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Attribute centrality and imaginative thought

THOMAS B. WARD, REBECCA A. DODDS,
KATHERINE N. SAUNDERS, and CYNTHIA M. SIFONIS
Texas A&M University, College Station, Texas

Participants' representations of the concept *human* were examined to differentiate three types of associations between concepts and their component attributes: the capacity of concepts to cue attributes (*attribute accessibility*), the capacity of attributes to cue concepts (*instance accessibility*), and the extent to which attributes are thought of as central to concepts (*attribute centrality*). The findings provide information about the concept *human* itself and, more generally, about the functionally distinct roles those different attribute–concept associations play in guiding imaginative thought. College students listed attributes that differentiate humans from other animals, rated the centrality of those attributes, and listed animals that possess those attributes. Other students drew and described extraterrestrials that possessed some of the attributes that were found to vary across those listing and rating tasks. Rated centrality was the most important determinant of an attribute's impact on imaginative generation. When the imagined extraterrestrials were supposed to possess attributes that had been rated as central to humans (intelligence, emotional complexity, or opposable thumbs), participants projected more aspects of human form onto them than when the creatures were supposed to possess less central attributes or when attributes were unspecified.

> Man is distinguished from other animals by his imaginative gifts . . . We are nature's unique experiment to make the rational intelligence prove itself sounder than the reflex.
>
> —Jacob Bronowski, *The Ascent of Man*, 1973

> From a distance of a hundred yards at twilight, you might almost mistake them for human. They'll have their heads at the tops of their bodies . . . their eyes in their heads . . . they'll walk on two legs, too, as we do.
>
> —Frank Drake, Preface, *Is Anyone Out There? The Scientific Search for Extraterrestrial Intelligence*, 1992

How do people conceptualize humans in relation to other living things? What attributes are associated most strongly with our concept *human*? We sought answers to those questions, partly for their own sake, but also with the goal of using *human* and its attributes as a case study of the multiple ways in which attributes and concepts can be thought of as associated with one another. We used standard listing and rating procedures, as well as tasks requiring imaginative thought, to examine distinct types of attribute–concept associations, including the tendency of attributes and concepts to cue one another and the judged centrality of attributes within concepts (see, e.g., Ahn & Sloman, 1997; Medin & Shoben, 1988; Sloman, Love, & Ahn, 1998). We argue that centrality plays a special role in influencing the form of imagined ideas, and more generally, that tasks of imagination can be powerful tools in helping to differentiate important aspects of conceptual structure.

Consider the opening quotes from Bronowski (1973) and Drake in Drake & Sobel (1992). Both statements highlight a strong link between the attribute of exceptional intelligence and the concept *human*, and they do so in ways that parallel different laboratory-based approaches to the study of conceptual structure. Bronowski begins with the concept *human*, and posits extraordinary mental capacity as a distinguishing attribute, whereas Drake begins with the attribute of intelligence and projects human form onto his imagined extraterrestrials. Bronowski's statement, then, resembles a data point from an attribute listing paradigm, in which participants are given a category as a cue and are asked to list the characteristic attributes of that category (see, e.g., Ashcraft, 1978; Hampton, 1979; Rosch, Mervis, Gray, Johnson, & Boyes-Braem, 1976; Tversky & Hemenway, 1984). In contrast, Drake's is similar to a product from a creative generation paradigm, in which participants imagine their own novel exemplars of a given category (Cacciari, Levorato, & Cicogna, 1997; Marsh, Landau, & Hicks, 1996; Smith, Ward, & Schumacher, 1993; Ward, 1994, 1995).

As in the case of Bronowski's and Drake's observations, results from creative generation and attribute listing tasks sometimes converge on the same crucial attributes of conceptual structures. For example, Ward (1994) asked college students to imagine and draw the kinds of animals that might live on other planets, and found that the vast of majority of imagined creatures possessed eyes and legs, even when the students were asked to use their wildest imagination. In addition, cuing participants to include specific properties, such as feathers or scales, led

The authors gratefully acknowledge the comments of John Coley, Susan Gelman, Doug Medin, Steve Smith, and two anonymous reviewers on earlier versions of this manuscript. Correspondence should be addressed to T. B. Ward, Department of Psychology, Texas A&M University, College Station, TX 77843 (e-mail: tbw@psyc.tamu.edu).

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them to develop imaginary creatures with conceptually correlated properties, such as wings and beaks or fins and gills (Ward, 1994). The fact that people project such properties onto their novel creations converges with the fact that participants also tend to list those properties as being characteristic of particular types of Earth animals in traditional attribute listing studies (e.g., Ashcraft, 1978; Hampton, 1979; Tversky & Hemenway, 1984).

It is important to note, however, that listing and creative generation tasks need not always highlight the same attributes, and that patterns of convergence and divergence across those paradigms can help to differentiate important aspects of conceptual structure. Here, we adopted a convergence–divergence approach to investigate three distinct ways of characterizing the strength of the association between a concept and its attributes. The first, called *attribute accessibility*, measures the extent to which a concept brings particular attributes to mind such that they are explicitly listed as being distinctive for that concept. For example, the fact that people tend to list attributes such as feathers and wings as characteristic properties of birds means that, operationally, they are high in attribute accessibility with respect to the concept *bird*. The second, called *instance accessibility*, measures the extent to which an attribute brings particular concepts to mind such that people explicitly list those concepts when cued with the attribute. For example, if people showed a strong tendency to list birds when asked to indicate the kinds of living things that had feathers, *bird* would be high in instance accessibility with respect to the attribute "feathers." Whereas the first two properties reflect the capacity of concepts and attributes to cue one another, the third, called *attribute centrality*, assesses the extent to which people consider an attribute to be central to a concept, independently of whether the concept evokes a listing of the attribute or vice versa.

