Sensitivity to matching features in a category construction task

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INTRODUCTION

The categorization of objects in the environment is one of the most fundamental human cognitive abilities. Much of this categorization occurs without external guidance or feedback, a situation often referred to as unsupervised learning or category construction.

Most previous research on category construction has used tasks in which participants were presented with a set of stimuli and asked to sort them into two groups[1]. However, these kinds of tasks limit the number of categories created and may force participants to place stimuli into “unnatural” groups they would not otherwise have chosen.

In order to facilitate the construction of natural categories, a new category construction task in which participants generate labels for stimuli is used in the current study[2]. Previous research utilizing this task has found that people show a clear sensitivity to abstract dimensional structures (DS categories), or the overall format and arrangement of parts, even when the objects being grouped together share no actual surface features[3].

This research also indicated that people are sensitive to instances with matching surface features (parts), and likely to group objects that share specific parts into the same subcategory[3].

OVERVIEW OF THE EXPERIMENT

The current study further explores people’s sensitivity to individual matching features in constructing novel categories by systematically manipulating the number of matching features shared between pairs of stimuli in a display. The degree of match was varied from one to four (out of four) matching features in order to assess how the probability of placing stimuli in the same category would be affected by how many surface features (specific parts) they shared. The resulting sensitivity function should be highly informative for evaluating computational models of learning and category goodness.

METHODS

Participants viewed a single 4x4 array of novel visual stimuli and were asked to create a binomial (letter-number) compound label for each to categorize them at “family” and “species” levels, e.g., A1, B1, B2, etc.

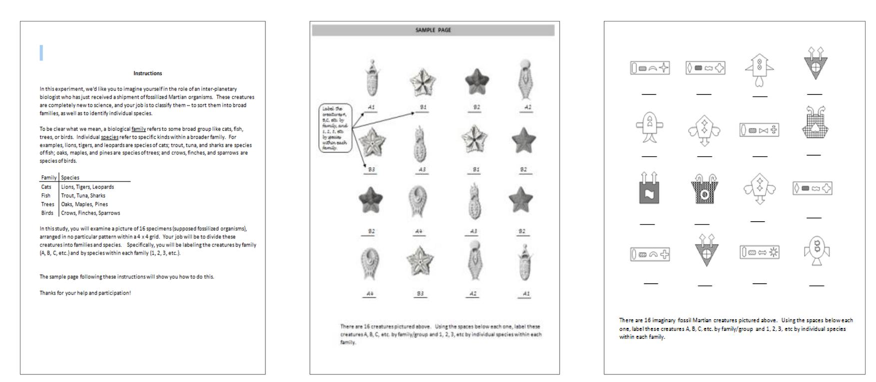


Figure 1. Sample of the booklets including an instructions, example, and stimulus page.

Three DS categories (groups of stimuli defined by abstract alignability or shared dimensional structure, but which vary in surface features) were included in each display (horned, winged, and box stimuli, below). Within each DS category there was one pair of stimuli that shared at least one feature in common. The number of matching features shared by these “repeated instances” was manipulated in a between-groups design from one to four, resulting in a total of four conditions.

