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

7

Situating Abstract Concepts

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Roughly speaking, an abstract concept refers to entities that are neither purely physical nor spatially constrained. Such concepts pose a classic problem for theories that ground knowledge in modality-specific systems (e.g., Barsalou, 1999, 2003a,b). How could these systems represent a concept like *TRUTH*?[1] Abstract concepts also pose a significant problem for traditional theories that represent knowledge with amodal symbols. Surprisingly, few researchers have attempted to specify the content of abstract concepts using feature lists, semantic networks, or frames. It is not enough to say that an amodal node or a pattern of amodal units represents an abstract concept. It is first necessary to specify the concept's content, and then to show that a particular type of representation can express it. Regardless of how one might go about representing *TRUTH*, its content must be identified. Then the task of identifying how this content is represented can begin.

The primary purpose of this chapter is to explore the content of three abstract concepts: *TRUTH*, *FREEDOM*, and *INVENTION*. In an exploratory study, their content will be compared to the content of three concrete concepts – *BIRD*, *CAR*, and SOFA – and also to three intermediate concepts that seem somewhat concrete but more abstract than typical concrete concepts – *COOKING*, *FARMING*, and *CARPETING*. We will first ask participants to produce properties typically true of these concepts. We will then analyze these properties using two coding schemes. Of particular interest will be the content of abstract concepts, and how it compares to the content of concrete and intermediate concepts.

We will not attempt to provide evidence that modality-specific systems represent abstract concepts. Once we have assessed their content, however,

[1] Italics will be used to indicate concepts, and quotes will be used to indicate linguistic forms (words, sentences). Within concepts, uppercase words will represent categories, whereas lowercase words will represent properties of categories.

we will speculate on how modality-specific systems could represent it. Notably, though, recent studies have obtained evidence for modality-specific representations in abstract concepts. Glenberg and Kaschak (2002) found that abstract concepts contain motor information, as did Richardson, Spivey, Barsalou, and McRae (2003). For evidence that other types of concepts are grounded in modality specific systems, see recent reviews by Barsalou (2003b), Barsalou, Niedenthal, Barbey, and Ruppert (2003), and Martin (2001).

RELATED ISSUES IN REPRESENTING ABSTRACT CONCEPTS

The issue of modal versus amodal representation is not the only important issue related to abstract concepts. Previous researchers have raised other important issues. In particular, previous researchers have suggested that situations, word associations, and metaphors are potentially important aspects of how abstract concepts are represented. We address each in turn.

Situation Availability[2]

In a series of studies, Schwanenflugel, Shoben, and their colleagues demonstrated that it is often difficult to think of a situation in which an abstract concept occurs (for a review, see Schwanenflugel, 1991). For example, what is a situation in which *TRUTH* occurs? Although a court trial might eventually come to mind, or a child confessing to a parent, it often takes a while to retrieve such situations. In contrast, situations seem to come to mind much more readily for concrete concepts. For *CHAIR*, situations like living rooms and classrooms come to mind quickly.

Schwanenflugel, Shoben, and their colleagues explored the role of situation availability across a variety of cognitive tasks. To do this, they first demonstrated the general advantage of concrete over abstract concepts (also see Paivio, 1986). Specifically, they showed that (1) lexical access is faster for concrete words than for abstract words (e.g., Schwanenflugel, Harnishfeger, & Stowe, 1988), (2) word comprehension is faster for concrete words than for abstract words (e.g., Schwanenflugel & Shoben, 1983; Schwanenflugel & Stowe, 1989), and (3) memory is better for concrete words than for abstract words (e.g., Wattenmaker & Shoben, 1987). Then, in the same studies, these researchers demonstrated that situation availability played a major role in these differences by manipulating the presence

[2] In the original work on this topic, Schwanenflugel and her colleagues referred to what we're calling "situation availability" as "context availability." We use "situation" instead, first, because the construct of a situation has played a central role in much of our recent work and in the work of other researchers (see Yeh and Barsalou, 2004, for a review), and second, because situations can be viewed as one possible form of context.

versus absence of a relevant situation. For example, participants might first read about a court trial before studying "truth" for a memory test, or first read about a living room before studying "chair." When relevant situations were present, abstract words were processed as well as concrete words. Participants accessed and understood both types of words equally quickly, and remembered them just as well.

These findings demonstrate two points about the processing of words. First, the meanings of words are not established in isolation. A word's meaning is typically not a stand-alone package of features that describes its associated category. Instead, words are typically understood and represented against background situations (cf. Murphy & Medin, 1985). When a situation is not available, a concept is difficult to process. Much early work on language comprehension reached this same conclusion (for reviews, see Bransford & Johnson, 1973; Bransford & McCarrell, 1974). Much recent work echoes this theme (e.g., Barsalou, 2003b; A. Clark, 1997; H. Clark, 1992; Yeh & Barsalou, 2004). In general, situations provide much useful information for understanding concepts. Understanding what *CHAIR* means relies not only on the physical properties of the object, but also on the settings in which it is found (e.g., classrooms) and the activities performed in them (e.g., attending lectures). Knowledge of chairs is inadequate if one does not know how they are used in relevant situations. For this reason, situations often appear central to the representation of concepts.

Second, retrieving situations for abstract concepts appears more difficult than retrieving situations for concrete concepts. At least the following two factors may be responsible. First, abstract concepts may be associated with a wider variety of situations than concrete concepts (Galbraith & Underwood, 1973). As a result of greater interference between competing situations, retrieving a single one may be more difficult than for a concrete concept. Second, when people process abstract concepts in the real world, there may typically be a relevant situation already in place. People may not typically entertain a concept like *TRUTH* unless a relevant situation is in place to which the concept applies. As a result, the conceptual system becomes oriented toward retrieving information about abstract concepts with relevant situations already in place. Conversely, because it is relatively unusual to process abstract concepts in situational vacuums, people draw blanks initially when receiving them out of context.

Word Association

People may not exactly draw a blank when processing abstract concepts in isolation. Instead, the word for an abstract concept may trigger highly associated words. Because no situation comes to mind immediately, other associated information becomes active. Because the memory cue is a word, other associated words come to mind, following the principle of encoding specificity (Tulving & Thomson, 1973). Note, however, that these words don't necessarily constitute conceptual meaning. Instead, as word associates become active, only their surface-level phonological forms are retrieved, accompanied by minimal meaning. Certainly, more semantic content could be retrieved on occasion. Nevertheless, meaning may often be processed minimally.

Several sources of evidence support the conjecture that abstract words encountered out of context initially activate superficial word associations. First, Glaser (1992) reviews much evidence that words in general often generate word associates, prior to the activation of conceptual information. Consider an example. Solomon and Barsalou (2004) found that participants used the strength of word associations in a property verification task when associative strength was a diagnostic cue for responding – they did not typically access conceptual knowledge. Participants adopted this strategy because the object and property words on true trials tended to be associated (e.g., "horse" – "mane"), whereas the object and property words on false trials tended to be unassociated (e.g., "chair" – "feathers"). Because word association strength predicted the correct response, participants did not need to access conceptual knowledge. Kan, Barsalou, Solomon, Minor, and Thompson-Schill (2003) reported fMRI evidence consistent with Solomon and Barsalou's behavioral findings. Glaser (1992) offers many such examples of surface-level word forms playing central roles in "conceptual" tasks. Together, these findings indicate that word associations can become activated quickly with minimal retrieval of conceptual information.

A second source of evidence further suggests that processing abstract concepts in isolation may initially produce word associations. As Pulvermüller (1999) reviews, lesion and neuroimaging studies have localized the processing of abstract concepts in left frontal areas. In these studies, participants usually receive isolated words for abstract concepts not linked to particular situations. Thus, retrieving situations should be difficult, and word associations could fill the conceptual void. Consistent with this account, left-frontal areas tend to be implicated with word generation processes (e.g., Thompson-Schill, D'Esposito, Aguirre, & Farah; 1997; Peterson, Fox, Posner, Mintus, & Raichle, 1989). The proximity of these areas to Broca's area further implicates word generation. To our knowledge, no neuroscience research has assessed the processing of abstract concepts in situations. It would be interesting to see if situational processing shifted brain activation outside word generation areas.

A third line of work also implicates word association in the processing of isolated abstract concepts. Krauth-Gruber, Ric, Niedenthal, and Barsalou (2004) had participants generate information about isolated abstract and concrete concepts under one of three instructional sets. One group produced word associations for the abstract and concrete concepts. A second group constructed an image of what each concept referred to and then described the image. A third group produced properties that are typically true of each concept. Of interest was whether property generation participants more resembled word association participants or imagery participants in the information produced. For concrete concepts, property generation participants produced essentially the same information as imagery participants, consistent with the conclusion that property generation participants used images to represent these concepts (also see Wu & Barsalou, 2004). For abstract concepts, however, property generation participants essentially produced the same information as word association participants, consistent with the conclusion that property generation participants initially accessed word associations for the isolated abstract words. When a background situation was not present, the initial information retrieved for the abstract concepts appeared to be word associations.

