Structural Differences in Abstract and Concrete Item Categories

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Abstract

We explored reasons why categories of abstract items, such as cognitive processes or communication, are weak determinants of abstract item similarity. Three experiments, using exemplar listing tasks and similarity ratings on the exemplars, compared the structure of taxonomic categories of abstract versus concrete entities. In comparison to concrete item categories, we found that there were consistently fewer typical items for abstract item categories, but that nonetheless item pairs within abstract item categories were rated about as similar to each other as items matched in typicality in concrete categories. Abstract item pairs from different categories were more similar than concrete item pairs from different categories, indicating lower semantic distance of the categories. Taken together, these data suggest that taxonomic categories are less informative for abstract than concrete items. We discuss alternative factors in abstract concept organization.

Taxonomies for Abstract Items

When asked to sort the items apple, cabbage, squirrel and duck into stacks, most people will presumably sort them into types of produce and animals. Concrete item categories have a strong, graded structure organized around prototypical items, and are relatively distinct from other categories. As a consequence, concrete item categories offer salient dimensions that are readily used in reasoning involving their members. Because of their family resemblance structure, in which items share groups of features with other category members, two typical items from the same category, such as squirrel and duck, are likely rated as similar. Categories are important organizational structures that enable us to use our knowledge in reasoning processes such as classification, similarity judgments, and to effectively acquire new knowledge through analogies and inferences. As such, categories touch upon and inform many areas of research that are central to cognitive science.

Categories for concrete things are only a subset of our knowledge. We also have representations of abstract and complex entities, such as processes, events, mental experiences, stories, and relations. Abstract concepts constitute a large and important part of our daily experiences and actions. Even so, very little is known about categories of abstract concepts. A complete understanding of the organization of our knowledge cannot be achieved unless we understand how other kinds of things are organized.

There are several reasons to expect that taxonomic categories for abstract items are not as distinct and salient as those for concrete items. First, some research has shown that abstract items (in this case, verbs) are not organized into distinct clusters, but that classes of such items overlap with others on many dimensions (Huttenlocher & Lui, 1979; Miller & Johnson-Laird, 1976). The features of concrete items are highly correlated; that is, given that two items share a feature, they typically share some other features as well, making them more similar to each other than to items in different categories. As a consequence, categories are more distinct from one another. In contrast, a verb may share features with verbs from many different categories to a similar extent. Hampton (1981) has made a similar proposal for abstract concepts in general. Thus, categories of relational concepts may overlap more and offer less constraint on their processing.

Second, taxonomic similarities appear to have little impact on similarity judgments of abstract concept pairs. When people rate the similarity of item pairs that are taxonomically similar and that also share a thematic relation, people tend to focus on the thematic relation for abstract items, but on the taxonomic relation for concrete items. For example, participants often rate jealousy and anger as similar because jealousy may lead to anger. Much less frequently, participants refer to the information that both are emotional states (Wiemer-Hastings & Xu, 2003). In contrast, given an item pair like cat and mouse, participants will more frequently refer to both being animals than to one chasing the other (Wiemer-Hastings & Xu, 2003; Wisniewski & Bassok, 1999). Participants use thematic relations as explanations for concrete item similarity judgments mostly when no taxonomic similarity is present; for abstract item pairs, thematic relations are used frequently also when items are taxonomically related.

One possible explanation for this striking effect is that taxonomic similarity of abstract items, e.g., the similarity of two emotions, or two cognitive processes, is not salient information. This raises the question how useful taxonomic abstract item categories are. Abstract categories may be useful for talking about groups of abstract items, such as events, but they may not reflect actual knowledge organization in memory. For example, the concepts joy, sadness, wedding and farewell could be organized into emotion terms and events, or into concepts of positive versus negative connotation, respectively. There is no salient dimension here along which to unambiguously split.
the four words into two groups, and the relations between joy and wedding, or sadness and farewell, are quite salient. If taxonomic classes of abstract items turn out to be of little functional use, the next question would be whether abstract items are organized around some alternative information. The results discussed above suggest thematic relations as one possible source for abstract category organization. Recently, it has been found that when given a choice, individuals routinely sort even concrete items around thematic relations (Murphy, 2001; Lin & Murphy, 2001). For example, when presented with the four items squirrel, mouse, nut, and cheese, people may sort them into pairs of animal and type of food (squirrel – nut; mouse – cheese) instead of animals and foods. Since such thematic relations have already been shown to play a very prominent role in similarity judgments of abstract item pairs, chances are good that they will provide dominant information to their categorization as well.