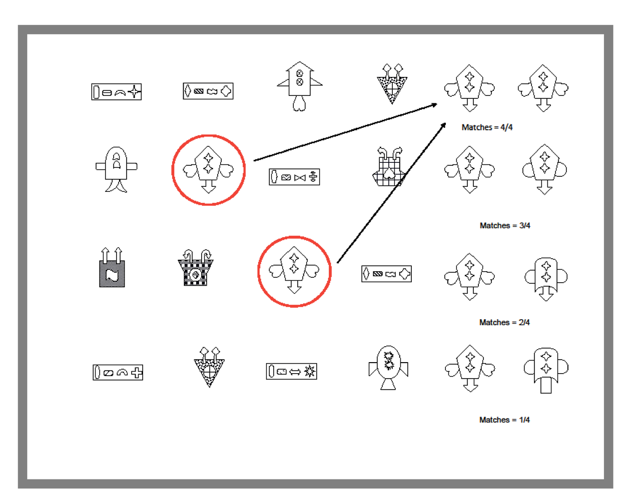
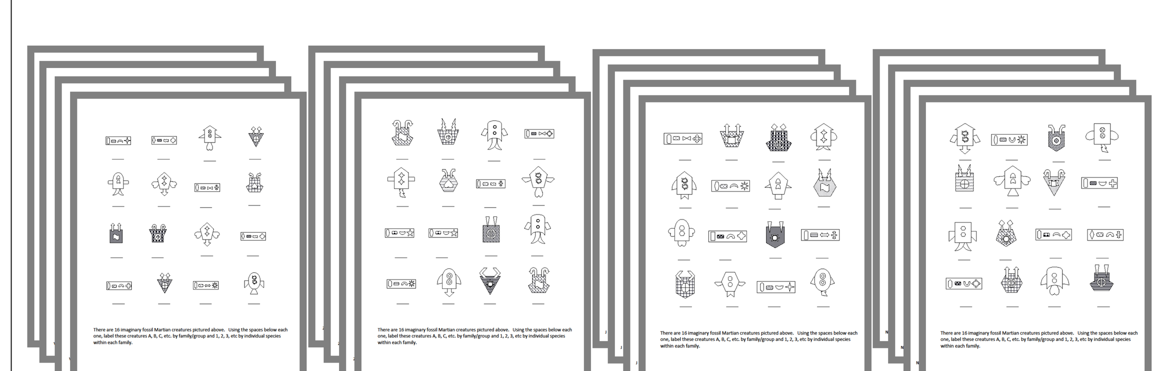
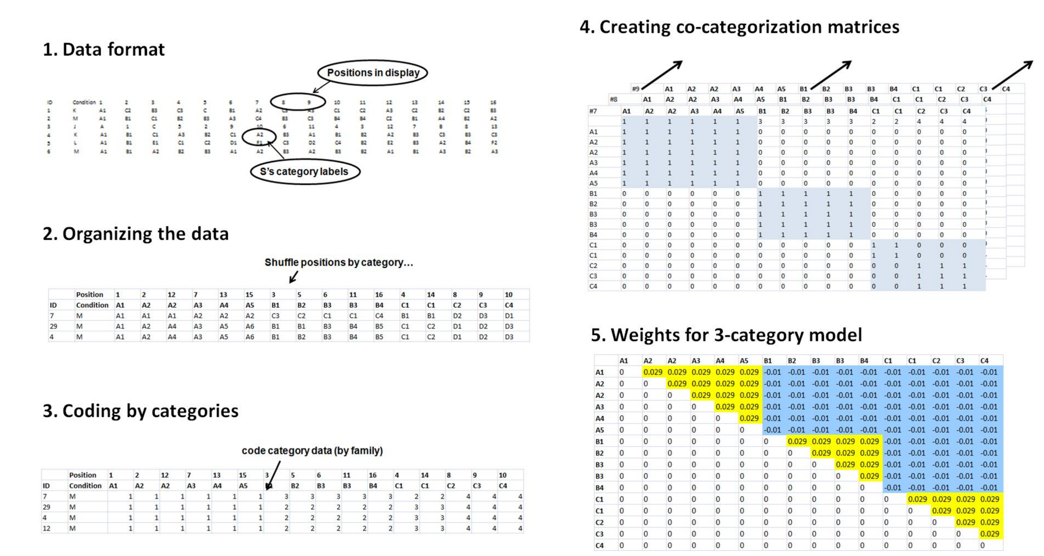


Figure 2. Sample visual display with four matching features, manipulation of matching features is shown to the right.

For counter-balancing purposes, four sets of visual displays were created with the number of matching features manipulated for each, resulting in a total of sixteen separate visual display pages (test booklets).



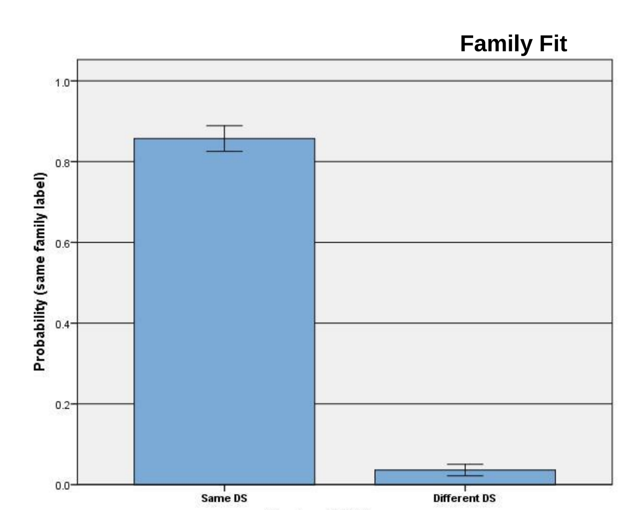
Data Manipulation and Analysis



The data from each participant was coded at family and species levels, converted to a matrix of same/different scores, and fits to various models were evaluated.

