

SHAPE BIAS SPECIAL SECTION

The shape of thought

Lori Markson,¹ Gil Diesendruck² and Paul Bloom³

1. Department of Psychology, University of California, Berkeley, USA

2. Department of Psychology and Gonda Brain Research Center, Bar-Ilan University, Israel

3. Department of Psychology, Yale University, USA

Abstract

When children learn the name of a novel object, they tend to extend that name to other objects similar in shape – a phenomenon referred to as the shape bias. Does the shape bias stem from learned associations between names and categories of objects, or does it derive from more general properties of children's understanding of language and the world? We argue here for the second alternative, presenting evidence that the shape bias emerges early in development, is not limited to names, and is intimately related to how children make sense of categories.

Introduction

Scholars interested in children's word learning have long observed that when children learn a new object name, they tend to generalize that name to other objects similar in shape (Brown, 1957; Macnamara, 1982). This has been dubbed 'the shape bias' (Landau, Smith & Jones, 1988), and it has been the focus of considerable recent attention, including the papers collected in this issue.

One prominent theory of the shape bias is that it is learned through an associationist learning mechanism (e.g. Landau *et al.*, 1988; Smith, Jones, Landau, Gershkoff-Stowe & Samuelson, 2002). By attending to recurrent patterns in the input, children come to learn that the linguistic context in which object names are commonly embedded corresponds to reference to similarly shaped objects. According to this 'attentional learning account', or ALA, a child will extend the word 'ball' on the basis of shape because she has learned that when people say 'This is a ball', they tend to point out things that are ball-shaped. The shape bias emerges once the child makes the second-order generalization that words in contexts such as 'This is a ___' are generalized on the basis of shape.

An alternative theory is that the relevance of shape emerges because children know that count nouns refer to object kinds, and they use shape as a cue to object kind (e.g. Bloom, 2000; Diesendruck, Markson & Bloom, 2003). According to this 'shape as cue' account, a child will extend the word 'ball' on the basis of shape because, (a) she knows that 'ball' is a count noun, and as such it refers to objects of the same kind, and (b) she knows that shape is a reliable cue to object kind. As Macnamara (1982, p. 139) put it, children appreciate that 'count nouns name things that have a characteristic form'.

Before contrasting these views, it is worth noting what they have in common. First, as with most theories of developmental psychology, they are both framed at a fairly abstract level. They make no specific claims about brain mechanisms. Second, both theories assume that children have powerful cognitive capacities prior to the emergence of the shape bias. In particular, both make the strong assumption that children already possess the capacity to figure out what new words refer to – they can somehow infer that the English word 'ball' is used to talk about balls. Third, they are both theories of learning and development. This is true in the obvious sense that they are about specific words, such as the English word 'ball', which even the most extreme nativist agrees have to be learned. Less trivially, there is evidence that children's use of object names changes in interesting ways in the course of development, and both theories attempt to explain this, albeit in different ways.

Finally, while there is always the temptation to declare victory on principled grounds, neither theory can be dismissed out of hand. An advocate of the ALA, for instance, should admit that it is *possible* that children generalize the word 'ball' on the basis of shape because they think 'ball' refers to balls and that balls tend to share the same shape. Similarly, an advocate of the shape-as-cue theory should admit that it is *possible* that children generalize the word 'ball' on the basis of shape because they have learned that this is how people use a certain type of word. The mechanisms that each theory posits – such as the capacity to form categories, or to learn from association – have independent support. Therefore the disagreement is not over what is possible – it is over what actually happens.

Address for correspondence: Lori Markson, Department of Psychology, University of California, 3210 Tolman Hall, MC 1650, Berkeley, CA 94720, USA; e-mail: markson@berkeley.edu

When, why, and how is shape important?