Considering how these distinct types of attribute–concept association are likely to influence the form of imagined ideas can help to differentiate them empirically and theoretically. Centrality has been shown to be distinguishable from other aspects of attribute–concept association, such as cue and category validity (see, e.g., Ahn & Sloman, 1997; Sloman & Ahn, 1999; Sloman et al., 1998), and we anticipate that centrality will also play a distinct role in imaginative cognition. Specifically, when asked to generate a novel entity that possesses an attribute that is central to a concept, the imagined entity can be expected to contain many other properties of that concept. The rationale underlying this view is as follows. First, it is likely that a given concept will be high in instance accessibility with respect to its most central attributes and will come to mind readily when they are given as cues. More importantly, because the centrality of an attribute is assumed to be determined by the extent to which other attributes are dependent upon it (e.g., Sloman et al., 1998), the supposed presence of a highly central attribute in a novel exemplar would strongly support the possibility that it also possessed those other dependent attributes. Thus, having brought a concept to mind in response to a central attribute, people would be likely to project its other properties onto their novel creations. Indeed, just as people find it difficult to imagine an ordinary concept instance that does not possess a central attribute, so they may find it difficult to imagine a novel exemplar that possesses a central attribute but not the other dependent attributes.

The other measures of the strength of association between an attribute and a concept can be predicted to be less influential in imagination. Although central attributes may be powerful cues for their associated concepts, high instance accessibility alone, without centrality, may not push participants to incorporate other properties of a retrieved instance into an imagined product. For example, although the attribute "red breast" might be a strong cue for *robin*, other attributes of robins are not strongly dependent on it and might not be projected onto a red-breasted novel creature even if *robin* were accessed as a potential starting point in an imagination task. Its lack of centrality does not necessarily conflict with those other attributes, but it does not uniquely support their presence in the way a more central attribute (e.g., "wings") would. Conversely, low attribute accessibility would not necessarily preclude a strong influence for an otherwise central attribute. That is, the fact that a concept fails to cue an attribute does not necessarily mean that the attribute will fail to cue the concept or that it will lack centrality with respect to the concept. For instance, people may be unlikely to list "hollow bones" as an attribute of *bird*, but highly likely to list *bird* as a kind of thing that has hollow bones, and highly likely to judge "hollow bones" to be central to the concept *bird* (e.g., flying and nesting in trees depend upon it). Similarly, high attribute accessibility does not necessarily entail high instance accessibility or strong centrality. Those types of attribute–concept associations are, at least in principle, dissociable.

To investigate these issues, across six experiments, we had people list the attributes of humans, rate the centrality of those attributes, list the living things that possess certain of those attributes, and generate extraterrestrials that possess attributes that were found to vary systematically across those tasks. By comparing and contrasting performance across the tasks, we hoped to identify the ways in which attribute–concept links manifested themselves in creative and noncreative tasks.

In a more general sense, the present studies are rooted in the creative cognition approach (Finke, Ward, & Smith, 1992; Smith, Ward, & Finke, 1995), which seeks to understand the role of basic cognitive structures and processes in creative as well as noncreative endeavors. The studies focus on a pervasive but neglected aspect of human cognition: extending the boundaries of concepts by imagining new exemplars. Instances of this type of conceptual expansion abound, from novelists who envision new heroines, to product designers who develop new consumer goods, to teachers who devise new schemes for teaching geometry lessons. Yet, until recently little empirical research was directed at this phenomenon (e.g.,

Brédart, Ward, & Marczewski, 1998; Marsh et al., 1996; Smith et al., 1993; Ward, 1994; Ward & Sifonis, 1997). Collectively these recent studies reveal how certain aspects of previously stored concepts and recent experiences can influence the form of novel ideas, but much remains to be learned, and creative generation tasks hold the key to more refined looks at how old knowledge guides new idea formation. Put differently, there is no doubt that existing knowledge representations guide imagination (see, e.g., Finke et al., 1992; Ward, 1994; Ward, Smith, & Vaid, 1997), but it is important to begin to specify exactly which aspects of knowledge are most influential. The present studies are an effort in that direction.

In addition to allowing an assessment of the role of attribute–concept links in creative generation, the present studies also provide information about the surprisingly neglected concept of *human*. To what extent do people share the belief, inherent in the opening quotes, that exceptional intelligence is a distinctive property of humans? What other properties might also be viewed as important? Although scientists, philosophers, poets, and playwrights have pondered the nature of humankind for millennia, cognitive psychology has provided little in the way of empirical data on the characteristic properties contained in people's representations of the concept *human*. The present studies are an attempt to provide some preliminary information in this regard.

EXPERIMENT 1

In the first experiment, participants performed an attribute listing task in which they wrote down the properties that distinguish humans from other animals. What attributes will be highest in accessibility for the concept *human*? That is, what attributes will most people list as the distinguishing features of humans? The results of the few empirical studies that have been conducted using receptive or reproductive procedures lead to the expectation that aspects of intellectual functioning will predominate in the listings. For example, a majority of college students *disagree* with the idea that nonhuman animals are similar to humans in their intellectual capacities, but a majority agree that they are similar to humans in their feelings and emotions (Burghardt, 1985). Further, even when students attribute certain cognitive abilities to nonhuman animals, humans are still distinguished, even from other primates (Eddy, Gallup, & Povinelli, 1993). Underlying these responses appears to be a conception of humans as being endowed with a more potent mental capacity than other species.

