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Young children show representational flexibility when interpreting drawings

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Acknowledgements: We wish to thanks the parents and children who participated in this work, which was supported in part by a British Academy grant to the first author. We also thank Professor Charlie Lewis for statistical advice.

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Abstract

Drawings can be ambiguous and represent more than one entity. In three experiments, we examine whether young children show representational flexibility by allowing one picture to be called by a second name. We also evaluate the hypothesis that children who are representationally flexible see the artist's intention as binding, rather than changeable. In Experiment 1, an artist declared what she intended to draw (e.g. a balloon) but then produced an ambiguous drawing. Children were asked whether the drawings could be interpreted differently (e.g. 'could this be a lollipop?) in the presence of a perceptually similar or dissimilar distractor (e.g., lollipop or snake). Six-year-olds accepted two labels for drawings in both conditions, but four-year-olds only did so in the dissimilar condition. Experiment 2 probed each possible interpretation more deeply by asking property questions (e.g., does it float?, does it taste good?). Preschoolers who understood that the ambiguous drawing could be given two interpretations nevertheless mostly endorsed only properties associated with the prior intent. Experiment 3 provided converging evidence that 4-year-olds were representationally flexible using a paradigm that did not rely upon modal questioning. Taken together, our results indicate that even 4 year olds understand that pictures may denote more than one referent, they still think of the symbol as consistent with the artist's original intention.

Keywords: pictures; drawings; intention; reference; flexibility

Young children show representational flexibility when interpreting drawings

The development of symbolic understanding is a crucial facet of human development (Deacon, 1997; DeLoache 2004). Visual symbols such as drawings can be understood in terms of the artist's attempt to communicate, represent, or express something. Under this interpretation, the artist's intent determines the referential content of the depiction (see Bloom, 2000). However, the contents of drawings are often ambiguous, as its elements are plurifunctional: a circle can represent a ball (sphere), cookie (disk), ring (loop) or even a hole (emptiness). Pictorial realism relies on the readiness with which a picture or drawing triggers recognition of contents (see Hopkins, 1998; Lopes, 1997; Sartwell, 1994; Schier, 1986). A mature understanding of pictures respects the artist's intent in creating the picture, while appreciating that a given drawing might be ambiguous, and could plausibly symbolize multiple referents. Children's understanding of pictures can therefore shed light on their emerging understanding of symbols and intention.

Children are sensitive to the artist's intent very early in development. Children as young as 30 months of age can spontaneously monitor an artist's gaze to infer referential intent. When taught a word for an ambiguous drawing ("this is a spoodle!") children mapped the novel word to the object the artist had intended to draw rather than a similarly shaped distractor that the drawing could also plausibly represent (Preissler & Bloom, 2008). They only did so during an intentional act of drawing, and not merely when associative cues were provided. Young children are also sensitive to how a picture was created when they are deciding how to name it; Gelman & Ebeling (1998) told 2-4 year old children that ambiguous pictures were either

created accidentally ("John spilled some paint on the floor") or intentionally ("John used some paint to make something for his teacher"). Children were more likely to name the intentionally produced creations (e.g. "man"), and showed a trend towards using material terms (e.g. "paint") to describe the accidentally produced ones, even though the pictures were identical. In addition, Bloom and Markson (1998) showed that 3- and 4-year-olds remembered which of their own drawings had been intended as a balloon and which a lollipop, even though the drawings themselves were compositionally identical (e.g. a simple circle and line). In their discussion, Bloom and Markson reported that children objected when the experimenter relabeled their picture, for instance calling the balloon a lollipop. It is possible that these children believed that pictures only refer to a single referent, but empirical investigation is required to confirm or deny this anecdotal report.

In contrast to findings prioritizing artist intention, Browne and Woolley (2001) found children instead sensitive to appearance when choosing a label for a drawing. In this study, the artist declared her intent ("I'm going to draw a bear") before making a drawing that looked more like a rabbit. Instead of using the artist's intent when naming the resultant picture, 4- and 7-year-olds relied on its appearance, calling the picture, for instance, a 'rabbit'. In this experiment, 4-year-olds did not seem to consider as binding what the artist himself said he was drawing (see also Richert & Lillard, 2002 for similar evidence).

The discrepant results of Bloom and Markson (1998) and Browne and Woolley (2001) open a field of new possibilities. Each pioneering experiment on its own is fine; it is in putting them together that explanatory puzzles arise, with important methodological differences. For instance, in one experiment the child draws, in the other the adult draws. A second difference

is that in one experiment there are two drawings (balloon, lollipop) that are perceptually similar, while in the other there is only one. It is conceivable then that a difference in the social variable of 'agency' coincides with a difference in the graphic variable of 'number of drawings' or, more likely, the type of comparison drawing (perceptually similar or not).

