COGNITION

Cognition 84 (2002) B11–B22

www.elsevier.com/locate/cognit

Brief article

Word learning is 'smart': evidence that conceptual information affects preschoolers' extension of novel words

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Received 19 September 2001; received in revised form 6 February 2002; accepted 20 February 2002

Abstract

Two experiments document that conceptual knowledge influences 3-year-olds' extension of novel words. In Experiment 1, when objects were described as having conceptual properties typical of artifacts, children extended novel labels for these objects on the basis of shape alone. When the very same objects were described as having conceptual properties typical of animate kinds, children extended novel labels for these objects on the basis of both shape and texture. Moreover, providing a salient perceptual cue (Experiment 2) did not interfere with children's reliance on conceptual information in extending novel words: when an object with eyes was labeled with a novel word in the context of a story describing the object as an artifact, children extended the label on the basis of shape alone (i.e. as though the object were an artifact). These results, which challenge directly the position that 'dumb attentional mechanisms' can account for word learning, stand as evidence for the central role of conceptual information in mapping words to meaning. © 2002 Elsevier Science B.V. All rights reserved.

Keywords: Language acquisition; Word learning; Concept development

1. Introduction

A central question in current discussions of early word learning is the degree to which the process is guided by conceptual knowledge or by the automatic activation of perceptually based associations (e.g. Gelman & Medin, 1993; Kemler Nelson, 1999; Mandler, 1993; Mervis, Johnson, & Scott, 1993). In support of the latter position, Linda Smith and her colleagues (e.g. Jones & Smith, 1993; Jones, Smith, & Landau, 1991; Smith, 1995, 1999; Smith, Jones, & Landau, 1996) have proposed that word learning is the result of a

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PII: S0010-0277(02)00015-X

"dumb attentional mechanism" (DAM) whereby young learners detect correlations between perceptual properties of objects and kinds of words. On this view, because early vocabularies are dominated by count nouns referring to shape-based categories, children first learn to link words with shape (Samuelson & Smith, 1999). The resulting 'shape-bias' leads children to extend novel nouns to objects that share the same shape (but not necessarily other properties) with a labeled target object, but not to objects that differ in shape (although they may share other properties with the target) (e.g. Graham & Poulin-Dubois, 1999; Landau, Smith, & Jones, 1988).

Proponents of the DAM account (Jones et al., 1991; Samuelson & Smith, 1999, 2000; Smith, 1995, 1999) have asserted that once children notice more specific correlations between words, perceptual features, and the importance of other perceptual dimensions, they begin to systematically vary their extension of novel words on the basis of those perceptual features. For example, if a solid object with the perceptual feature 'eyes' is labeled with a novel noun, 3-year-old children extend that word to other objects that share both shape *and texture* with the named object (Jones et al., 1991). In contrast, when the same object is presented without eyes, only the 'shape-bias' is triggered in naming. That is, children extend the word to all objects that share the shape of with the named object, regardless of texture. Implicit in the DAM account is the assumption that these perceptually based associations are evoked automatically and directly in the context of word learning, without appealing to any conceptual knowledge (in this case, the concept of animacy).

Although it is well documented that perceptual information plays an important role in word learning (e.g. Goldstone & Barsalou, 1998; Graham & Poulin-Dubois, 1999; Jones & Smith, 1993; Kemler Nelson, Frankenfield, Morris, & Blair, 2000; Mervis et al., 1993), and that it can, under certain conditions, overshadow conceptual information (Gentner, 1978; Landau, Smith, & Jones, 1998; Tomikawa & Dodd, 1980), an accumulation of evidence suggests that the DAM view may not provide a sufficient or accurate account of word learning (e.g. Becker & Ward, 1991; Booth & Waxman, 2001; Gelman & Coley, 1991; Gelman & Markman, 1987; Keil, 1994b; Kemler Nelson, 1995, 1999; Kemler Nelson, Frankenfield et al., 2000; Kemler Nelson, Russell, Duke, & Jones, 2000; Landau, 1994; Ward, Becker, Hass, & Vela, 1991). For example, Kemler Nelson and her colleagues (Kemler Nelson, 1995, 1999; Kemler Nelson, Frankenfield et al., 2000; Kemler Nelson, Russell et al., 2000) have shown that conceptual information (in the form of object functions) guides word extension in young children. After a novel target object performing a novel function was labeled with a novel word, 2-year-olds more often extended the word to objects that maintained features critical to the demonstrated function (even if they globally looked dissimilar to the target) than to objects that did not maintain these features (even if they globally looked similar to the target) (Kemler Nelson, Russell et al., 2000). Bloom, Markson, and Diesendruck (as reported in Bloom, 2000, p. 165) also demonstrated the influence of conceptual information (in the form of intended function) on preschoolers' word extension. When a nonsense object was labeled for 4-year-olds, a shape-bias emerged. However, if prior to testing, the nonsense object was removed from a form-fitting box, children exhibited no shape-bias, extending the novel word to the object, but not to its box. The fact that children appreciated that objects with the same shape could be different 'kinds of things' suggests that the effect of perception on word learning is not direct. On Bloom's account, shape is important, not because attention to it is automatically triggered by the presence of a new word, but because shape usually reflects the intentional design of the creator. It is this conceptual information, not shape, per se, that determines category membership.

