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The Use of Reference Points in a Sorting Task

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The research results presented here draw from data previously reported at SIG-CR 95 (Jörgensen 1995b). The theoretical perspectives of categorical perception are used to investigate the nature of similarity judgements in a pictorial environment and to develop a conceptual framework for exploration of the use of reference points in a sorting task. Both Boundary Reference Points and Prototype Reference Points are used by participants in the sorting task. The classification process does not appear to move in a linear or orderly way, and several suggestions concerning the nature of the use of reference points in classificatory behavior do not seem to be supported by this data. The results carry implications both for understanding the nature of classificatory behavior and for image indexing and retrieval applications.

1. Overview

Previous research by the author sought to describe the range and define the types of image attributes as reported by participants in a series of describing, sorting, and searching tasks with pictorial images (Jörgensen 1995a). Results from a sorting task suggested a strong relationship between the types of attributes described by participants and the groups into which participants placed the images. Similarity judgments among images as represented by group names were based on a wide range of attributes, which represented perceptual (in direct response to a visual stimulus), interpretive (a response requiring inference from prior knowledge), and reactive (emotional or judgmental) responses to the images. The current research examines the sorting task data from the theoretical perspective of categorical perception.

2. Introduction

Categorization is viewed as playing a critical role in perception, thinking, and language (Bruner 1973). A very general problem in cognitive science has to do with how humans categorize, or sort the "things" of the world into categories. These "things" can range from a concrete object to an abstract idea, and categorization, or "sorting," includes many differential responses to a thing, from detection and identification to verbal description (Harnad 1987). Categorical perception refers to the relationship between categorization and perception and it

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appears to proceed through two means: psychophysical processes involving such phenomena as the color spectrum or an acoustic continuum ("sensory perception") or through higher order categories ("generic knowledge") which are semantically based (Medin and Barsalou 1987). A review of evidence suggests that, at the conceptual level, classification is carried out neither by rigorous, nor by logical, nor by universal criteria, but rather employs more probabilistic means, often calling upon "unnecessary" features, various stimulus dimensions, or holistic properties (Harrison 1992).

This raises the question of the fundamental nature of similarity judgments in a visual context. Two theories have been proposed to account for the nature of similarity judgments among objects. The feature-theoretical approach (Tversky 1977; Tversky and Gati 1978) suggests that the similarity of two objects is expressed as a function of their common and distinctive features weighted for salience or importance; this theory allows for a variety of similarity relations over the same set of objects. This type of matching of properties has been the predominant approach to similarity, and relies on the concepts of prototypes, exemplars, and graded categories.

More recently, researchers suggest that this theory is in itself insufficient, as physical features alone do not predict classification performance. Principles specifying relevance and importance of properties are also needed, otherwise similarity becomes too flexible to account for conceptual coherence (Medin and Wattenmaker 1987; Lockhead 1992). Tversky's 1977 work showed that the relative weighting of a feature varies both with the stimulus context and experimental task, adding support to the argument that similarity depends upon more than matched feature sets.

Common features can be used to represent conceptual coherence, but it is not clear whether similarity is a by-product of conceptual coherence or is its determinant. Lawrence (Lawrence 1949; Lawrence 1950) proposes a theory of acquired equivalence and acquired distinctiveness, in which categorization is causative in the similarity among entities in a category. Furthermore, a concept is more than the sum of a set of independent features. Medin and Wattenmaker argue that "all the features that are characteristic of a bird do not make it a bird –

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unless these properties are held together in some kind of a 'bird structure.' This bird structure certainly consists of a large set of relational properties and not simply attributes" (Medin and Wattenmaker 1987, 31). Thus this approach holds that a list of features by itself is not adequate to explain classificatory behavior; decisions as to which items belong in a category are based both on features and other types of structural or functional relationships. The current research examines the results of a sorting task within the larger question of the nature of the relationship between categorization and perception.

