A Conceptual Account of Children's Difficulties Extending Adjectives across Basic-Level Kinds

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Infants begin to link the grammatical form of a novel word with its meaning in the first years of life (Booth & Waxman 2009; Waxman & Booth 2001). By 14 months, infants have already begun to link nouns specifically to object categories. In contrast, infants maintain broader expectations for adjectives, linking them to both object categories (e.g., *dog*) and object properties (e.g., *fluffy*). This developmental cascade is also reflected in the child lexicon. Children's success in linking nouns to object categories may help to explain why nouns tend to dominate their early vocabularies, outnumbering adjectives by overwhelming margins (e.g., Bates et al. 1994; Gentner 1978).

One particular challenge in children's acquisition of adjectives is the breadth of adjectives' application. The same adjective (e.g., "red") can describe individuals from many different basic-level kinds. That is, "red" is as appropriately applied to cars as it is to houses, yet cars and houses are distinctly different kinds of objects, from different basic-level categories. However, children are often better at extending a new adjective to objects within the same basic-level category (e.g., learning "red" on a red car and extending it to another red car) than they are at extending that same adjective to objects from different basic-level categories (e.g., learning "red" on a red car and extending it to a red house) (Klibanoff & Waxman 1998). This within-category advantage in adjective extension has been documented as early as 21 months and persists well into the preschool years (Klibanoff & Waxman 1998; Klibanoff & Waxman 2000).

Nevertheless, between two and four years of age, most children successfully acquire a set of adjectives that apply across different object categories (Frank et al. in press). Clearly, then, preschool-age children are capable of extending adjectives across category boundaries, and indeed, developmental research has revealed several factors that promote this early learning. First, introducing a novel adjective on multiple exemplars drawn from different categories is beneficial

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(Klibanoff & Waxman 2000; Mintz & Gleitman 2002; Waxman & Klibanoff 2000). When children hear the same adjective applied across different basic-level kinds (e.g., hearing "red" applied to a red car, a red horse, and a red ball), they can then successfully extend the adjective to objects from a range of different basic-level kinds (e.g., to a red bird or a red chair). Second, providing contrast within a given basic-level category is also advantageous. When children hear a novel adjective applied to one member of a given basic-level category (e.g., a red car) but not to another (e.g., a blue car), they go on to successfully extend adjectives to different basic-level kinds (e.g., a red bird). Importantly, neither providing multiple positive examples *within* a kind (e.g., two red cars) nor contrasting examples *across* kinds (e.g., a red car, a blue horse) facilitates successful extension. This suggests that children may initially map the novel adjective to the exemplar's object kind, or a kind-based property (e.g., object shape, function, etc.). But when provided with additional informative exemplars, children can rule out such interpretations, correctly map the adjective to the property, and then extend the adjective broadly, across kinds.

Children also benefit when novel adjectives are introduced in the context of a lexically specific head noun (e.g., "Look at the red *car*") rather than an underspecified head noun (e.g., "Look at the red *thing*") (Mintz 2005; Mintz & Gleitman 2002). Because the specific noun refers to the exemplar's object kind, children can infer that the novel adjective must refer to another property, one that is distinct from the object kind.

Although both explicit labeling and exposure to multiple, instructive exemplars help children to solve the problem of adjective extension, it remains an open question why they do so. Perhaps all that is required is information that rules out an exemplar's object kind as a candidate meaning for the novel adjective. Once the object kind interpretation has been eliminated, children may stand a much better chance of identifying the correct property dimension. Crucially, both labeling and multiple exemplars provide this logical elimination of object kind as a candidate meaning. Moreover, this possibility is also consistent with evidence that preschool-aged children tend to favor object kind information over other object properties in word learning tasks (Hall, Waxman, & Hurwitz 1993; Markman & Wachtel 1988). This account makes a bold prediction: if children never considered an object kind interpretation of the adjective in the first place, then the obstacles to extending novel adjectives broadly would be removed.

