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 it in generalities such as “ducks lay eggs”. It contrasts with extensional knowledge about actual individuals in the world, which we express in quantified statements such as “All US 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 point to our conceptual memory as the source of this logical failure. We represent concepts with prototypical properties, judging likelihood and argument strength on the basis of similarity between ideas. Evidence that our minds represent the world in this intuitive way can be seen in a range of phenomena, including how people interpret logical connectives applied to everyday concepts, studies of creativity and emergence in conceptual combination, and demonstrations of the logically inconsistent beliefs that people express in their everyday language.

How do you decide whether to categorize some discipline as a science, or some cultural product as a work of art? Classifying the world around us into labelled 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 the same words 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 into judgments that break the norms of correct reasoning. Recent work on this remarkable cognitive system has pointed to an important distinction between reasoning that uses Intensional versus Extensional aspects of conceptual knowledge as an explanation of what Tversky and Kahneman (1983) termed Intuitive Reasoning.

EXTENSIONS VERSUS INTENSIONS[2]

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 has a set of normative rules set out in first order set logic, as originally described by Aristotle in his analysis of syllogistic reasoning. Interestingly, a long tradition of research on this form of reasoning (e.g. Evans, 1982) suggests that (a) getting it right can be very difficult, requiring training and much intellectual effort, and (b) reasoning is highly susceptible to the effects of the particular content of the problems, and the motivation of the reasoner.

More recently a number of studies have been directed at an alternative form of reasoning, based on Intensions. The Intension of a concept is the set of *properties* that we associate with a term. The intension of the concept "bird" is the list of things that we consider 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, yet they work in different ways. Knowledge of the 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 intensions, they commonly generate a range of properties, some true of the whole category (birds have feathers), some only true of typical members (cats have tails), and some only true of a minority (dogs bite postmen). While extensional knowledge provides for clear reasoning about the world, intensional knowledge is full of the richness and vagueness that turns out to characterise 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 typically true of a concept, they found people produced four kinds of information: 1) taxonomic categories (a robin is a bird), 2) descriptions of physical appearance, make-up and function, 3) situational contexts in which the object plays a role, and 4) introspective or attitudinal judgments of how people felt about the object. The important point to note here is that people very readily generate these properties, at least for common concrete concepts (abstract concepts can be harder, see Hampton, 1981), and they do so without regard to whether the properties are true of the whole class or not. People make no demarcation between those properties that constitute the meaning of the word, and those that are simply beliefs 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 combining concepts with conjunction, disjunction or negation (see Hampton, 1997a, 2011). In one study (Hampton, 1988, Expt. 1) people judged whether each of a list of activities was a sport, whether each was a game, and whether each was a "sport which is a game". On the face of it, the latter phrase should just pick out activities which the person considers both sports and games. The results systematically deviated from this pattern. For example chess (a typical game), was not judged to be a sport. However it was considered a sport which is a game. Moreover "sports which are games" differed from "games which are sports". Similar non-logical effects were found with disjunctions ("a fruit or a vegetable") and negative phrases ("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 ever 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. Given the information that Linda was a radical student with interests in politics, participants (fallaciously) considered it more likely that Linda was a feminist bank teller, than that she was a bank teller. There has been much debate about the interpretation of this phenomenon (e.g. Hertwig & Gigerenzer, 1999). However the close parallel to the conjunctive overextension effect in categorization suggests a common explanation. Hampton (1987) proposed a model for combining the intensions of two concepts to create a new composite concept. The key element in the 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 the new "emergent" feature *"lives in an aquarium"*. Combining intensions involves an interaction of the information within each concept resulting in non-monotonic effects (Brewka et al., 1997; Hampton, 1997b). It is this creativity in combining concepts that leads to the violation of normative constraints on set membership and probability judgments.