Finally, it is worth noting that the retrieval of word associations during initial lexical access is consistent with theories like LSA (Landauer & Dumais, 1997) and HAL (e.g., Burgess & Lund, 1997). According to these theories, a word becomes associated to other words it cooccurs with in texts, with associative strength reflecting frequency and proximity of cooccurrence. Subsequently, when a word is encoded, its network of word associates becomes active. According to LSA and HAL, these associates constitute the word's meaning. Alternatively, these associates may simply be word forms that point to underlying concepts.

Metaphor

Some theorists have argued that the meanings of abstract concepts are grounded in concrete domains (e.g., Gibbs, this volume; Lakoff & Johnson, 1980; Lakoff & Turner, 1989). For example, the abstract concept, *ANGER*, is grounded in concrete phenomena, such as boiling water exploding out of a closed pot. We agree that metaphors often augment the meanings of abstract concepts, and make certain aspects of their conceptual content salient (e.g., Boroditsky & Ramscar, 2002).

Nevertheless, direct experience of abstract concepts appears central to their content (Prinz, Chapter 5, this volume). One reason is that people have considerable amounts of direct experience with abstract concepts. Consider *ANGER*. People have much experience with the external situations that trigger anger, what anger feels like subjectively, and how one acts and looks when angry. Indeed, norms for emotion concepts like *ANGER* contain detailed features of this experience (e.g., Fehr & Russell, 1984). Notably, these norms don't contain much mention of metaphors.

Direct experience of abstract concepts is important for another reason. A concrete metaphor can not be mapped into an abstract concept, if the abstract concept doesn't have it's own structure (e.g., Murphy, 1997). If an abstract concept has no structure based on direct experience, the concrete metaphor would have nothing to map into. Certainly, metaphors may interpret direct experience and add new material to it. The point is, however, that metaphors complement direct experience of abstract concepts, which often appears extensive.

Thus, our focus will be on the direct knowledge that people have of abstract concepts. Later, when we report an exploratory study, we will focus exclusively on direct knowledge. Indeed, we found little mention of metaphors when people described the content of abstract concepts.

HYPOTHESES ABOUT CONCEPTUAL CONTENT

A common assumption is that abstract and concrete concepts have little, if anything, in common. With respect to their content, they constitute two completely different kinds of concepts. In contrast, we propose that concrete and abstract concepts share important similarities. In particular, we propose that they share common situational content (Hypothesis 1). Where concrete and abstract concepts differ is in their focus within background situations, with concrete concepts focusing on objects, and abstract concepts on events and introspections (Hypothesis 2). As a result of these different foci, the representation of abstract concepts is more complex, being less localized in situational content than the content of concrete concepts (Hypothesis 3). Finally, because the content of abstract concepts is grounded in situations, this content can be simulated in modality-specific representations (Hypothesis 4). We address each hypothesis in turn.

Hypothesis 1. Concrete and Abstract Concepts Share Situational Content

As reviewed earlier, situations appear important for accessing and representing both abstract and concrete concepts. Consider the concrete concept, *HAMMER*. If people only know the physical parts of *HAMMERS* (e.g., *head*, *handle*), they lack an adequate concept of the category. Instead, people must also know the settings where the objects are used, such as the presence of two boards and nails, along with an agent for using them. People also need to know the actions that the agent performs (e.g., swinging the hammer), and also the events that result from these actions (e.g., the hammer head driving the nail into the boards). Finally, people need to know about the mental states of the agent, including goals (e.g., bind two boards together) and affective reactions (e.g., satisfaction when the nail is pounded in correctly). Only when all of the relevant situational content about *HAMMERS* is known does someone approach a full understanding of the concept. For a detailed account of how situational knowledge underlies the semantics of artifacts and natural kinds, see Barsalou, Sloman, and Chaigneau (in press).

Situations appear even more central to abstract concepts. Consider Barsalou's (1999) semantic analysis of an everyday sense of *TRUE*, namely, the sense that an agent's claim about the world is accurate. To represent this sense requires a situation that contains the following event sequence. First, a speaker makes a verbal claim about some state of the world to a listener (e.g., it's raining outside). Second, the listener constructs a mental representation of the speaker's claim (e.g., what raining outside might look like). Third, the listener perceives the part of the world that the claim is about (e.g., the weather outside). Fourth, the listener determines whether the represented claim matches or doesn't match the current state of the world. Fifth, if the claim matches the world, the listener concludes that the speaker's claim has the property of being *TRUE*; otherwise, it's *FALSE*. As this example illustrates, a complex situation is necessary to represent the meaning of *TRUE*, including multiple agents (e.g., speaker, listener), physical events (e.g., communication, states of the world), and mental events (e.g., representing, comparing). Without a situation, it would be impossible to represent the meaning of this abstract concept. Barsalou (1999) provides additional examples of how situations underlie other abstract concepts, such as *OR*, and also ad hoc categories, such as *THINGS TO STAND ON TO CHANGE A LIGHT BULB*.

As these examples illustrate, situations appear central to both concrete and abstract concepts. Thus, there should be strong similarities between their content. When we ask participants to describe the content of concepts, we should observe extensive mention of situations for not only for abstract concepts, but also for concrete ones.

Hypothesis 2. Concrete and Abstract Concepts Differ in Situational Focus

Where we propose that concrete and abstract concepts differ is in their focus on situational content. For concrete concepts, attention should focus on the respective objects against their background situations. In representing *HAMMERS*, the focus should be on hammer objects in their situations of use. Even though information about events and introspections exists in the representation, attention focuses on the critical objects and their specific properties.

In contrast, the focus for abstract concepts should be distributed across other types of situational content. Specifically, abstract concepts should focus on event and introspective properties. One basis for this prediction is Barsalou's (1999) preliminary analyses of abstract concepts, where these two types of properties played central roles. Complex configurations of event and introspective properties generally appeared necessary to capturing the meaning of an abstract concept. Further bases for this prediction are empirical findings from Wiemer-Hastings and her colleagues. In one line of work, the similarity between the linguistic contexts in which abstract concepts occur predicted the similarity of the concepts' meanings (Wiemer-Hastings & Graesser, 2000; see also Wiemer-Hastings & Graesser, 1998). Because these contexts were defined as verbs and prepositions, this correlation supports the proposal that events and settings are central for abstract concepts. In another study, introspective properties were especially important for predicting the differential abstractness of abstract concepts (Wiemer-Hastings, Krug, & Xu, 2001).

Hypothesis 3. Abstract Concepts are More Complex Than Concrete Concepts

According to Hypothesis 2, concrete concepts focus on objects in situations, whereas abstract concepts focus on events and introspections. An implication of this proposal is that the representations of abstract concepts should be more complex than those of concrete concepts. For concrete concepts, the focus is on a relatively local, spatially circumscribed region of a situation. In a *HAMMER* situation, for example, the focus is on the region that the hammer occupies.

For abstract concepts, however, the focus is on multiple components that are not localized but distributed widely. In a *TRUE* situation, for example, the focus includes the speaker's claim, the listener's representation of the claim, and the listener's assessment of the claim. All these components, and the relations between them, must be represented and integrated to evaluate *TRUE's* focal content. We have increasingly come to believe that abstract concepts seem "abstract" because their content is distributed across situations. Another contributing factor may be the centrality of introspective information, which may be more subtle to detect than entity information. Thus, in the study to follow, we expected to see more complex representations for abstract concepts than for concrete ones.

Hypothesis 4. The Content of Abstract Concepts Could, in Principle, Be Simulated

All of the conceptual content that we have discussed so far could, in principle, be simulated in the brain's modality specific systems. It is well known from both imagery and neuroscience research that people construct images of objects, settings, and events (see Barsalou, 2003b; Martin, 2001). Thus, all of this situational content could in principle be simulated as people represent concrete and abstract concepts.

In contrast, little direct evidence bears on the representation of the introspective information central to abstract concepts (also important but backgrounded for concrete concepts). Nevertheless, it seems quite plausible that introspective content could be simulated in mental images (for specific proposals, see Barsalou, 1999, 2003a). It seems possible to simulate the introspective experiences of emotions (e.g., happiness), drive states (e.g., hunger), and cognitive operations (e.g., comparing two imagined objects). There is no empirical or theoretical reason for believing that introspective content could *not* be simulated as part of a conceptual representation. Thus, we will assume that the presence of introspective content in conceptual representations does not constitute evidence against embodied theories of knowledge.

AN EXPLORATORY STUDY

To assess these hypotheses, we asked college students to produce the properties of three abstract concepts, three concrete concepts, and three concepts intermediate in abstractness. Because we wanted to explore the content of these concepts in an open-ended manner, we did not constrain participants' protocols to any particular type of information. Thus participants were simply asked to describe the properties that they thought were characteristic of each concept. As will be seen, these probes led to a diverse collection of responses.