Keil (1994b) has also argued that word learning cannot be wholly attributed to perceptual processes that exert their influence directly. In his view, "…a [shape] bias might exist, but its origins may not be simply in the form of a perceptual rule, but rather in terms of what sorts of properties are more central to understanding different sorts of kinds" (p. 185). In other words, shape becomes an important indicator of category membership for children, not by virtue of a direct correlation with categories, but because it is causally related to deeper conceptual qualities of objects from a broad range of ontological categories. For example, shape is intimately tied both to the functions of artifacts and to the behaviors in which animate objects can engage. Only for non-living natural kinds (e.g. rocks) is shape not clearly tied to deeper conceptual properties. Keil (1994b) reported preliminary evidence suggesting that the ontological domain of a labeled object influences preschoolers' extension of the novel word (see also Becker & Ward, 1991; Landau, 1994; Ward et al., 1991). For example, when a target object was described as a *kind of animal*, children extended the novel label on the basis of shape. Yet when the *same* object was described as a *kind of rock*, children accepted wide variations in shape, extending the label on the basis of color and texture instead. This suggests that in learning new words, children weight various perceptible dimensions (shape, color, texture) differently, depending upon conceptual information.[1]

This is a critical point. If providing conceptual information regarding the ontological kind of an object, in the absence of any distinguishing perceptual cues, can result in distinct patterns of novel word extension, a 'dumb attentional' account becomes less tenable. Rather than automatically triggering attention to other perceptual dimensions (shape and texture), eyes may provide a gateway through which children access existing conceptual knowledge regarding the ontological domain of the named object, and the dimensions that are central to that kind.

The current work was designed to provide a strong test of preschoolers' use of conceptual information regarding ontological kind in extending novel words. We examine the influence of conceptual information on word learning first in the absence of distinguishing perceptual information (Experiment 1) and then in the presence of conflicting perceptual information (Experiment 2).

2. Experiment 1

In this experiment we assess children's extension of novel words as a function of conceptual information about a labeled object's ontological kind. All children are presented with exactly the same target objects, labeled with the same novel nouns. Condi-

[1] Unfortunately, in the few details that Keil (1994b) provides regarding his study, he suggests that domain information was provided to the children in the form of familiar names (e.g. 'frog' or 'rock'). This design feature limits the conclusions that can be reached from the results. Under these circumstances, it could be argued that children are automatically attending to features that they had previously associated with the familiar words.

tions differ only in the manner in which target objects are described in a vignette. For half of the children, each object is described as an animate kind, while for the remaining half, it is described as an artifact.

If children's word extensions are guided by automatic, purely perceptual mechanisms, then the conceptual information provided in these vignettes should have no effect. Because the objects do not have eyes, or any other distinctive perceptual cues associated with the importance of particular dimensions, they should activate a default shape-bias, leading children in both the Animate and Artifact conditions to extend novel words on the basis of shape alone. Alternatively, if we are correct in proposing that children's word extension is guided by conceptual knowledge, then the vignettes should influence performance. Children who hear the objects described as artifacts should extend words on the basis of shape alone (replicating the 'no eyes' condition of Jones et al., 1991). In contrast, children who hear the objects described as animate kinds should extend words on the basis of both shape and texture (replicating the 'eyes' condition of that study). If this is the case, then children in both the Animate and Artifact conditions should extend words on the basis of shape and should fail to extend words on the basis of size. Importantly, children in the two conditions should differ in their texture-based extensions: those in the Animate condition should be more likely than those in the Artifact condition to extend words on the basis of texture.