The shape-as-cue view posits that children understand that count nouns refer to conceptual kinds or categories of objects, and that shape is an available, salient, and reliable cue to the kind of thing an object is (Bloom, 2000). Three predictions follow from this. First, sensitivity to shape should emerge prior to language learning. Second, shape should be taken as relevant even in non-linguistic contexts. After all, there is nothing intrinsically special about count nouns under this account; they are generalized on the basis of shape only because they tend to refer to object categories. And third, the shape bias should go away in those instances when shape is not a good cue to kind membership. In each case, the ALA – which views the shape bias as a fundamentally linguistic phenomenon, learned through exposure to adult speech – makes the opposite prediction.

Origins

A number of studies support the existence of a rudimentary notion of object kind in infancy. For example, 9- to 11-month-old infants make inductive generalizations on the basis of object kind (McDonough & Mandler, 1998). Furthermore, 7-month-old infants are influenced by shape in their inferences about object kind, generalizing to new instances on the basis of shape for specific categories of objects (Shutts, Markson & Spelke, 2003). Finally, in a classic experiment that was designed specifically to explore the role of linguistic experience in word generalization, Soja, Carey and Spelke (1991) found that before children had any understanding of the count–mass distinction, they generalized names for solid objects differently from names for non-solid substances. There are conceptual resources, then, that precede language.

To specifically investigate the role of shape, Graham, Diesendruck and Onysyk (2004) asked if 15-month-old infants rely on shape similarity in their generalizations of nonobvious object properties. Infants watched as an experimenter demonstrated that a novel object possessed a hidden property (e.g. it made a rattle noise when shaken). They were then presented with three test objects that matched the target object on shape, color, or texture, and were allowed to play freely with each of the objects while their actions on them were recorded. Importantly, in the experimental condition, the nonobvious property (e.g. noise) was disabled in the test objects, allowing a sensitive measure of infants' generalizations. Fifteen-month-old infants performed significantly more target actions on the shape match compared to the color and texture matches, suggesting that even at the earliest stages of word learning, children generalize nonobvious object properties on the basis of shape, even in a non-naming context.

To explore this issue further, a second study used an identical procedure with the exception that the target object and the three test objects were labeled with the

same label as the nonobvious property was modeled. Infants were then permitted to play freely with the test objects. If infants had somehow acquired a reflexive tendency to generalize labels on the basis of shape, they should again attempt more actions on the shape match. In contrast, the shape-as-cue view would predict an equal number of actions on all three kinds of test objects, because even though shape may be a good cue to object kind, sharing a common label is predicted to be an even better one. As predicted by the latter view, infants performed an equal number of target actions on the three different test objects, demonstrating no bias for the shape match.

Specificity

Is the role of shape limited to naming for older children? Proponents of the ALA have argued that the shape bias is primarily initiated in the context of language, particularly when children are exposed to a new word (e.g. Landau *et al.*, 1988), while the shape-as-cue view posits that shape is relevant to categorization more generally.

This was explored in Diesendruck and Bloom (2003). In various modifications of the standard lexical extension task, 2- and 3-year-old children selected a shape match (over a color or texture match) when asked to extend a new word to a novel object. But they also selected a shape match when asked to find another object that was the same kind of thing or shared a particular property. In other words, both name and kind fostered a shape bias in young children. Importantly, when children were simply asked to choose the test object that 'goes with' the target object, no shape bias was present. Thus, by 2 years of age, children view shape as a reliable cue to object kind, and not to any grouping of objects.

Malleability

The shape-as-cue account posits that shape gets its importance because of its perceived relevance to categorization. But in certain contexts, other cues might be more powerful. As such, the shape bias can be overridden, for both children and adults, by information either indicating that shape is less relevant for determining category membership and/or that there is another, more reliable, cue that can be used.

This has often been tested in the domain of artifacts (e.g. Bloom & Markson, 1998; Gelman & Bloom, 2000; Gelman & Ebeling, 1998). In one study, 3-year-old children were provided with information about a set of objects that made it sensible for two objects to share the same shape without being members of the same category (Diesendruck *et al.*, 2003). More specifically, children were shown a standard object that was given a novel label, and then asked which of two test objects – one that matched the target only in shape, and another that matched the target in color and texture – has the same name. In one condition, children were told that one of

the objects served as a container for the other object; in the other condition, the same objects were shown but this information was not given. As predicted, children extended the name to the shape-match in the control condition, but not in the container condition. As real-world examples of the same phenomenon, consider that a glove is the same shape as a hand, and that a violin case is the same shape as a violin – but nobody would call a glove ‘a hand’, or a violin case ‘a violin’. This is because for these sorts of cases, sameness of shape has another explanation, one that does not involve sameness of kind.