Waxman (2002) tested this claim. She presented preschool children with precisely the *same set* of visual stimuli but manipulated their conceptual construal of those stimuli by describing them either as "pictures of things" or "blobs of stuff". She reasoned as follows: if children construed an exemplar as a non-object (a "blob"), then the exemplar's object kind should be unavailable as a candidate adjective meaning. This should enable children to extend novel adjectives broadly across kinds. Results supported the claim: although all children were presented with precisely the same visual and linguistic information, those in the "blobs of stuff" condition successfully extended adjectives both within and across basic-level categories while those in the "pictures of things" condition extended novel

adjectives successfully *within*, but not *across* categories. This outcome reveals the power of conceptual/semantic factors on children's interpretation and extension of novel adjectives.

This outcome, though compelling, has thus far been documented in only a single study. Therefore, in the current experiment, we sought converging evidence, building upon Waxman's (2002) original design but strengthening it in several ways. First, we designed a new set of stimuli, normed in the same manner as Waxman (2002). Second, we focused solely on the property of *color*. In Waxman (2002), children's difficulty extending novel adjectives across categories was especially pronounced when the referent property was color (as compared to texture), even in the "blob" condition. By focusing on color, then, we provided the most stringent test of the power of conceptual construal to benefit adjective learning. Third, we included a new control condition, assessing preschool-aged children's baseline performance in this task when no adjectives were used. Finally, we assessed, for the first time, whether children's success in extending adjectives changed as the task unfolded.

1. Experiment 1: Stimulus Norming

The goal was to design a set of "flexible images"—images that children could construe either as objects or as non-objects, depending on how we described them. Like Waxman (2002), we normed these images in two studies: one to establish that children would construe them as non-objects and the other to establish that children would *also* construe them as objects.

1.1. Experiment 1a

In the first norming study, we identified which of an initial set of flexible images children were willing to construe as non-objects (see, e.g., Figure 1, column 2). To do this, we juxtaposed these flexible images with images that clearly depicted familiar objects (e.g., Figure 1, column 1), asking children to identify which images were "pictures of things" and which were "blobs of stuff." If children could construe the flexible images as non-objects, we expected they would do so here.

Participants. Eighteen toddlers (M_{age} = 32 months, ranging from 25.6- 37.8 months, SD = 4.2 months; 11 females) were recruited from the Evanston/Chicago area. Another six toddlers were excluded either due to experimenter error (1) or because they failed to complete at least half of the trials (5).

Materials. We first created six "training images" to clarify the nature of the task. Three depicted irregular, amorphous splotches (Figure 1, column 3); these were designed to illustrate the concept of "blob of stuff". The other three were detailed silhouettes of familiar objects, designed to illustrate the concept of "pictures of things" (Figure 1, column 1).

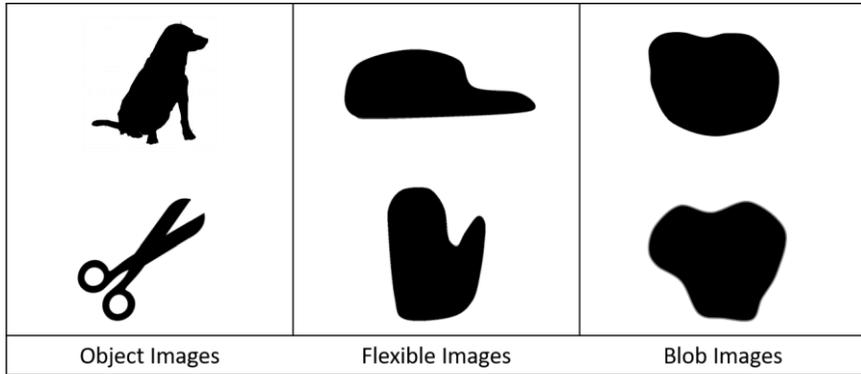| Object Images | Flexible Images | Blob Images |

Figure 1. Sample images from the three stimulus categories used in Experiment 1a. Object images were detailed silhouettes of familiar objects (e.g., dog, scissors). Flexible images were designed to be interpretable either as objects (e.g., baseball cap, mitten) or as blobs. Blob images were irregular, puddle-like splotches of a single color and did not resemble any familiar objects.

