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Thinking Intuitively: The Rich (and at Times Illogical) World of Concepts

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Abstract

Intuitive knowledge of the world involves knowing what kinds of things have which properties. We express this knowledge in generalities, such as "Ducks lay eggs." Intuitive knowledge contrasts with extensional knowledge about actual entities in the world, which we express in quantified statements, such as "All U.S. presidents are male." Reasoning based on this intuitive knowledge, while highly fluent and plausible, may in fact lead us into logical fallacy. Several lines of research have pointed to conceptual memory as the source of such logical failure. We represent concepts with prototypical properties, rather than with logical definitions, and we judge likelihood and argument strength on the basis of similarity between these prototypes instead of using correct notions of probability or logical inference. Evidence that our minds represent the world in this intuitive way can be seen in a range of phenomena, including people's interpretations of logical connectives applied to everyday concepts, the effects of creativity and emergent features in conceptual combination, and the logically inconsistent beliefs that people express in their everyday language.

Keywords

concepts, intension, reasoning, logic

How do you decide whether to categorize a discipline as a science, or a cultural product as a work of art? The classification of the world around us into labeled conceptual categories is probably the most fundamental of human cognitive achievements. It is not only the basis of our general factual knowledge, but also provides us with the basic tools for reasoning, learning, and communication. What is remarkable about this ability is the way it manages to serve so many apparently incompatible goals. With no obvious difficulty, we can use concepts and language to express poetic inspiration; to flatter, cajole, or insult others; or to argue legal cases before a judge. However, this flexibility comes at a cost: The same type of thinking that makes our concepts so flexible and adaptive can also lead us to make judgments that violate the norms of correct reasoning. Recent work on this remarkable cognitive system has pointed to an important distinction between reasoning that uses *extensional* versus *intensional* aspects of conceptual knowledge, extending what Tversky and Kahneman (1983) termed "intuitive reasoning."

Extensions Versus Intensions[1]

The extension of a concept is the class of things in the world to which it refers. The extension of "bird" is thus the set of all birds. Extensional reasoning about categories is based on a set of normative rules set out in first-order logic, as originally described by Aristotle in his analysis of syllogistic reasoning. Interestingly, a long tradition of research on extensional reasoning (e.g. Evans, 1982) has suggested (a) that getting it right can be remarkably difficult, requiring training and much intellectual effort, and (b) that it is highly susceptible to the effects of the particular content of problems and the motivation of the reasoner.

A number of more recent studies have been directed at an alternative form of reasoning based on intensions. The intension of a concept is the set of properties we associate with it. For example, the intension of the concept "bird" is the list of things that we consider to be generally true of birds, and that are relevant to their bird-ness—having two legs, hatching from eggs, and so forth. Although the extension and the intension of a concept are intimately linked, they work in different ways. Knowledge of a concept's extension allows you to make quantified statements. You can state that *all* ravens are black, that *some* birds do not fly, or that *no* swans are blue. In contrast, intensional knowledge is not usually quantified in this way. In fact, when people are quizzed about the intension of a concept, they commonly generate a range of properties, some true of the whole category (e.g., birds have feathers), some only true of typical members (e.g., cats have tails), and some only true of a minority (e.g., dogs bite postal workers).

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Whereas extensional knowledge provides for clear reasoning about the world, intensional knowledge is full of the richness and vagueness that turns out to characterize much of our everyday intuitive thought and language, for better or worse.

Intuitive Reasoning Based on Intensions

Intuitive reasoning is reasoning based on beliefs about the characteristic properties of things. What do those beliefs consist in? When Wu and Barsalou (2009) asked people to describe the characteristics that are typically true of a concept or class of things, they found that people produced four kinds of information: (a) taxonomic categories (e.g., a robin is a bird); (b) descriptions of physical appearance, makeup, and function; (c) situational contexts in which the class plays a role; and (d) introspective or attitudinal judgments of how the people felt about the class. The important point to note here is that people readily generate these properties, at least for common concrete concepts (abstract concepts can be harder to characterize; see Hampton, 1981), and they do so without regard to whether or not the properties are true of the whole class. People make no demarcation between those properties that constitute the meaning of a word, and those that are simply beliefs or even situational contexts associated with it. Given this tangle of beliefs, it is unsurprising to find that intuitive reasoning based on concepts deviates from logical norms. The following sections illustrate some of this research.