Two other factors besides concept abstractness were manipulated: situation availability (whether a concept was or was not preceded by the description of a situation) and concept form (whether a concept was presented as an entity, event, quality, etc.). These factors had little effect, so we do not report results for them. Because participants responded at their own pace for a full minute, they produced diverse content that obscured possible effects of these manipulations.

Analyses. To examine the content of participants' protocols, two coding schemes were applied. First, Wu and Barsalou's (2004) coding scheme established the amounts of taxonomic, entity, setting/event, and introspective content in the protocols (for additional applications of this coding scheme, see Cree & McRae, 2003; Krauth-Gruber et al., 2004; McRae & Cree, 2002). This coding scheme makes it possible to assess whether situational content occurs across all three concept types (Hypothesis 1). It also enables assessing whether different types of situational content are more important for concrete vs. abstract concepts (Hypothesis 2).

A second analysis established larger groups of properties in the protocols (e.g., extended descriptions of people, events, introspections, etc.). To capture these larger protocol units, a second coding scheme was developed. This scheme also captured the hierarchical relations that frequently integrated these larger units. As will be seen, analysis of these units and their hierarchical structure provides insight into the shared and distinctive properties of abstract, concrete, and intermediate concepts. Applying this scheme also allowed us to assess whether the representations of abstract concepts are more complex than those of concrete concepts (Hypothesis 3).

Finally, both analyses allow informed speculation about Hypothesis 4. Once these two analyses establish the content of abstract, concrete, and intermediate concepts, we can begin thinking about whether modality-specific systems could in principle simulate it.

Method

Materials. The critical materials included three abstract concepts, three concrete concepts, and three intermediate concepts. Each abstract concept took three forms: *TRUE, THE TRUTH, TRUTHFULNESS; A FREEDOM, TO FREE, FREELY; AN INVENTION, TO INVENT, INVENTIVENESS.* Similarly, each intermediate concept took three forms: *A COOK, TO COOK, SOMETHING THAT HAS BEEN COOKED; A FARM, TO FARM, SOMETHING THAT HAS BEEN FARMED; A CARPET, TO CARPET, SOMETHING THAT HAS BEEN CARPETED.* A single form was used for the three concrete concepts (*A BIRD, A SOFA, A CAR*), given that these concepts did not have similar variants. As described earlier, the form of concepts had no effect. Thus, we only report results collapsed across forms (e.g., results are combined for *A FREEDOM, TO FREE,* and *FREELY*).

Six lists of the nine critical items were constructed. Each contained one variant of each abstract concept, one variant of each intermediate concept, and all three of the fixed concrete concepts. One set of three lists was counter-balanced such that each variant of a concept occurred equally often, and also such that the variants of different concepts differed maximally within a given list. Each third of the list contained one abstract concept, one concrete concept, and one intermediate concept, in random orders. The entire counterbalancing process was performed twice, to produce a second set of three lists, so that a given concept's list position varied, along with its neighbors, in the respective third of the list.

A short paragraph was constructed for each concept that described a relevant situation. For variants of *TRUTH,* the paragraph described a boy telling his mom that he wasn't responsible for breaking a living room vase, and his mom believing him. Similarly, for *CAR,* a short paragraph described a woman using her car for commuting to work, and listening to music while doing so. As described earlier, the open-ended nature of the protocols obscured any effects of this manipulation, such that it receives no further discussion here.

Participants and Design. Initially, the study included 24 Emory undergraduates who participated for pay. Half received the words in isolation, and half received the words preceded by situations. Within each group, two participants received each of the six versions of the critical list.

Over the course of data analysis, three participants' data were lost due to computer problems (one situations subject and two no-situations subjects). For the remaining 21 participants, 4 of the 189 protocols (21 participants × 9 concepts) were also lost due to computer problems. No more than one protocol was ever lost per concept or participant, and these were distributed evenly across abstract, concrete, and intermediate categories. Because of this study's exploratory nature, these missing participants and protocols were not replaced. Because concept abstractness was manipulated within participants, every remaining participant's data could be assessed on this variable.

Procedure. Participants received the following open-ended instructions to produce the properties of concepts:

> The general purpose of this experiment is to study people's knowledge about the world. Our specific purpose here today is to learn more about people's understanding of a few specific concepts. Before we go any further, let me stress that there are no correct responses to the questions that I am about to ask you. Thus, please don't worry about whether you've come up with the right answer or not. This is not an issue at all. Instead, what we're doing here is performing a scientific experiment, where the purpose of this experiment is to understand how normal people like yourself think about various concepts. Here's what you can do to help us learn more about this. In a moment, when I ask you about various concepts, please respond with the very first thoughts that come to mind, and then keep responding with the thoughts that continue to come to mind, until I ask you to stop.

Later in the instructions, participants practiced producing properties for *TREE, BRICK, PENCIL,* and *CAMERA* verbally. The instructions did not give any examples of possible properties that could be produced, so as to avoid biasing participants' responses. On every trial, participants received the following instruction:

> Please report your thoughts as they come to mind.
> What characteristics are typically true of the following concept: [concept name]

When ready, participants began producing characteristics verbally for a full 1 min. Whenever a participant paused for 5 sec, the experimenter stated, "Please continue to describe your thoughts as they come to mind." When participants were in the middle of describing a property at the 1 min point, they were allowed to complete the description. A digital video camera captured each protocol to a computer, with participants consenting to the recording process.

Prior to the nine critical trials, participants produced properties for six randomly ordered practice concepts, which they did not realize constituted practice. As for the critical materials, two concepts were abstract (*INTEGRITY, VAGUE*), two were concrete (*A ROSE, A BRUISE*), and two were intermediate (*TO HAMMER, SOMETHING THAT HAS BEEN PAINTED*).

Analysis 1: Establishing the Content of Protocol Elements

Each of the nine critical protocols for a given participant was transcribed and coded using the Noldus software for digital video coding. As a judge viewed a protocol, she transcribed each statement into a file and coded it with one of the 45 coding categories from the Wu and Barsalou (2004) coding scheme.[3] These 45 coding categories fell into 5 general groups: taxonomic, entity, setting/event,[4] introspective, and miscellaneous. A taxonomic code was applied to statements that mentioned a taxonomic category related to the target concept. An entity code was applied to statements that described a property of a physical object. A setting/event code was applied to statements that described a property of a setting or event. An introspective code was applied to statements that described the mental state of someone in a situation.

The specific taxonomic coding categories were synonym, ontological category, superordinate, coordinate, subordinate, and individual. The specific entity coding categories were external component, internal component, external surface property, internal surface property, substance/material, spatial relation, systemic property, larger whole, entity behavior, abstract entity property, and quantity. The specific setting/event coding categories were person, nonperson living thing, setting object, social organization, social artifact, building, location, spatial relation, time, action, event, manner, function, physical state, social state, and quantity. The specific introspective coding categories were affect/emotion, evaluation, representational state, cognitive operation, contingency, negation, and quantity. The specific miscellaneous coding categories were cue repetition, hesitation, repetition, and meta-comment. For definitions of these categories, see Wu and Barsalou (2004), Cree and McRae (2003), McRae and Cree (2002), and Krauth-Gruber et al. (2004). Figure 7.1 presents a representative protocol coded with this scheme (also see Figure 7.2 later).

In analyzing the results, few differences of theoretical importance occurred at the level of the 45 specific codes. Instead, the interesting results appeared at the level of the general coding categories, aggregating across the specific codes within them. Thus, we only report results from the general level. To establish reliability, a second judge coded the statements for a single participant's nine concepts, and agreed with 95% of the codes given by the judge who coded all of the protocols. Similar levels of agreement using this scheme were reported in Wu and Barsalou (2004), where reliability averaged 90%.

Table 7.1 presents the proportions of protocol statements in the four general coding categories of interest: taxonomic, entity, setting/event, and introspective properties. For each of the 21 participants, the average proportion of properties was computed for each of the 4 general coding categories, once each across the 3 concepts for each of the 3 concept types. These proportions were subjected to an arcsin transformation that normalized variance (Winer, 1971), and then submitted to a mixed ANOVA having context, concept abstractness, and general coding category as factors. Unless noted otherwise, all reported tests were significant at the .05 level. Because the tests assessed a priori predictions, post hoc corrections were not employed. The large size of most F values further reduces the probability of a Type I error. *MSEs* are reported in arcsin units.