The attempt to develop a theoretical framework within which to examine these results is confounded by several competing definitions and models of categorical perception and by the wide separation among researchers studying categorical perception in sensory perception (SP) and researchers studying generic knowledge (GK) in categorization. Medin and Barsolou (1987) note that distinguishing between SP and GK is elusive. One way in which they differ has to do with the level of abstractness of defining features. SP categories are studied through empirical investigation of sensory processes, such as sound and color perception, while work on GK categories is tied to cognitive science issues and often focuses on natural and man-made objects. However, Medin and Barsalou note that many GK categories, especially those having to do with objects and people, depend heavily on perceptual properties and are thus defined perceptually to some extent.

Recently, researchers interested in categorization processes have suggested that SP and GK categories share deep similarities (Medin and Barsalou 1987; Harnad 1987; Burns 1992) and propose a unified framework focusing on similarities between SP and GK for investigating the phenomena of categorization. Among the empirical evidence Medin and Barsalou cite is the existence of sharp identification functions, within-category discrimination, typicality effects, and reference point effects in both SP and GK categories (1987, 470-74). They also note that assumptions concerning the differences among SP and GK processes have limited investigation in a number of these areas.

This research investigates one of these factors, the use of reference points in classification. Reference points are either salient values on dimensions that

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structure categories (Boundary Reference Points), or prototypes that contain characteristic and ideal features of the category (Prototype Reference Points). While both types of reference points appear to be extremely important for both SP and GK categories, Medin and Barsalou note that "little thought has been given to the possibility that people use boundary reference points during classification. Instead, every model we know of that uses reference points assumes that people use prototype reference points" (1987, 474-5). Medin and Barsalou pose several hypotheses concerning the role of reference points in classification: 1) subjects may use boundary reference points (BRP) in discrimination tasks and may use prototype reference points (PRP) in classification tasks; 2) an increasing number of categories may be accompanied by a move from BRP to PRP; and 3) experience with a category may enable a move from the use of PRP (when categories are initially uncertain) to the discovery of a salient criterion which becomes a BRP. These hypotheses are explored using the attribute data gathered in the previous research.

3. Background

The previous research has been fully described elsewhere (Jörgensen 1995a; Jörgensen 1995b). Participants, who volunteered for the task, were given a set of seventy-seven images and were told to sort them into groups in a way that would enable them to find the images for themselves at a later time. Eighteen participants completed the task, which was videotaped. The data from this task consisted of transcripts of participants' verbal reports as they sorted the images. The eighteen participants generated a total of 291 groups, ranging from six to twenty-nine groups per participant, with an average of about 16 categories per participant. Groups contained from one to twenty-seven images, with an overall average of five images per group. Both individual images and group names were coded according to attributes represented, and attribute data describing the group names were collapsed by the researcher into higher-level classes.

The previous research demonstrated a close relationship between the attributes described by participants and the groups into which they placed the images, as the distribution of attribute classes for the group names follows closely the distribution of attribute classes among the individually coded attributes for

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each image. Among these group names, 66.7% of the classes were composed of what were defined as "interpretive" categories of attributes rather than "perceptual" categories such as color or other visual element.

In the current study, the researcher returned to the data and focused on the attribute level rather than the class level of each named group (it should be noted that "attribute," as used in this research refers to a group of similar conceptual structures which are composed of a number of features; thus the attribute TYPE may be instantiated as "Landscape," "Portrait," etc., and each of these will have its own variable set of features). Group names and naming order were analyzed to evaluate the extent to which group membership is described by participants as being determined by the presence or absence of a salient attribute or by shared prototypical features constituting an attribute, and several proposals concerning the nature of the categorization process within the framework of categorical perception were examined.

4. Data Analysis

The current research expanded the previous research by adding a more detailed analysis of the *process* as well as of the final product of the sorting task. Therefore, interim named groups (which were later subsumed into other groups) and their associated attributes are included in this analysis, bringing the total number of named groups to 323, and the total number of coded attributes to 429. Each group name contained from one to four terms, representing from one to three attributes. Of these, there were 221 group names composed of a single coded attribute, 94 composed of two attributes, and 8 composed of three attributes. Figure 1 shows group names in order of naming for two participants.

