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Research Focus

Why learning and development can lead to poorer recognition memory

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Current models of inductive reasoning in children and adults assume a central role for categorical knowledge. A recent paper by Sloutsky and Fisher challenges this assumption, showing that children are more likely than adults to rely on perceptual similarity as a basis for induction, and introduces a more direct method for examining the representations activated during induction. This method has the potential to constrain models of induction in novel ways, although there are still important challenges.

Inductive reasoning involves using observations to modify confidence in beliefs. Such reasoning leads to conclusions that are probable rather than certain, and hence is thought to be crucial to people's everyday encounters with an uncertain world. Most current models of inductive reasoning in children [1] and adults [2] assume that categorical knowledge is central. For example, knowing that something is a member of a familiar category such as *cat* allows you to infer hidden properties, such as that it has a heart. This assumption is particularly useful when learning novel information. If you are told that a particular cat 'has beta cells inside its body' then you are likely to conclude that other cats share this property. The central idea is that people generalize properties along taxonomic lines, assuming that members of the same category will have many attributes in common.

A recent article by Sloutsky and Fisher [3] challenges this conventional account of inductive reasoning, and suggests that children and adults approach induction very differently. This conclusion was based on an innovative method for examining the kinds of representations that people activate during induction. Five-year-old children and adults were shown photographs illustrating that a novel property possessed by a target instance (e.g. a cat) was shared by members of the same category but not members of other animal categories. After completing the induction task, the subjects were given a surprise recognition-memory test, in which they were asked to discriminate between photographs used in the induction task and novel photographs of animals from the same categories. There were two remarkable findings. First, recognition performance by 5-year-olds exceeded that of adults, indicating that children encoded perceptual details during induction whereas adults encoded only category-level information ([3], and see also [4]). That is, adults did not distinguish between cats they had previously seen and cats they had not seen, but children did. Second, children could be trained to perform induction in an adult manner, focusing on categories, with the result that their recognition performance decreased to adult levels (see Figure 1). These findings raise important questions about the nature of the knowledge that is accessed during induction, the role of experience in the development of induction, and relations between induction and recognition.

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The role of similarity in inductive reasoning

Sloutsky and Fisher conclude that, without explicit training, young children rely primarily on perceptual similarity as a basis for inductive generalization. For adults, on the other hand, perceptual details are less relevant for induction. Although these findings provide a compelling demonstration of the role of perceptual similarity in children's induction, the implications for general models of induction require some further consideration. As the authors note it is usually assumed that adults make use of knowledge about category membership for induction. Most models of induction, however, also accord a significant role to the similarity (defined as the number of shared features) between inductive premises and conclusions. In the most widely cited theory of induction, the 'similarity-coverage'

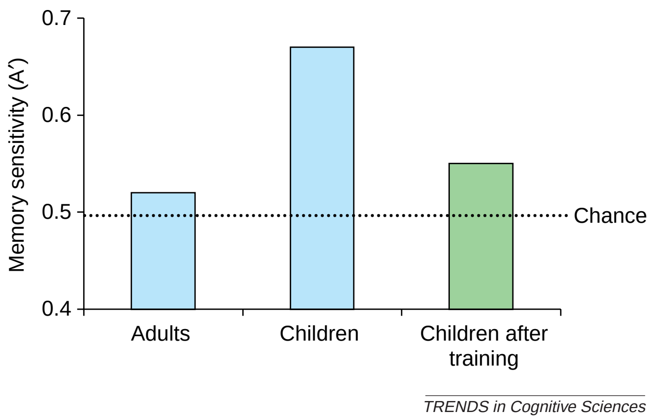

Figure 1. Memory sensitivity following inductive reasoning. The recognition performance of adults and children after making inductive inferences. Recognition sensitivity is assessed using A-prime, a measure that reflects the ability to discriminate between test items that were previously encountered during the induction training phase, and novel items. Without additional training emphasizing the role of categories in induction, children showed greater recognition sensitivity than adults. After such training, children's performance declined to adult levels. (Adapted from [3].)

model [2], an assessment of similarity between premise and conclusion items is one of two key processes that determines confidence in inductive arguments. Other models of adult induction [5] assume an even greater role for shared features. Therefore, caution is required when interpreting Sloutsky and Fisher's findings as evidence of a developmental trend from 'similarity-based' to 'category-based' induction, given that adults are also highly sensitive to similarity in induction.

Likewise, we would also point to the considerable body of evidence showing that children as young as 2 years of age can use category labels as a basis for inductive inference [1,6]. Like adults, young children are also capable of using general principles, such as the diversity of evidence for a particular property, as a basis for induction [7]. Hence, children might rely on more than one kind of attribute to make inductive generalizations. A key goal of future research on the development of inductive reasoning is to identify the factors that cause children to focus on particular stimulus attributes as a basis for making inferences (see also [8,9]).

Experience, development and inductive inference

Sloutsky and Fisher show that when children were taught about the 'category assumption', they performed induction in a manner similar to adults. During training, children were taught that animals with the same name belong to the same category and have 'the same stuff inside', and they practiced making inductive inferences based on categories. In subsequent recognition tests children performed as adults did, failing to discriminate between items that were used for induction and novel items belonging to the same category. This result is strong evidence for the role of experience in the development of induction based on categories. Strictly speaking, however, this finding still does not rule out the possibility that the category assumption is *a priori* in nature – after all, it was relatively easy to train children to follow this assumption.

