



Discussion

Deciding between theories of how reasoning develops is hard

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Abstract

Although Sloutsky agrees with our interpretation of our data, he argues that the totality of the evidence supports his claim that children make inductive generalisations on the basis of similarity. Here we take issue with his characterisation of the alternative hypotheses in his informal analysis of the data, and suggest that a thorough Bayesian analysis, although practically very difficult, is likely to result in a more finely balanced outcome than he suggests. © 2008 Elsevier B.V. All rights reserved.

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Perhaps to no-one's surprise, it turns out that deciding whether children and adults reason in the same way is not straightforward. Some researchers wish to argue that when generalising from one instance to another, both adults and children can proceed on the basis of shared category membership (for a review see [Hayes, 2007](#)). Other researchers, such as Sloutsky and his colleagues, argue that children reason on the basis of similarity between instances, whereas adults can reason on the basis of shared category membership. [Sloutsky and Fisher \(2005a\)](#), [Sloutsky](#)

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and Fisher (2005b) predicted that if adults reason on the basis of shared category membership whereas children calculate similarity, then children should have better memory for the items they reason about. Our contribution has been to examine the conclusions that may be drawn from apparent confirmations (see Sloutsky & Fisher, 2005a; Sloutsky & Fisher, 2005b; Wilburn & Feeney, 2008) of that prediction.

Although Sloutsky in his comment (Sloutsky, 2008) attributes to us a novel hypothesis about reasoning development, in fact our initial concern was that the Induction-Then-Recognition (ITR) paradigm might be confounded (see also Hayes, McKinnon, & Sweller, *in press*). Because inspection time was not controlled for, we thought it possible that children might spend longer inspecting the reasoning items than do adults, and accordingly remember them better. As we discussed in our original paper, there are many reasons apart from a similarity-based reasoning strategy why children might spend longer looking at the reasoning items. To take just one example, children might not be as pragmatically aware as adults. That is, although they are capable of category-based induction, they might not realise that doing the task in a category-based way is enough to satisfy the experimenter, and so they process the reasoning items more carefully than they need to. Consistent with this possibility, in two experiments we showed that children do spend longer looking at the items than adults, and that when adults and children are given a very short time (250 ms) to process the pictures, they reason about them equally well, and remember them equally badly. Interestingly, Hayes et al. (*in press*) have recently shown that when children and adults are given 2500 ms to process the pictures, adult recognition memory is superior to children's.

In his reply to our paper, Sloutsky agrees with us that his original findings with Fisher do not necessarily imply that children and adults reason differently. However, on the basis of an informal analysis of all of the evidence, he argues that the hypothesis that children and adults reason differently is better supported than the hypothesis that children attend more closely to the pictures. Of course we did not suggest this hypothesis as an alternative account of how children reason. Instead it was an alternative explanation of how the observed pattern of results might have arisen from a possible confound on the ITR paradigm. There are parallels here with Sloutsky and Napolitano's (2003) claim that because auditory information overshadows visual information, the fact that category labels are spoken to children during the triad task confounds conclusions that have been drawn from that task about the importance of category labels in children's inductive inference. Just as those authors would not want to put verbal overshadowing forward as a theory of how reasoning develops, neither did we intend inspection time as a general theory of reasoning development.

So, we agree that the hypothesis that we tested in our paper is not a good alternative theory of how reasoning develops. In our view, the sensible alternative hypotheses are (1) that children and adults do not differ and both can reason on the basis of similarity or category membership and (2) that children and adults differ because adults can reason on the basis of similarity or category membership whereas children can reason only on the basis of similarity. With these as the alternative hypotheses, we will consider Sloutsky's analysis of the evidence.

We agree with Sloutsky that it is very useful to consider all of the evidence together. However, a thorough Bayesian analysis is very difficult in this case. Sloutsky enumerates the effects in the literature for which he claims that each hypothesis can account and decides between the hypotheses on the basis of raw counts. Because his hypothesis can account for more of the effects than the alternative hypothesis, he favours his own hypothesis. To us this seems more like an example of abductive reasoning (see Thagard, 2007) to the best explanation rather than Bayesian reasoning. One problem for this analysis is that because Sloutsky agrees that his interpretation of the basic finding with the ITR paradigm is underspecified, it is very hard to argue that subsequent results, which involve extensions of that basic finding, uniquely support his view. Accordingly, we do not agree with the conclusion he draws.