Figure 1: Group Names in Order of Naming, Two Participants

Subject A	Subject H	
Animal Theme	Japanese/Oriental Art	Sad
Children's Art	Funny Pictures	Uncertain
Landscapes	Outdoor Scenes	
People Portraits	Abstract Animals	
Realistic	Don't Know What it Means	
Strange	Kingdoms/Power	
	Happy	

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The attributes composing group names represented a limited subset of the larger set of attributes named by participants in describing the images. The previous research defined 43 attributes relating directly to the content of the image; in the current research there were 30 different attributes represented in group names, with eight attributes occurring in only one group name. The number of attributes in group names is shown in Figure 2.

Figure 2: Attributes in Group Names, Occurrence, and Reference Point Type

ATTRIBUTE	NO.	%	EXAMPLE	REF. POINT TYPE
Type	43	10.0%	"Landscape"	BRP
Abstract Concept	42	9.8%	"Imaginary"	PRP
Object	41	9.6%	"Car"	BRP
Style	41	9.6%	"Surreal"	PRP
People	39	9.1%	"People"	BRP
Theme	23	5.4%	"Nature"	PRP
Format	22	5.0%	"Postcard"	PRP
Activity	22	5.0%	"Hunting"	PRP
Setting	20	4.7%	"Outdoor"	PRP
Representation	18	4.2%	"Drawing"	BRP
Social Status	18	4.2%	"Politicians/Leaders"	PRP
Category	15	3.5%	"Fantasy"	PRP
Atmosphere	13	3.0%	"Dreamy"	PRP
Color	11	2.6%	"Black and White"	BRP
Emotion	11	2.6%	"Happy"	PRP
Uncertain	11	2.6%	"No category"	-----
Time Reference	9	2.1%	"Modern"	PRP
Medium	6	1.4%	"Watercolor"	PRP
Symbolic	5	1.2%	"Making a Point"	PRP
Event	4	0.9%	"Circus"	PRP
Texture	3	0.7%	"Metallic"	PRP
Number	3	0.5%	"Two People"	BRP
Relationship	2	0.5%	"Family"	PRP
Artist	1	0.2%	"Like Wyeth"	PRP
Body Part	1	0.2%	"Lips"	BRP
Color Value	1	0.2%	"Dark"	PRP
Focal Point	1	0.2%	"Foci"	PRP
Perspective	1	0.2%	"Distorted"	PRP
Reference	1	0.2%	"New York"	PRP
Visual Component	1	0.2%	"Optical Illusion"	PRP

This research investigates the use of reference points in the sorting task and specifically looks at the role of BRPs in GK classification, which has generally

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been assumed to depend only on PRPs. The following operational definitions were used:

Boundary Reference Point: an attribute which is a salient characteristic; group membership is determined by the presence or absence of this specific attribute. If an image is placed into a group because "it has a _____ in it" the decision characterizes the use of a BRP. An example would be "it has a car in it."

Prototype Reference Point: an attribute which is defined by a number of common shared features; group membership is determined by the extent to which an image shares a set of characteristic features which define the attribute. An example would be "Mystic."

Each attribute composing a group name was designated as either a BRP or a PRP. As noted earlier, the distinction between SP and GK processes is difficult to define; the distinction between a BRP and a PRP shares similar problems. For instance, it can be argued that recognition of an object such as a "car" entails reasoning about the set of features which make up a car - wheels, doors, hood, steering wheel, headlights, carries passengers, a private vehicle. However, an ecological view of perception (Neisser 1987) would suggest that, while initially such objects must be reasoned about, survival requires that such objects become well-learned and only entail reasoning when they differ significantly from the prototype or exemplar. Therefore, common objects and people also become BRPs, and membership in a group is frequently determined by their presence or absence.

In addition, as the set of stimuli for this work is a set of images, they carry with them a specific set of concepts relating to visual imagery (no doubt determined in part by cultural and educational systems). For instance, the set of attributes labeled TYPE is composed of typical forms of representation such as "Landscape," "Portrait," and "Painting." Within this domain, these types also appear to be well-learned and are considered to be BRPs rather than PRPs. Thus those images characterized by the phrase, "It IS a (landscape, portrait, etc.)," are also defined as BRPs. Figure 2 contains a listing of attribute reference point designations.

