Categorization of Modeling Language Concepts: Graded or Discrete?

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Abstract. We investigate the category structure of categories common to conceptual modeling languages (i.e., the types used by languages such as actor, process, goal, or restriction) to study whether they more closely approximate a discrete or graded category. We find that most categories exhibit more of a graded structure, with experienced modelers displaying this even more strongly than the other participants. We discuss the consequences of these results for (conceptual) modeling in general.

Keywords: categorization, conceptual modeling, model semantics.

1 Introduction

We categorize the world around us in different ways depending on the subject matter. Some things we categorize more discretely, like natural things (e.g., fruits and plants), some things we categorize in a more graded way, such as artifactual things (e.g., tools, vehicles). These different categorization tendencies have been shown many times in research, starting around the time of Rosch et al. [7]. Also, they have been investigated by many others explicitly elaborating on the category structure for a number of natural and artifactual categories (cf. [2,1,4]). On the other hand, some work investigating this has had difficulties in finding significant differences in categorization tendencies between artifactual and natural categories (cf. [5]). Regardless of the debate whether particular kinds of categories are usually categorized in a particular way, it is clear that *we do not categorize everything in the same way.*

We aim to clarify whether the categories common to many modeling languages and methods (i.e., those types used by a language to instantiate domain concepts by) are categorized in a discrete or graded fashion. The implications of this for model creation and usage (particularly for models used to capture and document a certain domain) are important to be aware of. If a category from a language is typically judged in a discrete fashion, the semantics of models are likely easier to communicate, formalize, and keep coherent. However, if such a category is

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typically judged in a graded fashion, communicating it to others becomes more involved, requiring more explicit discussion, and the formalizations and tools we use need to explicitly support this structure.

2 Method

Participants: Fifty-six participants participated in the present study. Twenty-one of them were advanced (3^{rd} or 4^{th} year) students at an undergraduate university of applied science with a focus on computing science and modeling, thirty-five were employees at a public research center with a focus on IT and used modeling languages and tools to varying degrees. All participated voluntarily and received no compensation for their participation.
Materials: The materials used for the benchmark in the experiment were based on the list of exemplars reported on by Barr & Caplan [1]. We used 5 full, 5 partial and 5 non-members terms for both of the benchmarks. For the benchmark we included the categories FRUIT and VEHICLES. For the modeling part of the experiment we investigated the categories ACTOR, EVENT, GOAL, PROCESS, RESOURCE, RESTRICTION and RESULT. These categories result from an earlier performed analysis on modeling languages and methods [6]. The terms used for the members of the categories from the modeling languages are the terms used by the modeling language and methods, based on the official (or most-used) specification.
Procedure: The procedure was based on Estes' [3] setup. Participants completed the task through an on online survey. They were instructed to judge whether a list of given terms were either full, partial or non-members for the current category. Participants were informed beforehand that partial member scores meant that the exemplar belonged to the category, but to a less degree than others. This was first done for the two benchmark categories, and followed in the same way for each of the investigated categories from the modeling languages. The orders of the terms in each category were randomized for each participant.

3 Results

The proportion of graded membership judgments for the terms used in the benchmark which are partial members are shown in detail in Table 1. What was to be expected is that the typically discrete category (FRUIT) would show lower proportions of graded judgments compared to the typically graded category (VEHICLES). The given scores indicate the proportion of partial member judgments (e.g., 19% of students, 13% of beginning modelers, and 30% of expert modelers considered an avocado as a partial member of the FRUIT category). Shown are respectively the scores for students, beginning modelers, expert modelers, and the scores as reported by Barr & Caplan [1], and Estes [3].