The main concern of this paper is the question why people do not effectively use taxonomic abstract item categories, such as emotions, cognitive processes, actions, attitudes, attributes, and so on in category-related tasks such as similarity ratings. The main hypothesis was that abstract and concrete item categories differ in the amount of constraint that they place on membership. This was examined in two separate hypotheses. First, it was hypothesized that participants would generate fewer typical examples for abstract than for concrete item categories. That is, we expected that fewer abstract items would be listed by a large number of participants. Related to this issue, we also hypothesized that abstract item categories would be less distinct than concrete item categories. That is, we predicted that members of two abstract item categories would be almost as similar to each other as members of the same abstract item category. Abstract items from the same category may share comparatively fewer category-specific features, and may share relatively more features with members of other categories. Three experiments tested these hypotheses.

**Experiment 1**

Experiment 1 compared the numbers of types and tokens generated for abstract versus concrete item categories. In accordance with the first hypothesis, it was predicted that significantly more participants would list the same items for concrete categories than for abstract ones.

**Method**

Twenty participants generated exemplars for 24 commonly used categories, 12 for concrete, and 12 for abstract items. Example categories are tools, pets, object attributes, and positive emotions. Category lists were constructed from taxonomic trees and extended to include a variety of categories. Since there is no well-established taxonomic model for abstract items, abstract item categories were taken from ontologies and social categories. Each participant listed exemplars for all categories, to control for individual differences. Categories were listed in random order. There was no time limit. Participants were instructed to list as many exemplars for each category as they could think of.

**Results & Discussion**

For each category, types and tokens were calculated. Type scores count different exemplars, whereas tokens also count repeated mentions of exemplars. The ratio of both indicates the agreement among participants or the mean production frequency for each exemplar. A highly available exemplar should be mentioned by many participants, resulting in a higher production frequency or token / type ratio. Categories that place strong constraints on cognitive processing would be characterized by higher token / type ratios.

Abstract and concrete categories did not differ in the number of types that were generated. However, more idiosyncratic responses were generated for abstract item categories. Consistent with the prediction, more participants listed the same exemplars for concrete item categories (see Table 1), t (10)=7.93, p<0.001. For the vast majority of abstract item categories, individual exemplars were listed by fewer than 2 participants, whereas on average, at least 3 participants listed exemplars for concrete item categories.

**Table 1: Types and Token / Type Ratios from Experiment 1**

<table>
<thead>
<tr>
<th></th>
<th>Types</th>
<th>Tokens / Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete</td>
<td>37.75</td>
<td>3.41</td>
</tr>
<tr>
<td>Abstract</td>
<td>35.42</td>
<td>1.57</td>
</tr>
</tbody>
</table>

Token / type ratios for concrete item categories varied from 2.25 (foods) to 4.78 (pets), SD=0.79. In contrast, very few participants listed the same exemplars for abstract item categories. The token / type ratio varied only very little across the different abstract item categories (SD=0.43), with the token /type ratios ranging from 1.06 (prosocial actions) to 1.82 (social offenses). The only exception to this dichotomy was one abstract item category, object attributes, which is actually relatively concrete, and which had a ratio of 2.71. Without this category, the standard deviation of ratios for abstract categories was reduced to SD=0.26.

Overall, it seems that low agreement is a general characteristic of abstract item categories, which could indicate that these categories do not reflect actual organization in memory. Instead, participants may retrieve exemplars out of a different organization, leading to high response variation. A possible confound that may account for the observed differences was that abstract item categories tend to be broader categories than concrete item categories. Experiment 2 varied the breadth of the categories systematically to test this.

**Experiment 2**

Experiment 2 replicated the procedure used in Experiment 1 with categories of different specificity levels. One set of categories was at a broad, abstract level, another set was more specific. Generally, specific categories contain fewer members and should thus place stronger constraints on exemplar production. The expectation was, accordingly,
that agreement would be higher for specific categories. The categories used in this Experiment are shown in Table 2.