Conceptual Combination Using Logical Connectives

An absence of logical constraints shows up when people interpret phrases that combine concepts using conjunction, disjunction, or negation (see Hampton, 1997a, 2011). In one study (Hampton, 1988, Experiment 1), people were presented with a list of activities and judged whether or not each was a sport, a game, or a "sport which is a game." On the face of it, the last phrase should apply only to activities a person considered to be both sports and games. But the results systematically deviated from this pattern. For example, participants did not judge chess (a typical game) to be a sport. However, they considered it to be a sport which is a game. Moreover, changing the order of concepts within the conjunction resulted in different activities being included: Activities judged to be "sports which are games" differed from those judged to be "games which are sports." Similar nonlogical effects were found with combinations of concepts involving disjunctions (e.g., "a fruit or a vegetable") and negative phrases (e.g., "a sport which is not a game"). For example, many more people judged a mushroom to be "a fruit or a vegetable" than a vegetable, even though no one considered it to be a fruit.

Probably the best-known example of intuitive reasoning is the famous Linda problem in Tversky and Kahneman's (1983) conjunction fallacy. Being told that Linda was a radical student with an interest in politics, participants (fallaciously) considered it more likely that, after leaving college, Linda was a feminist bank teller than that she was a bank teller, although of course every feminist bank teller has to be a bank teller as well. There has been much debate about how to interpret this phenomenon (e.g. Hertwig & Gigerenzer, 1999). However, its close parallel to the overextension of conjunctive concepts in categorization suggests a simple explanation. In Hampton (1987), I proposed a model for combining the intensions of two concepts to create a new composite concept. The key element in this model is that the new concept may lose some of the features of its constituent parents and acquire new features of its own. As shown in Figure 1, only some of the features of pets and of fish are true of pet fish. To these one could add new, "emergent" features, such as "lives in an aquarium." Combining intensions involves an interaction of the information within each concept, resulting in nonmonotonic effects (Brewka, 1991; Hampton, 1997b). It is this creativity in combining concepts that leads to the violation of normative constraints on set membership and probability judgments.

Intuitive reasoning may lead to nonlogical judgments, but it is also a major source of creativity. In a recent exploration of this process, I and my colleagues (Gibbert, Hampton, Estes, & Mazursky, 2012) asked participants to think of novel hybrid products (i.e., consumer products with more than one function, like camera phones and fridge freezers) and how they might be developed. In the study, we gave students new product combinations to consider, like flashlight-slippers or pillow-phones. We confirmed that in combining concepts, people follow two stages. In the first stage, the features of each concept are simply pooled together. Thus, flashlight-slippers simultaneously fulfill the functions of footwear and of illumination. With further effort, however, the two functions can be integrated and their incompatibilities resolved. The pressure of

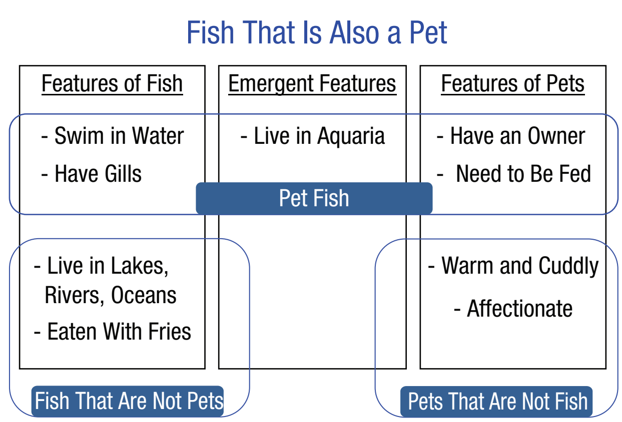

Fig. 1. In the composite prototype model, Hampton (1987, 1988) proposed that complex concepts inherit only some of the features of their constituent parts. In the example shown here, the features of fish and pets are divided into those that are true of pet fish (i.e., the conjunctive combination of pet and fish), those that are true of fish that are not pets, and those that are true of pets that are not fish. In the central box are features that are true of pet fish, but not of either fish or pets generally—so-called emergent features. General knowledge of the world is needed to determine which features will be inherited when two concepts are combined. Things that live in water cannot be warm and cuddly, and people do not like to cook and eat their pets.

walking on the heel could charge the flashlight-slippers' battery; the flashlight could come on automatically when the foot is inserted; the slippers would be ideal for visiting the bathroom at night without waking your partner.