A more detailed overview of the average amount of full, partial and non-member judgments for each investigated category is given in Table 2. The results

Table 1. Partial member proportions for the partial member terms of the benchmark

Category	Term	Student	Beginner	Expert	Ref. [1]	Ref. [3]
FRUIT	avocado	0.19	0.13	0.30	0.37	0.16
	coconut	0.24	–	0.05	0.38	0.37
	tomato	0.33	0.27	0.25	0.34	0.05
	cucumber	0.19	–	0.25	0.23	0.21
	rhubarb	0.14	0.20	0.15	0.45	0.26
VEHICLES	gondola	0.24	0.20	0.20	0.50	0.21
	tricycle	0.14	0.13	0.10	0.64	0.58
	wheelchair	0.29	0.27	0.50	0.70	0.63
	horse	0.48	0.27	0.55	0.54	0.50
	husky	0.38	0.27	0.55	0.27	0.21

are given for each investigated group (students, beginning modelers and expert modelers), and indicate the proportion of membership judgments. For example, students considered 47% of the presented terms for the ACTOR category to be full members, 18% to be partial members and 35% to be non-members. The primary points of interest here are the higher scoring partial and non-member results, as they indicate words actually used by modeling languages that are either only considered to be partially reflective of their category (e.g., a 'market segment' would be only considered somewhat an ACTOR), or are considered not to be exemplars of that category (e.g., a 'requirement unit' would not be considered an ACTOR).

Table 2. Average amount of membership scores (full, partial and non-members) for each group of investigated categories

	student ($n = 20$)			beginner ($n = 15$)			expert ($n = 21$)		
Category	full	partial	non	full	partial	non	full	partial	non
ACTOR	0.47	0.18	0.35	0.30	0.14	0.55	0.41	0.25	0.35
EVENT	0.46	0.14	0.41	0.39	0.16	0.45	0.29	0.19	0.51
GOAL	0.65	0.11	0.23	0.60	0.16	0.24	0.56	0.20	0.24
PROCESS	0.66	0.14	0.20	0.62	0.22	0.16	0.41	0.32	0.28
RESOURCE	0.59	0.19	0.22	0.62	0.19	0.20	0.54	0.22	0.24
RESTRICTION	0.50	0.21	0.29	0.55	0.18	0.27	0.39	0.24	0.37
RESULT	0.73	0.16	0.11	0.86	0.07	0.08	0.76	0.16	0.09
FRUIT	0.44	0.10	0.45	0.47	0.05	0.42	0.49	0.09	0.41
VEHICLE	0.48	0.14	0.37	0.49	0.13	0.37	0.51	0.20	0.29

It was expected that the partial member judgments for the natural and artifactual benchmark categories would show a difference, with the artifactual category displaying a higher proportion of graded judgments. Although compared to the results from Barr & Caplan [1] and Estes [3] the overall amount of graded judgments seems to be lower, the relative distribution still seems intact. This is the case for both the beginning and expert modelers (the proportion of some graded judgments for VEHICLES being at least twice as large compared to the ones for FRUITS). This is not the case for the student group, as the difference between the benchmark categories there was found to be much smaller. This could be explained by the lower amount of experience with (and exposure to) modeling (and modeling languages) students have.

On average the proportion of partial member judgments is 0.16 for students, 0.16 for beginning modelers, and 0.23 for expert modelers. When we compare these scores to the average proportion of partial member judgments for the discrete and graded benchmark categories in Table 2 (respectively 0.10 and 0.14 for the students, 0.05 and 0.13 for the beginning modelers and 0.09 and 0.20 for the expert modelers), we can see that for the two groups of modelers most scores shown for the categories from modeling languages more clearly reflect the graded benchmark category than the discrete one. Thus, as a careful first investigation we seem to have found support that most categories from modeling languages are of a graded nature. Given that the distribution of terms for these categories was not the same as the benchmark categories (i.e., the benchmark categories were made up of equal amounts of full, partial and non-members, while for the categories from the modeling languages we were unaware of this distribution, with them likely containing proportionally more full members) this makes it all the more acceptable to support the idea described in the introduction that *these categories can be seen as exhibiting a graded structure.*

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