<table>
<thead>
<tr>
<th>Broad</th>
<th>Specific</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>Action</td>
</tr>
<tr>
<td></td>
<td>Reasoning</td>
</tr>
<tr>
<td>Mental Processes</td>
<td>Mental Disorders</td>
</tr>
<tr>
<td>Communication</td>
<td>Object attributes</td>
</tr>
<tr>
<td>Events</td>
<td>Character Traits</td>
</tr>
<tr>
<td>Attitudes</td>
<td>Offensive Actions</td>
</tr>
<tr>
<td>Concrete</td>
<td>Animals</td>
</tr>
<tr>
<td></td>
<td>Wild animals</td>
</tr>
<tr>
<td>Plants</td>
<td>Pets</td>
</tr>
<tr>
<td>Foods</td>
<td>Tools</td>
</tr>
<tr>
<td>Liquids</td>
<td>Office Supplies</td>
</tr>
<tr>
<td>Natural Substances</td>
<td>Beverages</td>
</tr>
</tbody>
</table>

We also selected abstract and concrete item categories that were based on situations. Three such categories were based on scenes or settings, and three were based on events or scripts. Both have been shown to be efficient schemata for organizing knowledge in a systematic way (Shank & Abelson, 1977; Tversky & Hemenway, 1983). It has been argued that abstract items are characterized by situational contexts, rather than by internal features (Barsalou & Wiemer-Hastings, in press; Wiemer-Hastings & Graesser, 2000). Abstract concepts typically involve agents, goals, relations, actions and events, and emotional or cognitive experiences. As such, they are akin to abstract situation schemata, and may be organized around situations. Thus, we predicted that abstract, but not concrete, items generated for a given situation, are perceived as similar to each other.

**Method**

Sixty undergraduate students at Northern Illinois University participated in this experiment. Twenty participants each generated exemplars for broad categories, more specific categories and for situation categories that were either a setting (e.g., workplace) or an event (e.g., wedding). For the situation-based categories, abstract item instructions asked for “actions, events, or mental processes that could occur in the situation”; concrete item instructions asked for “objects occurring in the situation”. The settings and events were identical for both groups to allow for direct comparison. Altogether, there were ten broad and ten specific categories (five abstract, five concrete), and six situation-based categories.

**Results & Discussion**

As in the first experiment, we evaluated the results through token / type ratios. The data replicated the findings from Experiment 1. Table 3 shows the results. Interestingly, the use of more specific categories (e.g., offensive action instead of the broad action) did not improve agreement scores, even though it had an effect on the number of types listed.

The token / type ratio for broad category exemplars did not statistically differ between concrete and abstract items, suggesting that broad superordinate categories of concrete items structurally resemble abstract item categories. A significant difference was found for specific categories, where the token / type ratios were significantly higher for concrete than for abstract items ($t(8)=3.76, p<0.01$) and also higher for concrete items listed for broad categories ($t(8)=3.10, p<0.05$). That is, switching to a more specific category level increased category constraint for concrete, but not for abstract items.

The data suggest that the abstractness level does not have much of an impact on how many typical exemplars are produced for abstract categories. It seems, then, that the differences observed for concrete versus abstract items reflect a more general difference: Abstract item categories do not have many typical exemplars, and the few typical exemplars have relatively low typicality scores, as measured by the number of participants naming each. These first results suggest that categories may not provide the strong basis for inferences and similarity judgments for abstract items that is usually seen for concrete items.

**Experiment 3**

Previous experiments suggested that taxonomic category membership plays a minor role in similarity judgments for abstract items (Wiemer-Hastings & Xu, 2003). We suspect that this is due to overlapping categories, such that members of the same category may be only slightly more similar than members of different categories. Accordingly we predicted that, overall, item pairs should be more similar for items from the same category, but that this effect should be more pronounced for concrete item pairs than for abstract ones. That is, we expected that the difference in similarity for same- vs. different-category abstract item pairs would be significantly smaller than for concrete item pairs.

Alternatively, item pairs used in previous experiments were very untypical exemplars of their respective categories, which could have lowered the salience of their category membership. In the present experiment, we
control for this by collecting similarity ratings only for the most typical items for abstract item categories. If membership in the same taxonomic category does not substantially increase similarity ratings, compared to ratings of members of different categories, then typicality is unlikely the reason for people’s neglect of taxonomic similarity in similarity judgments.

