On Bodies and Events[1]

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A category is a category is a category. The whole point of categorization is to treat unlike things as if they were alike. After all, if we treated each encounter with each object or event as the unique thing it is, we would be unable to generalize, unable to learn, unable to remember, unable to communicate. Ignoring differences underlies all of cognition. But which differences to ignore? And are all categories alike, or do some, in particular those associated with our bodies and their actions, have a special status? First, we review the structure of categories, then the special features of bodies and events, and finally relate them together and to the topic of this book, imitation.

Structure of Categories

Defining Features or Family Resemblance? What has been termed the "classical theory" has been trounced in recent decades as a theory of how people decide on category membership or draw inferences about category members (e. g., Medin, 1989; Miller & Johnson-Laird, 1976; Rosch, 1978; Smith & Medin, 1981). At the core of the classical view is the notion of defining features, features that are singly necessary and jointly sufficient for category membership. Certainly some legal and mathematical categories, such as citizenship and odd number, have that character. But psychologists want to know how people think about categories: do they think of categories in terms of necessary and sufficient conditions? The evidence suggests otherwise. It suggests that people think of categories in terms of central tendencies or frequent features or typical examples. For one thing, people find it difficult to provide lists of features that are

[1] Harold Bekkering, Cathy Reed, and Wolfgang Prinz provided extensive and illuminating comments on an earlier

necessary or sufficient for category membership, for even such familiar categories as tables and trees. They do find it easy to generate examples of categories, to rate the examples on how good or typical they are, and to produce features of categories, though not necessarily necessary and sufficient ones.

Typicality. The features people produce for categories have a family resemblance structure (Wittgenstein, 1958). Not all the features are shared by all category members, but the more typical category members are more likely to have more of the shared features (Rosch & Mervis, 1975). A table, for example, does not have to have four legs and a horizontal top, though typical tables do. Graphic artists may have tables with slanted tops and cafe owners tables with a single leg. These are still tables, albeit atypical ones.

Basic Level. Natural categories, those formed spontaneously and used frequently within a culture, have a preferred level of abstraction, called the basic level, the level of chair and dog rather than the level of furniture and animal or kitchen chair and Pekinese. The basic level, also has a structural basis determined by category features (Rosch, Mervis, Gray, Johnson, & Boyes-Braem, 1975). People produce few features shared by members of superordinate categories like furniture, vehicle, or animal. In contrast, people produce many features shared by chairs, cars, and dogs, but not appreciably more for kinds of chairs, cars, and dogs. Given that specific levels of categorization entail more category distinctions, the basic level maximizes the amount of information conveyed by a category relative to the number of contrast categories. These fundamental features of natural categories, typicality within a category and basic level across levels of abstraction, have been extended beyond artifacts and natural kinds to other categories, colors (Rosch, 1975), scenes, the settings for objects (Tversky & Hemenway, 1983), events (Morris & Murphy, 1990; Rifkin, 1985; Rosch, 1978), people (Cantor & Mischel, 1979), and emotions (e. g., Ekman, 1984; Izard, 1992; Plutchik, 1993).

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draft, for which we are grateful.

Part Structure and the Basic Level. The basic level differs qualitatively as well as quantitatively from more abstract and more specific levels of categorization. Examining the features produced for categories at the three levels of abstraction, Tversky and Hemenway observed that features for superordinate categories generally referred to functions, such as "used for fixing things" for tool (Tversky & Hemenway, 1984). Features at basic and subordinate levels, in contrast, referred to observable properties, such as "handle" and "blade" for knife or "peel," "pulp," "seeds," "sweet," for apple. One kind of feature in particular proliferated at the basic level, namely, parts.

Part names have an inherently ambiguous ontological status. They refer simultaneously to appearance and to function. A "leg" has a certain appearance--it is vertically elongated--but it also has a certain function--support. Metaphoric uses of part names reflect both senses. The "head" of a pencil is the top, but the head of a committee is the coordinator. Tversky and Hemenway argued that the dual status of parts promotes inferences from appearance to function essential to deeper understanding and coherent conceptions of categories. Arms are long things that suggest reaching. Seats are the right shape, size, and height to invite sitting. The legs of a deer enable mobility, and the peel of an apple protects its' seeds. Parts, then, afford inferences from appearance to function.