In Samuelson, Perry, & Warrington (2007), children were unable to remember the name of their similarly shaped drawings when they were asked to produce 6 pictures in the same colored crayon (e.g. balloon, lollipop, yoyo, spoon, and the numbers 6 and 9). A second study showed that when the number of drawings was reduced from 6 to 2 (as in Bloom & Markson's (1998) original task), children were successful at naming even when the drawings were produced using a single color crayon. The authors point out that some perceptual cues were still available, though, as adults could independently categorize the children's purportedly indistinguishable drawings into balloons and lollipops at a rate greater than chance. It is possible children used these perceptual distinctions to guide their labeling. In the current study, we use drawings produced by the experimenter to avoid such perceptual cuing, and thus focus more specifically on the role of intentions. However, it should be noted that both perceptual and conceptual information play a role in terms of children's categorization.

In order to explore how children view the relationship between intent and representation, we devised a new unified design to probe children's commitment to intent when interpreting drawings. Experiments 1 and 3 specifically investigate whether 4- and 6-year-old children are willing to attach more than one label to a drawing. The first experiment uses two conditions to compare and equate the methodological differences in prior empirical

work. Experiment 3 uses a game-like paradigm to confirm the results of Experiment 1, which was obtained using modal questioning.

If children are willing to accept more than one label for an ambiguous drawing, we term this *representational flexibility*. Flexibility has been studied in relation to the production of children's drawings (Picard & Vitner, 1999), and the ability to create imaginative entities such as a man who does not exist has been taken as evidence of conceptual flexibility and representational change (Karmiloff-Smith, 1990; 1992; Adi-Japha, Berberich-Artzi, & Libnawi, 2010; Berti & Freeman, 1997). However, little is known regarding how children perceive other people's depictions with respect to flexible interpretations. This is especially important because it taps children's broader understanding of pictures and intentionality (see DeLoache, 2004; Allen, 2009), rather than just those they construct.

If children show representational flexibility, this may change conceptually how they think about a picture. We probe this second question in Experiment 2, where we ask children properties about each potential referent. One hypothesis is that the symbolic status of the picture actually changes; if, for example, a drawing of a balloon *could be* a lollipop, it is possible that the viewer now thinks of the picture as a lollipop, and only a lollipop. We term this 'changeable status'. An alternative possibility is that although the viewer acknowledges that the picture may represent something else (e.g. a drawing of a balloon could plausibly represent a lollipop), it is in fact bound to the original referent (e.g. it is still really a balloon). We refer to this possibility as 'bound status'. In both cases, the referential content is linked to artist intention, but the viewer weights this intention differently.

As adults, we understand that declared intent might become effective, ineffectual, abandoned or altered. Our research investigates the degree to which preschoolers take an individual's statement of intent as binding, so that the actual outcome has necessarily to be construed as what was intended, out of all competing possibilities, or less strongly as heuristically suggestive amongst possibilities. Overall, we investigate the degree to which children rely on artist intent, and whether respect for intent might hamper children's grasp that an ambiguous picture has possibilities other than what the artist intended. These studies can inform theories of pictorial development and links to early understanding of intentionality.

Experiment 1: When does intent bind outcome?

Bloom & Markson (1998) found that 4-year-olds used the artist's intent to name pictures. In this study, the child needed to distinguish between two competing drawings that looked nearly identical. Perhaps children relied heavily on artist intent in this case because of the need to distinguish between drawings that visually compete for each label: when in doubt, consult the artist. We tested this by adding a condition containing two *dissimilar* drawings, so no appeal to intent was needed in order to name each with a single label. Thus, in the Competing condition, the target drawing, for example a balloon, was paired with a lollipop, whilst in the new Noncompeting condition, the target drawing was paired with a visually distinct depiction, for example, a snake. The adult made the drawings, to (a) ensure experimenter control over the appearance of each drawing, and (b) give generality to the study by probing the child's broader understanding of pictures, rather than just those she makes herself.

Method

Participants

Forty-eight 4-year-olds (mean 4;5, range 3;9 to 4;11) and 46 6-year-olds (mean 6;4, range 6;0 to 6;10) were individually tested. Children were tested at the Bristol Cognitive Development Centre and local schools.

