Imagery, Context Availability, Contextual Constraint and Abstractness

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Abstract

A constraint-based theory of abstractness was investigated according to which abstractness of entities is a function of (i) perceptual observability and (ii) characteristics of contextual constraints. Participants performed ratings of context availability, imagery, and abstractness for 36 nouns that varied in abstractness and familiarity. The ratings were used to compare the predictions of abstractness ratings by context availability, dual coding theory and the constraint-based approach outlined in this paper. We found that only constraints explain variation of perceived abstractness for abstract concepts, whereas context availability and imagery are good predictors of the dichotomous distinction of concrete-abstract, and of variations of concreteness for concrete concepts only. A second study shows that introspection-based constraints are most critical for abstractness ratings. Implications are discussed.

Abstractness

Every-day communication is pervaded by references to abstract entities, such as *explanation*, *regret*, and *intention*. Typically, we think of an entity as abstract when it cannot be perceived. However, there are no clear-cut criteria for what makes entities abstract or concrete. Several theoretical approaches exist to predicting perceived abstractness. This paper compares three theories: dual-coding theory, context-availability theory, and our approach, called the *contextual constraint theory*.

We propose that perceived abstractness depends on two factors. 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. Together, we call this the *two-factor model of abstractness*. We will start by reviewing the plausibility of the dichotomy of abstract and concrete, as proposed by the first factor. The remainder of this paper will address the factors underlying abstractness variation within the groups of abstract versus concrete entities.

Abstract and Concrete: Dichotomy or Continuum?

Concrete and abstract nouns are commonly defined by reference to perceivability: Concrete entities are considered to be physical entities with characteristic shapes, parts, materials, etc., whereas abstract entities lack physical attributes (e.g., Crystal, 1995). The first proposed factor follows this broad distinction.

Some entities challenge the notion of a dichotomy of abstract and concrete entities. Examples for entities that cannot clearly be classified as abstract or concrete are *government*, *officer*, or *anger*. A *government* is abstract in that we cannot really point to who or what it is, but it is also concrete in that it involves a number of specific, concrete entities, such as people, buildings, and particular locations. *Officer* is a social agent term, referring to concrete individuals with characteristics defined by a particular social role or profession. Their roles are not obvious characteristics, but are inferred from more complex information, such as behavior patterns in specific situations.

Finally, emotion terms such as *anger* are a special group of entities. Emotions can be perceived within individuals who experience them. Outwardly, we can perceive emotion through nonverbal and verbal behavior. Still, emotions are qualitatively different from concrete entities such as cups and office chairs. In fact, they have been proposed to constitute a distinct group from both concrete and abstract entities (Altarriba, Bauer, & Benvenuto, 1999). The alternative view suggested by these challenges is a contiuum view, according to which all entities vary in concreteness, and the distinction of abstract versus concrete is an oversimplification.

A simple way to test both views is to ask people to rate the concreteness of a large sample of entities, including abstract and concrete ones. If concreteness is one dimension and all entities vary along this dimension, then ratings should be distributed pretty evenly across the entire scale. In contrast, if abstract and concrete entities were two distinct classes of entities, ratings should fall into two clusters. There would be a lot of entities rated as abstract, versus a lot of entities rated as concrete. That is, the distribution of

concreteness ratings would assume the shape of a bimodal distribution.

What is found is, in fact, that the ratings form two fairly distinct clusters with a different mode each. One mode is centered over the abstract half of the scale, the other mode is located over the middle of the concrete half. This finding has first been reported for 2172 words by Nelson and Schreiber (1992), and has been replicated here for an independently sampled set of 1660 nouns (see Figure 1).

