association pairs. Related to our predictions, we found a system^{intuit} x concept type interaction, *F*(2, 109) = 3.417, *p* = .036. This interaction signaled the possibility that proportions of participants who produced nonverbal/simulation^{intuit} word association pairs differed between at least two concept types, consistent with predictions 13 and 14. It also signaled the possibility that proportions of participants who produced nonverbal/simulation^{intuit} and verbal/linguistic^{intuit} word association pairs differed within at least one concept type, consistent with predictions 15 and 16. Accordingly, TUKEY tests were conducted on the interaction. Prediction 13, but not 14, was confirmed. Larger proportions of participants produced nonverbal/simulation^{intuit} word association pairs for concrete concepts (*M* = .437) than for very abstract concepts (*M* = .251), TUKEY HSD: *p* < .01, but not abstract concepts (*M* = .330). Similarly, prediction 15, but not 16, was confirmed. Larger proportions of participants produced verbal/linguistic^{intuit} than nonverbal/simulation^{intuit} word association pairs for very abstract concepts (*M* = .494 versus *M* = .251), TUKEY HSD: *p* < .01, but not abstract concepts (*M* = .436 versus *M* = .330).

3.1.3 DISCUSSION

Table 4 summarizes all of the predictions based on DCT, as well as the state of evidence for or against them. None of the predictions tested using numbers of unique word association pairs produced were confirmed. In contrast, several of the predictions tested using proportions of participants who produced word

Table 4. Summary of evidence for DCT predictions (P1-P16)

Predictions	*Evidence*	*Predictions*	*Evidence*
#s of unique pairs (system^{santos})		*#s of unique pairs (system^{intuit})*	
P1 NV/S: C > VA	No	P9 NV/S: C > VA	No
P2 NV/S: C > A	No	P10 NV/S: C > A	No
P3 VA: V/L > NV/S	No	P11 VA: V/L > NV/S	No
P4 A: V/L > NV/S	No	P12 A: V/L > NV/S	No
Proportions of participants (system^{santos})		*Proportions of participants (system^{intuit})*	
P5 NV/S: C > VA	Yes	P13 NV/S: C > VA	Yes
P6 NV/S: C > A	Yes	P14 NV/S: C > A	No
P7 VA: V/L > NV/S	Opposite (VA: V/L < NV/S)	P15 VA: V/L > NV/S	Yes
P8 A: V/L > NV/S	Opposite (A: V/L < NV/S)	P16 A: V/L > NV/S	No

Note. VA = Very Abstract, A = Abstract, C = Concrete, NV/S = Nonverbal/Simulation, V/L = Verbal/ Linguistic

association pairs were confirmed. This discrepancy might indicate that proportions of participants who produced word association pairs are more sensitive measures of conceptual representation than are numbers of unique word association pairs produced. Focusing on proportions of participants, we see that several analogous analyses using systems^{santos} and systems^{intuit} give conflicting results (i.e., P6 and P14, P7 and P15, and P8 and P16). First, analyses using systems^{santos} (P6) revealed that larger proportions of participants produced nonverbal/simulation word association pairs for concrete than abstract concepts, whereas analyses using systems^{intuit} (P14) failed to reveal this. Second, analyses using systems^{santos} (P7) revealed that larger proportions of participants produced nonverbal/simulation than verbal/linguistic word association pairs for very abstract concepts, whereas analyses using systems^{intuit} (P15) revealed the opposite (which was the prediction). Third, analyses using systems^{santos} (P8) revealed that larger proportions of participants produced nonverbal/simulation than verbal/linguistic word association pairs for abstract concepts, whereas analyses using systems^{intuit} (P16) failed to reveal this (or the opposite, which was the prediction). We offer two explanations for these results.

The first explanation assumes that systems^{santos} are accurate in the extent to which they assign categorical word association pairs to the verbal/linguistic system. In this case, the observed results may be due to predictions 7 and 8 overlooking the role of mediation processes in DCT (see Paivio, 2007, p. 101-102). Possibly, that analyses for P7 and P8 revealed significant results in the direction opposite to that expected was due to the following mediation process: (1) abstract concept verbal information activates concrete concept verbal information (e.g., cue/word: danger → word: highway), (2) concrete concept verbal information activates concrete concept nonverbal information (e.g., word: highway → image: a sign), (3) concrete concept nonverbal information activates concrete concept verbal information (e.g., image: a sign → word: sign), (4) concrete concept verbal information initiates a response (e.g., word: sign → target/word: sign). However, cases such as "danger → sign" appear to be rare in our data. Moreover, it is difficult to tell if reaction time findings are consistent with this process. Paivio, Clark, Digdon, and Bons (1989) found that it took around 1.1 seconds for words to be imaged (i.e., for the verbal system to activate the nonverbal system and produce a behavioral response). This is less than, for example, the 1.6 second average word association reaction time found by Wallenhorst (1965)[11], and so the mediation process above is not ruled out. However, most of the words in Paivio et al. (1989) were object words (i.e., concrete). Because starting with concrete words effectively skips step 1, 1.1 seconds is probably an underestimation of how long the process takes. In reality, it might take longer than 1.6 seconds. Finally, whether a mediation process is even tenable is unknown. For example, the earlier discussed findings linking abstract concepts directly to nonverbal processing (e.g., Wilson-Mendenhall et al., 2013; McRae et al., 2017) make such a process redundant.

The second explanation assumes that systems^{intuit} are accurate in the extent to which they assign categorical word association pairs to the verbal/linguistic system. In this case, a real difference between very abstract and abstract concept representation may account for the fact that (1) larger proportions of participants produced nonverbal/simulation^{intuit} word association pairs for concrete than very abstract (P13), but not abstract (P14), concepts, and (2) larger proportions of participants produced verbal/linguistic^{intuit} than

[11] It is also less than Jung's finding of a 1.95 second average for *universal* concepts, for which no description is given but which are contrasted with concrete concepts (*M* = 1.67 seconds) and presumably similar to abstract concepts (Jung, 1969, p. 235).

nonverbal/simulation$^{\text{intuit}}$ word association pairs for very abstract (P15), but not abstract (P16), concepts. This is in line with the two-factor model of abstractness, which says that there is a distinction between different types of abstract concepts (Wiemer-Hastings et al., 2001).

3.2 TESTING PERCEPTUAL SYMBOL SYSTEMS (PSS)

3.2.1 HYPOTHESES AND PREDICTIONS

In contrast to DCT, PSS argues that abstract concepts *are* represented in a nonverbal/simulation system (Barsalou, 1999, 2008). Furthermore, PSS argues that the focus in this system might be different for abstract and concrete concepts (Barsalou & Wiemer-Hastings, 2005). Simulations related to abstract concepts might focus on introspective and setting/event properties of situations, whereas those related to concrete concepts might focus on critical objects and their properties. Accordingly, we generated the predictions in Table 5, which use systems$^{\text{intuit}}$ (P17-18, P22-23) and classes (P19-21, P24-26). In generating these predictions, we assumed that simulations of introspective properties and critical objects/their properties produced word association pairs from the introspective and entity-based classes, respectively. We generated predictions 17, 18, 22, and 23 because they test the most basic assumption that distinguishes PSS from DCT. Note that these predictions used systems$^{\text{intuit}}$ but not systems$^{\text{santos}}$. This is because they address only the nonverbal/simulation system, and systems$^{\text{intuit}}$ offer the most conservative definition of this system. Any significant results hold for systems$^{\text{santos}}$. We generated the rest of our predictions with the goal of making within-concept type comparisons to contrast with Barsalou and Wiemer-Hastings (2005) between-concept type comparisons. This required interpreting the term "focus" in a specific way. Now, for simulations related to a given concept type (e.g., abstract) to *focus* on a given property type (e.g., introspective), all that was required was that said property type (e.g., introspective) be more important to said simulations than *at least one other* property type (e.g., entity-based).

Accordingly, we planned to compare *pairs* of classes. We left out comparisons involving the categorical and lexical classes because we characterize their word association pairs as belonging only partly, or else not at all, to the simulation system. We also left out comparisons involving the situational class because: (1) we wanted to limit our already large number of predictions, and (2) Barsalou and Wiemer-Hastings (2005) found setting/event (i.e., situational) properties to dominate every concept type, so using them would be unlikely to teach us anything new. Therefore, we were left with one comparison per concept type, each involving introspective and entity-based classes.

Table 5. Predictions based on PSS (P17-P26)

Prediction #	*Prediction*
P17	More than zero unique nonverbal/simulation word association pairs were produced for very abstract concepts.
P18	More than zero unique nonverbal/simulation word association pairs were produced for abstract concepts.
P19	Larger numbers of unique introspective than entity-based word association pairs were produced for very abstract concepts.
P20	Larger numbers of unique introspective than entity-based word association pairs were produced for abstract concepts.
P21	Larger numbers of unique entity-based than introspective word association pairs were produced for concrete concepts.
P22	Non-zero proportions of participants produced nonverbal/simulation word association pairs for very abstract concepts.
P23	Non-zero proportions of participants produced nonverbal/simulation word association pairs for abstract concepts.
P24	Larger proportions of participants produced introspective than entity-based word association pairs for very abstract concepts.
P25	Larger proportions of participants produced introspective than entity-based word association pairs for abstract concepts.
P26	Larger proportions of participants produced entity-based than introspective word association pairs for concrete concepts.