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Of the 429 attributes, 159 were of the BRP type according to the definitions given above, accounting for 37% of the total attributes. Of these, 55 (35%) were singly-occurring in group names ("Women"), and 104 (65%) occurred as part of a multi-attribute group name ("Animal Cartoon"). All participants used BRPs, and they accounted for 21% to 66% of the attributes in group names. The average percentage used was 37.8%, the median was 35.5, and the standard deviation was 12.9. Two-thirds of the participants thus fell within the midrange of values, indicating that there was a good consistency among participants in terms of their total usage of BRPs in the sorting task.

Order of use of BRPs and PRPs as group names was also analyzed. The use of BRPs occurred throughout the process. In one participant (who had the fewest named groups), they occurred only in later groups, but for all others they were used from the beginning to the end, with no particular patterns emerging.

5. Discussion

Based upon the above description of the occurrence of BRPs and PRPs, we may now consider several of the suggestions put forward in previous sections. The first suggestion, that subjects may use boundary reference points (BRP) in discrimination tasks and prototype reference points (PRP) in classification tasks, may be an observation which is directly tied to the experimental methodology being used. As most previous research in SP and GK categorization has been within rigidly controlled laboratory settings using a restricted set of variables and task definitions, the task may very well have limited the type of reference point used. Much research (including this author's) points to the impact of task. In addition, in an exploratory research setting, where the goal is to capture as wide a range of data and naturally occurring phenomena as possible, more complex behaviors emerge. Classification is one such complex behavior, and the current research suggests that discrimination is an integral part of classificatory behavior. Furthermore, it appears that discrimination occurs throughout the decision-making processes involved in classificatory behavior.

This also points toward the utility of a unified framework for considering both SP and GK processes. As noted earlier, it has been assumed that SP

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processes and outcomes are distinct from GK processes and outcomes, when in fact (it seems reasonable to suggest) they may both operate (at least, in the real world) in concert with each other.

The second suggestion, that an increasing number of categories may be accompanied by a move from BRP to PRP, also does not seem to be supported by the current results, as the use of BRPs occurred both throughout the process of naming groups for all participants. They also did not appear to increase in relation to the number of groups a participant generated.

There is some limited evidence supporting the third suggestion, that experience with a category may enable a move from the use of PRP (when categories are initially uncertain) to the discovery of a salient criterion which becomes a BRP. For instance, one participant created a group called "Landscapes," but then had difficulty reconciling that grouping with the variety of styles represented by the work. He finally concluded that the important criterion was that the image was "a landscape in which something (human) was embedded," eliminating all the other criteria that were confusing his decisions. However, one third of the group names were composed of both a BRP and a PRP, indicating that both types contributed to the formation of groups.

6. Limitations and Conclusions

There are several limitations upon the current research, most notably the problems discussed above in arriving at a satisfactory and useable definition and description of BRPs and PRPs. Another limitation is that the current research only analyzes the naming of the groups as representative of the process of classification. More detailed research at the level of the assignment of each individual image to a group may reveal further interesting trends. However, data for this is limited, as participants commented on an image which was used to define a group but often did not describe additional images in detail beyond assigning them to the group. At the end of the process, when participants were asked to describe the criteria upon which the groups were formed, images were sometimes described in more detail and these descriptions will be used for further research.

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Another question not addressed is whether additional conceptual structure is needed for conceptual coherence of a set of features comprising an attribute (the "bird" structure referred to above). Future analysis at the individual image level may provide further data about how these categories are structured, and replication of the task using more in-depth probing focused upon this issue may be in order.

However, this research does illustrate the importance of gathering data in a naturalistic setting in which the complexities of classificatory behavior can be described and analyzed in detail. This research seems to indicate that the process of classification involves discrimination and grouping behaviors which use both BRPs and PRPs throughout the process. More research of this type is needed if the agenda for a more holistic approach to categorical perception put forth by such authors such as Medin, Barsalou, Harnad, and Burns is to be met.

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