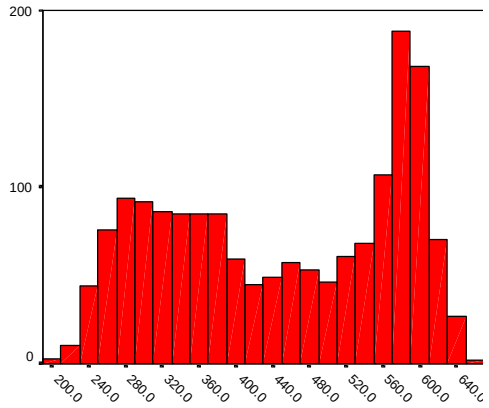

Figure 1
Distribution of concreteness ratings for 1660 nouns

The bimodal distribution is consistent with the view that abstract and concrete entities fall into two big clusters according to particular characteristics (e.g., tangibility or visibility). It is also obvious that, within these two clusters, entities vary in concreteness. What factors are causing this variance? The remainder of this paper addresses this question.

Variation in Abstractness

What information underlies the variance of abstractness in abstract entities? If an entity cannot be perceived, it is abstract. The lack of concreteness can account for it being abstract, but the same information cannot explain why some abstract entities are more abstract than others. For example, lack of perceptual information cannot explain why *principle* is rated more abstract than *idea*.

Our research aims to specify what factor(s) cause concrete entities to vary in perceived concreteness, and what factor(s) cause variance in the perceived abstractness of abstract concepts. Our studies are motivated by two lines of reasoning. The first directly follows from the *two-factor model of abstractness.* We do not think that perceivability accounts for the entire variation in concreteness. Instead, we assume a second factor. This intends to replace the commonsense notion that abstract concepts get more abstract to the degree that they get less perceivable (concrete). Second, it is quite likely that the difference between abstract and concrete is not so much a quantitative distinction, but a qualitative one. That is, it is conceivable that the factor or factors that make abstract entities more or less abstract are distinct from the factors that make concrete entities differ in concreteness. To identify possible factors, we next review theories that have been proposed to understand abstractness.

Theories of Abstractness

Theories pertinent to explaining abstractness include dual coding theory, context-availability theory, and contextual constraint theory. The predictions of each are discussed in turn.

Dual-Coding Theory / Imagery

The dual-coding model (Paivio, 1986) is one of the oldest theories about differences of abstract and concrete concepts. It proposes that the fundamental difference between abstract and concrete concepts is that only the concrete ones they are associated with imagery (henceforth IM) information, whereas both abstract and concrete concepts can be processed in a language-like code. The availability of two codes for the representation and processing of concrete concepts results in their processing advantage in many tasks, such as comprehension, word recognition and recall.

Applying the dual-coding theory to the prediction of perceived abstractness is fairly straightforward. The model is essentially dichotomous in its division of abstract and concrete, but one could derive the prediction from it that more concrete entities have higher imageability. If the dual-coding theory can be applied to variation of abstractness within the group of abstract entities, then one should find that abstract entities rated as most abstract are the entities that elicit the least imagery.

Context Availability Theory

The context availability theory (henceforth CA; Schwanenflugel & Shoben, 1983) argues that it is easier to think of a context for concrete objects than for abstract ones. The issue here is not whether a context can come to mind at all, but how long it takes to retrieve or construct it based on information in memory. Typical studies instruct participants to rate CA based on the time it takes to think of a context. If it takes a long time, then the rating should be low. If they can think of a context immediately, they should give a high rating.

Research has shown that CA ratings can account for a lot of effects labeled as concreteness effects, often even better than concreteness ratings themselves. If abstract words are more difficult to process because of less available context, then the prediction for abstractness ratings is that a word will be rated the more abstract, the less context is available for it.

Evidence Related to Context Availability

Rated CA has been shown to correlate highly with rated abstractness. Thus, it may offer a theoretical basis for predicting abstractness. However, Altarriba et al. (1999) found that the correlation of CA with concreteness differed for abstract, concrete, and emotion terms. Interestingly, the correlation was highest for concrete words (r = 0.68), second for emotion terms (r = 0.41), and lowest for abstract terms (r = 0.25). All three correlations were significant, but it is clear that the concreteness ratings for abstract words were only weakly related to CA, in comparison with the other groups.

The results cannot be applied directly to this work, because the sample used by Altarriba et al. was not limited to nouns. Another goal of the present study was to compare the correlations of ratings separately for abstract versus concrete entities, to examine whether the findings of Altarriba et al. hold up for a sample of nouns exclusively.