3.2.2 ANALYSES AND RESULTS

A one-sample t-test was conducted using numbers of unique nonverbal/simulation^{intuit} word association pairs for very abstract concepts. Prediction 17 was confirmed. More than zero unique nonverbal/simulation^{intuit} word association pairs were produced for very abstract concepts (*M* = 8.184, *SE*

= .672), $t(37) = 12.171$, $p < .001$. A one-sample t-test was also conducted on numbers of unique nonverbal/simulation^{intuit} word association pairs for abstract concepts. Prediction 18 was confirmed. More than zero unique nonverbal/simulation^{intuit} word association pairs were produced for abstract concepts ($M = 8.919$, $SE = .749$), $t(36) = 11.912$, $p < .001$.

A 3 (concept type) x 5 (class: categorical, entity-based, introspective, lexical, situational) repeated measures ANOVA was conducted using numbers of unique word association pairs produced for each class. Unrelated to our predictions, we found a main effect of class, $F(4, 436) = 129.767$, $p < .001$, as well as a previously seen main effect of concept type. Trends in Panel A of Figure 4 suggest that the main effect of class was due to multiple differences between multiple classes. Related to our predictions, we found a class x concept type interaction, $F(8, 436) = 18.281$, $p < .001$. This interaction signaled the possibility that different numbers of unique introspective and entity-based word association pairs were produced within at least one concept type, consistent with predictions 19-21. Accordingly, TUKEY tests were conducted on the interaction. Predictions 19 and 20 were confirmed. Larger numbers of unique introspective than entity-based word association pairs were produced for very abstract concepts ($M = 2.289$ versus $M = .026$), TUKEY HSD: $p < .01$, as well as abstract concepts ($M = 2.135$ versus $M = .054$), TUKEY HSD: $p < .01$. Prediction 21 was also confirmed. Larger numbers of unique entity-based than introspective words association pairs were produced for concrete concepts ($M = 3.730$ versus $M = .730$), TUKEY HSD: $p < .01$.

A one-sample t-test was conducted using proportions of participants who produced nonverbal/simulation^{intuit} word association pairs for very abstract concepts. Prediction 22 was confirmed. Non-zero proportions of participants produced unique nonverbal/simulation^{intuit} word association pairs for very abstract concepts ($M = .251$, $SE = .144$), $t(37) = 10.723$, $p < .001$. A one-sample t-test was also conducted using proportions of participants who produced nonverbal/simulation^{intuit} word association pairs for abstract concepts. Prediction

23 was confirmed. Non-zero proportions of participants produced unique nonverbal/simulation^{intuit} word association pairs for abstract concepts (*M* = .330, *SE* = .213), *t*(36) = 9.430, *p* < .001.

A 3 (concept type) x 5 (class) repeated measures ANOVA was conducted using proportions of participants who produced word association pairs for each class. Unrelated to our predictions, we found a main effect of class, *F*(4, 436) = 101.330, *p* < .001, as well as a previously seen main effect of concept type. Trends in Panel B of Figure 4 suggest that the main effect of class is due to multiple differences between multiple classes. Related to our predictions, we found a class x concept type interaction, *F*(8, 436) = 4.233, *p* < .001. This interaction signaled the possibility that different proportions of participants produced introspective and entity-based word association pairs within at least one concept type, consistent with predictions 24-26. Accordingly, TUKEY tests were conducted on the interaction. Predictions 24 and 25 were unconfirmed. It was not the case that larger proportions of participants produced introspective than entity-based word association pairs for very abstract concepts (*M* = .067 versus *M* = .002) or abstract concepts (*M* = .075 versus *M* = .001). However, prediction 26 was confirmed. Larger proportions of participants produced entity-based than introspective word association pairs for concrete concepts (*M* = .168 versus *M* = .061), TUKEY HSD: *p* < .01.

3.2.3 DISCUSSION

Table 6 summarizes all of the predictions based on PSS, as well as the state of evidence for or against them.

Table 6. Summary of evidence for PSS predictions (P17-P26)

Predictions	*Evidence*	*Predictions*	*Evidence*
#s of unique pairs (nonverbal/simulation^{intuit})		*Proportions of participants (nonverbal/*simulation^{intuit}*)*	
P17 NV/S: VA > 0	Yes	P22 NV/S: VA > 0	Yes
P18 NV/S: A > 0	Yes	P23 NV/S: A > 0	Yes
#s of unique pairs (class)		*Proportions of participants (class)*	
P19 VA: Intro > Entity	Yes	P24 VA: Intro > Entity	No
P20 A: Intro > Entity	Yes	P25 A: Intro > Entity	No
P21 C: Entity > Intro	Yes	P26 C: Entity > Intro	Yes

Note. VA = Very Abstract, A = Abstract, C = Concrete, NV/S = Nonverbal/Simulation

All predictions tested using numbers of unique word association pairs produced were confirmed. First, more than zero unique nonverbal/simulation$^{\text{intuit}}$ word association pairs were produced for very abstract concepts (P17) as well as abstract concepts (P18). These results suggest that abstract concepts are indeed represented in a nonverbal/simulation system. Second, larger numbers of unique introspective than entity-based word association pairs were produced for very abstract concepts (P19) as well as abstract concepts (P20). Third, larger numbers of unique entity-based than introspective words association pairs were produced for concrete concepts (P21). These results suggest that the focus within the nonverbal/simulation system is different for abstract and concrete concepts, particularly in the manner proposed by PSS.

By contrast, three of five analyses using proportions of participants who produced word association pairs were confirmed. Non-zero proportions of participants produced nonverbal/simulation$^{\text{intuit}}$ word association pairs for very abstract concepts (P22) as well as abstract concepts (P23), providing further support to the idea that abstract concepts are represented in a nonverbal/simulation system. Also, larger proportions of participants produced entity-based than introspective word association pairs for concrete concepts (P26). However, it was not the case that larger proportions of participants produced introspective than entity-based word association pairs for very abstract (P24) or abstract (P25) concepts.

3.3 TESTING LANGUAGE AND SITUATED SIMULATIONS (LASS)

3.3.1 HYPOTHESES AND PREDICTIONS

Here we test a claim that is not motivated by the abstract/concrete distinction, but may have implications related to it. LASS argues that when cues are words, as is the case in word association, the verbal/linguistic system is activated before the nonverbal/simulation system. Although we did not have reaction time data to test this directly, a suitable proxy in the form of target commonality was available, because "more frequent responses [on word association tasks] are quicker" (i.e., Marbe's Law; Schlosberg & Heineman, 1950; see also Cason & Cason, 1925). Therefore, we introduced a commonality variable.

We labeled each of our 1764 unique word association pairs common or uncommon. Unique word association pairs were considered common if their FSGs were greater than or equal to .022 (i.e., if they were generated by at least 2.2% of corresponding participants, which for most concepts meant around 3 participants) and uncommon if not. This criterion was chosen because it split our 1764 unique word association pairs as equally as possible (i.e., 858 common and 906 uncommon unique word association pairs). Then, we recalculated numbers of unique nonverbal/simulation$^{\text{santos}}$, verbal/linguistic$^{\text{santos}}$, nonverbal/simulation$^{\text{intuit}}$, and verbal/linguistic$^{\text{intuit}}$ word association pairs using the same procedures outlined in 2.2.3, but treating common and uncommon pairs as separate sets. For example, three common unique non-categorical and four common unique categorical nonverbal/simulation$^{\text{santos}}$ word association pairs were produced for 'walnut', so five (i.e., 3 + 4 / 2) common nonverbal/simulation$^{\text{santos}}$ word association pairs were produced for 'walnut'. Similarly, four uncommon unique non-categorical and four uncommon unique categorical nonverbal/simulation$^{\text{santos}}$ word association pairs were produced for 'walnut', so six (i.e., 4 + 4 / 2) uncommon nonverbal/simulation$^{\text{santos}}$ word association pairs were produced for 'walnut'.

In order to test LASS, we generated the predictions shown in Table 7, which are repeated for systems$^{\text{santos}}$ (P27) and systems$^{\text{intuit}}$ (P28). In generating these predictions, we reasoned that if verbal/linguistic system activation precedes nonverbal/simulation system activation when cues are words, we should expect the activity of the former compared to the latter to be larger at earlier as compared to later time points. In addition to these predictions, but contingent on their outcomes, we planned to investigate whether the commonality/time course effect interacts with concept type. However, no specific prediction was made in this regard.