An important direction for future research on the development of inductive reasoning, therefore, is to specify the kinds of environmental inputs that might lead children to focus on particular attributes of a stimulus (e.g. perceptual appearance, category membership, behaviour) as a basis for inductive generalizations. Recent work suggests that children learn some aspects of categorical relations by attending to correlations between perceptual features [10,11]. Parents also provide information about categorical relations in their everyday conversations with young children [12].

Induction, categorization and recognition

Another important contribution of Sloutsky and Fisher's work is to draw links between research on the cognitive processes involved in categorization and induction on the one hand, and recognition memory on the other. In most previous work the representations that people access during induction have been assessed indirectly – representations are inferred from people's judgments about the relative strength of competing inductive arguments [1,2,5,13]. Sloutsky and Fisher's use of a recognition memory task following induction suggests a more direct way of examining the representations used to draw inductive inferences. This method could be exploited to address a wider range of phenomena in inductive reasoning, going beyond the specific design used by Sloutsky and Fisher. For example, 5-year-old children make stronger generalizations from dogs to other animals than from bats to other animals, because dogs are considered more typical animals [14]. Children even do so when 'animals' are described in an abstract way, that is, without any picture presented. Perhaps when more typical category members such as *dog* are presented during induction (either verbally or pictorially), children would be more likely to access category-level representations and hence falsely recognize other category members, such as other dogs or other animals.

Furthermore, the method could be extended to include premises from a diverse range of basic level categories (e.g. subjects are told that cats *and* buffalos have beta cells). According to the similarity-coverage model this should lead to the activation of superordinate category information (i.e. the subject will retrieve information about a broader category such as *mammal*) and this information will influence inductive judgments. Competing accounts explain induction involving premises from multiple categories without recourse to superordinate information [5]. These accounts could make divergent predictions about whether people will discriminate between the items presented during induction and novel members of a relevant superordinate category in a subsequent recognition task.

Obtaining recognition data following induction might also offer a way of constraining future theories of inductive reasoning. Sloutsky and Fisher highlight the systematic relations between representations used for inductive and recognition judgments. Still, we would emphasize that most current models of category-based induction do not make detailed predictions about recognition, so further assumptions would be needed. One model that has attempted to link recognition, categorization and induction is Estes's composite-memory model [15]. In brief, this model assumes that previously encountered instances are stored in memory as an array of features with the category label treated as just one feature. When a recognition decision (does this item have the same features as an old item?), an inductive inference (given that this item is a member of a certain category X does it have feature Y?), or a categorization judgment (does this item belong to category X?) needs to be made, the target item is compared in parallel with all previously stored instances. Essentially the same decision algorithm is used for recognition, categorization and inference. This model has many similarities with other exemplar-based categorization models [16,17], which have been very successful in quantifying relations between categorization and recognition performance. A productive direction for future research would be to apply these models to data collected using Sloutsky and Fisher's induction-recognition paradigm. A possible outcome of such an enterprise would be the development of models that could draw together learning and decision mechanisms from recognition, categorization and inductive reasoning in children as well as adults.

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Book Review

Getting to grips with the brain problem

Philosophy of the Brain: The Brain Problem, by Georg Northoff. John Benjamins Publishing Co. 2004. €68.00/$81.95 (x + 429 pp.) ISBN 90 272 5184 3 (Europe)/1 58811 417 1 (US)

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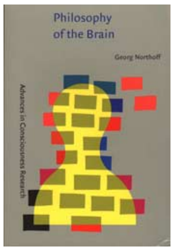

Those who are used to reading American, Canadian or British philosophy will find Georg Northoff's *Philosophy of the Brain* difficult, for this book is decidedly not written in one of those or any similar tradition. That is, readers expecting new ideas to be located in on-going academic discussions, or explanations of why and how the author's ideas diverge from others working on similar projects, or critical analyses of related conjectures will be disappointed. Those looking for philosophical arguments will also be disappointed, for this book provides none of that. Instead, this is a book outlining one man's vision for what a philosophy of the brain means.

I have to say I found this book frustrating, because there are many, many of us now working in and around the areas of neurophilosophy, philosophy of neuroscience, theoretical cognitive science, and so on, and we make claims that are very similar to what Northoff says. But it is unclear how and whether what Northoff has to say fits with the rest of us are doing. All that, I suppose, has been left as an exercise for the reader.

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Philosophy of the Brain concerns the reductive connections between mind and brain, a perennial problem in at least contemporary philosophy. Nothoff believes very strongly that dualistic assumptions built into the very language we use to talk about our minds and our brains lead philosophers and scientists alike astray. As a materialist, he is interested in making sure we appreciate the identity between our minds and our brains. At the same time, he is interested in making sure that, as materialists, we don't underestimate the complex metaphysics of our world.

For Northoff, the fact that our brains are embedded in bodies that live and interact in environments is of fundamental importance. What our brains do is continually shaped by what our bodies can do and what the environment is doing to both. All three elements mutually constrain one another.

It is here, at this very beginning of Northoff's articulation of what it means to be a human brain, that I began to question what his position actually is. For, I wonder, who exactly disagrees with this claim? Why is this view being presented as something novel, daring even? The latest fad in philosophy of mind is to highlight the brain's embeddedness as a way of understanding minds and there has been much published on this very idea of late. (And even