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Dumb mechanisms make smart concepts

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Abstract

There is an ongoing debate on the nature of the processes and knowledge involved in learning language. On one side of the debate, people argue that children learn words through deliberative processes that use propositional conceptual knowledge; on the opposing side, people argue that children learn words through automatic processes and knowledge based on learned associations among perceptual features. In this paper we concentrate on the Animate/Inanimate distinction as evidenced in children's novel noun generalizations. The results of two experiments with 3-year-olds and adults suggest that 1) automatic processing guides children's generalizations of novel nouns and 2) "conceptual" knowledge may be formed as a web of learned correlations.

Background

The nature of the processes and knowledge involved in children's learning of new nouns is a highly contentious issue. Children generalize names for things in appropriate ways depending on the kind of thing being named. For example they generalize names for artifacts by their shape; names for non-solid substances by their material; and names for animates by their shape and texture. The debate centers on the nature of the processes and knowledge involved in this behavior. On one side of the debate, people argue that children reason about category membership using slow, deliberative, conscious processes and propositional beliefs about categories and category structure (Gelman & Markman, 1987; Keil, 1994; Kemler-Nelson, Russell, Duke & Jones, 2000). On the opposite side, people support fast, unconscious, automatic processes and knowledge in the form of correlations among perceptual features (Smith, 1995; Smith, 2000; Smith, Colunga & Yoshida, 2003). Sometimes this debate has been framed in terms of whether children's early word learning is "smart" (reflective, conceptual) or "dumb" (built from more basic general and automatic processes). In this paper we concentrate on the Animate/Inanimate distinction as shown in children's novel noun generalizations. We show evidence that automatic processing guides children's generalizations of novel nouns, and suggest that the "conceptual" knowledge that enters word learning, even in adults, may be made out of correlations of perceptual features.

One widely used task to study children's word learning biases is the novel noun generalization task. In this

generalization task, children are shown an exemplar like those in Figure 1. They are told its name, and then asked what other things have the same name. When shown an exemplar like that in Figure 1a, with cues indicating it is a depiction of an animate thing, children systematically generalize its name only to new instances that match in both shape and texture, but not to things that match in shape only or texture only. When shown an entity without such features, children systematically generalize the name to new instances that match in shape, whether they match in other properties or not, as shown in Figure 1b. Jones & Smith, (1991) and others have suggested that children learn correlations between features and category structure -- between having eyes and being in a category organized by shape and texture, and between being angular (and without animacy features) and being in a category organized by shape. Consistent with theories and evidence on attentional learning, they suggest that in the novel noun generalization task, these features automatically increase attention to relevant properties, enabling children to attend to the right similarities according to the kind of the object at hand. This correlational learning account has been supported by showing that the requisite correlations between features and category organization exist across the first 300 nouns that children learn (Samuelson & Smith, 1999).

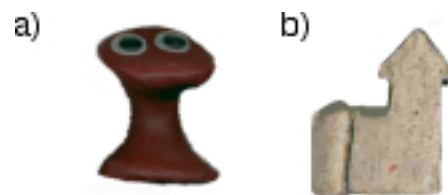


Figure 1. Examples of an exemplar with cues indicating it is a depiction of an animate thing, and an exemplar with artifact cues.

Recently, Booth and Waxman (2002) provided support for the alternative "smart" interpretation of children's performance in this task. Booth and Waxman presented exemplars in a context that construed them as animate or inanimate. The disambiguating context consisted of brief stories in which the experimenter gave the child information about the exemplar. For example, in the animate condition,

the experimenter introduced an exemplar as a Teema and explained that the Teema has a mommy and a daddy that love it very much and gave it hugs and kisses. Similarly, in the inanimate condition, the experimenters showed the same exemplar but this time introduced it as a Teema which is used by astronauts in their trips and will be replaced if it breaks. Their results showed that 3-year-olds can use the information in the stories to guide their generalizations of the novel noun – in the Animate condition, children generalized the novel name for the exemplar to other objects matching in shape and texture, but in the Artifact condition they generalized the novel name to any object that matched the exemplar on shape. Booth and Waxman take this result to mean that children word learning is “smart”, a result of deliberative processes operating on conceptual knowledge in the form of an unitary concept of animacy. Their account is illustrated in Figure 2a.