Table 7. Predictions and explorations based on LASS (P27-P28, E1-E2)

Pred. & Exp. #	*Prediction & Exploration*
P27, P28	Differences in numbers of common unique verbal/linguistic and nonverbal/simulation word association pairs produced by participants are more positive or less negative than difference in numbers of uncommon unique verbal/linguistic and nonverbal/simulation word association pairs produced by participants.
E1, E2	Does the commonality/time course effect differ across concept type? (this is contingent on finding the effect in P27, P28).

3.3.2 ANALYSES AND RESULTS

A paired-sample t-test was conducted using numbers of unique system^{santos} word association pairs. The first sample reflected how much more or less active the verbal/linguistic system was than the nonverbal/simulation system in producing common unique word association pairs. It was obtained by subtracting—on a per concept basis—the number of common unique verbal/linguistic^{santos} from nonverbal/simulation^{santos} word association pairs produced. For example, for common unique word association pairs involving 'walnut', this was 1 – 1 = 0, indicating that the two systems were equally active. The second sample reflected how much more or less active the verbal/linguistic system was than the nonverbal/simulation system in producing uncommon unique word association pairs. It was obtained by subtracting—on a per concept basis—the number of uncommon unique verbal/linguistic^{santos} from nonverbal/simulation^{santos} word association pairs produced. For example, for uncommon word association pairs involving 'walnut', this was 3 – 10 = -7, indicating that the nonverbal/simulation system was more active than the verbal/linguistic system. Prediction 27 was confirmed. Differences between numbers of unique verbal/linguistic^{santos} and nonverbal/simulation^{santos} word association pairs were significantly less negative among common (M = -3.089, SE = .235) than uncommon (M = -4.179, SE = .296) unique word association pairs, $t(111) = 3.154$, $p = .002$. Put another way, there was an average of 3.089 fewer common unique verbal/linguistic^{santos} than nonverbal/simulation^{santos} word association pairs, and an average of 4.179 fewer uncommon unique verbal/linguistic^{santos} than nonverbal/simulation^{santos} word association pairs.

An analogous paired-sample t-test was conducted using numbers of unique system^{intuit} word association pairs. Prediction 28 was confirmed. Differences between numbers of verbal/linguistic^{intuit} and nonverbal/simulation^{intuit} word association pairs were significantly more positive among common (M = .321, SE = .332) than uncommon (M = -1.429, SE = .361) unique word association pairs, $t(111) = 4.319$, $p < .001$. Put another way, there was an average of .321 more common unique verbal/linguistic^{intuit} than nonverbal/simulation^{intuit} word association pairs, and an average of 1.429 fewer uncommon unique verbal/linguistic^{intuit} than nonverbal/simulation^{intuit} word association pairs.

Explorations aimed at determining if the commonality effect differs by concept type used data from the above analyses. A 3 (concept type) x 2 (commonality: common unique verbal/linguistic^{santos} minus nonverbal/simulation^{santos} word association pairs, uncommon unique verbal/linguistic^{santos} minus nonverbal/simulation^{santos} word association pairs) repeated measures ANOVA was conducted. No concept x commonality interaction was found, $F(2, 109) = 2.654$, $p = .075$. Therefore, exploration 1 was unconfirmed. An analogous ANOVA using system^{intuit} also revealed no concept x commonality interaction, $F(2, 109) = 1.608$, $p = .205$. Therefore, exploration 2 was unconfirmed as well.

Because the FSG value we used to define common versus uncommon pairs was selected somewhat arbitrarily (i.e., the only consideration was how equal in size the two groups would be), we repeated our analyses using a different FSG value. This time, unique word association pairs were considered common if their FSGs were greater than or equal to .100 and uncommon if not. Prediction 27 was reconfirmed. Differences between numbers of verbal/linguistic^{santos} and nonverbal/simulation^{santos} unique word association pairs were significantly less negative among common (M = -.545, SE = .095) than uncommon (M = -6.723, SE = .399) unique word association pairs, $t(111) = 15.003$, $p < .001$. Put another way, there was an average of .545 fewer common unique verbal/linguistic^{santos} than nonverbal/simulation^{santos} word association pairs, and an average of 6.723 fewer uncommon unique verbal/linguistic^{santos} than nonverbal/simulation^{santos} word association pairs. Prediction 28 was also reconfirmed. Differences between numbers of verbal/linguistic^{intuit} and nonverbal/simulation^{intuit} unique word association pairs were significantly more positive among common (*M* = .411, *SE* = .139) than uncommon (*M* = -1.518, *SE* = .523) unique word association pairs, *t*(111) = 3.706, *p* < .001. Put another way, there was an average of .411 more common unique verbal/linguistic^{intuit} than nonverbal/simulation^{intuit} word association pairs, and an average of 1.518 fewer uncommon unique verbal/linguistic^{intuit} than nonverbal/simulation^{intuit} word association pairs. Furthermore, explorations using both system^{santos}, *F*(2, 109) = 1.216, *p* = .300, and system^{intuit}, *F*(2, 109) = 1.514, *p* = .225, once again revealed no interactions between the commonality/time course effect and concept type.

3.3.3 DISCUSSION

Table 8 summarizes the predictions and explorations based on LASS, as well as the state of evidence for or against them.

Table 8. Summary of evidence for LASS predictions (P27, P28) and explorations (E1, E2)

Predictions & Explorations		*Evidence*
	COMMON FSG >= 0.022, UNCOMMON FSG < 0.022	
#s of unique pairs (system^{santos})		
P27	Common V/L - Common NV/S > Uncommon V/L - Uncommon NV/S	Yes
E1	Does the effect from P27 differ across concept type?	No
#s of unique pairs (system^{intuit})		
P28	Common V/L - Common NV/S > Uncommon V/L - Uncommon NV/S	Yes
E2	Does the effect from P28 differ across concept type?	No
	COMMON FSG >= 0.100, UNCOMMON FSG < 0.100	
#s of unique pairs (system^{santos})		
P27-2	Common V/L - Common NV/S > Uncommon V/L - Uncommon NV/S	Yes
E1-2	Does the effect from P27 differ across concept type?	No
#s of unique pairs (system^{intuit})		
P28-2	Common V/L - Common NV/S > Uncommon V/L - Uncommon NV/S	Yes
E2-2	Does the effect from P28 differ across concept type?	No

Note. V/L = Verbal/Linguistic, NV/S = Nonverbal/Simulation

Prediction 27 was confirmed using two different criteria for word association pair commonality. Under the first criterion, an average of 3.089 fewer common unique verbal/linguistic^{santos} than nonverbal/simulation^{santos} word association pairs were produced, and an average of 4.179 fewer uncommon unique verbal/linguistic^{santos} than nonverbal/simulation^{santos} word association pairs were produced. Under the second criterion, an average of .545 fewer common unique verbal/linguistic^{santos} than nonverbal/simulation^{santos} word association pairs were produced, and an average of 6.723 fewer uncommon unique verbal/linguistic^{santos} than nonverbal/simulation^{santos} word association pairs were produced. Both of these findings indicate that the inferior activity of the verbal/linguistic compared to nonverbal/simulation system was less inferior in the production of common as compared to uncommon word association pairs. Prediction 28 was also confirmed using two different criteria for word association pair commonality. Under the first criterion, an average of .321 more common unique verbal/linguistic^{intuit} than nonverbal/simulation^{intuit} word association pairs were produced, and an average of 1.429 fewer uncommon unique verbal/linguistic^{intuit} than nonverbal/simulation^{intuit} word association pairs were produced. Under the second criterion, an average of .411 more common unique verbal/linguistic^{intuit} than nonverbal/simulation^{intuit} word association pairs were produced, and an average of 1.518 fewer uncommon unique verbal/linguistic^{intuit} than nonverbal/simulation^{intuit} word association pairs were produced. Both of these findings indicate that the verbal/linguistic system was more active than the nonverbal/simulation system for common word association pairs, but less active for uncommon word association pairs.

Recalling that more frequent responses are quicker, results from both predictions support LASS's claim that the linguistic system is activated before the simulation system when cues are words. But, while predictions regarding a commonality/time course effect were confirmed, explorations failed to find any evidence that the effect is influenced by concept type. Therefore, we found evidence for one of LASS's general claims, but failed to find evidence with bearing on the abstract/concrete distinction.