What is relevant for artifacts, for both children and adults, is the understood intention underlying an artifact’s creation – typically its intended function (Bloom, 2000, 2004). This hypothesis was explored in a set of earlier studies that pitted function against shape – and found that function lost; preschool children generally would ignore function in favor of shape when generalizing a word (Landau *et al.*, 1988; Smith, Jones & Landau, 1996). This would seem to favor the ALA, as it suggests that children’s naming reflects observed patterns in the input, not deeper intuitions about the nature of categories. More recent studies, however, discovered that when the objects and their corresponding functions were complex and unique – suggesting that they were designed specifically to fulfill that particular function – young children readily abandoned shape in favor of function in their naming practices (Kemler Nelson, 1995; Kemler Nelson, Frankenfield, Morris & Blair, 2000; Kemler Nelson, Russell, Duke & Jones, 2000).

Indeed, by 18 months of age, infants are sensitive to the presence of subtle cues to object function. This was shown in a study in which infants watched as the function of a novel, opaque object was demonstrated (e.g. scooping) (Christie, Markson & Spelke, 2005). The training object was then removed from infants’ view, and replaced with two test objects similar in appearance (e.g. shape), but transparent, allowing the internal, nonobvious structural components of the objects to be viewed by infants. One of the two objects (the target) possessed the structure necessary for the object to perform the previously demonstrated function (e.g. an internal shelf to support – similar to the bottom of a cup – scooped-up objects). The other object (the distracter) lacked the necessary structure (e.g. no shelf or bottom, but rather, a hollow tube). Infants were encouraged to select one of the test objects to perform the function. Infants selected the target object – the one with the appropriate functional structure – and performed more target actions on the target compared to the distracter. Importantly, in a control condition in which the object’s function was never demonstrated, infants tended to select randomly between the two test objects. Thus, 18-month-old infants are sensitive to kind information – in the form of nonobvious perceptual properties – that are essential to function.

The influence of conceptual information extends beyond children’s intuitions about creator’s intent. For instance,

knowledge of the causal properties of an object can override shape in young children’s categorizations and inductive inferences (Gopnik & Sobel, 2000). There is also compelling evidence to suggest that the ontological domain of an object influences children’s naming generalizations (Booth & Waxman, 2002; Keil, 1994). In this vein, a recent study presented 2-year-old children with novel objects paired with novel entities that were described as being either animate kinds or artifacts (Booth, Waxman & Huang, 2005). Two-year-old children extended the novel words primarily by shape (over texture and size) when the objects were described as artifacts, but did so on the basis of both shape and texture when the objects were described as animals. This provides a striking demonstration of how a child’s higher-level construal of an object can affect how it is named.

Along the same lines, Cimpian and Markman (2005) suggest that shape *per se* plays a limited role in children’s word generalizations. Across several experiments, they find that the shape bias is eliminated when objects are complex, when they are presented in context, and when children are not presented with a forced-choice decision. They agree (as does everyone else) that shape matters, but interpret their findings as demonstrating that it matters as a cue to category membership that is often overridden in many real-world contexts: ‘From very early on, then, children expect that words map onto kinds whose members share more than appearance’ (p. 1018).

Experience and development

Smith *et al.* (2002) and Samuelson (2002) describe longitudinal training studies in which children in their second year of life are taught names for categories organized by shape. This training was found to affect children’s subsequent word use patterns when they were later tested with novel stimuli. Most impressive is a corollary finding that children’s vocabulary development outside the laboratory showed a marked increase.