We also created 18 "flexible images", each of which was designed so that it could be construed as representing either a familiar object or a blob of stuff, akin to the shapes adults and children see in clouds (see Figure 1, column 2). Finally, we created an additional 18 detailed silhouettes of familiar objects. Each child viewed 18 flexible images and 18 object images.[1]

Procedure. Toddlers were tested individually in a lab playroom. To begin, the experimenter presented the six training stimuli, labeling each as either a "picture of thing" or a "blob of stuff," and then placing the blobs into one pile and the things into another. At this point, the experimenter invited children to help her sort the remaining cards. Each toddler viewed 36 cards (18 depicting familiar objects and 18 depicting flexible images), presented one at a time in random order. For each card, the experimenter asked whether it depicted a "blob of stuff" or a "picture of a thing." Children indicated their responses either verbally or by indicating the pile where it should be placed. If a toddler failed to respond for any given card, the experimenter provided a prompt. If the toddler still did not answer, the experimenter moved on to the next trial.[2]

Results. Children clearly understood their task and engaged in it readily. As expected, they almost uniformly identified the objects as objects

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[1] To expedite the norming process without lengthening the task, the flexible images were adapted on a rolling basis: after every 4 children, we removed and replaced any flexible stimulus which children sorted as an object more than 75% of the time. Ten candidate stimuli were removed and replaced in this way.

[2] Toddlers failed to respond on only 3.2% of flexible image trials and 4.9% of object images trials.

(M = 97.4%), but exhibited considerably more variability in sorting the flexible stimuli (M = 59.4% object-sorting). This suggests that, overall, children were sensitive to the ambiguity of these flexible images.

In accordance with our norming procedure, we identified 12 flexible images that a majority of children (≥ 50%) judged to be blobs (M = 58% blob-sorting). These stimuli, along with twelve of the familiar object stimuli, were then used in Experiment 1b.

1.2. Experiment 1b

To ensure that these flexible images could also be construed as objects, we recruited a new group of toddlers. The 12 flexible images selected in Experiment 1a were presented as part of a new naming task, in conjunction with twelve of the object stimuli from Experiment 1a. This time, however, toddlers were told that *all* images were "pictures of things" and were asked to name each image (e.g., "car"). This allowed us to determine a) whether toddlers could construe the 12 selected flexible stimuli as familiar objects, and b) which objects each image called to mind. The latter was an important control for Experiment 2, enabling us to ensure that none of our images could be interpreted as belonging to the same basic-level object category.

Participants. Twelve toddlers (M_{age} = 32.4 months, range: 28.6 – 36.2 months, SD = 2.67 months, 7 female) participated. Another two were excluded due to experimenter error (1) or failure to name any of the cards (1).

Materials. Each toddler viewed 24 stimulus cards, selected from Experiment 1a: 12 flexible stimuli (which had been classified as blobs by at least 50% of toddlers in Experiment 1a) and 12 of the familiar object stimuli (which had been almost uniformly classified as objects in Experiment 1a).

Procedure. The experimenter explained that she had a set of "pictures of things" and needed the child's help to figure out what they were pictures of. She then presented each card, sequentially in random order, asking the child to name it (e.g., "What do you think this is?"). Children's responses were recorded. If a child failed to name a card, the experimenter placed it at the bottom of her pile and presented it again later. If the child failed to name it the second time or denied at any point that it was a picture of an object, we recorded it as un-named.

Results. All 12 flexible images met the preset criterion of being identified as objects by at least 50% of children (M = 78%). Within the context of this task, children appeared quite willing to construe these images as pictures of familiar objects (e.g., cars, hammers, combs). In total, then, Experiments 1a and 1b yielded a total of 12 verified flexible images to be used in Experiment 2.

2. Experiment 2: Adjective Learning

Having successfully identified a set of stimuli that toddlers could construe flexibly, either as objects or non-objects, we went on to consider the question at hand: is toddlers' extension of novel adjectives influenced by their construal of

the exemplars we present? If toddlers' difficulties with adjective extension stem from a tendency to consider object kind as a likely candidate for adjective meanings, then children who construe the exemplars as objects (Object condition) should show the classic difficulty in extending the adjectives broadly, across categories. On the other hand, children who construe these same exemplars as non-objects (Blob condition) should succeed, accurately extending the adjectives to new exemplars with the matching color property. Finally, we included a Control condition, permitting us to assess toddlers' performance in the task when no adjective is mentioned and the exemplars' conceptual status is not manipulated. This condition is especially important in assessing how children's performance changes over time: any general practice effects resulting in improved performance over the course of the experiment should be evident here.