3.4 TESTING DIFFERENT REPRESENTATIONAL FRAMEWORKS (DRF)

3.4.1 HYPOTHESES AND PREDICTIONS

Different Representational Frameworks (Crutch & Warrington, 2005, 2007, 2010) argues that "abstract words have a relatively greater dependence than concrete words upon representations of semantic association and that concrete words have a relatively greater dependence than abstract words upon representations of similarity-based information" (Crutch & Warrington, 2010, p. 47). To generate and test predictions based on this claim (Table 9), our semantic association and semantic similarity measures were made relative to each other on a per concept basis. For numbers of unique word association pairs produced, this was achieved by dividing each concept's number of unique semantically associated word association pairs produced by its number of unique semantically similar plus semantically associated word association pairs produced. For example, for 'walnut', this was 9 / (9 + 6) = 0.600 = relative dependence on semantic association based on numbers of unique word association pairs produced. For proportions of participants who produced word association pairs, this was achieved by dividing each concept's proportion of participants who produced semantically associated word association pairs by its proportion of participants who produced semantically similar plus semantically associated word association

Table 9. Predictions based on DRF (P29-P32)

Prediction #	*Prediction*
P29	*Relative dependence based on #s of unique pairs:* Very abstract concepts have a greater relative dependence on semantic association than do concrete concepts ↔ Concrete concepts have a greater relative dependence on semantic similarity than do very abstract concepts.
P30	*Relative dependence based on #s of unique pairs*: Abstract concepts have a greater relative dependence on semantic association than do concrete concepts ↔ Concrete concepts have a greater relative dependence on semantic similarity than do abstract concepts.
P31	*Relative dependence based on proportions of participants:* Very abstract concepts have a greater relative dependence on semantic association than do concrete concepts ↔ Concrete concepts have a greater relative dependence on semantic similarity than do very abstract concepts.
P32	*Relative dependence based on proportions of participants*: Abstract concepts have a greater relative dependence on semantic association than do concrete concepts ↔ Concrete concepts have a greater relative dependence on semantic similarity than do abstract concepts.

pairs. For example, for 'walnut', this was .430 / (.388 + .430) = 0.526 = relative dependence on semantic association based on proportions of participants who produced word association pairs. With these measures of relative dependence, we generated the predictions listed in Table 9, which correspond directly to DRF's claims. Note that our measures have been relatively abstracted from their original forms at this point. For this reason, we refer to them simply as measures of "relative dependence".

3.4.2 ANALYSES AND RESULTS

A univariate analysis (concept x relative dependence on semantic association) was conducted using measures of relative dependence on semantic association based on numbers of unique pairs (alternatively, we could have used measures of dependence on semantic similarity). A main effect of concept type was found, $F(2, 109) = 8.038$, $p = .001$. Accordingly, TUKEY tests were conducted on the main effect. Contrary to prediction 29, very abstract concepts (*M* = .659/.341) had a smaller/larger relative dependence on semantic association/similarity than did concrete concepts (*M* = .810/.190), TUKEY HSD: $p < .01$. Contrary to prediction 30, abstract concepts (*M* = .739/.261) and concrete concepts (*M* = .810/.190) did not differ in their dependence on semantic association/similarity.

A univariate analysis (concept x relative dependence on semantic association) was conducted using measures of relative dependence on semantic association based on proportions of participants (again, we could have used measures of dependence on semantic similarity). A main effect of concept type was found, $F(2, 109) = 10.209$, $p < .001$. Accordingly, TUKEY tests were conducted. Contrary to prediction 31, very abstract concepts (*M* = .555/.445) had a smaller/larger relative dependence on semantic association/similarity than did concrete concepts (*M* = .797/.203), TUKEY HSD: $p < .01$. Contrary to prediction 32, abstract concepts (*M* = .695/.305) and concrete concepts (*M* = .797/.203) did not differ in their dependence on semantic association/similarity.

3.4.3 DISCUSSION

Table 10 summarizes the predictions based on DRF, as well as the state of evidence for or against them.

Table 10. Summary of evidence for DRF predictions (P29-P32)

Predictions		Evidence
#s of unique pairs (per type of relation)		
P29	SA: VA > C ↔ SS: C > VA	Opposite (SA: VA < C ↔ SS: C < VA)
P30	SA: A > C ↔ SS: C > A	No
Proportions of participants (per type of relation)		
P31	SA: VA > C ↔ SS: C > VA	Opposite (SA: VA < C ↔ SS: C < VA)
P32	SA: A > C ↔ SS: C > A	No

Note. VA = very abstract, A = abstract, C = concrete, SA = semantically associated, SS = semantically similar

None of the predictions were confirmed using either measure of relative dependence (i.e., based on numbers of unique word association pairs or proportions of participants). In fact, results were opposite to expectations whenever very abstract concepts were compared to concrete concepts. That is, very abstract concepts relied less rather than more on semantic association than did concrete concepts, and by consequence, more rather than less on semantic similarity. Figure 7 depicts these relationships, and contrasts them with DRF's predicted relationships.

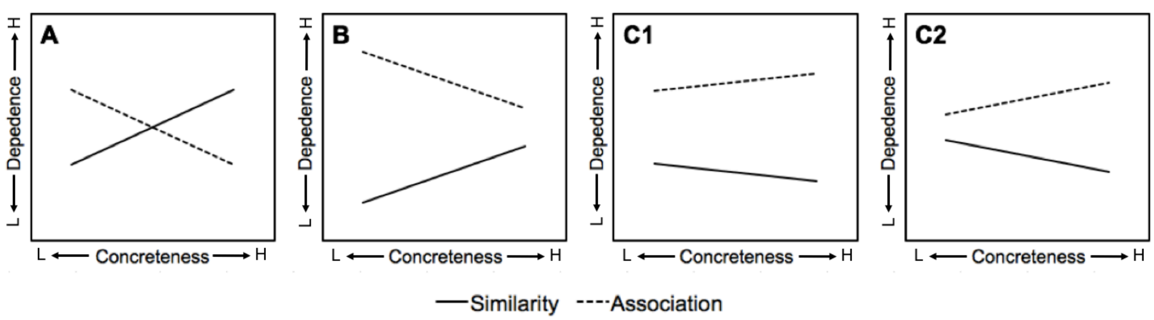

Figure 7. Two possible relationships between concreteness and semantic similarity/association proposed by DRF (A, B) compared to relationships found in the present study (C1 = relative dependence based on numbers of unique pairs, C2 = relative dependence based on proportions of participants). Parts of figure recreated from Crutch & Warrington (2010, p .48). Note that y-axes of graphs use different scales. Note that L = low, H = high.

The present results provide no support for DRF, and are also difficult to interpret in terms of other theories. For example, even if—as Crutch and Warrington

(2010) discuss—we equate semantic similarity with a nonverbal system and semantic association with a verbal system, the results continue to be elusive.

3.5 ADDITIONAL ANALYSES AND RESULTS

3.5.1 ADDITIONAL ANALYSES AND RESULTS

We include here extra results from the TUKEY tests performed on the concept type x system^{santos} and concept type x system^{intuit} interactions that were found (Table 11), as well as the concept type x class interaction that was found (Table 12). We save the implications of these results for the General Discussion.

Table 11. Extra results from TUKEY tests performed on the concept type x system^{santos} and concept type x system^{intuit} interactions (note: the two interactions are from separate ANOVAs)

Condition	*Avg. #s of pairs*	*TUKEY HSD*	*Avg. prop. of partic.*	*TUKEY HSD*
SANTOS				
Verbal/Linguistic				
Very Abstract – Abstract	-	-	.272 – .236	1.831
Very Abstract – Concrete	-	-	.272 – .253	.966
Abstract – Concrete	-	-	.236 – .253	.859
Nonverbal/Simulation				
Very Abstract – Abstract	-	-	.473 – .530	2.899
Very Abstract – Concrete	-	-	.473 – .618	**7.373
Abstract – Concrete	-	-	.530 – .618	**4.445
INTUIT				
Verbal/Linguistic				
Very Abstract – Abstract	9.289 – 6.892	*3.944	.494 – .436	1.713
Very Abstract – Concrete	9.289 – 5.730	**5.856	.494 – .434	1.772
Abstract – Concrete	6.892 – 5.730	1.899	.436 – .434	.059
Nonverbal/Simulation				
Very Abstract – Abstract	8.184 – 8.919	1.209	.251 – .330	2.333
Very Abstract – Concrete	8.184 – 8.189	0.008	.251 – .437	**5.492
Abstract – Concrete	8.919 – 8.189	1.193	.330 – .437	3.139

Note. * = $p < .05$, ** = $p < .01$

Larger numbers of unique verbal/linguistic^{intuit} word association pairs were produced for very abstract than concrete and abstract concepts, with no difference between the latter two. By comparison, there was no difference in proportions of participants who produced verbal/linguistic^{intuit} word association pairs between any of the three concept types.