Creative conceptual combination is a key demonstration of the power and adaptive value of intuitive reasoning based on intensions. Note that extensional reasoning about classes of objects in the world would offer no way to address this problem. Given that the sets of slippers and of flashlights do not overlap, the conclusion would simply be that no slippers are flashlights. Intensions take us from the real world into the world of possibilities.

The effects of creativity can also be seen when people form conjunctions of social categories (Hastie, Schroeder, & Weber, 1990; Kunda, Miller, & Clare, 1990). These categories are already familiar to psychologists because they are linked with the phenomenon of stereotyping—the association of intensional properties with categories without regard to their validity. In fact, stereotypes are a prime example of the way in which people's concepts may be driven by associative and irrational factors. Social categories are also a rich ground for studying conceptual combinations and intensional reasoning, given that people can simultaneously belong to many diverse categories. Consideration of surprising combinations of social categories (e.g., female car mechanic) leads to models of intensional combination that are similar to those described above (Hutter & Crisp, 2005).

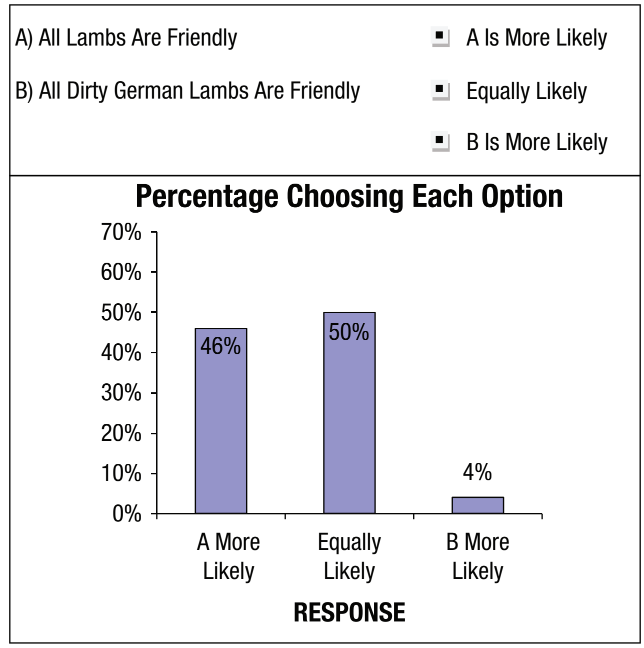

Fig. 2. The inverse conjunction fallacy. In Jönsson and Hampton (2006), participants were shown pairs of statements like those in the top panel and had to choose whether one of the two statements was more likely to be true or both were equally likely. The lower panel shows the results: When one statement was chosen as more likely, it was almost always statement A about the whole class, even though, logically, whenever A is true, statement B about the subclass must also be true.

An Alternative Conjunction Fallacy

Intuitive reasoning can also lead to other forms of fallacy. I and my colleague (Jönsson & Hampton, 2006) developed a corollary of Tversky and Kahneman's (1983) effect with our inverse conjunction fallacy. In this fallacy, people rate the likelihood of two universally quantified sentences being true. One sentence associates a property with a class, as in the sentence "All ravens are black"; the other associates the same property with a subclass, as in the sentence "All jungle ravens are black." Logically, whatever is true of all ravens must also be true of all jungle ravens. However, that was not reflected in participants' responses. Participants repeatedly claimed the properties were more likely to be true of the whole class than of some atypical subset. For example, we asked people to judge which of the two statements shown in Figure 2 was more likely to be true, or whether they were equally likely. The lower panel shows the results: When participants believed one statement was more likely than the other to be true, they were 10 times more likely to select the general statement than the more specific one.