Qualities of Different Kinds of Categories

Despite similarity in typicality and basic level structure, some classes of categories appear to differ qualitatively in revealing ways. The comparison of objects, both natural kinds and artifacts, to substances is enlightening. Objects normally have rigid shapes; indeed, shape is an excellent cue to the identity of an object. Substances, however, take the shape of their containers, and are characterized by texture, color, and material. Although the object/substance distinction is captured by the count/mass distinction in English, two year olds seem to grasp it prior to using or understanding the related syntactic terms (Soja, Carey, and Spelke, 1991). Consider further the contrast between natural kinds and artifacts. Children (and adults) are more likely to draw inferences, especially about unseen properties such as internal organs, for natural kinds than for artifacts; for artifacts, they are more likely to rely on perceptual similarity (e. g., Gelman, 1988; Keil, 1989; Keil & Batterman, 1984). Biological categories are regarded as having internal cores, perhaps genetic, that determine their appearance and behavior. Nonliving natural kinds, such as metals, are thought to have essences related to their molecular structures. Finally, artifacts are thought to have cores based on function or intended uses (see, for example, Carey, 1985; Bloom, 1996; Gelman, 1998; Keil, 1989; Rips, 1989). Beliefs about essences govern the kinds of and bases for inferences from categories. Nevertheless, demonstrating that such theories or cores are consistently related to judgements of category membership or to knowledge about categories or to inferences from categories has proved difficult (e. g., Malt, 1984; Malt & Johnson, 1992). The moral here may be that just as it is difficult to demonstrate necessary and sufficient features for particular categories, tables, dogs, or sand, it is difficult to demonstrate necessary and sufficient conditions for kinds of categories, artifacts, biological kinds, or physical kinds, objects or substances.

Bodies and Events

Bodies and events are candidates for privileged categories. We experience the world through our own bodies, frequently through the actions they perform. Prominent aspects of that experience involve the bodies and actions of others. Our bodies are integral to the events we perceive and participate in at every moment in time. Natural kinds and artifacts turn out to be crucial parts of events, acted upon by bodies. We have begun exploring the special characteristic qualities of bodies and events. Both bodies and events have salient part structures, the former in space, the latter in time. Let us turn first to bodies.

Bodies. In some ways, bodies are like other kinds of objects, especially those that move. But unlike other objects, which can only be experienced from the outside, bodies are experienced from the inside. We know what it feels like to move or be pushed, to have pleasure or pain, to feel cold or hot, to be sluggish or energetic. The privileged status of bodies may give them privileged cognition. Self-regulated imitation in neonates suggests that rudimentary understanding of others' bodies comes from actions performed by one's own body (Meltzoff & Moore, 1995). Other evidence comes from studies of Reed and Farah (1995; Reed, this volume). Observers judged whether pairs of photos of people in contorted postures were same or different. Same pairs depicted the same postures from a different angle. Different pairs differed in positions of arms or legs. Reed and Farah then introduced an interesting complication. While making the judgment, observers moved in a series of self-selected patterns different from the one to be remembered. When moving their arms, observers identified arm differences more accurately, and conversely, when moving their legs, observers identified leg differences more accurately. Special cognition of bodies has also been seen in experiments comparing apparent motion of bodies and artifacts. For bodies but not for artifacts, at longer interstimulus intervals, the shortest path of motion is not reported if that would violate the biomechanics of body movement (Chatterjee, Freyd & Shiffrar, 1996; Shiffrar & Freyd, 1993).

Body motion seems to underlie both these findings. Motion of body parts is intimately tied to function of body parts. Arm movements are critical to reaching, to crafting, to manipulating, to all the functions arms can do. Similarly, leg movements are critical to walking, kicking, and standing, some of the functions legs can do. Different sets of body motions are associated with different body functions. Legs and feet are involved in navigation, though they can also exert crude actions on objects, like kicking or trampling. Arms and hands are involved in manipulating objects and gesturing. Heads house the primary perceptual modes, and are involved in eating and communicating. The chest points forward, the primary direction of perception and motion. Body parts that perform more movements or functions are likely to be more significant body parts. Thus, a crude index of functional significance is the relative size on the sensorimotor map in the cortex, the popular homunculus with oversized hands and undersized back.

Certain body parts, typically head, arms, hand, legs, feet, backs, and fronts, are named in languages all over the world (Andersen, 1978; Brown, 1976). Notably, these are the parts children include in their early drawings of people, a large circle over a small one, with four sticks protruding, each with smaller protrusions (Goodnow, 1977; Kellogg, 1969). It stands to reason that the body parts more frequently named and drawn are more salient than others. Why are these parts more salient? Is it that they are larger? or more distinctive from the contour of the body? or more significant in our interactions with the world?

These alternatives--size, contour discontinuity, and significance--correspond to three theories of part recognition derived from theories of imagery or object recognition. The size theory derives from research on imagery. Participants were asked to image an animal, such as a tiger or a rabbit, and then asked to search the image to determine if it has a particular property, such as stripes (Kosslyn, 1980). Larger parts were verified faster than smaller ones, presumably because larger parts were detected faster. A theory derived from imagery would predict that larger parts, such as back or chest, are more salient than smaller ones, such as hand or foot. Some theories of object recognition maintain that objects are recognized by their parts, and that parts of objects are distinguished by discontinuities in their contours (e. g., Biederman, 1987; Hoffman & Richards, 1984). A discontinuity theory would predict that parts with greater contour discontinuity, such as head, hand, arm, leg, and foot, would be more salient than those with less contour discontinuity, such as chest and back. As part of their project on parts, Tversky and Hemenway collected norms on part goodness. Parts rated as good or significant tended to be both perceptually salient and functionally significant. For natural kinds and common objects, these were correlated, making it difficult to know which was critical, For example, the top of a table and the handle of a hammer are both perceptually salient and functionally significant. A theory based on part significance makes predictions similar to a theory based on part discontinuity; the exception for bodies is chest, which is relatively significant, but lacks discontinuity.