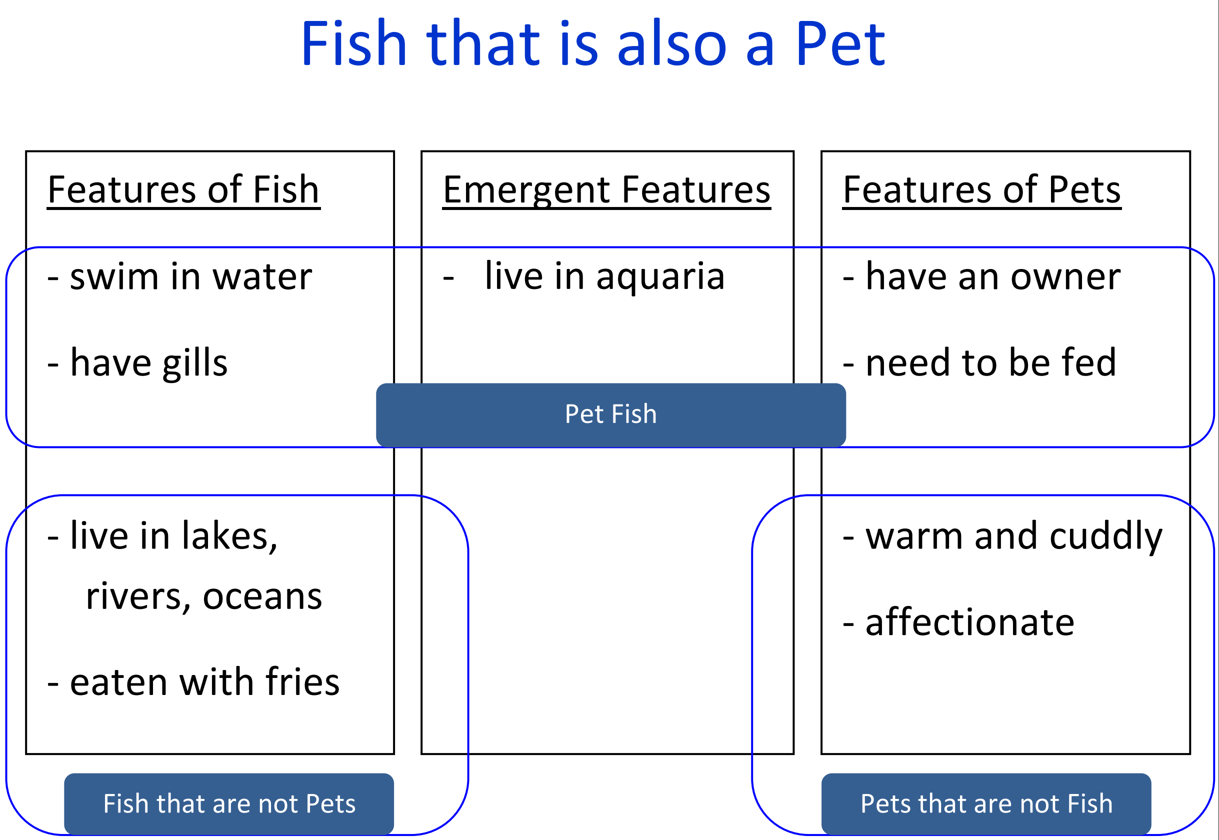

Figure 1. In the Composite Prototype Model, Hampton (1987, 1988) proposes that a complex concept will inherit only some of the features of its constituent parts. Here the features of fish and pet are shown divided into those that are true of Pet Fish (the conjunctive combination of pet and fish), those 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 by a complex concept. Things that live in water cannot be warm and cuddly, while people don't like to cook and eat their pets.

Intuitive reasoning may lead to non-logical judgments, but it is also a major source of creativity. A recent exploration of this process (Gibbert et al., 2012) asked participants to think of novel hybrid products (consumer products with more than one function, like phone-cameras or 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 combining the concepts follows two stages. In the first the features of each concept are simply pooled together. Thus flashlight-slippers simultaneously provide the functions of footwear and illumination. Further effort however can integrate the two functions, and resolve incompatibilities. Pressure of walking on the heel could charge the 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 the adaptive value of intuitive reasoning with intensions. Note that extensional reasoning about classes of objects in the world would have no way to address this problem. As the sets of slippers and flashlights do not overlap, the conclusion would just be that no slippers are flashlights. Intensions take us from the real world into the world of possibilities.

Social categories also show effects of creativity in forming conjunctions (Hastie et al., 1990; Kunda et al., 1990). They are also familiar to psychologists for the phenomenon of stereotyping – associating intensional properties to categories without regard to their validity. Social categories are also a rich ground for studying intensional reasoning, since people simultaneously belong to many diverse categories. Consideration of surprising combinations of social category leads to very similar models of intensional combination (Hutter & Crisp, 2005).

AN ALTERNATIVE CONJUNCTION FALLACY

Intuitive reasoning can lead to other forms of fallacy. Jönsson and Hampton (2006) developed a corollary of Tversky and Kahneman's (1983) effect with their 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 "All ravens are black", and the other associates the same property with a subclass as in "All jungle ravens are black". Logically, whatever is true of all ravens must also be true of all jungle ravens. However that is not how people responded. They 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 say which of the two statements in Figure 2 was more likely to be true, or whether they were equally likely. The lower panel shows the results; where a preference was expressed, the general statement was selected ten times more often than the more specific one.