Materials and Procedure

Children were randomly assigned to the Competing Drawing condition (N=24 4-year-olds, N=23 6-year-olds), modeled after Bloom and Markson (1998) or to the Noncompeting Drawing condition (N=24 4-year-olds, N=23 6-year-olds). In each condition, two trials were presented.

In the Competing Drawing condition the Experimenter drew two perceptually similar pictures (balloon and lollipop; plate and ball) while in the Noncompeting Drawing condition the Experimenter drew two non-confusable pairs (balloon or lollipop, and snake; plate or ball, and book). After a ten-minute filled interval, the experimenter showed the child one of the pictures (e.g. lollipop) and asked, "What is this a drawing of?" with correction as required if the child failed to remember the label (e.g., "no, that's my drawing of a lollipop"). This comprised the 'First-label question'. The selection of the picture was counterbalanced. After a brief pause, children were asked the Second-label question of the same drawing (e.g., "could this be a balloon?"). This was repeated for the second trial (e.g. plate/ball). In the Competing Drawing condition, this second label was the name of the already-existing competing drawing of the pair, while in the Noncompeting Drawing condition this second name had never been mentioned.

In both conditions, the target pictures were drawn first in each pair, and were equally often balloon/plate and lollipop/ball, drawn in different colours to help children distinguish them.

Results and Discussion

First-label question. Children recalled the Experimenter's declared intent well above chance in all conditions (4-year-olds: Competing condition 81% correct ($\chi^2(2, N = 24) = 22.9$, $p < .001$); Noncompeting condition 83% correct ($\chi^2(2, N = 24) = 24$, $p < .001$); 6-year-olds: Competing 72% correct ($\chi^2(2, N = 23) = 8.74$, $p < .02$); Noncompeting 91% correct ($\chi^2(2, N = 23) = 41.2$, $p < .001$). As in Bloom and Markson (1998), children successfully remembered the artist's original intent, and named the drawings accordingly. Given the slightly lower performance of the 6-year-olds in the non-competing condition, we ran separate chi-square analyses to compare performance to the other three groups; no significant differences were obtained (p=.108, .275, .896).

Second-label question. Table 1 shows the frequencies of children in each condition who accepted a second label for the target picture on 0, 1, and 2 questions. Four-year-olds differed from chance on both the Competing and Noncompeting conditions, $\chi^2(2, N = 24) = 11.3$, $p < .01$ and $\chi^2(2, N = 23) = 22.7$, $p < .001$, respectively. Importantly, when analyzing children who provided consistent responses by accepting a second label on either neither or both questions, the two conditions differed ($p < .005$, Fisher's exact test was used due to low cell frequency): children in the Competing Drawing condition tended to refuse to accept a second label on any trial ($p = .096$, binomial, two-tailed) in line with the inflexibility shown by Bloom and Markson (1998), but in the Noncompeting condition they were more likely to accept a second label ($p <$

.05, binomial). Thus, four-year-olds were ready to accept more than one label for a given drawing, but only when there was no competing drawing present.

Six-year-olds also differed from chance on both Competing and Noncompeting conditions ($\chi^2(2, N = 23) = 15.7$, $p < .001$ and $\chi^2(2, N = 23) = 7.70$, $p < .05$, respectively) but the developmental point is that amongst children who provided consistent responses there was no difference between the two conditions ($p = 0.73$, Fisher's exact test was used due to low cell frequency). This older group accepted more than one label for a given drawing even in the presence of a Competing drawing.

Table 1: Frequencies of children in each condition accepting a second label for the target picture on 0, 1, and 2 questions. (Experiment 1)

		0	1	2
4-year-olds	Noncompeting condition	4	4	16
	Competing condition	13	6	5
6-year-olds	Noncompeting condition	7	3	13
	Competing condition	8	5	10

We also examined the possibility that children's memory for the first label contributed to the second label performance. Specifically, children who forgot the first label and needed to be reminded might have been more willing to accept a second label. To test this, we re-ran the analyses including only children who correctly remembered the first label on both trials. The analyses all mirrored the prior results: 4-year-olds differed from chance on both the Competing

and Noncompeting conditions, $\chi^2(2, N = 16) = 12.0$, $p < .01$ and $\chi^2(2, N = 16) = 21.5$, $p < .001$, respectively. The 6-year-olds also differed from chance on the Competing $\chi^2(2, N = 11) = 6.1$, $p < .05$ and Noncompeting conditions, $\chi^2(2, N = 19) = 10.6$, $p < .01$. Consistent with our initial analyses, Fisher's exact tests comparing children who provided consistent responses showed that the performance differed between conditions for the 4-year-olds (p=.001), but not the 6-year-olds (p=1.0).