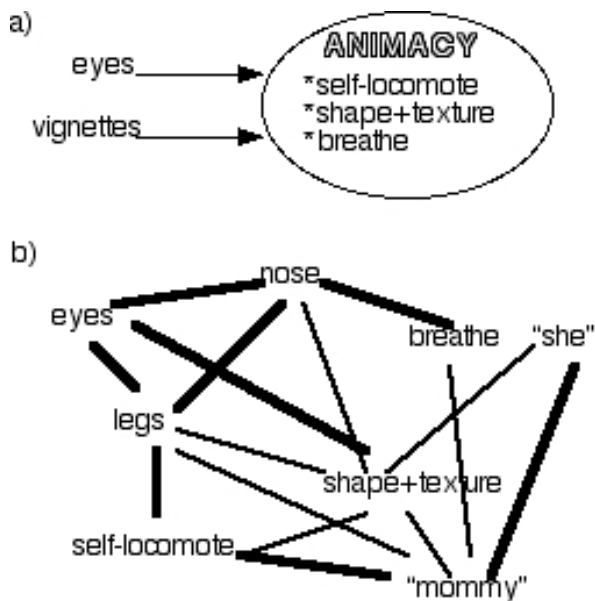


Figure 2. In Booth & Waxman's account, eyes, like vignettes, serve as a gateways to children's concept of animacy. In the correlational learning account, eyes and words like “she” or “mommy” are part of a web of correlations that is learned from the regularities that exist in animate categories in the world.

According to Booth and Waxman, the stories affect children's extension of novel nouns because they provide conceptual information relevant to the exemplar's ontological kind. That is, the Animate story identifies the exemplar as an animate, and the Artifact story identifies the exemplar as an artifact. Once children know the ontological kind of the exemplar, they have access to all the knowledge regarding that ontological kind, including the fact that shape and texture are central features for Animates and shape is the central feature for Artifacts.

The correlational learning account can also explain Booth and Waxman's findings. Novel nouns are extended on the

basis of learned correlations among perceptible properties. Having eyes correlates with having a mouth, correlates with being called “he” or “she”, correlates with animate-like motion patterns, correlates with attention to shape and texture. This web of correlations is the “knowledge” used in the novel noun generalization task through automatic processes, rather than through deliberative reasoning. Importantly, by this account any one cue can activate any other part of the web, *depending on the degree to which they have been correlated in the learner's experience*. Under this view, Booth and Waxman's results can be explained as a consequence of learned correlations among perceptible properties, including words. The vignettes shift children's attention because they are made out of words – words that correlate with categories of animates that are organized by shape and texture (like zebra, or snake) and words that correlate with categories of artifacts that are organized by shape (like hammer, or cup).

If the correlational story is correct, these words should cue attention to shape and texture in the Animate condition and attention to shape in the Artifact condition automatically, and without being strung together to form a coherent story *about* the exemplar. A strong test of this prediction would be to prime the children with animate-correlating or artifact-correlating words presented merely as a list and measure how this affects their performance in the novel noun generalization task. Under Booth and Waxman's explanation, reading children these words in a list should not have an effect since they are not put together into a coherent story that presents conceptual information regarding ontological status, nor are they presented as referring in any way to the exemplar. Thus, if children's novel noun generalizations are shifted by this priming, this attentional shift will not be attributable to any kind of deliberative process that reasons about the ontological status of the exemplar using the information given by the experimenter. Experiment 1 tests this prediction.

Experiment 1

Methods

Participants. 24 3-year-old children with a mean age of 42.6 months (range: 38.4-45.5 months) participated.

Materials. The stimuli consisted of two sets of eight abstract objects that could be construed as either animate or inanimate. Each set consisted of an exemplar object and 7 test objects that matched the exemplar in none, one, or more features of shape, texture or color. Figure 3 shows the diagnostic items, the ID test object matched the exemplar in all shape, color and texture features (but was different in size), there were also test objects that matched the exemplar in shape only, color only, texture only, shape + texture, shape + color, color + texture, and none of these features.

Two lists of words, one of animate-correlating words, the other of artifact-correlating words, were selected from the Animate and Artifact vignettes in Booth and Waxman (2002). Table 1 shows the words used.