What about a Bayesian approach? There are three elements to a Bayesian analysis: establishing the prior probabilities of each hypothesis; deciding the likelihood of each piece of evidence given each hypothesis; and updating belief in the hypotheses in the light of the evidence. Apart from the contentious issue of deciding which hypothesis is most likely a priori, the biggest practical problem in carrying out a Bayesian analysis is deciding how we should go about assigning likelihoods to the evidence under each of the hypotheses. For example, the finding that children and adults display high inductive accuracy and low recognition accuracy under shortened inspection times (Sloutsky's Finding 3) is highly likely given the hypothesis that children and adults reason in a category-based way, but initially seems quite unlikely given the hypothesis that children and adults reason differently. However, once we have added some additional background assumptions¹—that children have enough time to carry out a rough similarity calculation but not enough time to encode sufficient features for accurate recognition memory—we might be prepared to assign a high likelihood to this finding given Sloutsky's hypothesis. (Note here that Sloutsky gives two entirely different explanations for high inductive accuracy coupled with poor recognition memory. In adults this signifies category-based induction whereas it signifies similarity-based induction in children).

Similarly, the effects which Sloutsky argues cannot be accounted for under our alternative hypothesis, can be assigned a high likelihood under the hypothesis that children and adults reason in the same way, once some background assumptions have been made. For example, if we assume that children have poorer pragmatic skills than adults, then children's recognition memory may decrease after training (Finding 5) because the training makes clear to them that processing the stimuli just carefully enough in order to perform the task in a category-based way is all that is required of them (see Hayes & Heit, 2004). Accordingly, children may process the reasoning items less deeply, and remember them less well. That younger children remember the training less well (Finding 7) may be very likely under the hypothesis that children and adults reason in the same way, if one makes the non-contentious assumption that older children have better memory for instructions than younger children. Similarly, the gradual decrease in memory accuracy (Finding 8) observed

¹ Of course, adding assumptions to the hypothesis makes it less likely a priori.

by Fisher & Sloutsky, is highly probable under the hypothesis that children and adults reason in the same way, if one assumes, for example, that older children are more like to possess the pragmatic skills required to decide how little effort they can invest in the task and still satisfy the experimenter.

The remaining findings for which Sloutsky argues only his hypothesis can account, can easily be explained by an alternative that says that children and adults can reason on the basis of similarity and category membership. Thus, training does not affect the baseline condition (Finding 6) because it is not possible to perform the baseline task in a category-based way. In other words, it is impossible for training to result in less careful processing here. Similarly, under the hypothesis that children and adults can reason in a similarity- or category-based way, it is highly probable that adults will be accurate in recognising artificial stimuli that they have reasoned about. Adults are very likely to have used a similarity-based strategy to reason about stimuli for which they have no pre-existing categories.

We are not claiming that Sloutsky and Fisher's original reasoning is incorrect; all else being equal similarity-based processing of visual stimuli should lead to better recognition memory for those stimuli than category-based processing. We hope that Sloutsky & Fisher's important insight may lead to important discoveries about other processing distinctions in adult inductive reasoning (see Feeney, 2007a; Feeney, 2007b). However, because of differences in the way that adults and children may approach the ITR paradigm or process aspects of the visual images therein (see also Hayes et al., *in press*), it may not be possible to draw conclusions from the paradigm about developmental differences in reasoning. Just as Sloutsky and his colleagues have re-opened the debate about the importance of linguistic labels in the triad task (Sloutsky & Napolitano, 2003), we have subjected the conclusions that have been drawn from the ITR paradigm to close scrutiny. We feel that things are much more finely balanced than Sloutsky's comment on our paper suggests and it will be a significant challenge for researchers to decide between the alternatives.

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