Two results stand out. First, the majority of children were consistent on their two trials: 38 in each age group accepted a second label on both or on neither trial. Second, in the Competing condition, there was a decrease in the tendency to stick to artist intent after the age of four years. Bloom and Markson (1998) had effectively hit on the condition that activates reliance on artist intent: when two similar pictures are present, 4-year old children are likely to say that a balloon drawing depicts a balloon only, and decisively *not* a lollipop. Interestingly, the majority of 4-year-olds in the Noncompeting condition did allow two names per drawing; this unveils a condition in which children are representationally flexible, and also shows that their respect for artist intention in the Competing condition cannot be reduced to a bias in a general restriction on naming ('one drawing, one name'). However, it raises the question of how to characterize that representational flexibility, which we explore next.

Experiment 2: Properties of depicted objects

Experiment 1 showed that even 4-year-old children show representational flexibility when shown pairs of pictures that contrast in appearance. Here we further investigate this Noncompeting condition, and add questions about properties of the depicted referents

themselves. In this way, we can reveal whether children actually interpret the pictures according to the artist's original intent (e.g. it is only a balloon), alternative referent (e.g. it is now a lollipop) or both. Comparing and contrasting a question about representation with a question about real-world properties of a referent provides important information about preschoolers' conception of representation (e.g., in the seminal paper by Zaitchik, 1990). Our hypothesis is that labeling a drawing as 'lollipop' activates appropriate real-world properties, so the *non-pictorial* property of edibility would be brought to mind, not the property of floating in the air. In this second study, we added questions probing what real-world properties were endorsed for each picture.

We used a procedure similar to the Noncompeting Drawing condition of Experiment 1, in which children were reliably flexible. Consider a participant who agrees that the original balloon-drawing could be a lollipop. We probe whether edibility and floating (properties which are, respectively, associated with each of the interpretations) are now endorsed. The first possibility is that both are, showing that the participant has indeed envisaged both representations simultaneously. If only edibility is endorsed, in accord with the most recent label, the participant has shifted from the original intention to the new label, from balloon to lollipop. This pattern could occur because we used the question 'could it be an X?', which may bias some children towards thinking of the picture as the alternative, suggested, referent. The most interesting result would be if only floating were endorsed, which would show that a trace of the original balloon-intention was strong enough to override the more recent lollipop label.

Finally, we included an adult sample to confirm that flexibility is preserved in the steady state towards which children are presumably heading.

Method

Participants

Thirty 4-year-olds (mean 4;7 years, range 4;1 to 4;11), thirty 6-year-olds (mean 6;6 years, range 6;0 to 7;0), and 18 undergraduates (mean 20;4 years, range 19;0 to 21;1) participated. Children were tested at the Bristol Cognitive Development Centre and local schools; adults were tested at the Bristol Cognitive Development Centre.

Materials and Procedure

The Experimenter made three drawings (balloon, box, and ball; or lollipop, book, and plate, counterbalanced between participants) while clearly identifying her intent before and after drawing (e.g., "I'm going to draw a ball. There, that's my drawing of a ball."), and placed each one out of reach but in view. To introduce a short delay, the Experimenter then 'found' two unambiguous drawings (apple and kite), which she said had been made by another artist. The Experimenter playfully mislabeled one drawing (e.g., "look, it's a cow!"), and ensured that each child would accept and reject labels, appropriately saying both 'yes' and 'no'.

Attention was drawn to the original ambiguous drawings, and participants were asked, "What's this?" with correction when needed if they did not recall the label (e.g., "no, remember, I drew a ball"). Three 6-year-olds and four 4-year olds needed correction on a total of 15 drawings. Adults did not need correction. After a brief pause, participants were then asked whether the drawing could have a second label (e.g., "Could it be a plate?").

The non-pictorial property probe followed. As warm-up and comprehension check, participants were first asked property questions about each of the two unambiguous drawings

(e.g., for the kite: "Remember this one? If we eat it, does it taste good? If we drop it, does it bounce? Does it float in the sky?") The Experimenter then asked three property questions for each of her drawings: one property was true of one target drawing (e.g., "Does it bounce?" is true of balls but not plates), another property was true of the other target drawing (e.g., "Do we put food on it?" is true of plates but not balls), and the third property was true of neither (e.g., "Does it taste good?").