Participants. Fifty-one toddlers (M_{age} = 36.0 months, ranging from 29.2 - 42.1 months, SD = 3.6 months; 21 female) were recruited from the Evanston/Chicago area. All were native speakers of English. An additional 2 toddlers, who completed fewer than 8 of the 12 trials, were excluded.

Materials. For this experiment, we selected 14 images. Two were presented as training stimuli during the introduction phase (see Figure 2). These were selected from the training stimuli used in Experiment 1a, one illustrating a "blob of stuff" and the other illustrating a "picture of a thing." The remaining 12 images were the flexible images identified in Experiments 1a and 1b. These were presented at test. These images were organized to form 12 triads, each featuring a target exemplar and two test exemplars that differed in shape from the target but were identical to each other except in color. Each triad was presented in a book: the target image was displayed centered in the top half of the page with the two test images side-by-side in the bottom half. The target remained visible throughout each test trial. No triad featured a target-test stimulus pair which had been given the same object name in Experiment 1b.

Procedure. Children were tested individually in lab and assigned randomly to a condition. The experiment included two phases: an introduction and a test phase (see Figure 2). Throughout the experiment, children in all conditions saw precisely the same images. The only difference between conditions was in how the images were described; this varied systematically as a function of condition.

In the introduction phase, the experimenter presented a book and invited the child to read it with her. Before opening the book, she described its contents, referring back to the two training stimuli (see figure 2). Her description varied by condition. In the Object condition, she said that the book was "full of pictures of things"; in the Blob condition, she said it was "full of blobs of stuff." In the Control condition, no construal was offered: children were simply told the book was "full of pages."

Test trials immediately followed the introduction phase. All children completed 12 test trials, each of which involved three images—a target and two test images. These trials were presented in one of two random orders. In all test trials, the experimenter began by introducing the target. The way in which she described it, however, varied as a function of condition ("Look at this

blob/picture/page."). She then applied the novel adjective to the target in the Object and Blob conditions ("It's a *blickish* one!") but not in the Control condition. Finally, she revealed two new images, identical to one another except in color: only one matched the target image in color. In the Blob and Object conditions, the experimenter then asked, "Can you find another one that's *blickish*?" In the Control condition, she asked, "Can you find another one like it?" Children indicated their responses by pointing. The experimenter thanked children for their choices but offered no corrective feedback. If a child failed to make a choice (choosing neither image or both), the experimenter encouraged the child once again. If the child again failed to make a choice, the experimenter moved on.[3]

Condition	Introduction Phase	Test Phase (Sample Test Trial)
	Training exemplars: Blob exemplar Object exemplar	Target Color Match Color Mismatch
Blob	My book is full of **blobs of stuff**, like this one! Not pictures of things, like that one.	Target: Look at this blob! This is a [blickish] one! Test Exemplars: Can you find another one that's [blickish]?
Object	My book is full of **pictures of things**, like this one! Not blobs of stuff, like that one.	Target: Look at this picture! This is a [blickish] one! Test Exemplars: Can you find another one that's [blickish]?
Control	My book is full of **pages**, like this one! And like this one!	Target: Look at this page! Test Exemplars: Can you find another one like it?

Figure 2. Images used in training and in one representative test trial. After the introduction, each subject saw 12 test trials. In the Blob and Object conditions, children were asked to extend a novel adjective from the target (e.g., the 'mitten') to one of the test stimuli (e.g., the 'combs').

Model Fitting. Our analyses are based on maximal-likelihood linear mixed-effects binomial models because unlike traditional ANOVAs, they a) limit

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[3] Skipped trials were extremely rare: across all 51 children, only 7 trials were skipped.

spurious interactions and b) conform to the binomial nature of our data—children selected either the color-matched (correct) or the mismatched (incorrect) target stimulus on each trial (Jaeger 2008). To evaluate the impact of individual factors, we compared models with and without each factor using -2 log-likelihood ratio tests (Baayen, Davidson, & Bates 2008). Participants' and items' estimated intercepts were entered as random effects; all other factors were entered as fixed effects. Traditional ANOVAs yielded the same results.