Contextual Constraint Theory

Abstract entities are associated with contexts (Schwanenflugel, 1991; Wiemer-Hastings & Graesser, 1998). They "apply" to, or are manifested in, situations. This application is contingent on particular events and circumstances in the situation. For example, an idea is contingent on an agent with a mental event, which will be expressed verbally or in some kind of behavior, and can be evaluated. An idea is thought of in one moment, expressed in another, maybe rejected in a third. As such, many abstract entities have characteristics akin to verbs: they are related to observable events in a situation, which are defined temporally.

Depending on the situation aspects that an abstract entity is contingent on, it can occur in many or few kinds of context. Roughly, the more particular situation elements are necessarily involved in its manifestations, the more constrained its occurrence is. An entity that is contingent only on few, and rather abstract situation characteristics (such as the presence of some entity) can occur in all kinds of situations.

Do contextual constraints affect the abstractness of abstract entities? Conceivably, an entity that is not strongly constrained is more abstract than an entity that is contingent on a fairly extensive set of constraints. Additionally, entities that only occur when concrete situation aspects are present may be less abstract than entities that are contingent on abstract, unobservable, or complex temporal elements of situations, or of information that is only accessible to introspection (such as a mental process). To test this contextual constraint theory, the materials for the study were coded for contextual constraints.

Constraints Naturally, situations vary. For example, *ideas* occur in various settings, through different agents, related to different problems, and varying in quality. However, the underlying constraints, such as the presence of an agent, remain largely unvaried. To examine the influence of such constraints, a list of contextual constraints was derived from a simplistic situation model, as exhaustive as possible. The list consists of agents, objects, "issues", mental states, relations, and temporal information. The constraints were selected to be relevant to abstract concepts (see Table 1). These constraints are not intended to describe situations with all the richness of information they contain, but to identify abstract building blocks of situations, without regard to their specific contents.

Table 1: Contextual constraints on abstract entities

Concrete elements	**Introspective elements**
Agent	Goal
Agent 2	Knowledge / memory
Group (people)	Belief / attitude
Object	Feeling
Location	Mental event / thought
Utterance	**Relations**
Action	Agent-agent
Object attribute	Agent-other people
Nonverbal behavior	Agent-object
Situation elements	Agent-thematic subject
Issue / topic	Relation between two entities
Obstacle	Utterance-issue relation
Temporal aspects	
Relevance of past	
Relevance of future	
Changes between time slices (Event)	
Continuity of change between time slices (Process)	
Continuity of state between time slices (State)	
Time-adjacency of events (causality)	

Such constraints can play a powerful role in the processing of abstract concepts. Assuming that context information must be accessed to comprehend the concept (e.g., Schwanenflugel, 1991; Schwanenflugel & Shoben, 1983), constraints can be used to guide the

mental construction of a context example. As such, they functionally resemble schemata and scripts (Schank & Abelson, 1977). Constraints fall into several groups, including concrete situation elements, object attributes, agent characteristics, situation elements, relations, and information about temporal characteristics and sequences.

Study 1: Comparing Accounts for Abstractness

The experiment systematically compared to what extent different theories can predict abstractness ratings. Participants were asked to make ratings of the predictor variables for a set of 36 words.

Materials

Words were randomly sampled from about 2000 nouns collected from the MRC2 database (Coltheart, 1981). An exhaustive search was made for nouns for which frequency estimates (Kucera & Francis, 1967), familiarity, and abstractness ratings (Gilhooly & Logie, 1980; Paivio, Yuille, & Madigan, 1968; Toglia & Battig, 1978) were available.

The sample was divided into 6 sets of different levels of abstractness, based on the abstractness ratings from the MRC2 database. The range was divided into six equal-sized parts, regardless of the number of words falling into each section. Words were matched in familiarity across groups to control for familiarity effects (see Kacinik, Shears, & Chiarello, 2000). From each of the groups, six words were randomly selected to be included in the study. The words were the concrete words *bass, beehive, blossom, hairpin, insect, labyrinth, lace, mackerel, morass, nectar, owl, pest, prize, sedative, tree, venom, vine,* and *zone* and the abstract words *aspect, day, daybreak, desperation, emancipation, exception, formation, happiness, hope, inaction, ingratitude, jeopardy, mischief, pity, possession, removal, saga,* and *story*.