Table 1: List of animate-correlating and artifact-correlating words selected from Booth & Waxman (2002).

Animate	Artifact
mommy	take
daddy	worn
love	break
sleep	make
hugs	bought
kisses	use
hungry	
walking	
gobbled	
happy	

Procedure. Children were randomly assigned to either the Animate or Artifact condition. During the Priming Phase, the child and the parent were asked to repeat the words said by the experimenter. The experimenter then went through the corresponding list saying each word once and letting parent and child repeat it. None of the test objects or exemplars were in view during the Priming phase. The Priming Phase was followed by the Testing Phase. The list of words was put away and children were informed that now they were going to play a different game and they were introduced to one of the exemplars “This is a Teema.” and then asked for each of the test objects in that set “Is this a Teema?”. Each of the test objects were presented twice in one of two previously generated random orders. Then the second set was presented, preceded by a second Priming Phase, for a total of 28 trials. The order of the sets was counterbalanced across conditions.

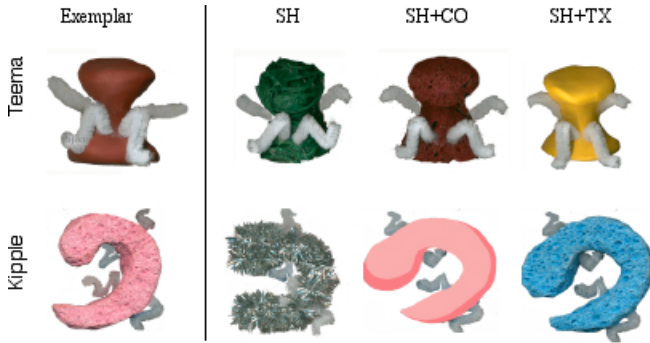


Figure 3. The two exemplars and some of their corresponding test items.

Results

The number of “yes” responses (the name applies) was submitted to a 2(Priming List) $\times$ 7(Test Item) repeated measures ANOVA. The analysis revealed a main effect of Priming List ($F_{(1,22)} = 5.38, P < .05$). That is, children overall said “yes” more when primed with the Artifact list of words than when primed with the Animate list. There was also a main effect of Test Item ($F_{(1,22)} = 37.21, P < .001$). No interactions were significant.

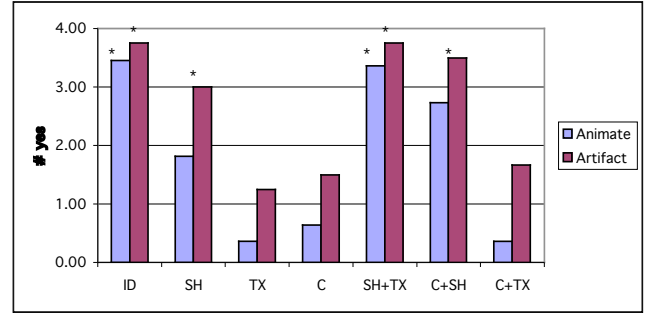


Figure 4. Results for Experiment 1.

Furthermore, post-hoc analysis revealed different patterns of noun extension in the two conditions. As shown in Figure 4, children in the Animate condition extend the name to the ID test object and to the shape+texture match, whereas children in the Artifact condition extend the name to the ID test object, the shape-only, the shape+texture and the shape+color matches. We counted the number of children who said “yes” more than expected by chance on each condition. On the critical test item, the shape-only match, there was a significant difference on the number of children who said “yes” more than expected by chance in the Animate versus the Artifact condition ($\chi^2(1, N=24) = 4.19, P < 0.05$). That is, children in the Artifact condition extended the name of the exemplar to all the test objects that matched it in shape, regardless of their size, color or texture, but children in the Animate condition extended the name of the exemplar more conservatively, only to those test objects that matched it in both shape and texture.

Discussion

At the very least, the results of Experiment 1 showed where the Animacy/Artifact information in Booth and Waxman’s vignettes comes from. Just hearing these words, without weaving them into a coherent story, was enough to shift children’s attention to features typical of animate vs. artifact categories – shape only for artifacts, shape+texture for animates. But more importantly, children’s novel noun generalizations were influenced by these words in a priming paradigm, without these words being heard at the same time that the exemplar or test objects were present. Apparently, these words automatically activate the attentional biases with which they are associated, a fact consistent with well-supported ideas about memory processes (). The result thus supports the idea that children’s novel noun generalizations depend on automatic processes that operate on learned correlations.