Results. We calculated, for each child, the proportion of trials on which they correctly selected the color-matched test image. As predicted, children more often selected the correct image in the Blob condition (M = 90%) than either the Object (M = 76%) or Control (M = 70%) conditions. See Figure 3.
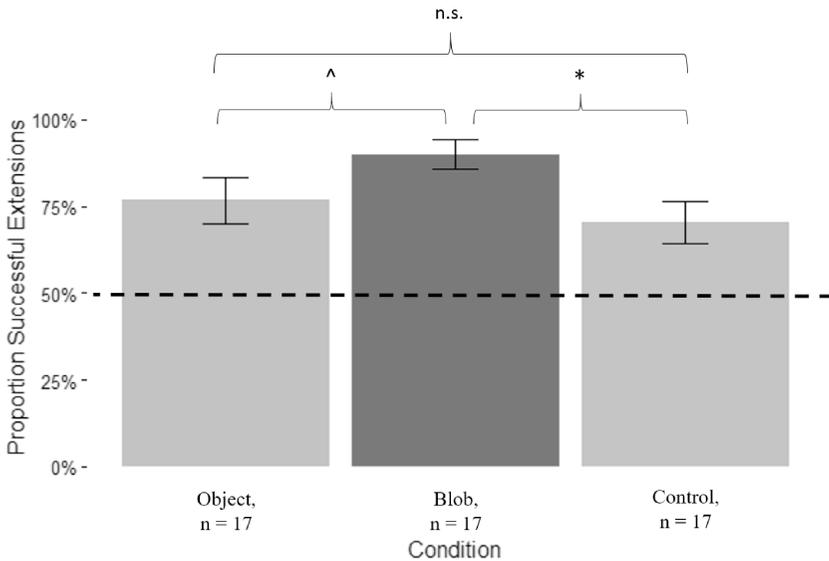

Figure 3. Proportion of trials on which children successfully selected the color-matched test image in each condition. Children in the Blob condition outperformed those in the Control condition, $p < .05$, and the Object condition, $p = .068$. There was no difference in the Object and Control conditions, $p > .3$. Error bars represent ± 1 SEM.

Preliminary analyses excluded the fixed effect of stimulus order, $p > .5$, and the random effect of item, $p > .3$. We then constructed a model including condition, age, and sex as fixed effects with individual participant intercepts estimated as a random effect.

This analysis revealed the predicted effect of condition, $X^2(2) = 8.55$, $p = .014$, but no effect of sex or age, $ps \geq .3$. Planned comparisons indicated that, as predicted, children in the Blob condition were more likely than those in the Control condition, $X^2(1) = 8.51$, $p = .004$, to correctly select the color-matched

test image. They were also marginally more likely to do so than those in the Object condition, $X^2(1) = 3.33$, $p = .068$. No effects of age or sex reached significance, ps > .10. These results suggest that when toddlers construed the images as non-objects, they more successfully extended novel adjectives to the correct test exemplars.

In addition to analyzing toddlers' accuracy aggregated across all 12 test trials, we examined whether and how their performance changed over the course of the experiment (see Figure 4). More specifically, we compared children's first two and last two trials. To assess changes in performance, we included trial block as a factor in a new binomial model. Results revealed a significant interaction between condition and trial block, $X^2(2) = 8.44$, $p < .05$, suggesting that children's learning patterns over the course of the experiment varied as a function of condition.
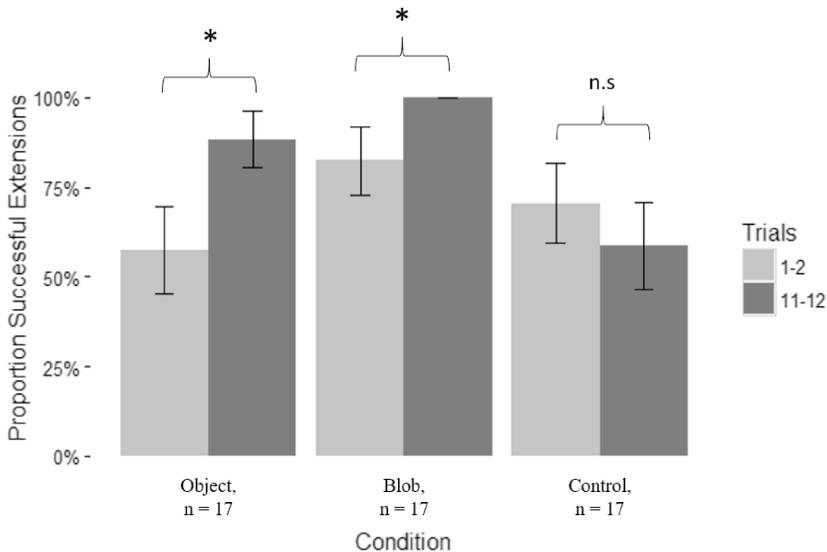