Method

Participants. The participants were 98 undergraduates enrolled in an introductory psychology class who received experimental credits for their participation.

Procedure. Participants were given response forms that included instructions to list the attributes that differentiate humans from other animals, that is, that make humans special or different from other animals. The forms also included eight blank lines on which participants were to write responses, though they were instructed that they should feel free to list more or fewer attributes. After reading the instructions, participants were given 2 min to write down their responses.

Coding. Pilot data revealed that people list a wide variety of specific terms referring to a smaller set of more general attributes. Thus, participants' responses were coded for statements that fit into those broad groupings. The groupings assessed in this study were mental abilities (e.g., intelligence, reasoning, abstract thought), language/communication (e.g., reading, writing, speaking), emotional capacity (e.g., love, hate, compassion), religious/moral properties (e.g., soul, religion, capacity for evil), consciousness (e.g., self-awareness, embarrassment, self consciousness), creative capacity (e.g., creativity, imagination), technical or manipulative abilities (e.g., tool use, manipulation of the environment), socioeconomic arrangements/institutions (e.g., schools, government, political or economic activities), familial/social relations (e.g., raising children), sexuality (e.g., number of mates), instinctual patterns (e.g., less governed by instinct), physical properties (e.g., opposable thumb, bipedal, larger brain), lifespan, clothing, and dominance over other species. In addition, there were several idiosyncratic features that were not further analyzed. One coder examined all statements for references to the broad categories and a second coder examined a randomly selected subset of 33 (34%) of the statements. They achieved a minimum of 91% agreement for each of the groupings of attributes.

Results and Discussion

The percentages of students listing properties consistent with each of the broad groupings are shown in Table 1. Inspection of that table reveals that, as expected, references to intelligent functioning dominated the responses. The two most commonly listed types of properties were mental abilities and language/communication, mentioned by 68% and 72% of the students. Although the language/communication percentage was slightly higher than that for the more general mental ability category, the difference was not significant. Importantly, the percentages of participants who listed mental abilities and language/communication were significantly higher than that for the next closest cluster of attributes, physical properties, mentioned by 42% of the respondents ($z = 3.68$ and 3.48, respectively). Also as shown in Table 1, fewer participants mentioned aspects of emotional capacity, religion or morality, technical or manipulative abilities, socioeconomic arrangements, and sexuality, with the percentages ranging from 20 to 33. Still fewer participants mentioned properties consistent with the remainder of the categories.

Because our primary focus from the beginning was on intelligence, for coding purposes we sought a conservative estimate of mental abilities that included general references to mental capacity, such as intelligence, but excluded references to other specific intellectual functions, such as language and creativity. However, it is not clear that those more specific references should be separated from the mental capacity category. For instance, reading and writing could well be taken as specific indicators of high intelligence, and our procedure may underestimate the extent to which people consider intelligence to be an

Table 1
Percentage of Participants' Responses in Experiment 1 That Fell into Each of the Broad Groupings

Property	Percent
Communication	72
Mental ability	68
Physical features	42
Technical/manipulative	33
Emotions	32
Socioeconomic institutions	25
Morality/religion	22
Sex/reproduction	20
Clothing	13
Instinct	15
Family	12
Lifespan	11
Consciousness	8
Dominance	7
Creativity	6

important attribute of humans. Collapsing across the groupings of mental ability and language/communication reveals that 92% of the sample mentioned one or the other or both attributes. In addition, participation in economic or legal systems does imply some level of intelligence, but we coded as mental abilities only direct references to those abilities, not activities that would depend on the abilities.

The results are consistent with previous surveys regarding people's perceptions of the relative intellectual and emotional capacities of humans and other animals (e.g., Burghardt, 1985). Even when people are given the opportunity to list any attributes that come to mind, rather than respond to experimenter presented properties, intelligence still dominates responding.

EXPERIMENT 2

If intelligence is important to our concepts of humans, how might that belief manifest itself in a creative generation task? Suppose we asked people to imagine that a species of animals from a distant planet was intelligent enough to have developed space travel. What other attributes would that species possess? Would they resemble the humanoid creature envisioned by Drake, or would they be less constrained?

In principle, the species could take virtually any form; no known physical laws would require them to share any other attributes with humans. Thus, by chance alone, there is no reason to expect striking commonalities across the kinds of creatures participants would imagine. However, if participants share a belief about a connection between exceptional intelligence and humankind, they might be expected to project the surface attributes associated with human form onto their imagined intelligent creatures.

There are specific and general reasons for expecting a link between intelligence and human form. In a specific sense, when people claim to have been abducted by (presumably intelligent) spacefaring extraterrestrials, they almost always describe creatures that have human characteristics (see, e.g., Malmstrom & Coffman, 1979). On the assumption that these reports emanate from imagined experiences, the preponderance of humanoid creatures suggests a correlation between high intelligence and human form in the conceptual representations of the respondents.

More generally, even young children expect members of natural categories to share clusters of attributes, some of which may be internal or unavailable to direct perceptual inspection (see, e.g., Gelman & Markman, 1986, 1987). Likewise, adults and children may also share a belief in psychological essentialism, which tells them that some internal essence underlies and determines the clusters of obvious and nonobvious properties that category members share (Gelman & Wellman, 1991; Medin & Ortony, 1989). For example, people may believe that some underlying essence is responsible for humans having the basic external shape and high level of intelligence that they possess. By this view, participants might assume that creatures that are highly intelligent (as humans are assumed to be) will possess human-like physical structures.

Method

Participants. The participants were 120 undergraduate volunteers recruited from psychology classes.