With respect to the situation-based categories, we had no strong predictions. However, we suspected that concrete items may be less constrained by such categories than by taxonomic categories, thus that situation-based abstract item categories may actually be more distinct.

Method

We used high-frequent exemplars collected in Experiment 2 for different category types to make sure they would be typical items for the categories. There were two constraints: first, we omitted some items that had been generated for multiple categories (with the exception of happiness and happy for one set for lack of alternative choices). Second, the exemplars selected from concrete versus abstract item categories were matched in typicality, for fair comparison. This means that the concrete item pairs used in Experiment 3 were not the most typical of their categories, but instead were matched in typicality (as measured by generation frequency in Exp. 2) to the abstract item pairs. Accordingly, the actual differences between these categories are likely strongly underestimated in this Experiment.

Fifty-seven undergraduates from Northern Illinois University participated in this experiment for course credit. Four participant groups were formed at random to judge the similarity of items generated for broad, specific, abstract situational, or concrete situational categories, respectively. For the broad and specific categories, participants were presented with three items from each of five categories, resulting in 15 items presented in random order. Abstract and concrete items were rated by the same participants, but were blocked to avoid contrast effects on the ratings. For the situation-based categories, there were six categories for abstract and concrete items each. Since 18 items had to be rated in pair-wise combinations, concrete and abstract items were presented between-subjects to avoid fatigue effects.

Each item was rated against each other item in the context of the entire list, to allow for category information to affect the ratings. Thus, if category information was accessible from the items, we expected that items associated with the same categories would be rated as more similar to each other than to items not belonging to the category. The order of ratings was varied so that item pairs were presented in ascending vs. descending order, and so that each item was presented equally often in first vs. second position of the item pairs. Ratings were made on a 6-point scale.

Results & Discussion

We predicted that the difference in similarity for abstract item pairs within and between categories would be significantly smaller than for concrete item pairs. A mixed ANOVA tested the effects of within-subject variables abstractness (concrete vs. abstract) and category membership (same vs. different), and between-subjects variable category level (broad vs. specific) on similarity ratings. The mean similarity scores for these variables are shown in Tables 4 for broad and specific categories.

Table 4: Ratings from Experiment 3

<table>
<thead>
<tr>
<th>Category</th>
<th>Broad Abstract</th>
<th>Broad Concrete</th>
<th>Specific Abstract</th>
<th>Specific Concrete</th>
</tr>
</thead>
<tbody>
<tr>
<td>Same</td>
<td>3.63</td>
<td>3.88</td>
<td>2.94</td>
<td>3.84</td>
</tr>
<tr>
<td>Different</td>
<td>2.74</td>
<td>1.98</td>
<td>2.00</td>
<td>1.45</td>
</tr>
<tr>
<td>Difference</td>
<td>0.89*</td>
<td>1.90*</td>
<td>0.94*</td>
<td>2.39*</td>
</tr>
</tbody>
</table>

Category Distinctness of Abstract Items

Similarity was rated significantly higher for items of the same categories than those of different categories across all item groups, \( F(1, 25)=154.88, \text{MSE}=0.21, \ p<0.001 \). This was a large effect, \( \epsilon^2=0.86 \). Further, consistent with our prediction, an interaction of category membership with concreteness was revealed, \( F(1, 25)=46.68, \text{MSE}=21, \ p<0.01 \). This effect was moderately high, \( \epsilon^2=0.65 \). As can be gathered from the difference scores in Table 4, concrete item categories had a larger semantic distance overall (difference \( M=2.14 \)) than abstract item categories (\( M=0.92 \)). Similarity ratings among abstract items were significantly higher for same-category pairs than between-category pairs, but, consistent with our predictions, this difference was significantly smaller than for concrete item categories.

Category Type

There was a small significant effect of category level, \( F(1, 25)=4.77, \text{MSE}=1.35, \ p<0.05; \ \epsilon^2=0.16 \). Overall, as we expected, specific categories produced greater differences in same-versus different category pair similarity. Table 4 shows that this effect is almost absent for abstract item categories (the interaction of category membership and concreteness approached significance, \( p=0.09 \)). So, specific categories of abstract items are not more distinct than broad categories – their members are quite similar to members of other specific categories. This suggests that low category distinctness is a general problem for abstract items categories that spans different category levels. This finding is consistent with the results from Experiment 2, which showed that category specificity had no impact on the production frequency of the exemplars.