Table 12. Extra results from TUKEY tests performed on the concept type x class interaction

Condition	*Avg. #s of pairs*	*TUKEY HSD*	*Avg. prop. of partic.*	*TUKEY HSD*
Categorical				
Very Abstract – Abstract	8.026 – 5.811	**6.077	.443 – .400	1.853
Very Abstract – Concrete	8.026 – 4.595	**9.413	.443 – .363	*3.447
Abstract – Concrete	5.811 – 4.595	3.314	.400 – .363	1.584
Entity-based				
Very Abstract – Abstract	.026 – .054	.077	.002 – .001	.043
Very Abstract – Concrete	.026 – 3.730	**10.163	.002 – .168	**7.152
Abstract – Concrete	.054 – 3.730	**10.019	.001 – .168	**7.147
Introspective				
Very Abstract – Abstract	2.289 – 2.135	.423	.067 – .075	.345
Very Abstract – Concrete	2.289 – .730	**4.277	.067 – .061	.259
Abstract – Concrete	2.135 – .730	*3.829	.075 – .061	.599
Lexical				
Very Abstract – Abstract	1.263 – 1.081	.499	.051 – .036	.646
Very Abstract – Concrete	1.263 – 1.135	.351	.051 – .071	.862
Abstract – Concrete	1.081 – 1.135	.147	.036 – .071	1.498
Situational				
Very Abstract – Abstract	5.868 – 6.730	2.365	.182 – .255	3.145
Very Abstract – Concrete	5.868 – 3.730	**5.866	.182 – .208	1.120
Abstract – Concrete	6.730 – 3.730	**8.177	.255 – .208	2.012

Note. * = $p < .05$, ** = $p < .01$

Larger numbers of unique categorical word association pairs were produced for very abstract than both concrete and abstract concepts. However, there was no difference in numbers of unique categorical word association pairs produced for abstract and concrete concepts. Furthermore, larger proportions of participants produced categorical word association pairs for very abstract than concrete concepts. However, there was no difference in proportions of participants who produced categorical word association pairs for abstract versus very abstract or concrete concepts.

In addition, larger numbers of unique entity-based word association pairs were produced for concrete than both very abstract and abstract concepts, with no difference between the latter two. Similarly, larger proportions of participants produced unique entity-based word association pairs for concrete than both very abstract and abstract concepts, with no difference between the latter two.

Finally, larger numbers of unique introspective as well as unique situational word association pairs were produced for very abstract and abstract concepts than for concrete concepts, with no differences between the former two

CHAPTER 4
GENERAL DISCUSSION

4.1 GENERAL DISCUSSION

4.1.1 REGARDING MAIN RESULTS

In this thesis, we described and, using word association, tested several theories of conceptual representation motivated by the abstract/concrete concept distinction (or, where not motivated by it, with potential implications related to it).

Dual Coding Theory (Paivio, 1986, 2007) argues that abstract concepts are represented in a verbal but not a nonverbal system, whereas concrete concepts are represented in both. We found no support for this claim using our first measure (i.e., "number of unique word association pairs..."), which treated all unique word association pairs produced by at least two participants as equally indicative of conceptual representation within a given system. By comparison, we found mixed support for the claim using our second measure (i.e., "proportion of participants..."), which treated unique word association pairs produced by at least two participants as more indicative of conceptual representation within a given system if produced by more participants. In the case of our second measure, we found two different patterns of results depending on how we assigned word association pairs to the verbal/linguistic and nonverbal/simulation systems.

When categorical word association pairs were assigned in equal proportion to the verbal and nonverbal system, larger proportions of participants produced nonverbal/simulation word association pairs for concrete than either very abstract or abstract concepts. This points to concrete concepts having greater representation in the nonverbal system than either very abstract or abstract concepts. Therefore, like some of the neuroanatomical studies discussed in the introduction (e.g., Holcomb, 1999), our study provides at least some evidence that concrete concepts share a privileged relationship with nonverbal processes.

Worth noting is that Marques and Nunes (2012) found no difference in proportions of sensorimotor-based (i.e., nonverbal/simulation) word association pairs produced for abstract and concrete concepts. One possible reason for this is that they chose not to include their taxonomic (i.e., categorical) word association pairs as part of either of their systems. This might have led them to underestimate numbers of sensorimotor-based (i.e., nonverbal/simulation) word association pairs produced for concrete concepts.

Another finding based on equal assignment of word association pairs to the verbal and nonverbal system was that larger proportions of participants produced nonverbal/simulation than verbal/linguistic word association pairs for very abstract and abstract concepts. This points to very abstract and abstract concepts having greater representation in the nonverbal than verbal system, which is clearly at odds with DCT's proposed asymmetry. Nevertheless, DCT is able to accommodate these findings because it allows for referential connections between its two systems (Paivio, 1986, p. 58, 2007, p. 101-102). Hypothetically, very abstract and abstract concepts may have generated nonverbal word association pairs through a verbal system intermediary. This finding also contradicts Marques and Nunes (2012) finding in which larger proportions of language-based (i.e., verbal/linguistic) than sensorimotor-based (i.e., nonverbal/simulation) word association pairs were produced for abstract concepts. Again, their choice to ignore taxonomic (i.e., categorical) word association pairs may be responsible for our differing results.

When categorical word association pairs were assigned solely to the verbal/linguistic system, larger proportions of participants produced nonverbal/simulation word association pairs for concrete than very abstract but not abstract concepts. This points to concrete concepts having greater representation in the nonverbal system than very abstract, but not abstract, concepts, which provides mixed support for DCT. Comparably, larger proportions of participants produced verbal/linguistic than nonverbal/simulation word association pairs for very abstract, but not abstract, concepts. This also points to very abstract, but not abstract, concepts having greater representation in the verbal than nonverbal system, which again provides mixed support for DCT. The pattern of results here also lends support to the two-factor model of abstractness, which says that not only is there a distinction between abstract and concrete concepts, but also between different types of abstract concepts (Wiemer-Hastings et al., 2001). It appears there are at least two types of abstract concepts, and that the more abstract type has greater representation in the verbal system. Direct comparisons between very abstract and abstract concepts support this idea. In our extra analyses, we found that larger numbers of unique verbal/linguistic[intuit] word association pairs were produced for very abstract than abstract concepts. Furthermore, we found that larger numbers of unique categorical word association pairs were produced for very abstract than abstract concepts, implying that the categorical aspect of the verbal/linguistic system is what really separates very abstract from abstract concepts.

Perceptual Symbol Systems (Barsalou, 1999, 2008) argues that abstract concepts *are* represented nonverbally, particularly in a simulation system. We found strong support for this claim using both of our measures. Significantly more than zero unique nonverbal/simulation word association pairs were produced for very abstract and abstract concepts. Furthermore, proportions of participants significantly larger than zero produced nonverbal/simulation word association pairs for very abstract and abstract concepts. Both of these results suggest that very abstract and abstract concepts are, indeed, represented in the simulation system. Putting aside the possibility of referential connections between systems, both results also oppose DCT's claim that abstract concepts are not represented in the nonverbal system.

PSS suggests also that the focus in the simulation system might be different for abstract and concrete concepts (Barsalou & Wiemer-Hastings, 2005). Simulations related to abstract concepts might focus on introspective and setting/event properties of situations, whereas those related to concrete concepts might focus on critical objects and their properties. We found strong support for these claims using our first measure. Larger numbers of unique introspective than entity-based word association pairs were produced for very abstract and abstract concepts. Furthermore, larger numbers of unique entity-based than introspective word association pairs were produced for concrete concepts. These findings are in general agreement with between-concept type findings from Barsalou and Wiemer-Hastings (2005) and Wiemer-Hastings and Xu (2005). By comparison, we found mixed support for PSS's claims using our second measure. As predicted, larger proportions of participants produced entity-based than introspective word association pairs for concrete concepts. However, it was not the case that larger proportions of participants produced introspective than entity-based word association pairs for very abstract or abstract concepts. Presumably, this was due to a floor effect, as proportions of participants who produced introspective as well as entity-based word association pairs for very abstract and abstract concepts were relatively small.

Language and Situated Simulations (Barsalou et al., 2008) argues that when cues are words, the verbal/linguistic system is activated before the nonverbal/simulation system. We found strong support for this claim using our first measure (which is the only measure we used to test LASS). Regardless of how we assigned word association pairs to the verbal/linguistic and nonverbal/simulation systems, differences in numbers of quickly-produced unique verbal/linguistic and nonverbal/simulation word association pairs were greater than differences in numbers of slowly-produced unique verbal/linguistic and nonverbal/simulation word association pairs. This points to linguistic system activation preceding simulation system activation when cues are words, as proposed by LASS and first supported by Santos et al. (2011).

Different Representational Frameworks (Crutch & Warrington, 2005, 2007, 2010) argues that "abstract words have a relatively greater dependence than concrete words upon representations of semantic association and that concrete words have a relatively greater dependence than abstract words upon representations of similarity-based information" (Crutch & Warrington, 2010, p. 47). In order to test this claim, we converted our two measures into measures of relative dependence on semantic association/semantic similarity. Regardless of which of our two converted measures was used, we found semantic similarity to be more important to very abstract than concrete concepts—in direct contradiction to DRF. Consequently, we found semantic association to be more important to concrete than very abstract concepts. These results mirror results from Marques and Nunes (2012), and add to a growing list of studies that have been unable to replicate findings from Crutch and Warrington (2005, 2007, 2010).