2.1. Methods

2.1.1. Participants

Twenty-four 3-year-olds (13 females) with a mean age of 43.09 months (range: 39.24–44.84 months) participated. All attended preschools serving middle- to upper-class suburbs of Chicago, IL and were acquiring English as their native language. Three additional children participated, but were replaced because they failed to consistently extend a novel word to the identity match. Because of the simplicity of this test, failing to extend on even a single identity trial was taken as evidence that the child either did not understand the task or was not paying attention.

2.1.2. Materials

The stimuli consisted of two sets of five abstract objects modeled closely after those described in Jones et al. (1991). Each set included two identical copies of a target wooden object and three distracters, each of which differed from the target on a single dimension. See Fig. 1 for 'shape-change' distracters. The 'size-change' distracter was four times larger than the target for the Dax set and five times larger for the Riff set. The 'texture-change' distracter was made of sponge for the Dax set and was covered with bubble-wrap for the Riff set.

Four vignettes (see Table 1) conveyed conceptual information about object kind. For each target object, one vignette conveyed animate information, and another conveyed artifact information.

2.1.3. Procedure

Children were tested individually in their preschools. They were randomly assigned to

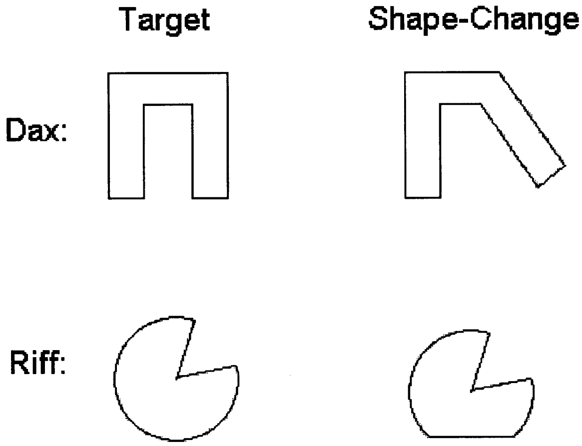

Fig. 1. Target objects with their associated shape-change test object.

either an Animate or Artifact condition. The experimenter presented the same objects to all participants throughout the 10 min procedure.

2.1.3.1. Training phase The Experimenter presented the Dax target along with a vignette (Table 1). The assignment of vignettes to targets was counterbalanced. The experimenter interjected questions to maintain the child's engagement. Children were praised for correct answers. Children who did not respond, said 'I don't know', or provided an incorrect answer were reminded of the correct information.

2.1.3.2. Test phase With the target object visible, the experimenter began by saying 'Now I am going to show you some other things. Each one might be a Dax or it might not be a Dax. I need you to tell me if you think each one is a Dax or is not a Dax, ok? Do you think you can do that?'

2.1.3.2.1. Extension to the identity match The experimenter presented the exact duplicate of the target and asked 'Is this another Dax?' The identity match was then removed from view.

2.1.3.2.2. Extension to the distracters The experimenter then presented, in random order, each of the distracter objects in turn, asking 'Is this another Dax?'

Extension tests were then repeated in the same order beginning with the experimenter saying 'Now, just so I have got it right, lets try this one more time.' She then provided a one-sentence summary reminder of the story. After the child completed all eight test-trials for the Dax set, the procedure was repeated with the Riff set, using the 'riff' label and the appropriate vignette.

2.1.4. Results

ANOVAs on the proportion of test objects accepted revealed a main effect of dimension-change in both the Artifact ($F(2, 10) = 8.85$, $P < 0.01$) and Animate ($F(2, 10) = 11.32$, $P < 0.01$) conditions (Fig. 2). However, post-hoc comparisons