Results and Discussion

Label questions. The four-year-olds accepted a second label for a target picture on 68% of trials (SD=.29), 6-year-olds on 83% of trials (SD = .42) and adults on 93% of trials (SD=.14). Data were arcsin transformed because proportions were used for analysis. As in the equivalent condition of Study 1, participants of all ages accepted a second label at a rate above chance ($t(29)=2.10$, $p<0.05$; $t(29)=5.03$, $p<0.001$; and $t(17)=7.48$, $p<0.001$, respectively).

Property questions. Over all 234 property questions, only 8 answers were uninterpretable, and only 10 involved endorsing a distractor property. These 18 responses (7.7%) were dropped from further analysis.

When participants rejected multiple labels for the drawing, they almost always endorsed only the original property (e.g., it bounces but neither holds food nor tastes good): 4-year-olds in 26/27 instances (96%), 6-year-olds in 12/13 instances (92%), and adults in all 4 instances (100%). In these cases, the prior intent was binding on the representation so that the drawing could only depict its original intended referent, and thereby activated *only* that referent's properties.

The most interesting question is whether participants who accepted multiple labels endorsed multiple properties. They did not. All age groups endorsed solely the original property more than they endorsed both relevant properties (4-year-olds: 27 vs 14; 6-year-olds: 47 vs 8; adults: 34 vs 4, respectively; all *p*s < 0.05, binomial). The artist's original intent tended to determine endorsement of real world, non-pictorial, properties.

Although for the number of trials on which children endorsed both relevant properties was low, we ran a phi test of association (see Agresti, 2013) for each trial to examine whether this differed between the children who rejected the second label group versus those who accepted it. None of the results were significant for the 6-year-olds or adults, which is likely due to the infrequent acceptance of the second property overall. For two of the three trials, we found a significant result for the 4-year-olds (balloon/lollipop: *phi* = .463, *p* = .011; box/book: *phi* = .459, *p* = .012). This suggests that whether the youngest children accepted a second label had an effect on whether they endorsed the property of the second referent. Indeed, for the two significant trials, these children *never* endorsed the property of the second referent if they did not allow it to be called by a second label.

Taken together, these results suggest that although children are representationally flexible and accept that a picture can refer to more than one entity, they still consider a symbol to reflect an artist's original intention. Thus, children of both age groups show a bound rather than changeable status in respecting the artist's original intention.

Experiment 3: Is intention binding using a non-modal paradigm?

In Experiments 1 and 2, we used modal questioning 'could it be…?' in order to deal with representational possibilities. The price to be paid for the rich openness of modals, giving children the maximal chance of comprehension, is that a variety of interpretations are possible. For example, the existential "could this be a lollipop?" might be interpreted as asking whether the drawings had been mislabeled, as in, "could this be the lollipop picture?". This interpretation of the question may be legitimate in the Competing condition, where the two perceptually similar pictures could be plausibly mixed up, but it makes less sense in the Noncompeting condition where there is no perceptually similar "lollipop picture". To avoid potential confusion, Experiment 3 taps the same construct of representational flexibility, using a complementary procedure. Here we incorporate pictures into a game and ask if a second participant can 'borrow' pictures to stand as a different referent. In this way, we avoid potential confusion over modal questioning and obtain both a verbal and behavioural response. We include only the younger age group (4 year olds), as this was the sample where we uncovered differences between the Competing and Noncompeting conditions, and to closely parallel the age range used in Bloom & Markson (1998).

Method

Participants

Twenty typically developing children were tested at the Centre for Human Development at Lancaster University (mean age 4;2 years, range 3;6-4;9 years). Half of the participants were male and half were female.

Materials and Procedure

Pretrials. In order to familiarize the children with the experimental 'game', several pre-trials were conducted. The experimenter introduced each child to a stuffed cat ('Kitty') and invited the child to play a game with Kitty. Kitty was shown two sets of pictures, each containing crude black and white drawings that either represented a single referent (such as a picture of a dog) or could plausibly represent more than one referent (such as circles, which could denote smarties or peas). The experimenter named the pictures (e.g. as smarties) and asked Kitty if the pictures could represent something else (e.g. if the dog picture could be a 'table' or the smarties picture could be 'peas'). Children were thus exposed to trials in which 'yes' was an acceptable answer and trials in which 'no' was an acceptable answer.

Test and control trials. Children were presented with 6 sets consisting of 4 pictures of a related theme (dinner, bedtime, park, art, birthday, things in the sky). Four sets were used for the test trials, and two sets were used in the control trials; these were fully counterbalanced. In a separate pilot study, ten undergraduates confirmed that the adult interpretation of the stimuli was as 'flexible' symbols. We selected items that would be familiar to British children of the age range tested and simply rendered (see Table 2 for list of stimuli).