Procedure. Participants were asked to imagine encountering a member of a species of animals that lives on a planet very different from Earth. They were asked to write detailed descriptions of their imagined creatures and also to draw front and side views of the animals. Half of the participants were told that the animal was highly intelligent and capable of space travel, whereas the other half were given no information about the intelligence of the animal.

Coding. Two trained individuals who were blind to the hypotheses of the study coded the drawings and descriptions for the number of eyes, ears, noses, mouths, arms, and legs, as well as the properties of symmetry, upright posture, a distinct head on top of the body, and senses located in the head. Coders also noted references to clothing, other artifacts, and modes of communication. Coder agreement was at least 94% for each coded property.

Results and Discussion

Differences Between Intelligent and Control Animals. Following Malmstrom and Coffman (1979), an operational definition of *humanoid* was established that included the conjunction of all of the following properties: bilateral symmetry, two legs, two arms, senses contained within a distinct head at the top of the body, and an upright posture.[1] Creations that fit all of those properties were considered to be humanoid. With that initial criterion, a significantly higher percentage of participants in the intelligent condition than in the control condition generated humanoid creatures (see first row of Table 2) [$\chi^2(1, N = 120) = 7.35, p < .01$]. Sample humanoid and nonhumanoid creations are shown in Figure 1.

Additional analyses were performed using both a more lenient and a stricter criterion for classifying creatures as humanoid. Using a lenient criterion, under which crea-

Table 2
Percentage of Participants in the Intelligent and Control Conditions of Experiment 2 Who Generated Imaginary Extraterrestrials Possessing Particular Properties

Property	Condition	
	Intelligent	Control
Humanoid form	45	22
Humanoid (lenient)	67	38
Two legs	68	40
Two arms	58	40
Upright	88	53
Humanoid (strict)	25	7
Communication	50	27
Clothing	20	2
Artifact interactions	30	3
Standard appendages	93	85
Standard senses	90	93
Symmetry	87	93

tures had to possess at least six of the seven key features, also revealed a significantly higher percentage of humanoid creatures in the intelligent than in the control condition (see second row of Table 2) [$\chi^2(1, N = 120) = 9.66, p < .01$]. In fact, as shown in Table 2, two thirds of the participants in the former group met the lenient criterion, which reveals a strong tendency by those participants to produce creatures that at least approximated human form in some respects. Consistent with this observation, creatures in the intelligent condition also were significantly more likely than those in the control condition to possess the individual component attributes of two legs [$\chi^2(1, N = 120) = 9.70, p < .01$], two arms [$\chi^2(1, N = 120) = 4.03, p < .05$], and an upright posture [$\chi^2(1, N = 120) = 17.79, p < .001$; Table 2].

A stricter criterion was also used because inspection of the drawings revealed that some creatures that possessed all of the relevant characteristics did not have the subjective, global appearance of being humanoid. All drawings were subsequently coded as either resembling or not resembling humans in a global sense. Creatures bearing a strong resemblance to other species (e.g., cats), varying from humans in the rough proportional sizes of component parts, and having substantially different facial features from those of humans were coded as not resembling humans. The sixth row of Table 2 shows the percentages of creatures in each condition that met the strict criterion of possessing all seven relevant features specified by the initial criterion and also being coded as humanoid in the more global sense. Although there was a reduction in the overall number of humanoid creatures with this procedure, those in the intelligent condition were still found to produce significantly more humanoid creatures than those in the control condition [$\chi^2(1, N = 120) = 7.56, p < .01$].

Also shown in Table 2 is the fact that participants in the intelligent condition were more likely to describe their creatures as having some form of communication [$\chi^2(1, N = 120) = 6.91, p < .01$], to depict or describe them as wearing some type of clothing [$\chi^2(1, N = 120) = 10.44, p < .01$], and to refer to artifacts other than clothing (e.g., houses) [$\chi^2(1, N = 120) = 15.36, p < .01$].

Similarities Between Intelligent and Control Creatures. As shown in Table 2, there were no differences between the intelligent and control conditions in terms of the tendency to depict creatures with at least one standard appendage (arms, legs, or wings) [$\chi^2(1, N = 120) = 2.16, p > .14$], at least one standard sense organ (eyes, ears, or nose; $\chi^2 < 1$), or the property of symmetry [$\chi^2(1, N = 120) = 1.48, p > .20$]. Thus, the different instructional conditions influenced the specific depiction of the form of the creature rather than the overall tendency to include Earth animal properties, such as appendages, senses, and symmetry. The differences that were evident (e.g., number of legs) can be described as alignable differences (Markman & Gentner, 1993), a finding suggesting that principles of structural alignment may be as relevant for understanding generative uses of categories as for explaining more traditional phenomena, such as classification and similarity judgment (e.g., Markman & Gentner, 1993, 1996; Medin, Goldstone, & Gentner, 1993).

EXPERIMENT 3

Telling people that an imaginary creature was highly intelligent, a property found in a listing task to differentiate people's concepts of humans from their concepts of other animals, led to an increase in the percentage of humanoid aliens. The result parallels other findings in which instructions to imagine aliens having feathers or scales, characteristic attributes of birds and fish, respectively (see, e.g., Hampton, 1979; Tversky & Hemenway, 1984), led people to produce birdlike and fishlike animals, respectively (Ward, 1994). Together, the results suggest that the attributes that most people explicitly identify as characteristic of a concept can increase the likelihood of projecting other properties of that concept onto newly generated ideas.