Instructions

Instructions varied to elicit different kinds of information associated with the words presented. Participants performed abstractness ratings, imageability ratings, and CA ratings of all 36 words. The words were presented in random order in each task. All the ratings were made on a 7-point scale.

The predictions of the dual-coding theory were tested by having participants rate the imageability of each entity. For CA, we used instructions used in previous research. We asked participants to rate how difficult it would be to mentally generate a context for the entity. For all tasks, participants were encouraged to make ratings according to their personal understanding of the words.

Results

Manipulation Check

The word sample was constructed based on the MRC2 abstractness ratings. We checked whether the perception of our participants agreed with these abstractness ratings. Abstractness ratings performed by the participants were highly correlated with the MRC2 abstractness ratings (r = 0.94, p < 0.001). This indicates that participants in our study in fact perceived entities selected as most abstract as most abstract, and the most concrete entities as most concrete.

Predicting Abstractness of Overall Sample

Multiple regression analyses for the three predictors found that CA (r = 0.66) and IM (r = 0.77) both predicted concreteness ratings for the entire sample (p < 0.01), and for the *concrete* sub-sample. Ratings for these two variables were also significantly different for abstract versus concrete words in t-tests (t (34) = 4.41, p < 0.01 for CA and t (34) = 6.33, p < 0.01 for IM.) The number of contextual constraints was not a significant predictor; however, the percentage of abstract constraints was a good predictor (r = 0.47, p < 0.05).

Some of the predictor variables, especially ratings for CA and IM, were highly correlated. Therefore, a stepwise regression with all predictors was performed to examine their relative contribution towards explaining the variance in abstractness ratings. Only 23 cases were valid for this analysis because for some entities, none of the contextual constraints applied.

Predictors in this analysis included (i) CA ratings, (ii) IM ratings, (iii) the number of contextual constraints (CC), and the percentage of abstract constraints (ACC). The two highest predictors, which both contributed significantly to the regression, were IM and ACC. Together, these variables explained more than half of the variance (R^2 = 0.56). The change in the amount of variance explained by IM was 0.36 (F (1, 21) = 11.99, p < 0.01); the change due to ACC was 0.2 (F (1, 20) = 8.89, p < 0.01). The other variables did not add any significant changes in the amount of variance explained.

Predicting Abstractness of Abstract Sample

The only substantial predictor for ratings on the abstract nouns was the percentage of abstract contextual constraints (marginally significant; r = -0.47, p = 0.52). This measure was computed as the percentage of constraints for an entity that are not directly observable, such as mental / introspective constraints and relations.

This suggests that constraints play an important role for abstract entities over and beyond CA and IM. However, the number of words in this study was very limited. A second study was conducted to examine whether this finding holds up for a large set of abstract entities. Further, the second study involved entities of relatively high abstractness only, with less variance than in Study 1. Abstractness ranged from 2.2 to 3.6 on a 7-point scale, with a mean of 2.88 (SD=0.35). The result is a critical test of whether contextual constraints are discriminating enough to predict variation at such a fine level.

Study 2: Constraints and Abstractness

A total of 121 abstract nouns were coded for the contextual constraints described above. The coding indicated whether each constraint was *by necessity* part of a context in which the entity could occur. For example, *determination* requires an agent (who is determined), an agent goal, a certain attitude, and a stretch of time during which the attitude and goal do not vary (a state). Coding reliability on a 25% subset of the words, measured as correlation and Cohen's kappa, was significant (p<0.01) for three independent coders.

Based on the codes, we computed the number of constraints and the percentage of abstract constraints for each noun. Additionally, the codes were summarized across types of constraints to test whether particular kinds of constraints would yield particularly strong or weak predictions. The constraint groups were (1) concrete entities, (2) temporal constraints, (3) relational constraints, and (4) introspection-related constraints.