Situations and Abstract Items

Table 5 shows the mean similarity scores obtained for situation-based categories. The pattern of similarities is almost reverse from the one obtained for taxonomic categories: Abstract item pairs are more similar for same-category pairs than concrete ones, and abstract item categories are more distinct.

In comparison to taxonomic categories, the most striking difference is the low similarity of concrete items of the same situation-based category. Abstract items that are typical for a given situation seem to be as highly similar to each other as members of the same taxonomic abstract item category. This is an important finding because it suggests that situations put semantic constraints on abstract, but not on concrete items. Accordingly, situation knowledge may
affect abstract item processing (such as similarity ratings) relatively more than concrete items.

Table 5: Ratings for Situation–Based Categories

<table>
<thead>
<tr>
<th>Category</th>
<th>Abstract</th>
<th>Concrete</th>
</tr>
</thead>
<tbody>
<tr>
<td>Same</td>
<td>3.44</td>
<td>2.28</td>
</tr>
<tr>
<td>Different</td>
<td>2.50</td>
<td>1.78</td>
</tr>
<tr>
<td>Difference</td>
<td>0.94*</td>
<td>0.50</td>
</tr>
</tbody>
</table>

In an ANOVA, the interaction of concreteness and category membership approached significance, \( p=0.07 \). Specifically, only similarity ratings of abstract items differed significantly for pairs of the same versus pairs of different categories. The semantic distance was the same for taxonomic and situation categories for abstract items. In contrast, there was a drop in distinctness for concrete situation-centered categories (\( M=0.50 \)) as opposed to the taxonomic categories.

Conclusions

We have shown that abstract and concrete item categories differ systematically. The observed differences may explain some of the processing differences for abstract and concrete items. In particular, abstract item categories were found to have exemplars with low production frequencies, i.e., very few exemplars are named by two or more individuals. Experiment 2 showed that the token / type ratio for abstract item categories is at the same level as that for general concrete item categories. Thus, asking for exemplars of mental processes may be somewhat akin to asking for exemplars of objects. However, they differ from broad concrete item categories in at least two important respects: First, more specific subcategories of abstract items do not evoke exemplars with higher production frequencies, as they do for concrete items. Experiment 2 showed that in fact, the token / type ratio dropped slightly from broad (1.63) to specific (1.49) abstract item categories. At the same time, the number of different exemplars mentioned was lowered, suggesting that the more specific categories were indeed smaller categories.

Second, Experiment 3 shows that broad concrete item categories are more distinct than either broad or specific abstract item categories. Thus, we do not think that the difference between abstract and concrete item categories can be reduced to a difference in the abstraction level with abstract item categories being “super-superordinate” categories. An alternative explanation may be that abstract item categories are not organized around typical exemplars which, having most resemblance to the other exemplars, are recollected most often. Instead, it may be that participants have to actively construct the category as an ad hoc category. Memory for abstract concepts does not seem to be organized around taxonomic categories that can be recalled easily using a category label.

Further, the data suggest that abstract categories, regardless of category level, are less distinct from each other than concrete categories. Rated similarity is significantly higher for members of the same category versus members of different categories. However, the difference is much smaller than for concrete item categories (with the notable exception of situation-based categories). At this point, it is important to remember that the concrete exemplars used in the third Experiment were actually not the most typical exemplars of their categories by far, that is, the differences we observed in category distinctness probably substantially underestimate actual differences.

Considering these differences, it does not come as a surprise that taxonomic categories are used less as a basis for similarity judgments of abstract than of concrete item pairs. We also predict based on these data that there would be little agreement in sorting tasks using abstract items since there does not seem to be a strongly organized categorical structure for abstract items.

The data raise the question how meaningful abstract item categories are. Are they merely nominal in function, to enable us to talk about them at an abstract level? Or do they have any impact on the representation and processing of abstract concepts? Our data do not give conclusive answers to these questions but suggest that categorization of abstract items follows different principles and perhaps functionalities from that of concrete items. Referring to related studies, in what follows we will outline a few hypotheses. First, it is informative to link the present findings to studies that explore the content of abstract concepts in comparison to concrete concepts. Second, research on similarity processes, which are presumably involved in categorization, suggests that thematic relations may be an important source for structuring abstract concepts. It is possible that this is linked to the first issue—that the content of abstract concepts is more compatible with thematic than with taxonomic processing.