TABLE 7.1. *Proportions of Property Types for Different Concept Types from Analysis 1*

	Property type			
Concept type	**Taxonomic**	**Entity**	**Setting/Event**	**Introspective**
Concrete	.07	.26	.46	.21
Intermediate	.04	.22	.53	.22
Abstract	.05	.15	.52	.28
Average	.05	.21	.50	.24

Overall Differences in Content. The proportions for the four general coding categories differed ($F(3,57) = 160.13$, $MSE = .02$ arcsin). As Table 7.1 illustrates, setting/event properties were produced most often in the protocols. Half of the properties produced, .50 overall, described aspects of settings and events. Notably, introspective properties were next most frequent (.24), followed by entity properties (.21), and taxonomic categories (.05). In statistical tests of the adjacent differences, setting/event properties were

[3] An updated version of the Wu and Barsalou (2004) scheme was used that incorporated additional categories found by McRae and Cree (2002) to be important.

[4] In Wu and Barsalou (2004), McRae and Cree (2002), and Cree and McRae (2003), "setting/event properties" were referred to as "situational properties." We refer to them as "setting/event properties" here because we use "situation" more generally to include introspective information, not just external information about settings and events in the world.

Position	Latency	Analysis 1	Protocol	Analysis 2
1	0.0	M-cue	a bird	
2	2.8	M-cue	a bird	
3	4.6	E-exsurf	(like) tiny	
4	5.6	E-sys	(and) fragile	**E** (S=4.6, L=3, H=1, M=0)
5	7.0	E-exsurf	(and) colorful	
6	9.2	M-meta	I think of	
7	9.7	E-quant	really	
8	10.0	E-exsurf	little	
9	10.4	E-excomp	feet	**E** (S=9.7, L=5, H=1, M=0)
10	11.2	M-repit	(and) little	
11	11.8	E-excomp	beaks	
12	12.8	M-hesit	um	
13	13.4	M-meta	think of like	
14	14.4	E-exsurf	(the) sounds	
15	14.9	M-cue	they [birds]	**EVB** (S=14.4, L=4, H=1, M=0)
16	15.1	E-beh	make	
17	16.2	E-beh	(the) chirping	
18	17.0	M-meta	and then I think of like	
19	18.1	S-time	morning	**TM** (S=18.1, L=1, H=1, M=0)
20	19.3	M-cue	(when) they [birds]	
21	19.8	S-action	(like) wake	**EVA** (S=18.1, L=4, H=2, M=1)
22	20.1	S-person	me (up)	
23	20.6	M-meta	and stuff	
24	21.9	M-meta	and I think of	
25	24.5	M-hesit	um	
26	26.5	M-cue	(maybe like the) birds	
27	27.3	S-person	(that) I	
28	27.6	S-action	see	**EVA** (S=26.5, L=6, H=2, M=1)
29	27.8	S-loc	(at the) beach	**L** (S=27.8, L=1, H=1, M=0)
30	28.2	I-cogop	like	
31	28.6	C-subord	seagulls	**T** (S=28.2, L=2, H=1, M=0)
32	29.1	M-meta	and stuff	
33	29.5	M-meta	then I think of like	
34	31.4	M-repit	(how) they [seagulls]	**T** (S=31.4, L=1, H=1, M=0)
35	31.9	I-eval	(can be like) annoying	
36	33.4	E-beh	(like like) flying around	**IE** (S=31.4, L=5, H=2, M=0)
37	34.4	S-action	(trying to) get	**EVB** (S=33.4, L=3, H=1, M=0)
38	35.0	S-object	food	
39	35.5	M-meta	and stuff	
40	36.6	M-meta	I think of like	
41	37.3	C-subord	pigeons	**T** (S=37.3, L=1, H=1, M=0)
42	38.2	S-spat	in	
43	38.6	S-loc	(like) downtown areas	**L** (S=38.2, L=2, H=1, M=0)
44	40.8	M-repit	(that) they're [pigeons]	
45	41.1	S-physt	(like) dirty	
46	41.6	I-eval	(and) gross	
47	43.0	M-hesit	um	**IE** (S=36.6, L=15, H=2, M=0)
48	44.3	M-hesit	then I	
49	46.1	M-meta	think of like	
50	48.1	M-repit	grossness	
51	49.5	M-repit	(and like) dirtiness	
52	50.4	M-meta	and stuff	
53	51.4	I-contin	[be] cause	
54	51.9	M-cue	(of the) birds	
55	55.5	M-hesit	and um	
56	57.5	M-meta	think of like	
57	58.6	S-object	bird-feeders	
58	59.5	S-quant	(and) different	
59	59.9	M-repit	bird-feeders	**L** (S=58.6, L=4, H=1, M=0)
60	60.6	S-object	(and) bird-baths	

FIGURE 7.1. Example of an analyzed protocol for *BIRD*. Position and latency (sec) for each coded statement in the protocol is shown. Text in parenthesis was produced in the protocol but not coded. Text in brackets was added by the coder to facilitate interpretation. The codes from Analyses 1 and 2 are also shown., along with the brackets used to indicate clusters in Analysis 2. For Analysis 1, C-* represents a taxonomic statement, E-* represents an entity statement, S-* represents a

significantly more likely than introspective properties ($F(1,57) = 44.15$, $MSE = .02$ arcsin); introspective properties did not differ from entity properties ($F(1,57) = .84$, $MSE = .02$ arcsin, $p > .25$); entity properties were significantly more likely than taxonomic properties ($F(1,57) = 30.24$, $MSE = .02$ arcsin).

These results offer support for Hypothesis 1, namely, background situational information is central to the representation of concepts. Properties that described settings and events were mentioned most often overall, and introspective properties were mentioned frequently as well. Entity properties were also mentioned, but overall, they only occurred at a rate of .21, whereas setting/event and introspective properties occurred at a combined rate of .74. Clearly situational information is central to the knowledge that people have about concepts.

Differences Between Concept Types. Are there departures from the overall trend at each level of concept abstractness? A significant interaction between concept abstractness and general coding category indicated that this ordering differed somewhat between concrete, intermediate, and abstract concepts ($F(1,57) = 15.18$, $MSE = .02$ arcsin). Although informative differences occurred between these concept types, as described shortly, the overall trend across types tended to occur for each individually. As Table 7.1 illustrates, setting/event properties were always most important, followed by introspection and entity properties (whose ordering differed slightly between types), with taxonomic properties always last. The interaction notwithstanding, it's clear that setting/event information is central for every category type.

The differences responsible for the interaction support Hypothesis 2, namely, concrete concepts focused on entity properties within situations, whereas abstract concepts focused on setting/event and introspection properties. A planned comparison to test this prediction used the following contrast weights: for concrete concepts, the means were weighted $+2$ (entity), -1 (setting/event), -1 (introspective); for abstract concepts, the means were weighted -2 (entity), $+1$ (setting/event), $+1$ (introspective). In support of Hypothesis 2, this comparison was significant ($F(1,57) = 16.94$, $MSE = .02$ arcsin). Although participants spent much time describing situations for all concepts, they focused more on entities for concrete concepts, and more on settings, events, and introspections for abstract concepts. Intermediate concepts fell in between, having

FIGURE 7.1 (*cont.*) setting/event statement, I-* represents an introspective statement, and M-* represents a miscellaneous statement. * represents the name of the specific code applied to the statement, which was not used in the analysis. See the text and the appendix for further detail on the coding schemes.

intermediate levels of the information distinctive for concrete and abstract concepts.

Analysis 2: Establishing Hierarchical Systems of Larger Protocol Units

The Wu and Barsalou (2004) coding scheme produces a micro-analysis of a protocol, parsing it into very small units and coding their individual content. Clearly, however, sets of these small units form larger groups, which the Wu and Barsalou scheme doesn't capture. Thus, this second analysis attempted to identify these groups. On the basis of examining the protocols, coding categories for these groups were developed and applied to the protocols. As the Appendix illustrates, larger groups of statements often described various types of entities, events, and introspections, along with taxonomic categories and social institutions. Figure 7.2 presents a representative protocol for an abstract concept coded with this scheme. For a representative example of a concrete concept, see Figure 7.1 presented earlier.

Coding Procedure.. To establish the reliability of the coding scheme, a second judge independently coded all of the protocols. For clusters that both judges identified, they used the same code 88% of the time. The second judged failed to include 10% of the clusters that the first judge included, and added 2% additional clusters. Thus agreement on these clusters was reasonably high.

Several other aspects of each cluster were coded besides its content. First, the average latency to the beginning of each cluster was recorded. The cluster labels in Figures 7.1 and 7.2 provide the starting cluster latencies using "$S =$".

Second, the average length of each cluster was recorded (i.e., the number of Wu and Barsalou statements it contained). Note that we included clusters of only a single statement if that statement contained information for a particular cluster type in the analysis. Single-statement clusters were included so that every occurrence of each content type would be counted in this analysis, even when short. Figures 7.1 and 7.2 illustrate examples of single-statement clusters. The cluster labels in Figures 7.1 and 7.2 provide cluster length using "$L =$".

Third, the average hierarchical level of each cluster was recorded. As Figures 7.1 and 7.2 illustrate, clusters were often embedded within each other hierarchically. The lowest level clusters received values of 1. Clusters that contained at least one level-one cluster received values of 2. Clusters that contained at least one level-two cluster received values of 3, and so forth. The cluster labels in Figures 7.1 and 7.2 provide hierarchical level using "$H =$".