But is it possible that the concept of animacy is nothing but learned correlations of perceptible features? At least intuitively, it would seem that adults have a concept of animacy that corresponds to the kind of conceptual knowledge Booth and Waxman are talking about. Certainly, adults know the word “animate” and understand the words “living thing”. Do these concepts enter into their generalizations of novel nouns? Will adults differentially

generalize names for ambiguous stimuli if told the exemplar represents an animate entity vs. an artifact? One reason to believe they may not is that “animate” – the word – as such, is probably not very correlated with perceptual category formation, that is, with deciding the range of instances that go in a category. If the knowledge used in this task comes from learned correlations, the word “animate” in and of itself may not be potent enough to activate attention to shape and texture. A better cue would be one that is strongly associated with perceptual category decision and category name extensions.

In contrast, by Booth and Waxman’s account, the word “animate” should directly activate adults’ concept of animacy, indeed, and should therefore direct adults to the relevant knowledge within that concept, enabling them to reason that the relevant properties for categorization are shape and texture.

Experiment 2 tests these ideas using two experimental conditions. In one, adults were told the exemplar is an animate or an artifact; in the other, they were given additional perceptual cues (motion) correlated with animates or artifacts.

Experiment 2

Methods

Participants. 40 undergraduate students participated in this experiment.

Stimuli. The two sets of objects used in Experiment 1 were used in this experiment.

Procedure. Participants were randomly assigned to one of 4 conditions: WordOnly-Animate, WordOnly-Artifact, Word+motion-Animate, and Word+motion-Artifact. Participants were introduced to the exemplar of a set and told “This is a Teema. It is an animate. It is a living thing” in the WordOnly-Animate condition; “This is a Teema. It is an artifact. It was made in a factory” in the WordOnly-Artifact condition. In the Word+motion condition, the exemplar was presented with the corresponding phrases but they were also moved in a walking or slithering motion in the Animate condition or in a rolling or hammering motion in the Artifact condition. Each participant saw both sets and the order of the sets was counterbalanced across conditions. As in Experiment 1, each participant was queried on each of the 7 test-objects twice, for a total of 28 trials.

Results.

We first consider performance in the WordOnly conditions (Figure 5). The number of “yes” responses was submitted to a 2(Kind) x 7(TestItem) repeated measures ANOVA. The analysis revealed a main effect of TestItem ($F_{(1,18)} = 41.763$, $P < 0.001$) and no other main effects or interactions. There was no significant effect of Kind, that is of hearing Animate versus Artifact instructions ($F_{(1,18)} = 1.153$, $P > 0.2$). Post-hoc analysis on the critical test item, the shape-only match, also yielded no significant difference between conditions ($\chi^2(1, N=20) = .2197$, $P > 0.05$). In short, when the

ontological kind information consisted solely of words like “animate” and “artifact”, attention was not shifted consistently with ontological kind.

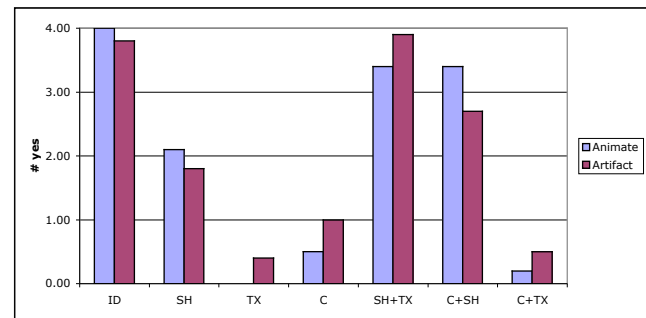


Figure 5. Results for the Word Only condition in Experiment 2.