In the third experiment, we asked whether or not an attribute *must* be listed or endorsed by a large percentage of participants in a receptive task to have a major impact on creative generation. At issue is the idea that people do not always list all of the attributes that are plainly important to a given concept, and that those unreported attributes might nevertheless be expected to influence imagination. In the present experiment, emotional complexity was the particular attribute used to investigate the question. Recall that most people agree that animals are similar to people in emotions and feelings (Burghardt, 1985), and that less than one third of the participants in Experiment 1 listed complex emotions as a distinguishing feature of humans.

Method

Eighty participants from the same population as that used in the previous experiments generated imaginary animals that might live on another planet. Half were told that the creatures were emotion-

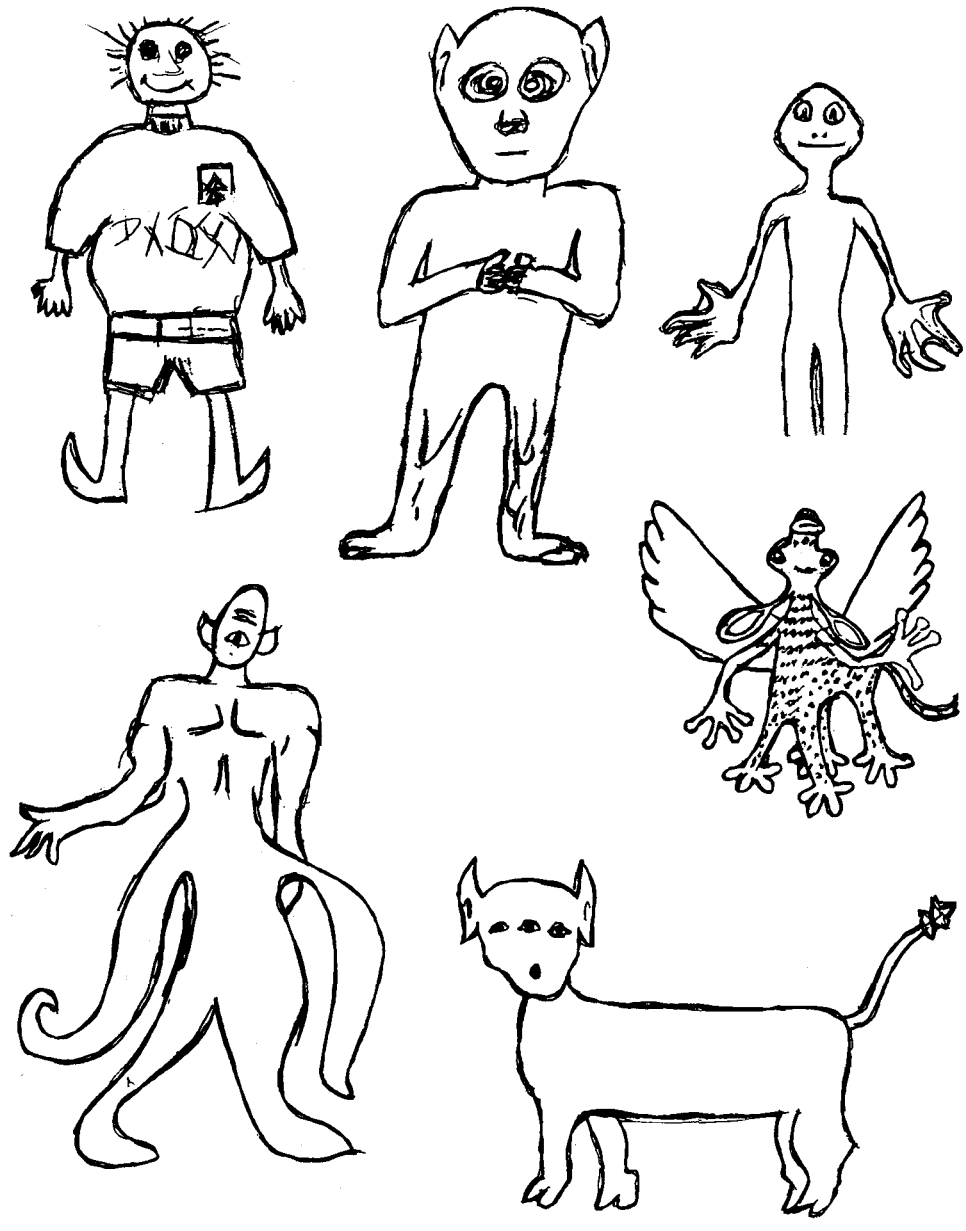

Figure 1. Examples of humanoid and nonhumanoid creatures from Experiment 2.

ally complex and capable of different forms of love, and half received no special information about the creatures.

Results and Discussion

Using the primary measure of Experiment 1, we found that participants in the emotional complexity condition were significantly more likely than those in the control condition to produce humanoid creatures [51% vs. 29%; $\chi^2(1, N = 90) = 4.63, p < .05$]. Those percentages are very close to the percentages for participants in the intelligent and control conditions, respectively, of Experiment 2. Evidently, even attributes that are not listed explicitly by the majority of people for a given concept can nevertheless push imaginative creations in the direction of correlated properties from that concept. This divergence between explicit listing and a more indirect projection of properties via imagination is also consistent with Barrett and Keil's (1996) observation that people who explicitly endorse a doctrine of an omnipotent God nevertheless make indirect, inference-based memory errors that reveal a concept of a more anthropomorphic and limited God. In other words, people indirectly project onto

Table 3
Attributes and Their Centrality to the Concept *Human*

Attribute	Centrality Rating
Language	7.57
Economic systems	7.57
Dominant species	7.47
Intelligence	7.37
Emotional complexity	7.17
Conscience	6.97
Spirituality	6.80
Upright posture	6.77
Opposable thumbs	6.73
Decision making	6.70
Problem solving	6.57
Individuality	6.53
Creativity	6.50
Rationality	6.37
Expressive face	6.33
Skin	6.17
Hair mostly on head	5.97
Drives (e.g., hunger)	5.07
Forming groups	5.00
Arms	5.00
Legs	4.87

their concept of God properties that are different from those that they explicitly endorse.