In our work on bodies, we asked a straightforward question (Morrison & Tversky, 1997). Which of these theories, size, discontinuity, or significance, best accounts for the time it takes to verify body parts? We selected those body parts commonly named across languages and sketched by young artists, head, arm, hand, chest (front), back, leg, and foot. There were two types of experiments: those that compared named body parts to body parts highlighted on a realistic rendering of a body and those that compared two bodies in different orientations, each with one part highlighted. Parts were highlighted with a white dot. Bodies were shown in profile in a variety of realistic postures and possible and impossible orientations. In both sets of studies, participants responded "same" when the named part was the same part as the highlighted part or when the two highlighted parts were the same, and responded "different" otherwise.

Body Part Verification Times. Image size failed as a theory in both kinds of experiments, the named part-body comparisons and the body-body comparisons, and in a third paradigm using disembodied parts. In fact, image size was negatively correlated with verification times, probably because it correlates negatively with both contour discontinuity and significance. Remember that the largest parts, "back" and "chest," are also the least discontinuous and low in significance.

The two remaining and correlated theories predicted verification times quite well. Intriguingly, for the body-body comparisons, contour discontinuity correlated better with part verification times but for the name-body comparisons, part significance correlated better. Qualitative aspects of the data support this. For the body-body comparisons, "chest," which lacks discontinuity but is relatively significant, was relatively slow, second-to-last; however, for the name-body comparisons, "chest" was relatively fast, second to head.

Why should significance predict body part verification better when naming is entailed but discontinuity predict better when bodies are compared directly? When two bodies appear together on the screen, and the task is to say whether the white dot appears on same or different parts, the bodies seem to be perceived just like any other object, as visual forms, shapes with part boundaries suggested by contour discontinuities. Searching for the dots and comparing across objects does not require any cognizance of what the objects or the parts are. When a named part appears to be compared with a highlighted part, the name itself must be comprehended and transformed into an expectation of a subshape bearing a constrained spatial relation to the whole. This comprehension and translation seems to activate functional features in addition to perceptual ones. For the name-body comparisons, then, part verification speed seems to depend mental representations of the body that reflect internal experience of the body.

Events. Let us now turn to categories encompassing some of the functions bodies fulfill: events. The world presents us with a continuous stream of activity which the mind parses into events. Like objects, they are bounded; they have beginnings, (middles,) and ends. Like objects, they are structured, composed of parts. However, in contrast to objects, events are structured in time. Uncovering the perceived structure of events was our first goal. We selected everyday, goal-directed events involving a single actor. While natural events like hurricanes happen independent of people, and human events may involve multiple actors with cooperative or conflicting goals, we took action by a single goal-directed agent as a reasonable prototype.

Perhaps because they are the stuff of life, events have attracted the interest of philosophers, statisticians, sociologists, and psychologists of all varieties, not to mention artists, writers, and poets. Cognitive scientists have studied top-down knowledge of events. Schank and Abelson (1977), Bower, Black and Turner (1979) and others have observed that knowledge of events embedded in scripts allows inferences and understanding. Because we know that going to a restaurant includes being seated, ordering, and eating, we can understand why a hungry person heads for a restaurant, and why that person shouldn't be hungry afterwards. Script knowledge forms a partonomic hierarchy; each high-level activity of the restaurant script can be decomposed into parts. The driving force for the script view of events is a hierarchical goal structure. Going to a restaurant is a way to satisfy the goal of reducing hunger. Once the overall goal is chosen, the script entails subgoals, getting seated, ordering, and so on.

Social psychologists have developed a powerful set of techniques for studying bottom-up perception of events. They have asked not just how events are conceived, but how they are perceived as they unfold. In a typical task, observers segment continuous activity into either coarse or fine natural units, called breakpoints. Breakpoints are thought to be cued by perceived large changes in physical activity (Newtson, 1973). One issue is whether perception of events is hierarchical. If perceivers actively encode events in terms of hierarchically organized schemas, breakpoints at a coarse time scale should coincide with breakpoints at a fine time scale. Some maintain that this is the case (e. g., Newtson, 1973; Newtson, Hairfield, Bloomingdale, & Cutino, 1987); others maintain that event unit boundaries are flexible, altered by momentary schemas (e. g., Cohen & Ebbesen, 1979).