Table 2. Stimuli set for Experiment 3. The experimenter's 'missing' item and substitute in the child's display are highlighted in bold.

Experimenter's Picture Set		Child's Picture Set	
Bedtime	**pillow,** bed, teddy, clock	School	**book**, coat, bus, rucksack
Park	**slide**, tree, swings, duck	Beach	**sandwich**, spade, bucket, starfish,
Dinner	**plate**, fork, napkin, spoon	Football	**ball**, jersey, goal, trainers
Art	**pencil**, paint set, cup, brush	Insects	**worm**, spider, ladybird, butterfly
Birthday	**balloon**, cake, hat, present	Sweets	**lollipop**, ice cream, sweetie, chocolate,
Sky	**moon**, star, cloud, plane	Lunch	**banana**, lunchbag, apple, bottle

Test trials. For each set of pictures, 4 individual drawings were placed in front of the child and labelled. For instance, the child was shown 'things from a birthday' (balloon, hat, cake, present; see Figure 1). This constituted the child's pictures, and the child was encouraged to label and talk about the pictures in order to emphasize the communicative function of the stimulus set and ensure children could name the pictures accordingly. The experimenter then placed a separate set of pictures in front of Kitty (e.g. sweets) but one picture was 'missing' (e.g. lollipop). Crucially, for the test trials, the picture Kitty needed to complete her set looked identical to one of the pictures in the child's set (e.g. the balloon). The child was told that Kitty's picture of a lollipop was missing, and was then asked if Kitty could borrow a picture to use in her display. The main question was whether a picture that looks the same, but is intended to be something else, is an acceptable substitute for another referent.

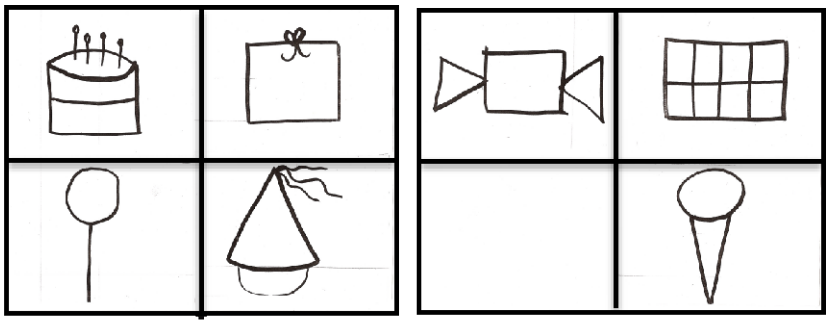

Figure 1. Example of stimuli for the Test trials in Experiment 3. The child's picture set ('things from a birthday') includes a balloon and Kitty's picture set ('sweets') is missing a lollipop.

Control trials. Two control trials were included to ensure children were not simply handing over any picture to please the experimenter. The control trials contained two sets of four related pictures, identical to the procedure of the test trials. In the control trials, however, none of the child's pictures resembled the picture Kitty wanted to borrow. Thus, here children should answer 'no' when the experimenter asked to borrow a picture from the child's display in these trials if they are paying attention to what the picture looks like.

Coding. Response categories for test trials included: participant says yes and chooses flexible (correct) picture; participant says yes and chooses incorrect picture, or participant says no. To permit parametric analysis, each correct answer (e.g. participant says 'yes' and chooses the correct picture) was summed across trials for each participant, allowing for a maximum score of 4. Results were compared to a chance level of 25% for the test trials, as the child could select from 4 possible drawings in each trial. For control trials, responses were scored as

incorrect (participant says yes and hands over any of the pictures) or correct (participant says no and does not select a picture), and thus chance was set at 50%.

Results and Discussion

We first compared performance across trials to probe for stimulus differences. Of 15 individual McNemar tests, only one was significant ('things in the sky' vs. 'park'; p=.012), thus responses were collapsed across trials.

Overall, children answered 'yes' and selected the correct picture on 73.75% (59/80) of the trials, answered 'yes' but selected an incorrect picture on 2.5% (2/80) and said 'no' on 23.75% (19/80). In contrast, children (correctly) said 'no' on the control trials 80% of the time (32/40). A one-sample t-test revealed a significant difference from chance performance both for the test trials ($t(19)= 6.09$, $p<.001$) and control trials ($t(19)= 5.34$, $p<.001$).