Position	Latency	Analysis 1	Protocol
1	0.0	M-cue	true
2	5.5	S-socart	(as a) concept
3	7.0	M-cue	true
4	7.6	S-quant	always
5	7.9	S-action	(seems to be) used
6	9.6	I-cogop	to refer
7	10.2	C-ont	(to) something
8	10.7	E-sys	(that is) dependable
9	14.0	M-hesit	and
10	17.7	I-neg	not
11	18.2	I-rep	seen to be
12	20.6	E-sys	variable
13	20.9	I-rep	(so there's a) sense
14	22.2	E-sys	constancy
15	27.8	M-cue	true
16	28.3	S-quant	always
17	30.4	M-hesit	(seems to) kind of
18	31.9	I-contin	compel
19	32.4	S-person	people
20	32.8	I-cogop	(to) think about
21	36.3	M-repit	(what) really
22	38.0	I-rep	(is what their) beliefs
23	38.8	M-repit	really
24	39.2	M-repit	(are or how they) really
25	41.4	I-cogop	think
26	41.8	C-ont	things
27	42.1	S-physt	should be
28	44.3	M-hesit	um
29	44.9	S-quant	(and in) all
30	45.4	S-quant	(those) instances
31	46.6	I-cogop	(the kind of) idea
32	47.0	S-quant	(of) rarely [unintelligible text]
33	48.3	I-cogop	(seems to) invest
34	49.6	I-rep	(it with a kind of) weight
35	50.5	M-hesit	(of) um
36	52.9	I-eval	significance
37	54.5	M-hesit	and
38	56.2	M-meta	I mean in the sense of
39	57.1	I-emot	ultimacy
40	58.6	M-hesit	um
41	59.0	I-eval	(it's kind of) difficult
42	59.6	S-action	to talk about
43	60.4	M-cue	true
44	61.2	S-person	(as a) cultural scholar
45	63.4	S-time	after
46	63.9	S-socart	post-modernism
47	64.6	I-contin	but
48	64.6	I-rep	I think
49	64.7	M-cue	it [true]
50	65.0	S-physt	lingers

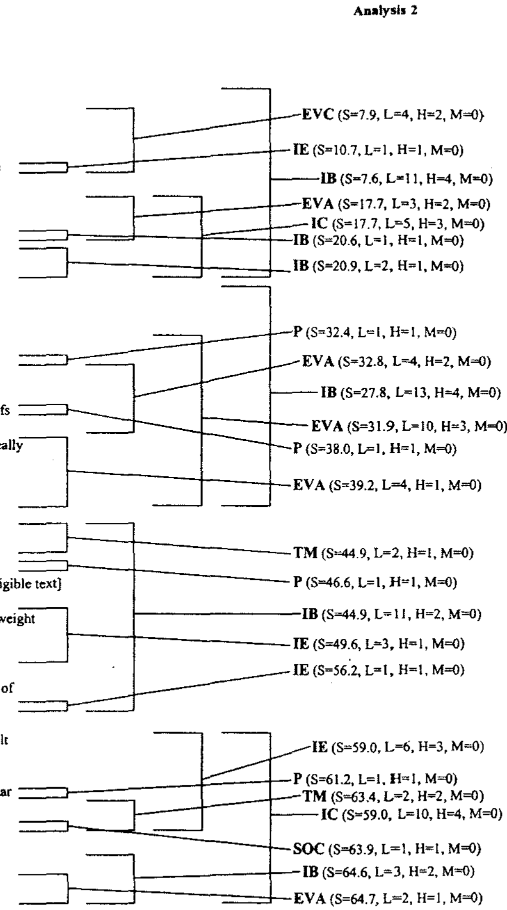

FIGURE 7.2. Example of an analyzed protocol for *TRUE*. Position and latency (sec) for each coded statement in the protocol is shown. Text in parenthesis was produced in the protocol but not coded. Text in brackets was added by the coder to facilitate interpretation. The codes from Analyses 1 and 2 are also shown., along with the brackets used to indicate clusters in Analysis 2. For Analysis 1, C-* represents a taxonomic statement, E-* represents an entity statement, S-* represents a setting/event statement, I-* represents an introspective statement, and M-* represents a miscellaneous statement. * represents the name of the specific code applied to the statement, which was not used in the analysis. See the text and the appendix for further detail on the coding schemes.

Cluster Content: Overview. On the average, participants produced 23.50 clusters for concrete concepts, 24.40 for intermediate concepts, and 23.75 for abstract concepts. Table 7.2 presents the proportions of clusters falling into the 14 coding categories of Analysis 2 at each level of concept abstractness.

TABLE 7.2. *Proportion of Cluster Types Across Concept Types from Analysis 2*

	Cluster Type													
		Space-Time		Entities			Event			Introspection				
Concept Type	Taxonomic Category	Location	Time	Object	Person	Characteristic Behavior	Non-Agent	Agentive	Communication	Goal	Evaluation/Affect	Belief	Contingency/Complex Relation	Social Institution
Concrete	.12	.12	.03	.14	.06	.06	.02	.18	.01	.01	.12	.06	.06	.02
Intermediate	.06	.10	.03	.23	.07	.00	.00	.21	.00	.02	.11	.05	.08	.03
Abstract	.05	.02	.03	.05	.20	.00	.01	.18	.05	.02	.09	.11	.12	.08
Average[a]	.08	.08	.03	.14	.11	.02	.01	.19	.02	.02	.11	.07	.09	.04

Note: The total number of clusters was 1,436 for concrete concepts, 1,539 for intermediate concepts, and 1,346 for abstract concepts.
[a] Averages are weighted by the number of observations in each concept type x cluster type cell of the design.

Because one participant's data were lost prior to Analysis 2, only 20 participants were included, 10 with situations and 10 without. For these 20 participants, the average proportion of properties produced in each of the 14 coding categories was established across the 3 concepts at each level of concept abstractness. These proportions were subjected to an arcsin transformation that normalized variance, and were then submitted to a mixed ANOVA having context, concept abstractness, and coding category as factors. Unless noted otherwise, all reported tests were significant at the .05 level. Because all tests assessed a priori predictions, post hoc corrections were not employed. The large size of most F and t values further reduces the probability of a Type I error. *MSE*s are reported in arcsin units.

As Table 7.2 illustrates, the results from Analysis 2 converge on the same basic conclusions as Analysis 1. On the one hand, the distributions of cluster types are similar across concrete, intermediate, and abstract concepts, indicating that similar types of situation information underlie all three concept types (Hypothesis 1). On the other hand, differential emphasis exists on the different types of situational information for concrete vs. abstract concepts (Hypothesis 2). There is also evidence for greater complexity in abstract concepts (Hypothesis 3).

In the ANOVA, cluster type exhibited a main effect, indicating that some cluster types were more likely than others ($F(13,234) = 53.96$, $MSE = .007$ arcsin). Some of the more common cluster types included agentive events (.19), objects (.14), persons (.11), and evaluations/affects (.11). The importance of a given cluster type was often similar for the three concept types. For example, agentive events and evaluations/affects were important for all three, whereas times, non-agentive events, and goals were relatively unimportant for all three. Clearly, though, important differences occurred, as indicated by a significant interaction between concept type and cluster type ($F(26,234) = 16.84$, $MSE = .007$ arcsin). As will be seen, the specific differences underlying this interaction are consistent with Hypotheses 2 and 3.

Cluster Content: Dominant Cluster Types for Concrete Concepts. First we consider cluster types that tended to be more important for concrete concepts than for abstract ones (intermediate concepts will be included as relevant). As Table 7.2 illustrates, object clusters were more important for concrete and intermediate concepts than for abstract concepts (concrete vs. abstract, $F(1,234) = 11.57$, $MSE = .007$ arcsin; intermediate vs. abstract, $F(1,234) = 48.29$, $MSE = .007$ arcsin). This pattern supports the prediction that concrete and intermediate concepts both focus on physical objects in situations. Interestingly, more object clusters occurred for intermediate than for concrete objects ($F(1,234) = 11.57$, $MSE = .007$ arcsin). This contrasts with the finding from Analysis 1 that entity properties were produced equally often for both concept types. The analysis of cluster length, however, will show that object clusters were longer for concrete concepts than for intermediate ones (Table 7.3). This pattern suggests the following conclusion. For concrete concepts, a single object tends to be salient (e.g., *SOFAS*), such that participants describe it at length. For intermediate concepts, a *configuration* of objects is often salient, such that participants describe each of them briefly (e.g., *TO COOK* refers to a cook, food, a stove, utensils, etc.). As a result, more clusters occur for the intermediate concepts, albeit shorter.