Conceptual Content

Hampton (1981) found that not all abstract concepts fit a prototypical structure and suggested that this may be due to lower feature correlations. Most likely, this is related to the content of abstract concepts. Hampton suggested on the basis of feature lists that their content consists of social components of situations, e.g., agents, behaviors, and goals. More recent findings are consistent this view. Analyses of conceptual content through property generation tasks suggest that abstract concepts have few “properties” in the classical sense (i.e., perceptual or functional features, parts) but instead have a high percentage of features that are related to situations and to subjective experiences in a situation (Barsalou & Wiemer-Hastings, in press; Wiemer-Hastings, Krug & Xu, 2001; Wiemer-Hastings & Xu, under review). Knowledge of situations is also linked to concrete concepts (e.g., part of our knowledge of chairs is that a person can sit on them to eat or to write), but concrete concepts are further distinguished through a high proportion of entity properties (i.e., external and internal parts, surface features, etc.), of which abstract concepts have very few or none.

Abstract concepts have two specific characteristics that are likely related to the observed lack of distinctive categories for abstract items. One is the smaller set of
features that are used to describe them, which may reflect that the concepts themselves have a lot more overlap than concrete concepts do. This could be directly linked to the high similarity scores of exemplars listed for different categories (Experiment 3). This may be accentuated even more by the other characteristic, namely that features of abstract concepts are significantly less specific than those of concrete concepts (Wiemer-Hastings & Xu). For example, a concrete item may be linked to a specific action (e.g., eating) while an abstract item may simply be linked to some action. The differentiation of categories requires a relative large feature basis to arrive at categories that are characterized by somewhat distinct clusters of features. General features are not likely to offer such differentiation.

Hierarchical category structures have been linked to correlated features. Concrete item properties such as parts and functions may be systematically correlated, e.g. because of causal links between their features (e.g., a bee can fly and has wings – it can fly because it has wings). In contrast, situation properties can be more flexibly linked to form a seemingly unlimited variety of abstract concepts. An agent can be found in a large variety of situations and there are few constraints on their specific set-up. Thus, categories governed largely by situational features may all overlap since they would all involve the same kinds of features, to different extents. For example, emotions and cognitive processes would both involve a person, a situation that the emotion / cognition is related to, and an element of introspective experience. As a result, abstract item categories may have more overlap with less distinction.

### Taxonomic versus Thematic Relations

One central purpose of categories is to allow for inferences about novel objects, based on their similarity to known objects. Likewise, categories in memory enable us to generate instances that could serve a particular function. Categories can be structured around taxonomic information, where several items are a kind of X (e.g., gadgets, emotions) or thematic information, where items fill complementary roles in a proposition. For example, they may be related via an instrument function (knife, meat), a causal relation (cause, effect) a temporal sequence (question, answer) or through a variety of other relations. Both taxonomic and thematic relations are part of our knowledge of abstract and concrete concepts, but there may be a functional advantage in the majority of situations to using one over the other when dealing with concrete or abstract concepts. In particular, as suggested by the findings discussed initially in this paper, taxonomic inferences may be more critical for novel concrete objects or reasoning involving objects, while thematic inferences may be more functional when processing abstract concepts. For example, to specific actions require objects with specific functional or perceptual features; identifying one is facilitated by categories organized around functional and perceptual features. In contrast, abstract item categories may have less practical relevance. For example, to understand an emotion, it may be more important to process events and traits leading up to it than to have quick access to other emotions.

Our data suggest that taxonomic relations of abstract items are comparatively weak. We suggest that abstract items may be organized quite differently from concrete items. For example, Experiments 2 and 3 show that situations provide as much structure for abstract items as taxonomic categories. While concrete items are used across different situations, abstract items that occur in a similar context are perceptually interrelated. We suspect that in the future, cognitive scientists may discover quite different structural principles for abstract item categories, and that they will centrally involve thematic relations.

### References


Wiemer-Hastings, K., & Xu, X. (under review). *Content differences for abstract and concrete concepts*.