These results provide converging evidence to Experiments 1 and 2; very young children are able to treat drawings as flexible symbols that may refer to more than one referent. Four-year-old children were willing to accept that a picture of a plate, for instance, could depict a ball in a different context. Importantly, children were only willing to see a picture as a flexible symbol when it looked like more than one referent – a picture of a dog could not be taken to refer to a table. Together with Experiments 1 and 2, these results provide convergent evidence that young children have a flexible interpretation of pictures when a visually competing drawing is not present. In this study, we avoided any verbal ambiguity associated with using a modal line of questioning 'could it be an X'.

General Discussion

When shown two perceptually similar pictures side-by-side in Experiment 1, most four-year-olds did not allow a picture created with a specific intent (e.g. balloon) to be called by another name (e.g. lollipop). It is notable how strong the effect is: the task does not demand that preschoolers deny that the balloon-drawing depicts a balloon, merely that there is a *possibility* that it could depict something else. These results are in line with Bloom and Markson (1998), who anecdotally reported that children protested when their own perceptually similar drawings were mislabeled.

Importantly, we uncovered a procedurally-comparable condition in which, when there is no competing alternative drawing, children as young as four are open to the possibility that one picture may be called by more than one name. It seems that Bloom and Markson (1998) hit on the very conditions under which 4-year-olds show most inflexibility; when they do not have to keep track of two perceptually similar drawings, as in our Non-Competing condition, 4-year-olds are open to the possibility that one picture may be called by more than one name. Children of this age may have failed the Competing condition because they had difficulty inhibiting the primary label in the presence of a perceptually similar distractor (Livesey & Morgan, 1991) or reconciling two potential identities for a single referent (Gopnik & Astington, 1988; Flavell, Flavell, & Green, 1983). Indeed, both these abilities appear to develop gradually between ages 3 and 5.

The success in the Non-Competing condition and in Experiments 2 and 3, however, suggests that 4-year-olds have *representational flexibility*, or the ability to acknowledge a new representational possibility. The flexible use of symbols including pictures has been argued to

set humans apart from other species (DeLoache, 2004), and flexibility has been shown before in young children in categorization tasks (Defeyter, Avons, & German, 2007; Blaye & Bonthoux, 2001). Specifically, Defeyter et al. (2007) found that 5-year-old children were able to generate more novel functions for familiar artifacts (e.g. brick) than a 7-year-old group. When novel objects were presented and no functional information was provided in a second study, both groups were able to equally generate novel functions. These results suggest that both groups show flexibility in object understanding, although the older children have a qualitatively different type of representation about artifacts that specifically incorporates design features. With regard to pictures, openness to alternative possibilities lies at the heart of pictorial imagination and inventiveness during childhood (Lightfoot & Milbrath, 2010), and its developmental trajectory is of central interest in analyses of pictorial reasoning (Freeman, 2004; 2006).

As seen in Experiment 2, the artist's statement of intent triggered in viewers' minds the real world and its properties. In this way, the drawings fulfilled a prime function of pictorial representation. However, while participants understood the ambiguous drawing as depicting a plate, stating, for example, that it doesn't bounce, they still allowed it to be called a ball. Thus children have a bound, rather than changeable, interpretation of the link between intention and pictorial identity. Although they acknowledge that pictures can be used flexibly and receive more than one name, they favour the artist's original intention when they reason about the picture and the properties of its referent. This persistence of properties is also evidence that participants who accepted a new label for a drawing had not simply forgotten the original label. As the rate of forgetting was low in Experiment 1 and our focus in the second study was on

potential endorsement of multiple properties for a single picture, we did not explicitly record whether children needed to be reminded of the original label in Experiment 2. However, we ruled out a memory-based explanation for our findings in Experiment 1. When we ran the analysis on only children who remembered the label, results were consistent with the whole sample analysis in showing flexibility in naming. This result, coupled with the overwhelming endorsement of only the original property in our second study (which suggest they children did not indeed forget it) suggests that memory performance did not account for our data. However a direct analysis is needed to conclusively rule this out and examine the relation between memory and property acceptance. Nevertheless, children's flexibility is impressive for occurring despite activation from the older representation, directed by artist intent, which dominated children's real-world referent identification.

The link between intentions and a picture's identity is akin to how we think about artifacts (Bloom, 1996). We name, categorize, and use objects based upon the intentions of the person who designed the object (German & Johnson, 2002; Keleman, 1999; Diesendruck, Markson, & Bloom, 2003). Children as young as 3-years-old will classify objects as belonging to the same kind if their function is sufficiently highlighted, even if the objects differ in appearance (Diesendruck, Markson, & Bloom, 2003). Thinking of artifacts in terms of design - the 'teleological stance' – however, can result in functional fixedness where individuals have difficulty seeing an alternative use for an object, even when it is superior or advantageous (Keleman, 1999). The fact that children endorse properties of the original label in Experiment 2 suggests that children do see the artist's intention as binding, however they also allow pictures to be called by another name in all three experiments, which suggests that pictures created by

others retain flexibility of use. It is possible that children may show a stricter level of fixedness when evaluating their own constructions, which is an open question for future research.