Locations were also more important for concrete and intermediate concepts than for abstract ones (concrete vs. abstract, $F(1,234) = 14.29$, $MSE = .007$ arcsin; intermediate vs. abstract, $F(1,234) = 9.14$, $MSE = .007$ arcsin). Concrete and intermediate concepts did not differ. This pattern suggests that people often think of physical objects in particular physical locations. In contrast, abstract concepts appear less tied to particular settings, and more tied to particular types of events, as we will see.

Finally, characteristic behaviors were important only for the concrete concepts (concrete vs. abstract, $F(1,234) = 5.14$, $MSE = .007$ arcsin; concrete vs. intermediate, $F(1,234) = 5.14$, $MSE = .007$ arcsin). When describing these objects, participants often discussed the behaviors that these entities typically exhibit (e.g., for *BIRDS*, they fly, nest, etc.).

In summary, this pattern is consistent with Hypothesis 2. Although concrete concepts are associated with much of the same situational information as abstract concepts, concrete concepts focus more on the physical aspects of situations, including objects, locations, and typical behaviors. Intermediate concepts also tend to focus attention on objects and locations.

Cluster Content: Dominant Cluster Types for Abstract Concepts. We next consider cluster types that tended to be more important for abstract concepts than for concrete ones. As Table 7.2 illustrates, person clusters were more important for abstract concepts than for concrete and intermediate concepts (abstract vs. concrete, $F(1,234) = 51.57$, $MSE = .007$ arcsin; abstract vs. intermediate, $F(1,234) = 41.29$, $MSE = .007$ arcsin). This suggests that abstract concepts may often have a more social character than concrete concepts, drawing attention to the properties of people and the relations between them. Further evidence for this conclusion is the trend towards significance for communicative events. As Table 7.2 illustrates, descriptions of communication tended to be more likely for abstract concepts than for concrete and intermediate ones (abstract vs. concrete, $F(1,234) = 2.29$, $MSE = .007$ arcsin, $p < .25$; abstract vs. intermediate, $F(1,234) = 3.57$, $MSE = .007$ arcsin, $p < .10$). As Table 7.2 further illustrates, social institutions were mentioned most often for abstract concepts (abstract vs. concrete, $F(1,234) = 5.14$, $MSE = .007$ arcsin; abstract vs. intermediate, $F(1,234) = 3.57$, $MSE = .007$ arcsin, $p < .10$). Together, these three findings suggest that social

TABLE 7.3. *Average Cluster Length and Hierarchical Level for Cluster Types Across Concept Types from Analysis 2*

		Cluster Type												
		Space-Time		Entities		Event				Introspection				
Concept Type	Taxonomic Category	Location	Time	Object	Person	Characteristic Behavior	Non-Agent	Agentive	Communication	Goal	Evaluation/Affect	Belief	Contingency/Complex Relation	Social Institution
Average length														
Concrete	2.59	2.39	1.62	2.23	1.56	3.74	3.32	4.65	5.25	5.38	4.10	5.15	7.92	4.09
Intermediate	5.40	2.37	1.17	1.52	1.50	1.00	4.20	3.89	4.89	4.52	3.92	5.71	9.23	2.43
Abstract	3.48	1.53	1.51	1.21	1.38	1.00	2.44	3.68	3.59	3.64	2.78	6.15	8.82	1.96
Average[1]	3.49	2.30	1.44	1.69	1.45	3.66	3.23	4.06	3.98	4.43	3.72	5.75	8.73	2.35
Average hierarchical level														
Concrete	1.14	1.07	1.00	1.09	1.00	1.29	1.42	1.63	1.25	1.67	1.40	1.74	2.16	1.50
Intermediate	1.47	1.12	1.00	1.06	1.04	1.00	1.80	1.66	1.67	2.08	1.50	1.95	2.53	1.23
Abstract	1.29	1.11	1.05	1.05	1.04	1.00	1.22	1.68	1.56	1.64	1.47	2.06	2.60	1.15
Average[a]	1.25	1.10	1.02	1.07	1.03	1.29	1.43	1.66	1.52	1.80	1.45	1.94	2.47	1.21

[a] Averages are weighted by the number of observations in each concept type x cluster type cell of the design.

situations may often be central to the content of abstract concepts. This is consistent with Hypothesis 2's prediction that abstract concepts focus attention on complex conceptual structures in background situations.

Abstract concepts were also most likely to exhibit two forms of introspection. First, beliefs tended to occur more often for abstract concepts than for the other two concept types (abstract vs. concrete, $F(1{,}234) = 3.57$, $MSE = .007$ arcsin, $p < .10$; abstract vs. intermediate, $F(1{,}234) = 5.14$, $MSE = .007$ arcsin). Processing abstract concepts often triggered a participant's opinion on these concepts. Second, contingency and other complex relations also tended to occur most often for abstract concepts (abstract vs. concrete, $F(1{,}234) = 5.14$, $MSE = .007$ arcsin; abstract vs. intermediate, $F(1{,}234) = 2.29$, $MSE = .007$ arcsin, $p < .25$). This finding is consistent with the conclusion that the conceptual content of abstract concepts is more complex than the content of concrete concepts. Because abstract concepts often depend critically on multiple pieces of information distributed across a situation, complex relations are needed to coordinate them.

Cluster Latency. The average latency across all clusters was 30.29 sec, which is what would be expected in a protocol that lasts about 60 sec. Notably, the average latencies did not vary substantially from this overall average, indicating that a given type of cluster could occur at just about any point in a protocol, for a given type of concept. There appeared to be little tendency for a particular type of cluster to occur early or late, with this flexibility holding equally for different concept types and for different cluster types.

Cluster Length. The top half of Table 7.3 presents the average lengths of clusters. Average cluster lengths did not differ significantly between concrete (3.67), intermediate (3.55), and abstract concepts (3.69). However, cluster lengths did vary considerably across cluster types. Cluster length increased from physical clusters (location, time, object, person), to event clusters (characteristic behavior, nonagentive, agentive, communicative), to introspective clusters (goal, evaluations/affects, belief, contingency/complex relations). Specifically, the average cluster length for event clusters (4.00) was longer than for physical clusters (1.75) ($t(2{,}613) = 18.51$, $SE = .12$). In turn, the average cluster length was longer for introspective clusters (5.90) than for events clusters (4.00) ($t(2{,}296) = 9.08$, $SE = .21$). One interpretation of this pattern is that physical components were relatively easy to describe, and therefore required short clusters. When clusters described events and introspective states, they become increasing complex conceptually, thereby requiring longer descriptions.

Hierarchical Level. The bottom half of Table 7.3 presents the average hierarchical level of clusters. As Hypothesis 3 predicts, the average hierarchical level of a cluster increased with concept abstractness, indicating greater organizational complexity in abstract concepts. Clusters for intermediate concepts (1.46) had higher hierarchical levels than clusters for concrete concepts (1.37) ($t(2{,}973) = 5.09$, $SE = .02$). In turn, clusters for abstract concepts (1.57) had higher hierarchical levels than clusters for intermediate concepts (1.46) (1.37) ($t(2{,}883) = 5.35$, $SE = .02$).

Hierarchical level also varied across cluster types. Specifically, hierarchical level increased from physical clusters (location, time, object, person), to event clusters (characteristic behavior, non-agentive, agentive, communicative), to introspective clusters (goal, evaluations/affects, belief, contingency/complex relations). The average hierarchical level for event clusters (1.62) was higher than for physical clusters (1.06) ($t(2{,}613) = 20.29$, $SE = .03$). In turn, the average level was higher for introspective clusters (1.93) than for event clusters (1.63) ($t(2{,}296) = 7.36$, $SE = .04$).

One interpretation of this pattern is as follows. Physical components are most primitive and therefore constitute the lowest level of description. In turn, events tend to build on physical components and thus establish higher-level clusters that include physical ones. Finally, introspective clusters tend to be highest because they often integrate lower- and intermediate-level clusters for physical components and events. Consistent with this account, contingency/complex relations (2.47), along with beliefs (1.94) and goals (1.80), tended to reside at the highest hierarchical levels.

One final aspect of hierarchical level concerns its relation to cluster length. As a cluster increases in level, it should tend to incorporate increasing numbers of Level 1 clusters, such that its overall length increases. To test this hypothesis, the overall averages for cluster length were correlated with the overall averages for cluster level. The resulting correlation was .97, indicating that hierarchical level played a major role in cluster length.

Episodic vs. Generic Memory. Because episodic memories were observed in the protocols, each cluster was coded for whether it appeared to be an episodic vs. generic memory. Clusters were coded as episodic when they obviously contained an autobiographical memory, or when they met Nelson's (1986) person, tense, and article criteria for being episodic. In Figures 7.1 and 7.2, M = 0 indicates generic status and M = 1 indicates episodic status.