Table 1
Vignettes presented along with the target objects

Animate:	
A.	Wow, look at this Dax/Riff! You know what? I have something very special to tell you about this Dax/Riff. Do you want to hear it? Listen carefully now because I am going to ask you some questions about what I say. This Dax/Riff has a mommy and a daddy who love it very much. So who loves this Dax/Riff very much? That's right – and they love it so much that when this Dax/Riff goes to sleep at night, they give it lots of hugs and kisses. Ok, so when the Dax/Riff goes to sleep, its mommy and daddy give it lots of what?
B.	Wow, look at this Riff/Dax! You know what? I have something very special to tell you about this Riff/Dax. Do you want to hear it? Listen carefully now because I am going to ask you some questions about what I say. This Riff/Dax is usually very hungry. One day when it was walking through the forest, this Riff/Dax found 6 candy bars. Can you believe that!? So where was this Riff/Dax walking when it found the candy bars? That's right! And it was so happy when it found them that it jumped up and down and gobbled up all the chocolate. Ok, so what did the Riff/Dax do when it found the candy?
Artifact:	
A.	Wow, Look at this Dax/Riff! You know what? I have something very special to tell you about this Dax/Riff. Do you want to hear it? Listen carefully now because I am going to ask you some questions about what I say. This Dax/Riff was made by an astronaut to do a very special job on her spaceship. Now who made this Dax/Riff? That's right, and the astronaut always takes her Dax/Riff with her when she flies to the moon. Ok, so where does the astronaut always take her Dax/Riff?
B.	Wow, look at this Riff/Dax! You know what? I have something very special to tell you about this Riff/Dax. Do you want to hear it? Listen carefully now because I am going to ask you some questions about what I say. Danny usually keeps this Riff/Dax in his basement. But one day Danny took it outside because he needed to use it to fix something. Now why did Danny take this Riff/Dax out of the basement? That's right, and when his Riff/Dax got worn out doing the job, Danny went to the store and bought a new one. Ok, so where did Danny go to buy a new Riff/Dax?

revealed different patterns of extension in the two conditions. As predicted, children in the Artifact condition accepted size-change ($M = 1.00$) and texture-change ($M = 0.92$) test objects more frequently than they accepted shape-change ($M = 0.48$) test objects (LSD $P < 0.05$). Children in the Animate condition accepted the size-change ($M = 0.98$) test objects more frequently than they accepted either shape- ($M = 0.40$) or texture-change ($M = 0.65$) test objects (LSD $P < 0.05$).

Further analyses confirm our prediction that the principle difference between the Animate and Artifact conditions was in children's responses to the texture-change stimuli. Children in the Artifact condition accepted texture-change test objects more frequently than did children in the Animate condition (one-tailed $t(22) = 1.89$, $P = 0.036$). Although our prediction licensed the use of a one-tailed test here, we sought to fortify our conclusions with an additional, perhaps more sensitive, analysis. We calculated the proportion of trials on which children consistently accepted the texture-change test objects (i.e.

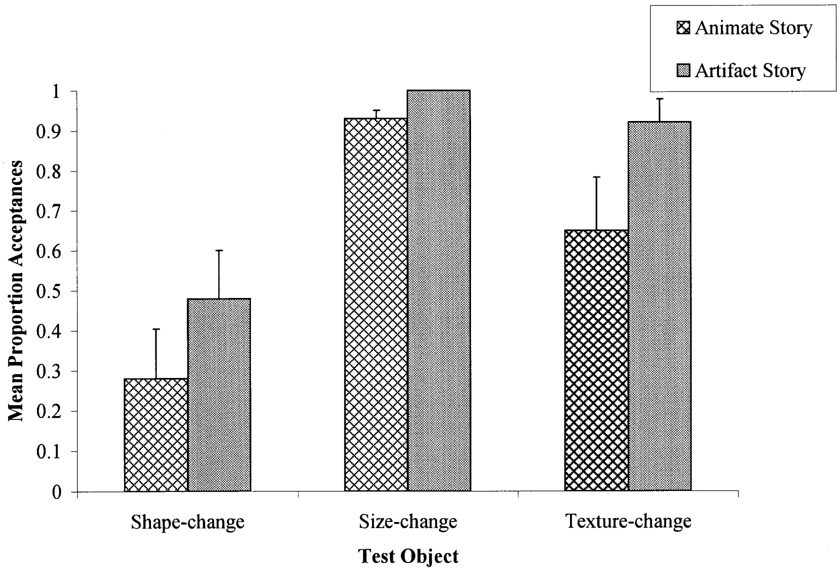

Fig. 2. Mean proportion of acceptances of each type of test object as an appropriate referent for the novel word in each condition of Experiment 1. Thatched bars represent data collected from children hearing Animate stories while solid bars represent data collected from children hearing Artifact stories.

instances of saying 'Yes' on both texture-change test objects for a particular target). As predicted, children were more likely to consistently accept the texture-change test objects in the Artifact (88%) than in the Animate condition (63%) ($\chi^2(1, N = 24) = 3.78$, $P < 0.05$).