EXPERIMENT 4

The attributes of intelligence and emotional complexity both increased the likelihood that participants would generate humanoid imaginary creatures, yet the former was spontaneously listed (Experiment 1) and endorsed (Burghardt, 1985) more often as an attribute that differentiates humans from other animals. Why should this be so? What type of association with *human* might intelligence and emotional complexity both possess that could explain their equally powerful influence on imagination?

One account of the discrepancy stems from the fact that people do not always spontaneously list all of the attributes that are important to their concepts (e.g., Murphy & Medin, 1985; Tversky & Hemenway, 1984). Thus, despite the differential likelihood of people listing the attributes of intelligence and emotional complexity, both properties may be equally crucial to people's conceptions of humanness. People might well judge emotional complexity to be true of animals other than humans, and thus not list it as a distinguishing feature of humans. Yet, they still might view it as a highly central property of humans, important to our identity as a species. In other words, it may be that frequent listing is a sufficient, though not necessary, indicator of the centrality of an attribute within a given concept, and that centrality to the concept, rather than listing frequency, is the more crucial determinant of the structure of new ideas.

Recent studies concerned with attribute centrality suggest that it is a multifaceted construct, and that different measures might be more or less relevant to different goals (e.g., Ahn & Sloman, 1997; Sloman et al., 1998). In particular, Sloman et al. have characterized *conceptual centrality* in terms of how integral a feature is to a concept, or the extent to which the feature provides conceptual coherence. This type of centrality is thought to be associated with the immutability of a feature, that is, the extent to which other concept features depend on that feature or would be changed in some way if it were changed. Operationally, Sloman et al. measured conceptual centrality or immutability by asking people questions such as how easily they could imagine instances without the feature, how good an example of the category an instance would be that did not possess the feature, and so on. The various measures of immutability were highly correlated with one another, but could be differentiated from other measures of feature potency, such as cue validity and category validity.

In the present experiment, we assessed the centrality of intelligence, emotional complexity, and a wide variety of other features to people's representations of the concept *human*. To the extent that rated centrality is a better predictor of a feature's impact on imagination than is the frequency of it being listed as a distinguishing feature, intelligence and emotional complexity should be highly and equally rated.

Method

Thirty participants from the same pool as in the previous experiments rated, on 9-point scales, how central certain attributes were to the identity of humans as a species. The instructions described centrality in terms of how essential each attribute was to the participant's idea of what it means to be human, and how difficult it would be to imagine the attribute being absent in typical humans. The attributes, which were presented in a randomized order, are listed in Table 3 in order of rated centrality.

Results and Discussion

Our major interest was in ratings of intelligence and emotional complexity, but for completeness, the mean ratings for all of the attributes we assessed are depicted in Table 3. As can be seen in that table, intelligence and emotional complexity were both rated as highly central (7.37 and 7.17, respectively). The small difference between them was not significant [$t(28) = .41$, $p > .60$]. Clearly, then, emotional complexity is judged to be as central as intelligence to the identity of humans as a species, even though many fewer individuals spontaneously list it when asked for properties that differentiate humans from other creatures.

Thus, an apparent divergence between creative generation and attribute accessibility findings prodded a closer look at the relative importance of attributes of the concept *human*, and revealed that emotional complexity, at least by some measures, is as crucial to humanness as is intelligence. In addition, the implication is that attribute centrality, as revealed by rating procedures, may be a more important conceptual structuring force on imagination than is attribute accessibility, as measured by the number of individuals who list an attribute as being characteristic of a concept.

Again, there are a number of reasons why people might not list central attributes. For example, being central to the identity of one concept does not necessarily imply an exclusive possession of an attribute. Thus, people might believe that humans are not the only animals that can have complex emotional lives (see, e.g., Burghardt, 1985). Consequently, when asked to list attributes that distinguish humans from other animals, people tend not to write down emotions. In effect, complex emotions may be low in cue validity or attribute accessibility with respect to *human*, not because they are uncharacteristic of humans, but because they are also associated with other animals. In contrast, having the capacity to experience a range of complex emotions may nevertheless be viewed as a crucial aspect of humanness, with the result that it is rated as being high in centrality. Rated centrality appears to be the more crucial determinant of the form of imagined ideas.

EXPERIMENT 5

The centrality ratings obtained in Experiment 4 also provide an opportunity to contrast attribute centrality with an additional measure of the strength of the connection between a concept and its attributes, namely the capacity of attributes to cue category instances, or *instance accessibility*. Of particular interest is the fact that opposable thumbs were rated as significantly more central than arms [6.73 vs. 5.00; $t(28) = 3.33, p < .01$]. The high rating for opposable thumbs confirms that the college students tested in our studies share the anthropological wisdom that opposable thumbs are an integral feature of what it is that makes us human.

Despite the fact that opposable thumbs are judged to be more central than arms to humanness, our intuition is that the attributes are equally likely to bring humans to mind. If this intuition is confirmed, we will subsequently be able to contrast rated centrality and the capacity of an attribute to bring a concept to mind in terms of their influence on generative thinking.