Although functional fixedness can explain why children did not accept a second property associated with a picture, it doesn't explain why children were willing to accept two names. There are other situations where children use two labels to refer to a single picture. A picture of an apple can also be called a fruit, as children begin to understand the relation between basic level and superordinate category membership (Mervis & Crisafi, 1982). In this case, the picture can be construed as referring to a single referent. Other research on ambiguous figures (such as Jastrow's classic 'duck/rabbit' image) shows that preschool children provide two labels for a single picture only when informed of the possibility that a second interpretation exists, naming it as a duck *and* a rabbit (Rock & Mitchener, 1992; Gopnik & Rosati, 2001). Our questioning might have therefore alerted children that a second label was possible. One key difference between our stimuli and traditional ambiguous figure pictures of course is that the latter can be perceived as two distinct referents that tend to flip back and forth. Our pictures did not involve this dual nature, and thus children may have been willing to use two names in response to questioning, but because the picture did not change perceptually, they only linked the picture with only a single (original) referent.

The challenge remains to identify precisely what conception of possibility is involved in children's acceptance of multiple labels for a single drawing. In Experiment 1, we used a rich modal question ("Could it be a lollipop?") as a broad gauge of the flexible interpretation of drawings. This richness could be turned into a precise analytic tool for both competing and noncompeting conditions, by decomposing it into clarifications such as, "Could someone use

this picture as a picture of a lollipop?", "Could this be mistaken for a lollipop picture?", "Could this also be a picture of a lollipop?", and so forth. It is possible that children interpreted this intentionally vague question in different ways. The experimenter herself suggested the alternative label, and thus it is also possible that participants saw her as changing her own intention of what the picture represented. Experiment 3 was designed to counter these criticisms using a more directed question, and revealed complementary evidence, in that 4-year-old children also treated drawings as flexible symbols.

In Experiment 3, children provided both verbal (yes or no) and behavioural responses (by handing over a picture) when asked if an independent entity could 'borrow' a picture to complete her display. Four year olds allowed a picture to be called by a different name, but only when the picture could plausibly represent a second referent (i.e. balloon and lollipop). By asking the children to retrieve a picture, we could ensure that their response to the original question was not simply to please the experimenter, or potentially interpreted differently by individual children.

Results from these three experiments make it feasible for the first time to pose a precise question of what mechanism supports children's understanding of the relations between intent and possibility. Asking both representational and 'real-world' questions is typical for researchers in the areas of theory of mind and also pictorial understanding; we can look to these literatures to ascertain predictors of the flexible interpretation of symbols. For instance, indices of preschoolers' advances in understanding relations between pictorial representation and reality were identified by Robinson, Nye and Thomas (1994) and Robinson, Riggs and Samuel (1996), and these may be tested for potential predictors of the

competitive/noncompetive difference. For the theory-of-mind domain, one would look at direct tests of discriminating intended from unintended acts and consequences for predictors, on the grounds that pictorial appearance is just one tool used by children to infer what was in the artist's mind (Bloom & Markson, 1998; see also Kennedy, Gabbias & Pierantoni, 1990). A third approach would look at the child's own drawing for evidence of the advance of the understanding of graphic possibilities, following the approach pioneered by Karmiloff-Smith (1990) in her representational redescription model. These are all useful ideas for future work.

Holding a flexible stance towards pictures involves an awareness that an artist's intent might well determine how to identify what a drawing is *of*, but cannot constrain what the same drawing *could be of* or *could be seen as*. Both aspects, intent and possibility, are traceable from preschool to adult. While young preschoolers certainly have problems with aspects of pictorial symbolic functions (see Callaghan, 1999; DeLoache, 2004; Nye, Thomas & Robinson, 1994; Thomas, Nye, Rowley & Robinson, 2001), even children as young as four are engaging with the mature pictorial stance that a declared prior intent is suggestive, but is not necessarily binding on a viewer. This suggests that intention is intricately linked to representational understanding (see also Preissler & Bloom, 2008; Bloom, 2000), and, critically, is used early in development to help children make sense of visual representations and formulate a flexible theory of pictures.

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