2.1.5. Discussion

These results document the influence of conceptual information on word extension in young children. Three-year-olds extended novel words differently depending on the ontological kind of the object being labeled. Children in the Artifact condition extended the words based on shape alone, while those in the Animate condition extended the words based on both shape and texture. Because precisely the same objects were presented in both conditions, this effect cannot be explained by any theory that relies solely on attention to perceptual information in word learning. In the next experiment, we go on to examine the generalizability of this effect, asking whether conceptual information continues to influence children's word extension even in the presence of a clear perceptual cue (eyes) that 3-year-old children have already strongly associated with other perceptual dimensions (shape and texture).

3. Experiment 2

We address this question by presenting children with conflicting perceptual and concep-

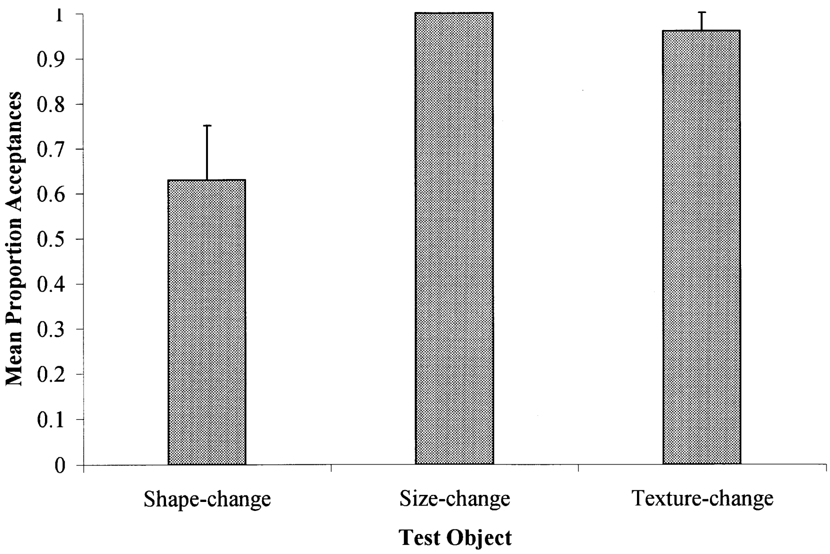

Fig. 3. Mean proportion of acceptances of each type of test object as an appropriate referent for the novel word in Experiment 2.

tual information. We added a strong perceptual cue to animacy (eyes) to each target object, yet provided strong conceptual information describing it as an artifact. If word extension is guided solely and automatically by perceptual information, then when children encounter a perceptual cue strongly associated with the importance of both shape and texture (eyes), they should extend novel labels on the basis of these dimensions. In contrast, if the influence of conceptual information endures, even in the presence of a strong perceptual cue to the contrary, then children should be less likely to be 'captured' by the eyes. Two alternative patterns of word extension are possible in this case. First, the conceptual information in the vignette may be sufficiently compelling to lead children to an extension pattern consistent with an artifact interpretation of the novel word (i.e. based on shape alone). Alternatively, children may become confused by the conflicting conceptual information, with eyes suggesting animacy and the vignette suggesting artifacthood. This confusion might yield an extension pattern intermediate between that expected for an animate and artifact interpretation.

3.1. Methods

3.1.1. Participants

Twelve 3-year-olds (four females) with a mean age of 41.86 months (range: 37.43–44.80 months) were recruited from middle-class families in the greater Chicago area. All were acquiring English as a native language. Two additional children were eliminated due to behavior extremely disruptive to testing. All children successfully extended the novel word on 'identical' test trials.

3.1.2. Materials and procedure

The stimuli and procedure were identical to those used in the Artifact condition of Experiment 1, except that plastic eyes were glued onto all objects.