In the present experiment, we had different groups of participants list living things that have opposable thumbs and living things that have arms. In contrast to Experiment 1, where the focus was on the extent to which the concept brings attributes to mind, here we focus on the extent to which the attributes bring the concept to mind.

It is important to note that at issue in this experiment is not whether, in the actual distribution of attributes in the animal world, opposable thumbs are more uniquely associated with humans than are arms. If we assume a technical definition of "arm" to include any forelimb of a vertebrate, then many more kinds of creatures have arms than have opposable thumbs. However, what is crucial is what comes to mind to participants as they think about living things with certain attributes. Our intuition is that participants will adopt a common-sense interpretation rather than a technical definition of "arms," but it is crucial to establish empirical support for this view. *Operationally*, are thumbs any more likely than arms to bring humans exclusively to mind? Is the instance *humans* any more accessible given the attribute of "opposable thumbs" than the attribute of "arms?" If not, we will have evidence that, like attribute accessibility and centrality, these two aspects of the link between a concept and its attributes are dissociable.

Method

Twenty-six participants sampled from the same population as in the previous experiments were asked to quickly list the first instances that came to mind for a set of seven concepts. The set included six filler items (e.g., breakfast foods, water vehicles) and one of two critical items, either "living thing that has opposable thumbs" or "living thing that has arms." Half of the participants received forms inquiring about opposable thumbs and half received forms inquiring about arms. The critical item always occurred as the fourth of the seven items.

Results and Discussion

Of most importance, the groups were both highly likely to list humans, and those in the opposable thumbs group were no more likely than those in the arms group to do so (77% vs. 100%), nor to list humans first (69% vs. 85%), nor to list only humans (23% in both cases). In fact, not only was there no statistical difference, but also the small difference that did exist was in the direction of more people listing humans in response to the attribute of arms. Thus, regardless of the technical definition of "arm" or its actual distribution among animals in the world, the attribute of arms is at least as likely as that of opposable thumbs to bring humans to mind, whereas the latter is rated as significantly more central to human identity (Experiment 4). Our sample of students appeared to adopt the lay sense of the term *arms* rather than the more technical sense, and the measures of instance accessibility and centrality could be dissociated.

EXPERIMENT 6

The finding that opposable thumbs and arms are equally likely to bring humans to mind provides the opportunity to distinguish further between attribute centrality and the extent to which an attribute activates concept instances. Which, if either, is more influential in determining the form of imagined new ideas from the domain? To examine this question, we asked people to develop imaginary animals that had either opposable thumbs or arms. If centrality is the more important determinant of imagination, then the former group would be expected to produce more humanoid aliens. If the capacity of an attribute to bring a concept to mind is the only crucial determinant, then there is no reason to expect a difference.

Method

In this experiment, 25 participants from the same pool as in previous experiments were asked to generate imaginary extraterrestrials that had opposable thumbs, and 28 were asked to generate extraterrestrials that had arms.

Results and Discussion

Using the primary measure of Experiment 1, we found that participants who were told that the creature had opposable thumbs were significantly more likely than those who were told that the creature had arms to produce humanoid extraterrestrials [52% vs. 21%; $\chi^2(1, N = 53) = 5.37, p < .05$]. Indeed, the participants in the arms condition appeared no more likely than the two previous groups of control participants to produce humanoid aliens. The findings converge with those of the other experiments in this series in suggesting that the centrality of a concept's attributes is particularly influential in the structuring of new ideas. It appears to be a more important aspect of conceptual knowledge than is the extent to which the concept evokes the attributes or the attributes activate the concept in listing tasks.

GENERAL DISCUSSION

The findings are consistent with the idea that the attributes of high intelligence and human form are correlated in people's conceptual representations. Mirroring the statements by Bronowski and Drake, participants in the present experiments listed aspects of mental functioning more than any other attribute as distinguishing properties of humans, and they were more likely to project human form onto imagined extraterrestrials of high intelligence than onto those whose intelligence was unspecified. The link is not unique, however, in that participants also tended to project human attributes onto extraterrestrials described as being emotionally complex, and as having opposable thumbs. At the same time there is something special about all of those attributes; it is not the case that just any attribute that happens to be true of humans will increase the likelihood of humanoid aliens being generated, as evidenced by those participants who were asked to generate aliens that had arms.

A key aspect of the attributes that had a strong impact on imagination is their rated centrality to the concept in question. Other measures of conceptual structure, such as attribute accessibility and instance accessibility, appear to be less critical. A low frequency of listing does not preclude the influence of an otherwise highly central attribute (e.g., emotional complexity), nor does a high probability of activating the concept guarantee the influence of a noncentral attribute (e.g., arms). Our interpretation of this pattern of findings is that central attributes achieve their influence over imagination by cuing their associated concepts and supporting the projection of other concept properties onto the novel entity.

The fact that centrality was found to be so influential in determining the form of newly developed ideas suggests an interesting perspective on the nature of centrality. To some extent, the operational definition of centrality reflects how easily people can imagine a typical category instance that does not possess a given attribute (Ahn & Sloman, 1997; Sloman et al., 1998). The more central the attribute, the harder it is to imagine a typical instance without it. What the present results suggest, then, is that "ease of imagining" may well be a two-way street. That is, attributes whose absence from otherwise typical category members is difficult to imagine may be the same attributes whose presence makes the absence of other attributes difficult to imagine. Thus, just as people have difficulty imagining a typical human without some (relatively) high mental capacity, so they appear to have difficulty going in the other direction—that is, conceiving of a novel creature that possesses a comparable level of intelligence but that does not also possess other human attributes. It is not impossible to do so; many of the "intelligent" creatures did not have human form. However, a bidirectional difficulty in ease of imagining may have produced high centrality ratings and a statistically measurable bias in the direction of human form.