A) All lambs are friendly	■ A is more likely
B) All dirty German lambs are friendly	■ Equally likely
	■ B is more likely

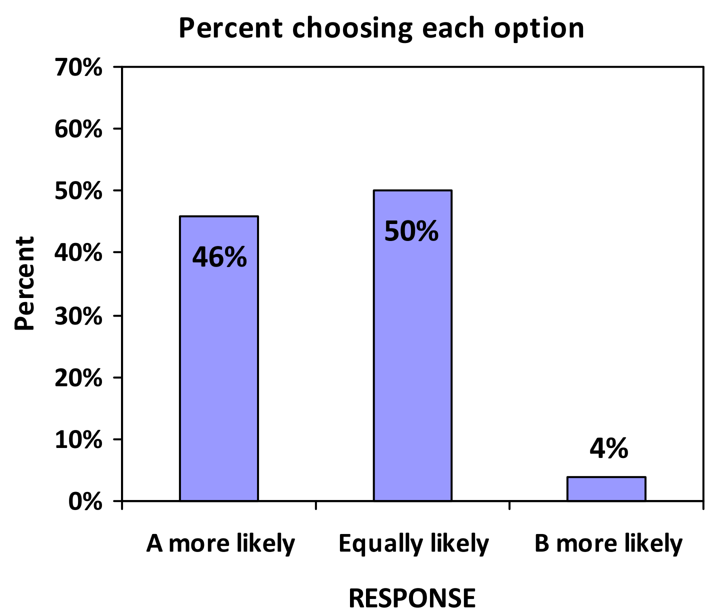

Figure 2. The Inverse Conjunction Fallacy. In Jönsson & Hampton (2006) participants chose between pairs of statements as in the top panel. The lower panel shows that when one statement was chosen as more likely, it was almost always the unmodified statement A, even though logically whenever A is true, B must also be true.

The Inverse Conjunction Fallacy is just one of a range of similar phenomena, in which the logic of a subset-superset relation fails to be understood. In his Premise Specificity Effect, Sloman (1993) showed that people consider an argument such as (1) to be stronger than an argument such as (2), even though, given that all apples are fruit, they are both perfectly valid.

1) Apples are of the dioecious genus, therefore McIntosh apples are.
2) Fruit are of the dioecious genus, therefore McIntosh apples are.

With intensional knowledge, one class being a subset of another is something that 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).

GENERICS 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 expressing a truth which is resistant to counterexamples. Typical generics are (3) and (4)

3) Ducks lay eggs
4) Mosquitoes carry malaria

These sentences strike us as clearly true, even though we realise that only adult female ducks lay eggs, and only a small proportion of mosquitoes carry malaria. A study by Leslie et al. (2011) established that generic statements can still be considered true when given universal quantification, as in "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 people's judgment of its truth, but it does not trigger extensional thinking to any great extent. What makes generic sentences true is not the absence of counterexamples, but the question of what is a relevant fact. For example, while "Canadians are right-handed" is true of a majority of Canadians, it is not judged as generically true (Leslie et al., 2011). Future research needs to address the question of why and how particular properties become incorporated into the intensional knowledge of a concept.

A study 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 in a continuous way as John gets taller. This intuition 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 (see Figure 3) showed a picture of men of different heights and asked people to judge whether the statements listed in the Figure were true or false. Remarkably, the results completely defied logic. For example, 45% 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 claimed that *both* these statements were true. Of 16 people 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 such judgments, since both logics are founded in extensions. To combine "tall" and "not tall" and arrive 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.

Figure 3

#2 is tall	True	☐	False	☐	Can't tell	☐
#2 is not tall	True	☐	False	☐	Can't tell	☐
#2 is tall and not tall	True	☐	False	☐	Can't tell	☐
#2 is neither tall nor not tall	True	☐	False	☐	Can't tell	☐

Figure 3. In Alxatib and Pelletier (2011), the vagueness of "tall" was investigated. The same four statements were judged for each of the 5 suspects. People's judgments of the four statements as True or False for suspect #2 frequently violated the constraints of logic. For example many participants rated the first two sentences false, but at the same time rated the third sentence as true.

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 on the other hand allows us to think creatively and to adapt our concepts and language to new contexts and challenges. The lack of logical constraints will often pose a serious problem – as in the case of social stereotypes, which are notoriously resistant to counterexamples. Indeed the "loose thinking" with 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, then the better able we will be to exploit its positive flexibility and circumvent its logical failings.

End notes

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2. Terms such as concept, intension and extension as used in philosophy refer to the *actual* state of the world. The concept BIRD refers to the actual class of birds and their properties. People may have correct or false ideas about this concept. For the psychology of concepts, however, we must (necessarily) restrict ourselves to what people believe, whether correct or not. The terms intension and extension should be understood in this way – as mental contents.

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Recommended Further Readings

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 that shows how people will accept generic statements with little evidence, but then assume them to have much wider application.*

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Hampton, J.A. (2011).Conceptual Combinations and Fuzzy Logic. In R.Belohlavek and G.J.Klir (Eds.) *Concepts and Fuzzy Logic,* (pp. 209-231). Cambridge: MIT Press. *A review of the difficulty of handling conceptual combinations with fuzzy logic.*

van Deemter, K. (2010) (see reference list). *A highly readable account of the problem of vagueness and its treatment in cognitive science.*