Figure 4. Proportion of trials on which children successfully extended the novel adjective to the color-matched test exemplar at the beginning of the task (Trials 1-2) and the end (Trials 11-12). Children in the Object and Blob conditions showed improvement over the experiment, $p \le .05$, while children in the Control condition did not. Error bars represent ± 1 SEM.

An analysis of the simple effect of trial block within each condition reveals clear differences across conditions. In the Blob condition, children were initially accurate (82.3% accuracy on the first two trials) and improved further over the course of the task, t(16) = 2.07, $p = .05$. Indeed, on the final two trials, these toddlers performed at ceiling, exactly 100% accuracy. In contrast, in the Object condition, children began at near-chance levels (57.5% accuracy in the first block), but showed impressive and significant improvement by the end of the task,

t(16) = 2.60, *p* = .002, finishing with 88.2% accuracy in their final block. This demonstrates for the first time that given practice extending other adjectives on the basis of exemplar color, children eventually become more accurate in extending novel color adjectives—even when they are applied to objects. Finally, in the Control condition, children's performance did not change significantly between trial blocks, t(16) = .78, *p* > .3: accuracy was 70.6% on the first two trials and 58.8% on the final two. Thus, although all children saw the same images, those learning adjectives (Blob and Object conditions) became increasingly accurate in their extensions as the experiment progressed while children who were asked only to "find another one" (Control condition) showed no such improvement.

3. General Discussion

This work provides new evidence of the power of conceptual status in adjective learning. Our findings converge with those of Waxman (2002), demonstrating that children are more successful in adjective extension when adjectives are applied to non-objects ("blobs") instead of objects. This suggests that children's apparent difficulty in extending adjectives across categories is not a function of the perceptual distance between exemplars but of the exemplars' conceptual status as members of distinct categories. Moreover, for children to successfully make these across-category extensions, eliminating object kind as a candidate adjective meaning appears to be a crucial step. In previous studies, providing multiple exemplars and explicit noun labels may have helped children to take this step (e.g., Mintz & Gleitman 2002; Waxman & Klibanoff 2000). Here, in the Blob condition, we more directly removed the object kind meaning from consideration by asking children to construe our exemplars as non-objects. As a result, children showed a robust and consistent ability to extend the novel adjectives broadly.

Our findings also provide the first examination of the time-course of children's adjective learning in an experimental context. This provides additional support for the claim that construing exemplars as non-objects facilitates adjective learning: even within the first two trials, children in the Blob condition successfully extended novel adjectives (82.3% accuracy), and by the end of the experiment, they were performing at ceiling (100% accuracy). This is especially remarkable because children made each extension from a single target, without the benefit of a lexicalized head noun. Under these conditions in prior work, excepting Waxman (2002), toddlers had always failed to extend adjectives broadly. Merely changing children's conceptual construal of the same exemplars is sufficient to immediately and substantially improve their performance.

However, our current results go further, suggesting that regardless of construal, children's ability to extend novel adjectives broadly improves with practice. Children in both the Blob and Object conditions showed significant improvement over the course of the experiment. How can we account for this improvement over time? To begin, these results are clearly not attributable to the

benefits of multiple exemplars for adjective learning: because children learned a new adjective on each trial, every adjective was demonstrated on only one exemplar. Nor is this pattern attributable to general task demands: children in the Control condition showed no evidence of change over the course of the experiment. Instead, the results suggest that children hearing novel adjectives in the context of a color-based decision task become increasingly willing to accept exemplar color as a plausible meaning for *subsequent* novel adjectives. This result is especially striking in the Object condition. While children initially struggled with the task, as in previous studies, they improved dramatically over time. Previous research did not assess children's performance over time and so may have underestimated children's ability to adapt their adjective learning strategies to the task at hand.