4.1.2 REGARDING ADDITIONAL RESULTS

Outside of our predictions, we found several more relevant results. When categorical word association pairs were assigned solely to the verbal/linguistic system, larger numbers of unique verbal/linguistic word association pairs were produced for very abstract than concrete concepts. This echoes Marques and Nunes' (2012) finding in which larger proportions of language-based (i.e., verbal/linguistic) word association pairs were produced for abstract than concrete concepts. However, we hesitate to interpret our finding as direct support for DCT. DCT argues that abstract concepts are represented in the verbal but not the nonverbal system, whereas concrete concepts are represented in both. It does not necessarily follow that larger numbers of unique verbal/linguistic word association pairs should be produced for very abstract than for concrete concepts. In fact, larger numbers of unique verbal/linguistic word association pairs could be produced for very abstract than for concrete concepts, and at the same time, very abstract concepts could be relatively more dependent on the nonverbal system than concrete concepts—in direct contradiction to DCT. This might be the case if, for example, the average number of unique verbal/linguistic versus nonverbal/simulation word association pairs for very abstract concepts is 10 versus 20, respectively, and for concrete concepts is 5 versus 5, respectively. Admittedly, this is an extremely contrived example. In our study, these values for very abstract concepts were 9.289 versus 8.184, respectively, and for concrete concepts, they were 5.730 versus 8.189, respectively. Nevertheless, it is unknown if, relative to nonverbal/simulation^{intuit} word association pairs, larger numbers of unique verbal/linguistic^{intuit} pairs were produced for very abstract than concrete concepts. Worth noting is that similar arguments may be applied against our own predictions, such as the prediction that "larger numbers of unique nonverbal/simulation^{intuit} word association pairs were produced for concrete than very abstract concepts". Larger numbers of unique nonverbal/simulation word association pairs could be produced for concrete than very abstract concepts, and at the same time, concrete concepts could be more relatively more dependent on the verbal system than very abstract concepts. However, because DCT explicitly claims that abstract concepts have no representation in the nonverbal system, whereas concrete concepts do, we feel our prediction was justified from an a priori perspective.

Larger numbers of unique categorical word association pairs were produced for very abstract than concrete concepts. Furthermore, larger proportions of participants produced categorical word association pairs for very abstract than concrete concepts. Because numbers of unique lexical word association pairs as well as proportions of participants who produced them did not differ between concept types, these findings suggest that the categorical class was responsible for the abovementioned finding involving verbal/linguistic system differences between very abstract and concrete concepts. This is especially noteworthy because Marques and Nunes (2012) did not include categorical (i.e., taxonomical) word association pairs as part of their language-based (i.e., verbal/linguistic) system. Therefore, while we get comparable results, we appear to get them for different reasons.

When categorical word association pairs were assigned solely to the verbal/linguistic system, larger numbers of unique verbal/linguistic word association pairs were produced for very abstract than abstract concepts. Additionally, there was no difference in numbers of unique verbal/linguistic word association pairs produced for abstract and concrete concepts. Taken together, these results suggest—in line with the two-factor model of abstractness (Wiemer-

Hastings et al., 2001)—that there are two types of abstract concepts, and that they are represented in the verbal/linguistic system to differing extents.

Larger numbers of unique categorical word association pairs were produced for very abstract than abstract concepts. Additionally, there was no difference in numbers of unique categorical word association pairs produced for abstract and concrete concepts. Because numbers of unique lexical word association pairs did not differ across concept types, these findings suggest that the categorical class was responsible for the abovementioned finding involving verbal/linguistic system differences between very abstract and abstract concepts. Note also that we found no difference in numbers of unique introspective word association pairs produced or proportions of participants who produced them for very abstract and abstract concepts. This opposes earlier work showing that abstract concepts differ among each other according to the amount of introspective information they contain (Wiemer-Hastings et al., 2001).

Larger numbers of unique entity-based word association pairs were produced for concrete than both very abstract and abstract concepts. Furthermore, larger proportions of participants produced entity-based word association pairs for concrete than either very abstract or abstract concepts. This is in general agreement with Barsalou and Wiemer-Hastings (2005) finding that, relative to other types of properties, concrete concepts rely on entity properties more than do abstract concepts. However, we hesitate to interpret our finding as direct support for PSS. PSS argues that simulations related to abstract concepts might focus on introspective and setting/event properties of situations, whereas those related to concrete concepts might focus on critical objects and their properties. It does not necessarily follow that larger numbers of unique entity-based word association pairs should be produced for concrete than very abstract or abstract concepts. In fact, larger numbers of unique entity-based pairs could be produced for concrete than very abstract or abstract concepts, and at the same time, concrete concepts could focus less on them. This might be the case if, for example, the average number of unique entity-based word association pairs versus all other word association pairs for concrete concepts is 6 versus 30, respectively, and for very abstract concepts is 5 versus 5, respectively. Admittedly, this is an extremely contrived example. In our study, these values for concrete concepts were 3.730 versus 10.190, respectively, and for very abstract concepts, they were 0.026 versus 17.446, respectively. These values bode well for PSS, but formal analysis is still required to determine if, relative to all other unique word association pairs, significantly larger numbers of unique entity-based word association pairs were produced for concrete than for very abstract concepts.

Larger numbers of unique situational word association pairs were produced for very abstract and abstract concepts than for concrete concepts. This is in general agreement with Barsalou and Wiemer-Hastings (2005) finding that, relative to other types of properties, abstract concepts rely on setting/event properties more than do concrete concepts. For reasons similar to those outlined above, we hesitate to interpret this finding as direct support for PSS.

Finally, larger numbers of unique introspective word association pairs were produced for very abstract and abstract concepts than for concrete concepts. This is consistent with abstract concepts being more emotionally valenced than concrete concepts (Kousta et al., 2011).

4.1.3 LIMITATIONS AND FUTURE WORK

The present study includes several limitations. The first is that it does not control for frequency and familiarity ratings, which introduces a potential confound. Chaffin (1997) found that, among *semantic* word association pairs[12], high-frequency/familiarity concepts (i.e., stimulus words) tend to produce event-based (comparable to our situational) word association pairs, whereas low-frequency/familiarity concepts tend to produce definitional (comparable to our categorical) word association pairs. Because our very abstract and abstract

[12] Comparable to all word association pairs in our study excluding lexical pairs.

concepts were more frequent and familiar than our concrete concepts, and because larger numbers of unique situational word association pairs were produced for them, there is a degree of overlap between Chaffin's results and ours, at the high end. However, in our defense, our concrete concepts and two sets of abstract concepts may not have been different enough to reproduce Chaffin's finding. The difference in familiarity between our concrete concepts and our two sets of abstract concepts was small; approximately 20 to 30 on a 700-point scale. In addition, all three concepts types had in common the fact that they produced *generally high* ratings. In fact, the least familiar words used in our study were canoe and saxophone. Note that this may also be the reason why we did not replicate Chaffin's results for low-frequency/familiarity concepts.

The second limitation is that we do not control for part of speech across concept types. It is known that word association cues tend to evoke targets from their own grammatical class (Deese, 1965, p. 103). For example, nouns tend to evoke nouns, and verbs tend to evoke verbs. It is conceivable, then, that some of our results were driven not by differences in concept type, but rather part of speech. Consider, for example, the likely scenario that entity-based targets are more often nouns than are other targets. Because our concrete concepts were almost universally nouns whereas our very abstract and abstract concepts were around 40% nouns, findings such as "larger proportions of participants produced nonverbal/simulation [largely entity-based] word association pairs for concrete than very abstract concepts" could be due to nouns evoking nouns, rather than greater representation in the nonverbal/simulation system for concrete than very abstract concepts.

The third limitation is that all assignments of word association pairs to classes were ultimately up to the discretion of a single coder. Although, the coder attempted to avoid systematic bias of any sort in their assignments, and although assignments were influenced by the initial two coders, it would be preferable to have multiple coders in this role. Having multiple coders also enables the calculation of inter-coder reliability.

The final limitation is that the study does not directly address DCT's proposal regarding referential connections between its systems. Doing so may have given us insight into the validity of our two measures. For example, if no evidence was found in support of referential connections, results for predictions 7 and 8 would be more difficult to explain using DCT (recall, these results showed that larger numbers of unique nonverbal/simulation than verbal/linguistic system word association pairs were produced for very abstract and abstract concepts—opposite to expectations). Consequently, we might favor the intuition-based over Santos-based characterization of systems, but more importantly, our first measure over our second measure.

Future work should focus on addressing the major limitations we have outlined. That is, it should: (1) control for frequency and familiarity ratings across concept types, (2) control for part of speech across concept types, (3) rely on multiple coders for final assignments of word association pairs to classes, and (4) examine more directly the potential role of referential connections between DCT's systems.

Regarding the fourth limitation, one option is to examine reaction times for nonverbal/simulation word association pairs for very abstract and abstract versus concrete concepts. If referential connections are involved, very abstract and abstract concepts are likely to produce nonverbal/simulation word association pairs in the following manner: (1) abstract concept verbal information activates concrete concept verbal information (e.g., cue/word: danger → word: highway), (2) concrete concept verbal information activates concrete concept nonverbal information (e.g., word: highway → image: a sign), (3) concrete concept nonverbal information activates concrete concept verbal information (e.g., image: a sign → word: sign), (4) concrete concept verbal information initiates a response (e.g., word: sign → target/word: sign). By comparison, concrete concepts are likely to produce nonverbal/simulation word association pairs in this manner: (1) concrete concept verbal information activates concrete concept nonverbal information (e.g., cue/word: balloon → image: sky), (2) concrete concept nonverbal information activates concrete concept verbal information (e.g., image: sky → word: sky), (3) concrete concept verbal information initiates a response (e.g., word: sky → target/word: sky). Based on the steps involved in these two routes, a fair assumption is that individuals are faster at producing nonverbal/simulation word association pairs for concrete than very abstract and abstract concepts[13]. Note that the data from the present study could, in theory, be used to examine this idea. For example, we might compare the proportion of common to uncommon unique nonverbal/simulation word association pairs for very abstract concepts to the proportion for concrete concepts. Of course, actual reaction times are preferable.