To study the cognitive structure of events, we first sought to determine whether mundane events are perceived hierarchically. We began with a principled way of choosing events and a principled way of evaluating hierarchical structure, based both on the breakpoint technique and the language of description (Zacks & Tversky, 1997, 1999). It is possible that coarse units will be distinguished by goals and fine units by changes in physical activity, so that the breakpoints of these may not coincide. To select events to study, we asked undergraduates to rate a large set of events taken from previous norms and other sources on frequency and familiarity. From them, we chose two familiar events, making a bed and doing the dishes, and two unfamiliar events, fertilizing a plant and assembling a saxophone, which could be easily filmed from a fixed camera.

By tapping a key to indicate breakpoints, observers segmented the filmed events twice, once into the coarsest units that made sense and once into the finest units that made sense (in counter-balanced order). Some observers described the activity of each segment as they segmented, and others only segmented. To determine if segmentation was hierarchical, the breakpoints of fine and coarse units were compared for each observer. Hierarchical segmentation is indicated by greater than chance coincidence of coarse unit boundaries to fine unit boundaries.

Indeed, the analysis of coincidences supported hierarchical segmentation of the events. Moreover, describing the segments while parsing led to a higher degree of hierarchical segmentation than silent parsing, despite the fact that segmenting and describing take more cognitive resources than simply segmenting. The greater perceived hierarchical structure is probably due to greater top-down conceptualization induced by describing. There was a smaller effect of event familiarity: parsing of familiar events yielded a greater degree of hierarchical structure.

The analysis of the descriptions of coarse and fine segments supported hierarchical perception of events. Consider, for example, one participant's transcript for making a bed. The coarse unit description began: "walking in," "taking apart the bed," "putting on the sheet," "putting on the other sheet," "putting on the blanket." The coarse unit "putting on the sheet" consisted of the following fine units: "putting on the top end of the sheet," "putting on the bottom," "unfolding sheet," laying it down," "straightening it out." Note that each coarse unit entails interacting with a different object. By contrast, each fine unit involves interacting in a different way with the same object, usually indicated by a different verb. Statistical analyses supported these observations. In fine units, objects were referred to more vaguely than in coarse units, often by use of pronouns or omission, and actions more specifically. For both coarse and fine units, the descriptive language was intentional and goal-directed, consisting of actions on objects. The analysis of language illuminates why top-down and bottom-up segmentation of events correlate. Interacting with different objects is likely to entail both different goals and different physical activity. Similarly, changing the mode of interacting with the same object is likely to entail different subgoals as well as different actions. Thus breaks in activity are likely to correspond to breaks in goals and subgoals.

Implications for imitation. In imitation, one body perceives the actions of another and produces them. The path from perception to performance is complex and mysterious. The discoveries of automatic copying of action in certain apraxias (Goldenberg, this volume) and single neurons responsive to both perception and production of the same action (Rizzolatti, Fadiga, Fogassi, and Gallese, this volume) suggest that copying action sequences may be hard-wired. Yet what is imitated is not a sequence of actions. From the first hours of life, imitations seem to be modulated toward goals (Meltzoff and Moore, 1995). Intentional imitations by young children copy the effects on objects, the goals, though they may not copy the actions (Bekkering, Wohlschlager, and Gattis, in press; Meltzoff, 1995). Much of the research reported in this volume suggests that humans and other animals represent activity in a format that supports both perception and action. Our work suggests that these representations capture structure at a fairly abstract level. Rather than representing sequences of actions, what seems to be represented are configural features of the body that reflect our experiences in bodies and configural features of events that reflect our experiences as goal-seeking creatures.

Interweaving categories: objects, bodies, events, and scenes.

We began by considering the paradigmatic case of objects, then turned to qualitative features distinguishing kinds of categories, here, bodies and the events they partake in. Bodies and objects play critical roles in segmentation of events. Consistent with this view are Byrne's and Whiten's (this volume) results on objects in gorilla and child imitation, Goldenberg and Hagmann's (1998) observations of apraxics unable to infer tool use, and Jellema, Baker, Oram, and Perrett's and Rizzolatti, et al.'s (this volume) discovery of neurons in monkeys responsive to actions on objects. For infants, too, actions on objects appear to be critical for inferring intentions and segmenting events (Baldwin & Baird, 1996; Meltzoff, 1995; Meltzoff & Moore, 1998; Sharon & Wynn, 1998; Woodward, 1998). These separate categories, bodies, events, and objects, are intimately intertwined, and further intertwined with categories of scenes, the settings for events. Body parts that are functional in actions are more salient; events--goal-directed sequences of actions--are segmented by objects and actions on objects; scenes are characterized by the objects they contain and the activities they support. Cognition of central categories is not just embodied, it is embedded.

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