Results

All measures were submitted to a correlation with abstractness ratings from the MRC2 database. The astonishing result was that only the group of introspection-based constraints was significantly correlated (r=-0.21, p<0.05). This group includes mental constraints (goals, feelings, attitudes and beliefs, knowledge, and thoughts) and relational constraints between agents and other agents, objects, or issues. The percentage of abstract constraints yielded the second highest correlation (r=-0.14), but it was not significant. The finding for introspective constraints is interesting because it supports the recent proposal by Barsalou (1999) that introspection plays a central role in the processing of abstract concepts.

Overall, the result is consistent with the finding in study 1 that constraints play a role in our perception of abstractness. Importantly, the second study shows that constraints -- at least some of them – are good predictors even when fine discrimination is required.

Discussion

The results show that IM and CA are limited in explaining abstractness variations. Whereas ratings for both can account for the differences between abstract and concrete in general, they do not explain the variance in abstractness for different abstract concepts. This replicated the finding by Altarriba et al. (1999). The number of contextual constraints did not significantly predict abstractness ratings, but the abstractness of the constraints was a relatively strong predictor.

The findings are consistent with the two-factor model of abstractness, according to which abstractness and concreteness are determined by two different kinds of information. For concrete entities, both CA and IM were good predictors of the variation of ratings. For abstract concepts, the most critical type of information was the type of contextual constraint involved.

Research focusing on abstract concepts, rather than mere differences between concrete and abstract concepts, should presumably not be conducted on the basis of the assumptions made by CA and IM alone, since apparently these theories account mostly for the differences of the dichotomous classes of abstract and concrete entities. Research aiming to reveal characteristics of abstract entities should additionally take into account information that is specifically relevant to them, such as a system of context constraints that may guide our identification of these entities in context. The present results suggest that introspective processes and information, and to some extent abstract constraints in general, may be a good candidate for this abstract concept-specific information.

A system of constraints such as the one presented in Table 1 may further be useful in investigations of context effects, as they have been reported in previous research on abstract concepts. For example, some studies on CA effects produced the inconsistent result that abstract concepts were not processed faster when presented in context. A principled way to predict *what* context information is relevant to an abstract entity may account for such findings: Perhaps, the abstract words were presented in contexts that did not instantiate the relevant constraints.

Concrete versus Abstract

Maybe one of the most interesting implications of the findings is that constraints put the relevant information *outside of* the rated entity. That is, it is not an aspect of the entity itself that makes it abstract, but it is the abstractness of the constraints on situations in which it is used. This point offers a nice bridge to the CA theory, which argues that abstract concepts are abstract

because less context for their processing is available in memory.

The constraints may offer an explanation for this phenomenon. The more abstract the constraints are, the less guidance we have in constructing a mental context (or a simulation, see Barsalou, 1999). The constraints are there but they leave open most aspects of the concrete context. For example, the concept *comparison* requires (among other abstract constraints) the presence of two entities to be compared. The constraint does not dictate these entities to be of any particular nature, thus, they could be people, essays, houses, laws, feelings, etc.

In the case of a less abstract entity, such as *arrival*, the constraints involved are of a more concrete nature, and thus more effectively constrain the number of contexts we could construct to process the concept. An arrival involves an agent, an action (movement), and a particular location that the agent moves towards. These constraints can readily be used to simulate a fairly concrete situation in which an arrival takes place.

Features and Constraints

An interesting thought to pursue in future research is that features may fulfill the same function for concrete entities as abstract contextual constraints do for abstract entities. Thus, it is possible that the number of features / concreteness of features decrease from the concrete to the abstract pole, whereas the abstractness of the contextual constraints decreases from the abstract to the concrete end.

Familiarity Effects

This study controlled for familiarity effects through strategic sampling. Future research could examine an interesting question in connection to CA: It is likely that highly familiar concepts are represented with default contexts, which can easily be accessed, whereas contexts for other concepts have to be constructed.

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