4.1.4 CONCLUSION

Taken as a whole, our results point to DRF as an untenable theory of abstract and concrete concept representation. However, they do little to arbitrate among DCT and PSS. The reason for this is that our two measures produce largely contrasting results. However, if we assume that our first measure is a better estimation of conceptual representation—as Deese might be inclined to do (1965, p. 175)—a clearer picture emerges. In this picture, we find that PSS is strongly supported by our results. By contrast, DCT is almost universally unsupported by them. Of course, this is mere speculation. If we choose to speculate instead on behalf of our second measure, we reach conclusions that could be interpreted as more favorable to DCT.

Finally, we might remark on the novelty of this study. While earlier studies have used word association to test theories motivated by the abstract/concrete distinction, ours is the first study use word association and: (1) find evidence for DCT's claim that concrete concepts are represented in the nonverbal system to a greater extent than are abstract concepts (i.e., predictions 5, 6, and 13); (2) find

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[13] Note that participants are faster at generating word association pairs for concrete than abstract concepts *in general* (de Groot, 1989). It is possible, then, that between-concept type differences in reaction time for nonverbal/simulation word association pairs drive this effect.

evidence in total opposition to DCT's above claim (i.e., predictions 7 and 8); (3) test and find evidence for PSS's claim that simulations related to abstract concepts focus on introspective properties (i.e., predictions 19 and 20); (4) test and find evidence for PSS's claim that simulations related to concrete concepts focus on entity-based properties (i.e., predictions 21 and 26); (5) test and find evidence for LASS's claim that linguistic system activity precedes simulation system activity when cues are words (i.e., predictions 27 and 28); (6) find evidence for the two-factor model of abstractness (Wiemer-Hastings et al., 2001); and (7) find evidence for the claim that abstract concepts are more emotionally valenced than concrete concepts (Kousta et al., 2011).

4.2 SUMMARY

In this thesis, we described and, using word association, tested several theories of conceptual representation motivated by the abstract/concrete concept distinction (or, where not motivated by it, with potential implications related to it). These included Dual Coding Theory (Paivio, 1986, 2007), Perceptual Symbol Systems (Barsalou, 1999, 2008), Language and Situated Simulations (Barsalou et al., 2008), and Different Representational Frameworks (Crutch & Warrington, 2005, 2007, 2010). We found mixed support for Dual Coding Theory and Perceptual Symbol Systems, strong support for Language and Situated Simulations, and no support for Different Representational Frameworks.

It is our hope that future investigations will benefit from the protocols laid out in this thesis, which demonstrate how the abstract/concrete concept distinction can be studied using word association.

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APPENDICES

Appendix A. Very abstract, abstract, and concrete concepts

VERY ABSTRACT	*ABSTRACT*	*CONCRETE*
Ability	Advice	Ant
Anxious	Afraid	Apple
Awkward	Allow	Balloon
Blame	Angry	Bed
Bored	Brave	Boot
Challenge	Cause	Canoe
Chance	Confidence	Cheese
Concept	Crisis	Cherry
Depressed	Danger	Climb
Eager	Dare	Clock
Easy	Definition	Cream
Effect	Excited	Cucumber
Genuine	Extra	Dolphin
Gone	Fear	Drum
Guilt	Freedom	Eagle
Hope	Friendship	Elephant
Impossible	Habit	Garlic
Independent	Happy	Gown
Instance	Here	Hammer
Justify	Hesitate	Jacket
Know	Ignore	Knife
Logic	Join	Pencil
Luck	Lazy	Piano
Manner	Less	Pickle
Must	Lonely	Pig
Nervous	Mad	Pliers
Opinion	Memory	Raccoon
Other	Missing	Robin
Polite	More	Saw
Proud	Neglect	Saxophone
Purpose	Panic	Screwdriver
Reality	Quality	Stove
Regret	Relief	Tangerine
Unfair	Sad	Telephone
Unique	Safety	Turtle
Unknown	Same	Violin
Vague	Surprise	Walnut
Value		

Appendix B. Data profile for an example concept, 'walnut'

type	*concept/ cue*	*target*	*group size*	*# of partic.*	*FSG*	*sub-class*	*class*	*system santos*	*system intuit*	*type of relation*
concrete	walnut	peanut	147	30	.204	c-coord	categorical	both	V/L	similar
concrete	walnut	nut	147	25	.170	c-super	categorical	both	V/L	assoc.
concrete	walnut	pecan	147	14	.095	c-coord	categorical	both	V/L	similar
concrete	walnut	tree	147	13	.088	s-loc	situational	NV/S	NV/S	assoc.
concrete	walnut	crack	147	7	.048	s-action	situational	NV/S	NV/S	assoc.
concrete	walnut	squirrel	147	7	.048	s-living	situational	NV/S	NV/S	assoc.
concrete	walnut	almond	147	6	.041	c-coord	categorical	both	V/L	similar
concrete	walnut	chestnut	147	3	.020	c-coord	categorical	both	V/L	similar
concrete	walnut	shell	147	3	.020	e-excomp	entity-based	NV/S	NV/S	assoc.
concrete	walnut	acorn	147	2	.014	c-coord	categorical	both	V/L	similar
concrete	walnut	brown	147	2	.014	e-exsurf	entity-based	NV/S	NV/S	assoc.
concrete	walnut	cookie	147	2	.014	e-whole	entity-based	NV/S	NV/S	assoc.
concrete	walnut	eat	147	2	.014	s-action	situational	NV/S	NV/S	assoc.
concrete	walnut	food	147	2	.014	c-ont	categorical	both	V/L	assoc.
concrete	walnut	peas	147	2	.014	c-coord	categorical	both	V/L	similar

	# OF UNIQUE PAIRS	*PROP. OF PARTIC.*
CLASS		
Categorical	8	.572
Entity-based	3	.048
Introspective	0	.000
Lexical	0	.000
Situational	4	.198
SYSTEM^{santos}		
Nonverbal/Simulation^{santos}	11	.532
Verbal/Linguistic^{santos}	4	.286
SYSTEM^{intuit}		
Nonverbal/Simulation^{intuit}	7	.572
Verbal/Linguistic^{intuit}	8	.246
TYPE OF RELATION		
Semantically similar	6	.388
Semantically associated	9	.430

Appendix C. Scheme modified from Wu & Barsalou (2009)

CATEGORICAL (C)
A category in the taxonomy to which a concept belongs.

■ SYNONYM (C-SYN) – A synonym of a concept (e.g., car-automobile, cat-feline, humiliate-embarrass).

■ ANTONYM (C-ANT) – An antonym of a concept (e.g., ability-inability, absent-present).

■ SIMILAR CONCEPT (C-SIM) – A concept with a similar meaning that is not actually a synonym (e.g., hot-warm, abduct-steal, ignore-leave).

■ ONTOLOGICAL CATEGORY (C-ONT) – A category for a basic kind of thing in existence, including *thing, substance, object, human, animal, plant, location, time, activity, event, action, state, thought, emotion* (e.g., cat-animal, computer-object).

■ SUPERORDINATE (C-SUPER) – A category one level above a concept in a taxonomy (e.g., car-vehicle, apple-fruit, guilt-feeling).

■ COORDINATE (C-COORD) – Another category in the superordinate category to which a concept belongs (e.g., apple-orange, oak-elm).

■ SUBORDINATE (C-SUBORD) – A category one level below the target concept in a taxonomy (e.g., chair-rocking chair, frog-tree frog, habit-smoking).

■ SUBTYPE (C-TYPE) – A type of a concept that is neither strictly a subordinate nor an instance (e.g., ability-physical).

■ INDIVIDUAL (C-INDIV) – A specific instance of a concept (e.g., car-my car, house-my parents' house, awkward-me).

ENTITY-BASED (E)
Properties of a concrete entity, either animate or inanimate. Besides being a single self-contained object, an entity can be a coherent collection of objects (e.g., forest).

■ EXTERNAL COMPONENT (E-EXCOMP) – A three-dimensional component of an entity that normally resides on its surface (e.g., car-headlight, tree-leaves).

■ INTERNAL COMPONENT (E-INCOMP) – A three-dimensional component of an entity that normally resides completely inside the closed surface of the entity (e.g., apple-seeds, jacket-lining).