The links observed between human form and the relatively nonobvious attributes of intelligence and emotional complexity support an essentialist view that people expect similarity of internal or nonobvious properties to be associated with similarity of external properties and vice versa (e.g., Gelman & Wellman, 1991; Medin & Ortony, 1989). Psychological essentialism has been described as supporting concept formation and induction, but it also may structure creative generation. That is, people may take the presence of a particular property (e.g., intelligence) as evidence for a particular type of essence and generate a novel exemplar to be consistent with other manifestations of that essence (e.g., with human form).

An alternative account is that the findings reflect, not the operation of an elaborate, theory-based conceptual system, but rather the consequence of a simple exemplar retrieval mechanism. When people are told that an imaginary creature is intelligent enough to have developed space travel, that property may lead them to retrieve the only known exemplar that possesses that attribute, namely humans. Consequently, they base their creature on humans and produce an entity with human surface features. Consistent with this interpretation, Ward (1994) found that participants who were told the imaginary creatures had feathers tended to report retrieving and basing their creatures on birds, whereas those who were told the creature had scales or fur reported relying on fish and reptiles, or mammals, respectively. However, the fact that arms bring humans to mind, but do not increase the percentage of humanoid aliens, suggests that bringing a concept to mind is not enough for there to be an influence of an attribute on imagination.

Yet another possibility is that participants' creations were influenced by reports of alien abductions or other fictional accounts from books or movies. However, participants rarely report relying on this type of information, and are more likely to report that they based their creations on particular instances of Earth animals (Ward, 1994).

The theoretical focus of the present studies was on the multiple ways in which the links between attributes and concepts can be characterized, and on the fact that central attributes, such as intelligence, are particularly influential

in imagination. The studies were not focused on the reasons why people might hold intelligence, or any other attribute, to be a central property. Nevertheless, Sloman et al.'s (1998) analysis of conceptual centrality may be applicable to the present results. Those authors claimed that centrality was determined by dependency structures in which the most central attributes were those on which many other attributes depend. Thus, it may be that intelligence is central because so many other key properties of humanness, such as being the dominant species and participating in economic systems, depend on it.

Although we have argued that central attributes support the presence of other attributes that depend on them, it is important to note that dependencies could conceivably operate in the opposite direction. That is, our data do not uniquely support the claim that, in people's concepts of humans, physical attributes such as two-leggedness and upright posture *depend* on intelligence. In fact it may be the case that the capacity for intelligent-seeming behavior is viewed as more dependent on certain physical properties than vice versa. For instance, people may believe that opposable thumbs, which allow us to grasp and manipulate objects, afford intelligent behavior rather than the other way around, or that they may be, at best, a covariate of intelligence. Thus, although it is possible that people depict intelligent extraterrestrials as having human form because human form is dependent on intelligence in their representations of the concept *human*, it is also possible that they do so because intelligence is dependent on certain aspects of that form. In any case, because of its centrality, intelligence leads to a projection onto imaginary animals of multiple aspects of the human concept, possibly even those that may not be directly tied to the dependency structure. Some properties may be carried over more as a by-product of the projection process than because of their connection to the dependency structure. More generally, then, the attributes projected onto newly developed category instances need not be ones that are themselves directly dependent on the central attributes of the category in question.

Whether we characterize the results as emerging from a belief about the essential nature of humans, a dependency structure, or a more superficial correlation between the stored attributes of a retrieved exemplar, the results indicate that people's concepts about the human animal include some type of link between the properties of intelligence, emotional complexity, and human form. The stored links are so strong that people project them onto imaginary creatures from other worlds that could, in principle, take virtually any form.

Importantly however, there is no claim here that these are the sole distinguishing features in people's concepts of humans, or even necessarily the most crucial ones. As an example, although the differences did not approach significance, aspects of language and communication were listed slightly more often and rated as slightly more central to humanness than were aspects of general intellectual capacity. Because our focus was more on general intelligence, and because of the concern that participants in creative generation tasks would simply take language properties as indirect indicators of intelligence, we did not pursue such properties separately. Nevertheless it is possible that they would play a distinct and separate role in imagination. In addition, dominance over the environment, spirituality, or possession of a conscience may also be crucial. Although most participants did not list those properties in Experiment 1, Experiment 4 revealed them to be highly central to human identity.

In addition, the properties seen as important by the North American college students in the present studies may not be central to the concepts held by other groups of individuals. For instance, developmental changes in concepts about humans (Carey, 1985; Johnson, Mervis, & Boster, 1992) and possibly cultural differences might lead to differences in the properties that are listed or projected onto novel creations. Likewise, there may be commonalties or differences in central attributes across other categories of animals, such as predators and domestic animals (see, e.g., Coley, 1995). A combination of receptive and generative paradigms would be ideal for examining such variations in our concepts about ourselves and other living things. Further, beliefs about central attributes may or may not correspond to the actual situation in the world, making the paradigms useful for identifying discrepancies between folk knowledge and scientific knowledge.

How we view ourselves in relation to other living things may be of theoretical and empirical interest, but it also can have practical consequences. For instance, the notion that animals cannot reason or experience pain in the way that humans do may have been associated in the past with exceptionally cruel treatment of animals (Salisbury, 1994). Thus, understanding how humans view humans in the broader sense appears an important topic of investigation.

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NOTE

1. A preliminary report of a portion of these findings was briefly presented in Finke et al. (1992).

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