The inverse conjunction fallacy is just one of a range of similar phenomena having to do with the failure to understand the logic of a subset-superset relation. Consider the following two arguments:

1. Apples are of the *Dioecious* genus; therefore, McIntosh apples are.
2. Fruit are of the *Dioecious* genus; therefore, McIntosh apples are.

In a demonstration of what he termed the *premise specificity effect*, Sloman (1993) showed that people consider arguments such as Statement 1 to be stronger than arguments such as Statement 2, even though, given that people understand that all McIntosh apples are apples, and that all apples are fruit, the two statements are equally valid. With intensional knowledge, the fact that one class is a subset of another can carry different degrees of confidence (Hampton, 1981), or even different degrees of truth (see Hampton, 2011, for a discussion of fuzzy logic and intensional reasoning).

Generic Statements and Vagueness

The most direct evidence for intuitive thinking is in our use of language. When we describe the nature of the world, we typically use "generic" sentences. These are unquantified statements whose truth is resistant to counterexamples. For example, the sentences "Ducks lay eggs" and "Mosquitoes carry malaria" are typical generics.

These sentences strike us as clearly true, even if we realize that only adult female ducks lay eggs and only a small proportion of mosquitoes carry malaria. A study by Leslie, Khemlani, and Glucksberg (2011) established that generic statements can still be considered true when they are given universal quantification, as in the sentence "All ducks lay eggs." It is as though instead of the sentence meaning “everything that is a duck lays eggs,” it means something like “a relevant fact to know about ducks is that some lay eggs.” Quantifying the sentence with “all” may reduce the likelihood that people will judge it to be true, but it does not trigger extensional thinking to any great extent. The truth of generic sentences depends not on the absence of counterexamples but on what is considered a relevant fact. For example, although “Canadians are right-handed” is true of a majority of Canadians, it is not judged as being generically true (Leslie et al., 2011). Future research needs to address why and how particular properties become incorporated into the intensional knowledge of a concept.

The last study to be described here, which provides a particularly dramatic demonstration of the gulf between intuitive thought and the constraints of logic, is Alxatib and Pelletier’s (2011) study of vague sentences, such as “John is tall.” The truth of the statement “John is tall” appears to increase smoothly as John gets taller. This contradicts Aristotle’s law of excluded middle, according to which either a proposition is true or its negation is. There has been much debate about how to handle vagueness in logic (van Deemter, 2010), but for the psychologist the interesting question is whether people obey simple logical constraints when judging vague statements as true or false.

Alxatib and Pelletier showed people a picture of men of different heights (see Fig. 3) and asked them to judge whether statements about the men were true or false. Remarkably, the results completely defied logic. For example, 45% of participants agreed that Suspect 2 was both tall and not tall, and 54% agreed that he was neither tall nor not tall. More than that, many participants claimed that *both* of these statements were true. Further, of 16 participants who said that both of the first two statements in Figure 3 were false, 11 also said that their conjunction (the third statement) was true!

These results bring home an important point about the use of vague terms like “tall.” Neither classical logic nor any standard variant of fuzzy logic can handle judgments using such terms, because both types of logic are founded in extensions. Combining “tall” and “not tall” and arriving at “partly tall” requires the averaging of the two properties to arrive at something in between—an operation on the intensional meaning of the terms.