■ EXTERNAL SURFACE PROPERTY (E-EXSURF) – An external property of an entity that is not a component, and that is perceived on or beyond the entity's surface, including *shape, color, pattern, texture, touch, smell, taste*, *sound,* etc. (e.g., watermelon-oval, apple-red).

■ INTERNAL SURFACE PROPERTY (E-INSURF) – An internal property of an entity that is not a component, that is not normally perceived on the entity's exterior surface, and that is only perceived when the entity's interior surface is exposed, includes *color, pattern, texture, size, touch, smell, taste*, etc. (e.g., apple-white, watermelon-juicy).

■ SUBSTANCE/MATERIAL (E-MAT) – The material or substance of which something is made (e.g., floor-wood, shirt-cloth).

■ SPATIAL RELATION (E-SPAT) – A spatial relation between two or more properties within an entity, or between an entity and one of its properties (e.g., car-window above door, watermelon-green outside).

■ SYSTEMIC PROPERTY (E-SYS) – A global systemic property of an entity or its parts, including *states, conditions, abilities, traits*, etc. (e.g., cat-alive, dolphin-intelligent, car-fast).

■ LARGER WHOLE (E-WHOLE) – A whole to which an entity belongs (e.g., window-house, apple-tree).

■ ENTITY BEHAVIOR (E-BEH) – A chronic behavior of an entity that is characteristic of its nature, and that is described as a characteristic property of the entity, not as a specific intentional action in a situation (e.g., tree-blows in the wind, bird-flies, person-eats).

■ ABSTRACT ENTITY PROPERTY (E-ABSTR) – An abstract property of the target entity not dependent on a particular situation (e.g., teacher-democrat, transplanted californian-buddhist).

■ QUANTITY (E-QUANT) – A numerosity, frequency, size, intensity, or typicality of an entity or its properties (e.g., jacket-an article of clothing, cat-four legs, tree-lots of leaves, apple-common fruit, watermelon-usually green, apple-very red).

INTROSPECTIVE (I)

A property of a subject's mental state as he or she views a situation, or a property of a character's mental state in a situation.

■ AFFECT/EMOTION (I-EMOT) – An affective or emotional state toward the situation or one of its components by either the subject or a participant (e.g., magic-a sense of excitement, vacation-I was happy, smashed car-anger, panic-anxiety, nervous).

■ EVALUATION (I-EVAL) – A positive or negative evaluation of a situation or one of its components by either the subject or a participant (e.g., apples-I like them, vacation-I wrote a stupid paper, crisis-bad). Typically more about the situation or component than about the perceiver, often attributing a trait to it (e.g., beautiful, common). Use i-emot when the focus is more on the perceiver and on a traditional emotional state.

■ REPRESENTATIONAL STATE (I-REP) – A relatively static or stable representational state in the mind of a situational participant, including *beliefs, goals, desires, ideas*, *perceptions*, etc. (e.g., smashed car-believed it was not working, tree-wanted to cut it down, tree-had a good view of a bird in it).

■ COGNITIVE OPERATION (I-COGOP) – An online operation or process on a cognitive state, including *retrieval, comparison, learning*, etc. (e.g., watermelon-I remember a picnic, rolled grass-looks like a burrito, car-I learned how to drive).

■ CONTINGENCY (I-CONTIN) – A contingency between two or more aspects of a situation, including: conditionals and causals, such as *if, enable, cause, because, becomes, underlies, depends, requires,* etc.*;* correlations such as *correlated, uncorrelated, negatively correlated*, etc.; others including *possession* and *means* (e.g., car-requires gas, tree-has leaves depending on the type of tree, vacation-free from work, magic-I was excited because I got to see the magician perform, car-my car).

■ NEGATION (I-NEG) – An explicit mention of the absence of something, with absence requiring a mental state that represents the opposite (e.g., car-no air conditioning, apple-not an orange).

■ QUANTITY (I-QUANT) – A numerosity, frequency, intensity, or typicality of an introspection or one of its properties (e.g., truth-a set of beliefs, buy-I was very angry at the saleswoman, magic-I was quite baffled by the magician).

LEXICAL (L)

A purely language-based associate.

■ MORHPOLOGICAL (L-MORPH) – A form of the word that is not an antonym (e.g., hope-hopeful).

■ COMPOUND CONTINUATION FORWARD (L-COMPF) – The cue plus response is a phrase, with no other plausible relation (e.g., eager-beaver).

■ COMPOUND CONTINUATION BACKWARD (L-COMPB) – The cue plus response is a phrase in the opposite direction, with no other plausible relation (e.g., beaver-eager).

SITUATIONAL (S)

A property of a situation, where a situation typically includes one or more agents, at some place and time, engaging in an event, with one or more entities in various semantic roles (e.g., picnic, conversation, vacation, meal).

■ PERSON (S-PERSON) – An individual person or multiple people in a situation (e.g., toy-children, car-passenger, furniture-person, brave-soldier).

■ LIVING THING (S-LIVING) – A living thing in a situation that is not a person, including other animals and plants (e.g., sofa-cat, park-grass, fear-snake).

■ OBJECT (S-OBJECT) – An inanimate object in a situation, except buildings (e.g., watermelon-on a plate, cat-scratch sofa, freedom-flag).

■ SOCIAL ORGANIZATION (S-SOCORG) – A social institution, a business, or a group of people or animals in a situation (e.g., freedom-government, radio-kmart, picnic-family, dog-pack, freedom-country).

■ SOCIAL ARTIFACT (S-SOCART) – A relatively abstract entity—sometimes partially physical (book) and sometimes completely conceptual (verb)—created in the context of socio-cultural institutions (e.g., farm-a book (about), farm-a movie (about), invention-a group project, (to) carpet-a verb).

■ BUILDING (S-BUILD) – A building in a situation (e.g., book-library, candle-church, guilt-court, safety-home).

■ LOCATION (S-LOC) – A place in a situation where an entity can be found, or where people engage in an event or activity (e.g., car-in a park, buy-in Paris).

■ SPATIAL RELATION (S-SPAT) – A spatial relation between two or more things in a situation (e.g., watermelon-the ants crawled across the picnic table, vacation-we slept by the fire).

■ TIME (S-TIME) – A time period associated with a situation/relationship/internal state or with one of its properties (e.g., picnic-fourth of July, sled-during the winter, friendship-lasting, forever). When an event is used as a time (e.g., muffin-breakfast), code the event as s-event.

■ ACTION (S-ACTION) – An action (not introspective) that an agent (human or non-human) performs intentionally in a situation (e.g., shirt-wear, apple-eat, advice-listen). When the action is chronic and/or characteristic of the entity, use e-beh.

■ EVENT (S-EVENT) – A stand-alone event or activity in a situation where the action is not foregrounded but is on a relatively equal par with the setting, agents, entities, etc. (e.g., watermelon-picnic, car-trip, church-wedding, surprise-party). Use s-action when the action is foregrounded (e.g., use s-action for church-marry, but use s-event for church-wedding).

■ OUTCOME (S-OUT) – An outcome of an event or internal state (e.g., competition-win, crisis-death, humiliate-hurt).

■ CAUSE (S-CAUS) – An event/situation/internal state that causes an emotional cue word, or is typically associated with it (e.g., stress-work, disappoint-fail).

■ MANNER (S-MANNER) – The manner in which an action or event is performed in a situation (e.g., watermelon-sloppy eating, car-faster than walking). Or, manners/behaviours associated with an internal state (lazy-slow, anxious-jumpy). That is the modification of an action in terms of its *quantity, duration, style,* etc. Code the action itself as s-action, s-event, or e-beh.

■ FUNCTION (S-FUNC) – A typical goal or role that an entity serves for an agent in a situation by virtue of its physical properties with respect to relevant actions (e.g., car-transportation, clothing-protection).

■ PHYSICAL STATE (S-PHYST) – A physical state of a situation or any of its components except entities whose states are coded with e-sys, and social organizations whose states are coded with s-socst (e.g., mountains-damp, highway-congested).

■ SOCIAL STATE (S-SOCST) – A state of a social organization in a situation (e.g., family-cooperative, people-free).

■ QUANTITY (S-QUANT) – A numerosity, frequency, intensity, or typicality of a situation or any of its properties except of an entity, whose quantitative aspects are coded with e-quant (e.g., vacation-lasted for eight days, car-a long drive).

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Aujla, H., & Nedjadrasul, D. (2015). Low-dose nociceptin/orphanin FQ reduces anxiety-like performance in alcohol-withdrawn, but not alcohol-naïve, male wistar rats. *Neuropharmacology*, *93*, 1–6.

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SELECT HONOURS & AWARDS

2016-2017 Ontario Graduate Scholarship
2016-2017 Western Graduate Research Scholarship
2015-2016 NSERC Canada Graduate Scholarship-Master's
2015-2016 Western Graduate Research Scholarship

RELATED EMPLOYMENT EXPERIENCE

UNIVERSITY OF WESTERN ONTARIO
2016-2016 Graduate Teaching Assistant
2015-2015 Graduate Teaching Assistant

UNIVERSITY OF WINNIPEG
2009-2015 Teaching Assistant