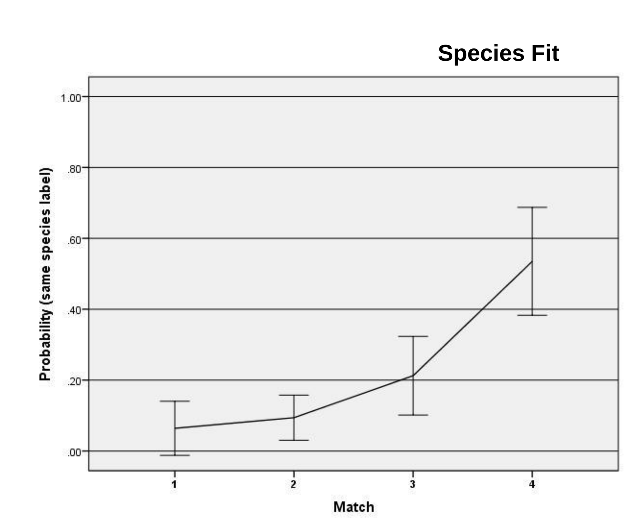
RESULTS

Consistent with previous findings, items from the same DS category were much more likely to receive the same family label than items from different DS categories, t(137) = 40.04, $p < .001$.



Same DS	0.857
Diff DS	0.036

The number of shared features strongly affected the probability of giving the two repeated instances the same species label, F(3,134) = 17.20, $p < .001$. Identical instances sharing all four features were grouped together significantly more often than instances sharing one, two, or three features ($p < .001$, Bonferroni comparisons). There were no significant differences among the latter three groups (all p's > .25).



Features Shared	Effect
1	0.064
2	0.094
3	0.212
4	0.535

DISCUSSION

People showed strong sensitivity to overall alignability of dimensional structure, overwhelmingly assigning family labels based on the DS categories. This is consistent with previous results, and further validates the reliability and applicability of the binomial labeling task.

Participants showed a *none-any-all* sensitivity pattern to the number of shared features in the repeated instances, with one matching feature having a significant effect on category construction, no significant increase from one to three matching features, and a substantial increase from three to four (all) matching features. The lack of effect between levels one and three, if real, is somewhat surprising from the perspective of normative models of categorization, and suggests that people may have difficulty integrating across features when comparing stimuli presented simultaneously in a visual array.

NEXT STEPS

The immediate question raised by these results is whether the non-any-all pattern is real and will generalize to other situations.

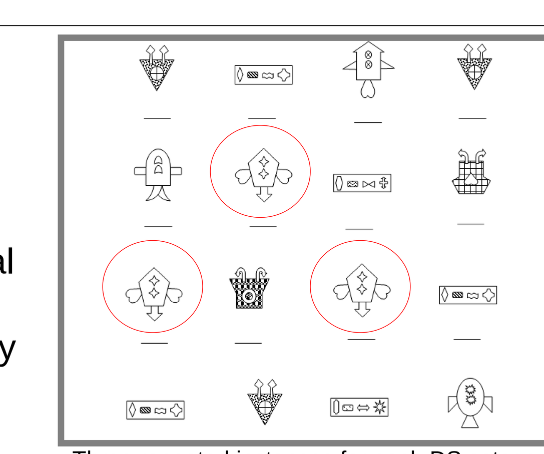
Verbal Categorization

Verbal stimuli will be used to assess sensitivity to matching features across modalities; will the same pattern of results be obtained as with visual stimuli?

A related question is whether the shape of the sensitivity function depends on category size, i.e., will it generalize to larger categories?

Repeated Instances

The number of repeated instances will be manipulated; will individual matches have larger or smaller impact as category size is increased?



Three repeated instances for each DS category

References

[1] e.g., Medin, D. L., Wattenmaker, W. D., & Hampson, S. E. (1987). Family resemblance, conceptual cohesiveness, and category construction. *Cognitive Psychology, 19*, 242-279.
[2] e.g., A binomial labeling task for category construction. Clapper, J. P. (2012) *Psychonomics*.
[3] e.g., Discovering categories in multi-object visual displays. Clapper, J. P. (2011). *Western Psychological Association*.