This is a dramatic finding, with potential practical relevance. But it provides no direct support for the ALA. As a general point of logic, showing that a certain experience can improve a child’s ability does not show that this experience is why the ability exists in the first place. If one finds that training with flashcards improves children’s multiplication skills, it would not follow that the proper theory of how children learn to multiply must involve flash cards. More specifically, the Samuelson and Smith *et al.* interventions could not have *created* a shape bias, given that there is independent evidence (reviewed above) that children of this age already tend to generalize on the basis of shape. At best, then, these training procedures succeeded in strengthening a tendency that is already in place.

From the perspective of Samuelson (2002) and Smith *et al.* (2002), this tendency was formed through associative learning, and the training helped the process along by

giving children ever more associative learning. But a different interpretation, equally consistent with their data, is that this tendency exists because of children's linguistic and conceptual knowledge – that is, their understanding that count nouns refer to object kinds – and the training helped reinforce this understanding. In fact, it is unclear why the development of a shape bias would lead to an increase in a child's *general* vocabulary. A more compatible explanation for the observed acceleration in children's vocabularies is that training reinforced their understanding that count nouns refer to object kinds. This alternative predicts that children trained on novel categories organized by shape would generalize not only on the basis of shape, but also perhaps on other aspects of objects indicative of category membership, such as function – if such exemplars were available. The ALA, in contrast, would predict children's generalizations to be restricted to shape.

Training studies *could* be relevant to adjudicating between different theories of the shape bias. What one would need to do, though, is to train children on something that would not reinforce what they already know. As an example, imagine giving children extensive laboratory experience where object names are structured on the basis of category-*irrelevant* features. For instance, objects could get one name when they are on the table and another name when they are on the floor. By the logic of the ALA, this would be an unethical study, because, just as repeated object naming on the basis of shape should improve children's word learning outside of the laboratory, repeated object naming on the basis of some other property should impair it. We suspect, however, that children would be unharmed. They would treat this unnatural use of words as an unusual game, one that has no bearing on real-world naming and generalization.

Concluding remarks

Earlier in this paper, we described the debate between these two conceptions of the shape bias as an empirical one, to be settled by the data. But perhaps not everyone would agree with this. In a recent response to two sets of studies that we have described above – Booth *et al.* (2005) and Cimpian and Markman (2005) – Smith and Samuelson (2006) argue that, contrary to what those researchers assumed, their results are actually fully compatible with the ALA. Smith and Samuelson conclude that the current debate is 'so unclear' that researchers can conduct virtually the same experiments and get the same results, but disagree as to whether the results support the ALA or challenge it. They suggest that what is *really* at issue here is a larger theoretical debate over the very nature of cognition, between those who believe that there is a distinction between perception, cognition, and action, and those, like Smith and Samuelson, who hold that 'knowledge is *embedded* in, *distributed* across, and *inseparable* from the real-time processes of perceiving, remembering,

attending, and acting . . .' (p. 1342). If this is what we are disagreeing about, then a few laboratory experiments are not going to settle the issue.

We see things differently, however. The associationist explanation of the shape bias proposed by Landau *et al.* (1988) offered an elegant explanation of children's naming, it made strong and interesting predictions, and motivated considerable empirical and theoretical progress. But if there is now no consensus as to how to test the current version of their theory – the ALA – this should be a cause for concern. It would suggest that the ALA has become so flexible and powerful that it has lost its value as psychological explanation – and hence fails to provide support for Smith and Samuelson's more general theory of embodied cognition.

To sum up, we have suggested here that the shape bias is not an autonomous aspect of cognition. It is not learned and understood as an arbitrary fact about the world, separable from everything else children know about language and objects. Instead, it is a by-product – it emerges from the interaction of other capacities that children possess, some having to do with language (such as their understanding that count nouns refer to object kinds), some having to do with categorization (such as their understanding that shape is often intimately related to object kind). From this perspective, it is hardly an accident that the English words 'ball' and 'tiger' tend to refer to things that are ball-shaped or tiger-shaped, nor is it an amazing coincidence that the same words in other languages work the same way. Rather, the shape bias falls out from more general facts about how language works and how humans make sense of the world.

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