Overall, episodic content occurred in 11% of the clusters, but increased with concreteness (8% for abstract concepts, 10% for intermediate concepts, 14% for concrete concepts). This trend is consistent with much research showing that concrete concepts are better cues for memory (e.g., Paivio, 1986), and also for analogy (e.g., Gentner, Ratterman, & Forbus, 1993; Ross & Kilbane, 1997). Nevertheless, all concept types accessed episodic information. Interestingly, the least likely clusters for a given concept type tended to produce the most episodic access. Thus, concrete object and location clusters were more likely to produce episodic memories for abstract concepts than for concrete concepts, whereas social and introspective clusters were more likely to produce episodic memories for concrete concepts. One possibility is that infrequently retrieved types of information aren't as automatized or generic as frequent types, and thus rely more on episodic memories for their content.

Summary of Analyses 1 and 2

Both analyses offer support for Hypothesis 1, namely, common situational content is produced across concrete, intermediate, and abstract concepts. Regardless of the concept, participants tended to describe background situations, including information about entities, settings, events, and introspections. In Analysis 1, 50% of protocol content described settings and events, 24% described introspections, and 21% described entities. Although these values varied somewhat by concept type, all concept types included significant amounts of each content type. Analysis 2 similarly found that clusters for physical settings (36%), events (24%), and introspections (29%) occurred consistently across concrete, intermediate, and abstract concepts.

Both analyses also offer support for Hypothesis 2, namely, the focus on situational content differs for concrete and abstract concepts, with intermediate concepts lying in between. In Analysis 1, the percentage of entity properties increased from abstract (15%) to intermediate (22%) to concrete (26%) concepts. Similarly, in Analysis 2, concrete concepts had higher percentages of objects (14%), locations (12%), and characteristic behaviors (6%) than did abstract concepts (5%, 2%, and 0%, respectively). These patterns suggest that concrete concepts focus more on objects, locations, and behaviors in situations than do abstract concepts.

Conversely, abstract concepts focus more on social aspects of situations, such as people, communication, and social institutions. Abstract concepts also focus more on introspections, especially beliefs and contingency/complex relations. In Analysis 1, the percentage of introspection properties was higher for abstract concepts (28%) than for concrete and intermediate concepts (21%, 22%). In Analysis 2, person clusters were higher for abstract concepts (20%) than for concrete concepts (6%), as were communicative events (5% vs. 1%), and social institutions (8% vs. 2%). Similarly, belief clusters were higher for abstract concepts (11%) than for concrete concepts (6%), as were complex/contingency relations (12% vs. 6%). Thus, both Analyses 1 and 2 indicate that concrete and abstract concepts emphasize different aspects of situational content.

Analysis 2 also offered support for Hypothesis 3, namely, that abstract concepts are more complex than concrete concepts, with intermediate concepts lying between. As concept abstractness increased, so did hierarchical

complexity. Specifically, the average hierarchical level of clusters increased from concrete (1.37) to intermediate (1.46) to abstract concepts (1.57). As concepts became more abstract, the structures describing them included greater depths of nested clusters.

The following pattern across the different cluster measures brings out the nature of this increasing complexity. As Table 7.2 illustrates, abstract concepts were nearly twice as likely to have contingency/complex and belief clusters than were concrete concepts (23% vs. 12% overall). As Table 7.3 illustrates, contingency/complex and belief clusters were the two longest types of clusters observed (8.73 and 5.75 vs. values that ranged from 1.44 to 4.43 for the other cluster types). As Table 7.3 further illustrates, contingency/complex and belief clusters were also the highest hierarchically, along with goal clusters (2.47, 1.94, and 1.80 vs. values that ranged from 1.02 to 1.66 for the other cluster types). Putting all this together, abstract concepts were most likely to have the types of clusters that were especially long and especially high hierarchically. Consistent with Hypothesis 3, conceptual structures for abstract concepts were more complex than those for concrete concepts.

DISCUSSION

This exploratory study provides evidence for Hypotheses 1, 2, and 3. Clearly, though, this study only constitutes a preliminary attempt at establishing the representation of abstract concepts. Many issues remain unresolved, and much further research remains to be done.

Was the Particular Nature of the Task Responsible for the Results?

In the exploratory study reported here, diverse types of information were produced for both concrete and abstract concepts. Not only did participants produce information about objects and events, they produced considerable introspective information about idiosyncratic beliefs and complex contingencies. Furthermore, they produced episodic information along with generic information. Is this information typical of what people produce for concepts? Or was something unusual about this study responsible?

Perhaps the open-ended nature of our probe was a factor, namely, participants were told that there were no "correct" properties to produce, and that they should produce information as it came to mind. Participants were not asked to focus their responses in any particular manner, such as providing concept definitions. Furthermore, we required that participants respond for a full 1 min, which probably contributed further to the diverse content obtained.

Another set of factors concerns the particular concepts studied. First, only three concepts were studied for each type. Perhaps these particular samples of concepts biased responses. Second, concepts of very different types were mixed together. Perhaps carry-over effects occurred from one concept type to another (e.g., perhaps the introspections important for abstract concepts carried over to concrete concepts).

We agree that future studies should be aware of such factors, and that resolving their effects is important. Nevertheless, we do not believe that these factors distorted the results of this study. First, we believe that the open-ended nature of our probe is a desirable quality in exploring conceptual content. Problematically, when probes restrict responses, the responses obtained may be tailored online to the information requested. As a result, the responses may not provide a representative account of the underlying information in memory. For example, when researchers present a vertical column of short blanks on a page, and ask participants to list the defining features of a concept, this may produce online processing tailored to the constraints of the task. Participants may scan across many situations, and try to find common properties that fit in the short blanks. Even though participants may actually be retrieving a diverse collection of situations, the response method may not allow them to express it. Instead, the response format may more reflect the experimenter's a priori belief that feature lists represent concepts. We believe that open-ended response collection enables more direct measurement of the underlying information stored for a concept.

Second, the types of content observed here have been observed before. Previous studies using the Wu and Barsalou coding scheme have observed similar distributions of content (e.g., Cree & McRae, 2003; Krauth-Gruber et al., 2004; McRae & Cree, 2002; Wu & Barsalou, 2004). More recently, Wiemer-Hastings and Xu (2004) have found that situational properties are produced more often than entity and introspective properties in a larger sample of concrete and abstract concepts than explored here. Again, concrete concepts were more likely to produce entity properties, whereas abstract concepts were more likely to produce introspective properties (this pattern was more accentuated in their data than in ours). Notably, these distributions were produced in much shorter protocols than those collected here. Thus, increasing research converges on the distributions of content observed here for concrete and abstract concepts.

Third, we agree that it is important to study more than three concepts per concept type. Nevertheless, the concepts studied here are representative of their respective types. Clearly, *TRUTH*, *FREEDOM*, and *INVENTION* are abstract concepts, whereas *SOFA*, *CAR*, and *BIRD* are concrete. Although various subtypes of abstract and concrete concepts may exhibit somewhat different content, we suspect that the general trends observed here are likely to be observed.

Finally, it may well be true that carry-over effects occurred between concept types, and that different results would be found for a pure list of

abstract or concrete concepts. Nevertheless, an important question to ask is what this would tell us. People don't normally process either concrete or abstract concepts in isolation. Instead, these concept types are almost always processed together, as a quick examination of any text will indicate. Thus, a mixed list may represent actual processing conditions better than a pure list. If carry-over effects are occurring, they may reflect a natural phenomenon that enters into the normal processing of concrete and abstract concepts.

Does the Conceptual Content Observed Here Constitute Core Knowledge?

In the concepts and categories literature, the representations studied are typically much simpler than the ones observed here. In category learning research, conceptual knowledge often consists of exemplars or prototypes defined by only a few physical properties. In work that focuses on concepts in higher cognition, even these representations are relatively simple, often taking the form of a single feature list, or a single relational structure. Not only is the amount of content vastly smaller in these standard representations, the content is also vastly restricted, excluding not only introspective information, but also much event information (cf. Markman & Ross, 2003). Clearly, idealization is a useful scientific strategy, and it has led to many important discoveries in the categorization literature. Nevertheless, it may be misleading to assume that these simpler representations constitute the content of conceptual knowledge. Conceptual knowledge may include much larger amounts of content, and also a much wider variety.

On the basis of our findings, a reader might be convinced that a concept contains larger amounts of more varied knowledge than usually assumed, but still argue that most of this knowledge is relatively peripheral to the concept's core content. This view, however, assumes not only that core knowledge exists for concepts, but also that it is most central. On this view, a concept is like a dictionary or encyclopedia entry that attempts to define a category with a centralized summary representation.

Since Wittgenstein (1953), however, empirical findings have not been kind to this view. Not only is it intuitively difficult to define most natural concepts, there appears to be little empirical evidence for such definitions (e.g., Hampton, 1979; McCloskey & Glucksberg, 1978; Rosch & Mervis, 1975). Furthermore, extensive research on exemplar models has suggested that diverse collections of exemplars can implement many conceptual functions (e.g., Medin & Schaffer, 1978).