Figure 6 shows adults’ performance in the Word+motion conditions. Again, the number of “yes” responses was submitted to a 2(Kind) x 7(TestItem) repeated measures ANOVA. The analysis revealed a main effect of TestItem ($F_{(1,18)} = 26.543$, $P < 0.001$) and a significant interaction between Kind and TestItem ($F_{(2,18)} = 3.024$, $P < 0.01$). Post-hoc analysis confirmed a different pattern of responses in the Animate and Artifact conditions for the shape match. There was a significant difference on the number of adults who said “yes” more than expected by chance on the shape-only match in the Animate versus the Artifact condition ($\chi^2(1, N=20) = 5.4945$, $P < 0.025$). As predicted, participants were more likely to accept the shape only match in the Artifact than in the Animate condition. Thus, adult’s novel noun generalizations, when given additional perceptual cues highly correlated with ontological status, did generalize names according to kind – by shape and texture for Animates and by shape for Artifacts.

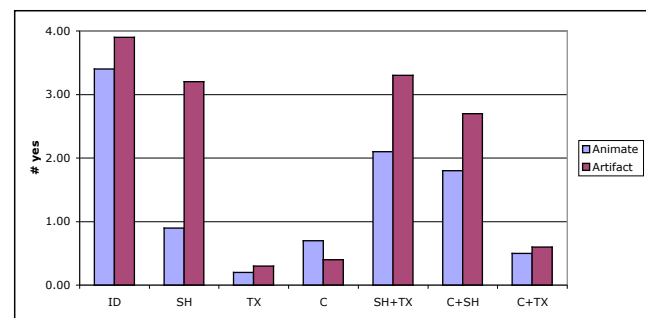


Figure 6. Results for the Word + motion condition in Experiment 2.

Discussion

As expected from the correlational learning account, adults do not show evidence of the animate/artifact distinction in their novel noun generalizations when the only

information they get about the kind of the exemplar is in the form of phrases like “is an animate” and “is a living thing”. They do, however, show differing patterns of generalizations when perceptual correlations, in the form of motion cues, are added. This result suggests that, although adults most likely understand what the word “animate” and what the phrase “living thing” mean, this may not be the kind of information that enters in generalizing a novel noun. It also suggests that reasoning about the implication of the ontological status of the exemplar is not the kind of process that primarily guides the extension of novel nouns. Instead, this result suggests that the knowledge that constrains novel noun generalizations is formed by learned correlations of perceptual features and category structure.

General Discussion

Put together, the results of the two experiments support the idea that automatic processes operating on learned correlations of perceptual information can guide word learning. The results of Experiment 1 showed that just listening to a list of words correlated with animates (or a list of words correlated with artifacts) is enough to shift children’s attention to the features that typically organize categories of animates (or artifacts). The fact that the lists of words -- without forming complete sentences, without referring to the exemplar, without even co-occurring with the exemplar -- can shift attention in kind-specific ways suggests an explanation to Booth and Waxman’s results that does not need to appeal to any form of deliberative reasoning on the part of the child. It could be, however, that when given complete sentences forming coherent stories, children do take advantage of that information and more deliberative processes that work on this more propositional information are invoked, but the results in Booth and Waxman (2002) and the results in Experiment 1 can be explained as simple priming, operating on previously learned associations. Further experiments are necessary to determine when this more “conceptual” knowledge is used in extending a novel noun.

Furthermore, the results of Experiment 2 suggest that what we think of as more “conceptual” knowledge may be, at the end, nothing more than a web of correlations, including perceptual features, words, category structure, contexts, and so on. The adults in this experiment failed to shift their attention when explicitly told that the exemplar was animate or artifact, but had no problem doing so when given further correlational support, like watching the to-be-construed-as-animate exemplar “walk” or used as a hammer. Clearly, adults do have highly abstract knowledge about animates and artifacts, and in a different task they might show this. For example, if the task were to make inferences about the exemplar, being told that it is to be construed as an animate might lead to more sound reasoning than watching it “slither”. However, it seems that when it comes to extending a novel noun, adults, like children, rely on automatic processes guided by learned correlations.

Conclusion

Extending a novel noun in ways consistent with the ontological kind of its referent is certainly a “smart” thing to do -- it allows word learning to proceed quickly and carves the world into useful partitions. However, this “smartness” may be the product of rather “dumb” processes such as associative learning and generalization by similarity. Through the application of these dumb mechanisms in a world that presents regularities we may create smart concepts.

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