3.1.3. Results and discussion

A one-way repeated measures ANOVA on the proportion of test objects of each type accepted as referents of the novel word (Fig. 3) revealed a main effect of dimension-change ($F(2,21) = 4.59$, $P < 0.05$). Children more frequently accepted size-change ($M = 1.00$) and texture-change ($M = 0.96$) than shape-change ($M = 0.63$) test objects (LSD $P < 0.05$). Furthermore, infants accepted texture-change test objects more frequently in the current experiment than in the Animate condition of Experiment 1 (one-tailed $t(22) = 2.25$, $P < 0.025$).

As in Experiment 1, this difference was confirmed by an analysis of consistent texture-change acceptances. Children demonstrated proportionately more consistent acceptances of the texture-change test objects in the current experiment (92%) than in the Animate condition of Experiment 1 (63%) ($\chi^2(1, N = 24) = 5.54$, $P < 0.05$). This pattern of extension mirrors the results observed in the Artifact condition of Experiment 1 despite the fact that the current stimuli had eyes.

4. General discussion

The current results demonstrate the power of conceptual information in young children's word extension. In Experiment 1, 3-year-olds extended novel words differently depending on whether the labeled object was described as having the conceptual properties of an artifact or an animal. Moreover, providing a salient perceptual cue did not alter this effect (Experiment 2). When objects with eyes were labeled in the context of a story describing the object as an artifact, children extended the label in a manner consistent with the vignette rather than the salient perceptual cue.

These results challenge two central tenets of the DAM account of early word learning. First, the current evidence challenges the notion that perceptual information alone contributes to the process (e.g. Jones et al., 1991; Smith, 1995, 1999; Smith et al., 1996). We have shown that conceptual information also permeates early word learning, even in the face of conflicting perceptual cues.

Second, our results challenge the view that perceptually based associations are automatically and directly activated in early word learning. In our view, perceptual cues are important because they can serve as gateways to conceptual information regarding ontological status. We suggest that eyes influenced performance in Jones et al. (1991) because eyes, like our vignettes, allowed access to conceptual knowledge regarding the object features and dimensions relevant to category membership within the animate domain (i.e. shape and texture) (Keil, 1991, 1994a). Because we did not assess or manipulate the relative salience of these two routes (perceptual and linguistic) to conceptual information, it is impossible to ascertain their relative power in guiding word learning. It may be that we differentially highlighted the conceptual information conveyed through our vignettes by calling attention to it socially (i.e. by asking questions about it). However, the fact that the information provided in our vignettes took precedence over that provided by the perceptual cues in Experiment 2 accords well with accumulating evidence documenting that young children readily distinguish between what an object looks like and what it truly is (e.g. Flavell, Flavell, & Green, 1983; Gelman & Coley, 1990, 1991; Keil, 1989; Mandler, 1993, 2000; Soja, Carey, & Spelke, 1991, 1992). Our results are consistent with the observation that even when an artifact (e.g. a toy stuffed dog) is designed to closely resemble an animate object (e.g. with eyes and a furry texture), 3-year-old children do not expect it to *behave* like an animate object.

Is there any way in which the DAM account can accommodate the current data? We are unable to anticipate how this would be possible without abandoning the account's core reliance on the automatic activation of purely perceptually based associations. For example, one might attempt to account for the current results by suggesting that different patterns of attention were automatically triggered by differences in the language used to talk about animates versus artifacts. However, because our animate and artifact vignettes were closely matched in terms of sentence lengths and structures, it is difficult to imagine what these differences might consist of without resorting to consideration of their semantic content. Alternatively, one might argue that perceptual information did automatically trigger patterns of attention in our word learning task, but that conceptual information influenced what perceptual information entered into the process in the first place (e.g. artifact vignette focuses attention on inanimate properties like rigidity and angularity of shape). In our view, however, this explanation ascribes a critical entry-point role for conceptual information that strikes at the heart of the DAM account.

In conclusion, we argue that preschoolers' behavior directly challenges 'dumb attentional' accounts of word learning that rely solely on the automatic activation of perceptually based associations. Instead, preschoolers' behavior is consistent with 'smart' mechanisms of word learning in which conceptual information figures importantly in accounting for this dramatic and uniquely human process.

Acknowledgements

This research was supported by NIH grant #HD-08595-02 to the first author and NIH grant #HD-28730 to the second author. We are grateful to the children and caretakers who participated in these studies. We are also indebted to Yi Ting Huang for her assistance with data collection.

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