Barsalou (2003a, 2003b) presents an alternative to the core knowledge view (also see Barsalou, Niedenthal et al., 2003). On this account, a concept generates a multitude of situational representations, each tailored to guiding goal-directed activity with a particular concept instance in a particular situation. For example, the concept for *CARS* produces diverse situational representations that guide various car activities, such as driving, fueling, washing, buying, etc. Furthermore, each of these situational representations contains entity, setting, event, and introspective information relevant to the respective goal-directed activity. On this view, learning a concept establishes the ability to completely represent a wide variety of situations relevant to interacting with the concept's instances. As a result, a concept becomes a large collection of situational representations.

This account explains the results of the exploratory study here. When people produce information about a concept in an unconstrained manner, they retrieve and describe a wide variety of situations in a relatively haphazard manner, regardless of whether the concept is concrete or abstract. Furthermore, these situations exhibit the diverse content observed here, including entity, setting, event, and introspective information. Finally, much personalized content is included, such as beliefs, opinions, and episodic memories, because this information supports individualized interactions with concept instances. Because people differ in the goals, values, and experiences associated with a concept's instances, their knowledge becomes tailored to optimize their particular interactions with them.

An important question is whether a core definition exists across situations. One possibility is that such definitions don't usually exist explicitly in memory. Instead, when people are asked to produce a definition, they sample from situations in memory, and produce an online definition that covers just these situations (e.g., Barsalou, 2003a, 2003b; Medin & Ross, 1989; Ross, Perkins, & Tenpenny, 1990). If a person performs this activity a lot, and thoroughly samples situations from memory, a core definition might become explicitly established. Nevertheless, this definition may still be relatively peripheral. As people encounter concept instances in the world, they may be more likely to retrieve a situational representation suited to interacting with it, rather than the definition, which may not be particularly useful.

If this account is correct, it suggests an important direction for future research. Rather than allowing people to produce the content of a concept in an unrestricted manner, it might be useful to have them produce content relevant to a specific situation. If the primary role of concepts is to serve situated action, then studying their actual use in situations may provide insights into them. Not only might this be true for abstract concepts, it may be equally true for concrete ones.

Can Embodied Theories Explain the Content of Abstract Concepts?

For most of this paper, we have focused on the content of abstract concepts, having little to say about embodiment. Establishing the content of abstract concepts, however, is an essential first step in explaining how embodied theories could represent them. We can only begin formulating embodied accounts once we have identified the content of these concepts. We believe that the importance of this first step constitutes an appropriate contribution for an edited volume on embodied cognition.

As we have seen, abstract concepts focus on social, event, and introspective content, while also including, less centrally, content about physical settings. How might embodied theories represent this situational content? One answer is that the conceptual system stores memories of situational perceptions, and then later simulates these memories to represent concepts (Yeh & Barsalou, 2004). To see this, consider the content of perception. At any given moment, people perceive the immediate space around them, including the setting, objects, agents, and events present. They also perceive current introspective states, including affects, drives, and cognitive operations. Most importantly, even when people focus attention on a particular entity or event in the situation, they continue to perceive the background situation – it does not disappear. If perceptual experience takes the form of a situation, and if a conceptual representation simulates perceptual experience, then the form of a conceptual representation should take the form of a perceived situation. When people construct a simulation to represent a category, they should tend to envision the category in a relevant perceptual situation, not in isolation. When people conceptualize *CHAIR*, for example, they should attempt to simulate not only a chair, but a more complete perceptual situation, including the surrounding space, along with any relevant agents, objects, events, and introspective states.

In principle, it seems possible that an embodied view could represent all of the content observed here for abstract concepts. Because all of this content is perceived in the situations that involve abstract concepts, this content could, in principle, be simulated later when representing these concepts. If these states existed at the time of processing an actual situation, there is no reason why they cannot be reenacted later. Clearly, though, much further research, aimed at addressing this particular proposal, is necessary.

APPENDIX CODING CATEGORIES FOR ANALYSIS 2

In the examples shown below for each coding category, the target concept is shown in lower case italics, and the coded information is shown in upper case.

Taxonomic Category (*T*)

A concept from the same taxonomy as the target concept, including superordinates, subordinates, coordinates, and individuals; for nonobjects, may be antonyms or other related concepts from the same taxonomic field, unless a dependency between them is stated; often contrastive; for personality traits, go with *P* if the focus is on the person, but go with *T* if the focus is on the taxonomy; also includes contrasts within a category across multiple types of things, discussing different kinds of things at high level, etc. (e.g. *bird*–ANIMAL, *truth*–LIE).

Space and Time

Location (L). A place where an entity or event occurs; may be an environmental setting, or a larger contextual object (e.g., *bird*–GEORGIA, *a carpet*–ON THE FLOOR).

Time (TM). A time when an entity or event occurs; may be a time of day, year, holiday, etc. (e.g., *sofa*–PRETTY SOON (I'M GETTING A COUCH); *to invent*–RIGHT NOW (WHAT WE HAVE IS THE RESULT OF INVENTIONS).

Entities

Object (O). An entity; a physical/structural property of a physical entity; not a person; can be a description of either a target entity or some other entity in a situation (e.g. *bird*–WINGS; *car*–WHEELS).

Person (P). A person; a property of a person, often an agent in a situation; typically a personality trait, ability, or mental capacity, although physical properties are possible, too; for personality traits, the focus is on the person, not on a taxonomy, in which case use T; do not include goals, which go in IG; etc. (e.g., *to cook*–A LOT OF MOTHERS; *true*–A CULTURAL SCHOLAR).

Events

Characteristic Behavior (EVB). The characteristic behavior of an entity described in an aggregate manner (e.g., *bird*–SINGS; *a farm*–GRASS GROWTH).

NonAgentive (EVN). A nonintentional event typically involving inanimate objects (e.g., *car*–AXELS ROT; *to carpet*–YOUR HOUSE GETS FLOODED).

Agentive (EVA). An event involving an agent; not typically an aggregate statement about the characteristic behavior of an entity (EVB); typically a event initiated by an agent that has an effect on a patient; nonhumans can be agents as long is the event is not an aggregate description of their characteristic behavior; (e.g. *to cook*–YOU HEAT SOMETHING UP ON THE STOVE; *true*–PEOPLE THINK ABOUT WHAT THEIR BELIEFS REALLY ARE).

Communication (EVC). Any act of communication (e.g., *true*–WHEN WHAT YOU'RE SAYING IS NOT A LIE; *freedom*–PEOPLE ON TV SAYING WHATEVER THEY WANT TO BE SAYING).

Introspections

Goal (IG). The goal or intention of an agent; often "the reason" for something (e.g. *true*–PEOPLE DON'T REALLY WANT TO KNOW WHAT'S GOING ON; *cook*–TO MAKE EXACTLY WHAT YOU WANT TO EAT).

Evaluation/Affect (IA). An evaluation or emotion (typically by the subject), (e.g., *pigeon*–DIRTY; *freedom*–INTERESTING TO ME).

Belief (IB). An at least somewhat tenuous belief (typically held by the participant); typically a claim about fact or the state of the world; not something obvious or known; not knowledge; instead, something that is contestable; often an opinion; when evaluation is salient, use IE; if a contingency is present, use IC; if the opinion is strong, stay with IB (e.g.; *justice*–BEAUROCRATIC; *sofa*–YOU DON'T SIT RIGID ON A SOFA).

Contingency/Complex Relation (IC). A contingency of some sort, a dependency, necessity, possession, part-whole relation, or some other complex relation; contingencies can be if-then relations, or dependencies, such as a concept depending on some property for its definition, where the relation is stated explicitly (could be a necessity); other complex relations may apply as well, such temporal relations, an agent possessing something, part-whole relations, etc.; typically the arguments of each relation should be coded as well with some other cluster code; other lexical signals include because, unless, only if, after, before, etc. (e.g., *true*–DIFFICULT TO DISCUSS AFTER POST MODERNISM; *freedom*–THE IDEA OF FREEDOM IMPLIES DIFFERENT KINDS OF FREEDOMS).

Social Institution or Artifact (SOC)

A culturally created object, institution, or concept (e.g. *bird*–TWEETY BIRD, *true*–POSTMODERNISM).

ACKNOWLEDGMENTS

The research in this article was supported by National Science Foundation Grants SBR-9905024 and BCS-0212134 to Lawrence W. Barsalou.

We are grateful to Courtney Emery, Rachel Robertson, Kyle Simmons, Christy Wilson, Melissa Armstrong, and Susan McManus for assistance with the study reported here. We are also grateful to Aron Barbey, Diane Pecher, Rolf Zwaan, and two anonymous reviewers for helpful comments. Address correspondence to Lawrence W. Barsalou, Department of Psychology, Emory University, Atlanta, GA 30322 (barsalou@emory.edu, http://userwww.service.emory.edu/~barsalou/).

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