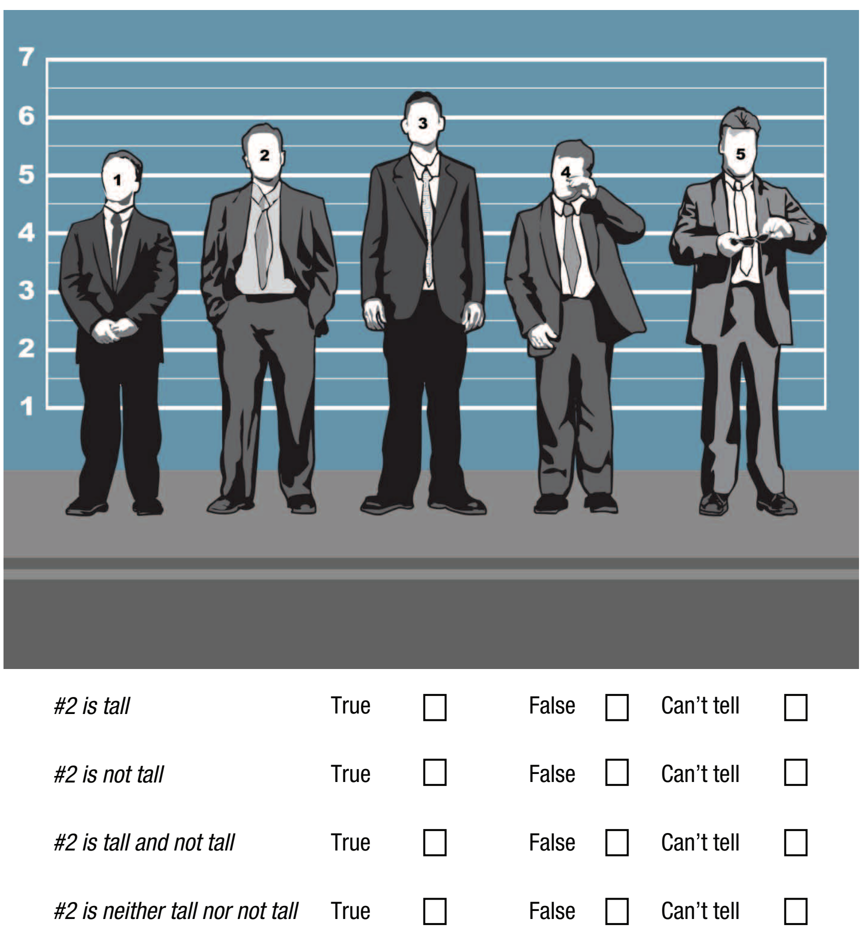

Fig. 3. In Alxatib and Pelletier (2011), the vagueness of “tall” was investigated. Participants judged the truth of four statements with regard to each of the five suspects shown in the picture. Participants’ judgments of the four statements as true or false for Suspect 2 frequently violated the constraints of logic. For example, many participants judged the first two sentences to be false, but judged the third sentence to be true. Reprinted from “The Psychology of Vagueness: Borderline Cases and Contradictions,” by S. Alxatib and F. J. Pelletier, 2011, *Mind & Language, 26*, p. 307. Copyright 2011 by John Wiley and Sons. Reprinted with permission.

Conclusions

In this brief review, I have proposed that much human thought operates intuitively, using intensions. Intuitive reasoning fails to meet the standards of logic, but it also allows us to think creatively and to adapt our concepts and language to new contexts and challenges. The lack of logical constraints can often pose serious problems—as in the case of social stereotypes, which are notoriously resistant to counterexamples. Indeed, the "loose thinking" for which professors frequently berate their students is also likely to stem from this form of reasoning. The more we can understand about how we represent concepts and how our minds use that knowledge, the more we will be able to exploit its positive flexibility and circumvent its logical failings.

Recommended Reading

Cimpian, A., Brandone, A. C., & Gelman, S. A. (2010). Generic statements require little evidence for acceptance but have powerful implications. *Cognitive Science*, *34*, 1452–1482. An empirical study showing that people will accept generic statements on the basis of little evidence, but then assume that they have much wider application.

Hampton, J. A. (2007). Typicality, graded membership, and vagueness. *Cognitive Science*, *31*, 355–383. A detailed exploration of the problems of intension-based categorization.

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van Deemter, K. (2010). (See References). A highly readable account of the problem of vagueness and its treatment in cognitive science.

Declaration of Conflicting Interests

The author declared that he had no conflicts of interest with respect to his authorship or the publication of this article.

Note

1. Terms such as "concept," "intension," and "extension" are used in philosophy to refer to the *actual* state of the world. For example, the concept "bird" refers to the actual class of birds and their properties. People may have correct or false ideas about concepts in this sense. For the psychology of concepts, however, we must (necessarily) restrict ourselves to what people believe, whether it is correct or not. In this article, the terms "intension" and "extension" should be understood in this way.

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