Open questions remain as to exactly why construing images as non-objects facilitates toddlers' broad extension of novel adjectives. The simplest explanation is that this manipulation helps children by convincing them that the exemplars do not belong to object kinds. This may disrupt children's focus on object-kind-based features, like shape, allowing other candidate meanings, like color, to be considered. However, it is also possible that interpreting an exemplar as a member of a *substance* kind actually re-orders children's semantic priorities, elevating color properties in the process. The current findings are compatible with either of these accounts; to tease them apart, future work might consider the implications of substance kinds for word learning with a variety of adjective types.

There are, however, several alternative accounts of these findings. Some have argued that children's difficulty extending adjectives broadly is the result of pragmatic flaws in the experiments. For example, the question "Can you find another one that is blickish?" may lead even adults to expect that the extension set will include exemplars of the same kind as the target (Hiramatsu, Rulf, & Epstein 2010). Although in principle this could yield excellent performance within kinds but poor performance across them—much like previous work has shown—our study reveals the limitations of this account. First and foremost, the pronominal "one" was given an antecedent here. Our questions were always of the form "Look at this blob/picture/page. It's a blickish one. Can you find another blickish one?" Thus, "one" referred back to a noun ("blob," "picture," or "page"), which should have reduced any pragmatic issues. This is especially true because *all* the exemplars in a given trial could be accurately described by that noun. Moreover, the pragmatics of the question are equivalent across conditions, so they cannot account for the conditions' differing levels of performance.

Additionally, these results cannot be explained in terms of previous findings demonstrating that "thing" provides inadequate support for adjective extension (Mintz 2005; Mintz & Gleitman 2002). Mintz (2005) argued that the category "thing" may fail to facilitate adjective learning because it lacks any defining features: it fails to eliminate any of the adjective's potential meanings. In our study, however, all of the nouns ("blob", "thing", and "page") meet this same criterion of failing to eliminate potential meanings. In particular, "thing" and "blob of stuff" are, essentially, two sides of the same coin: there's little reason to

suggest that one, but not the other, would help children rule out a large set of potential adjective meanings. Therefore, these results are quite distinct from findings contrasting "thing" with more informative nouns like "ball." The informative nouns facilitate adjective learning by matching up with already-identified candidate meanings (e.g., "round") and removing them from consideration as the adjective's meaning. The noun "blob," on the other hand, does not match up with any candidate meanings. Instead, it operates by changing the conceptual features that are *available* to, or prioritized by, the child when she is identifying candidate meanings for a novel adjective.

Children's successful extension of adjectives in the Blob condition, as well as in the final trials of the Object condition, demonstrates that by 36 months, children's difficulties with adjective extension are primarily conceptual, not perceptual. Children clearly can form property-adjective mappings and use them to extend adjectives accurately across kinds: they did so successfully throughout the task in the Blob condition. However, children struggled to make perceptually equivalent extensions when object kind information was available to them as a rival adjective meaning. All things being equal, then, 36-month-old children seem to accept object kinds as meanings for novel adjectives, much as they do in infancy. This striking developmental continuity is in line with a broader literature suggesting that a focus on objects and object kinds inhibits children's ability to identify the object features and relations present in a variety of learning scenarios (Ferry, Hespos, & Gentner 2015; Hoyos, Shao, & Gentner in progress; Loewenstein & Gentner 2005; Soja, Carey, & Spelke 1991; Soja 1994). Indeed, our work is consistent with the suggestion that the relatively slow integration of adjectives into the child lexicon is partially a result of children's difficulty in discarding object-kind-based meanings. Here, we demonstrate that construing an exemplar as a non-object has the power to counteract this difficulty and so facilitate children's adjective learning. Future research may reveal more of the cues that young children, even those younger than 48 months, use to learn and apply the growing number of adjectives in their lexicons.

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