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Early Understanding and Production of Graphic Symbols

Tara C. Callaghan

Young children's ability to understand and produce graphic symbols within an environment of social communication was investigated in two experiments. Children aged 2, 3, and 4 years produced graphic symbols of simple objects on their own, used them in a social communicative game, and responded to experimenter's symbols. In Experiment 1 ($N = 48$), 2-year-olds did not effectively produce symbols or use the experimenter's symbols in the choice task, whereas 3- and 4-year-olds improved their drawings following the game and performed above chance with the experimenter's symbols. Ability to produce an effective graphic symbol was correlated with success on a task that measured understanding of the experimenter's symbols, supporting the claim that children's ability to produce a graphic symbol rests on the understanding of the symbolic function of pictures. In Experiment 2, 32 children aged 3 and 4 years improved their third set of drawings when they received feedback that their drawings were not effective communications. The results suggest that production and understanding of graphic symbols can be facilitated by the same social factors that improve verbal symbolic abilities, thereby raising the question of domain specificity in symbolic development.

INTRODUCTION

For many years the psychological debate over what makes humans unique among animals has been played out in the trenches of language research. The generally accepted view is that although intense training may result in the acquisition of a gestural lexicon in our close primate relatives, the system is limited. Language acquisition in the human infant does not require the kind of training needed for sign production in chimpanzees. The fact that language symbols universally emerge early in development and quickly dominate representational efforts of the very young, speaks to their importance in human cognition. Much of the research that explores symbolic functioning is based on studies of verbal language, although studies of symbolic play extend our understanding of this process to the nonverbal domain. Researchers have argued for a link between language and symbolic play acquisition (McCune, 1995; McCune-Nicolich, 1981; Tamis-LeMonda & Bornstein, 1994), but the issue of whether a single process or several domain-specific processes (Karmiloff-Smith, 1992) underlie symbolic functioning needs further exploration.

In the current study, the emergence of a graphic symbol system is explored. Like play, graphic symbols are nonverbal; and like words and play, they are a mode of communication available to children. The social interaction that occurs around children's early scribbles and representational drawings is much like that which occurs around infant's babbles and early words (Bruner, 1983a). Young children are quick to show their productions to others, and others are quick to respond to them as though they were intentional and meaningful communications. Perhaps because of this scaffolding, children appear to grasp the relation between graphic symbols and their referents very early in development. Two decades ago, Gardner (1973) argued that drawing should be studied as a symbol system, but very little research has adopted this perspective. In the current research, I frame a new approach to drawing development, borrowing from the view that competent production in the verbal symbol system is facilitated by social learning (Bruner, 1983b; Tomasello, 1992; Vygotsky, 1978). Thus, I see drawing as a symbol system emerging within an environment of social communication.

From this perspective, it is important to establish when children become aware that pictures can stand for particular things, and when they can then use this understanding to intentionally produce a drawing that will communicate to others. Clearly, children must understand the symbolic function of pictures before they can intend to produce a graphic symbol. As DeLoache, Pierroutsakos, and Troseth (1997) have argued, the development of this understanding is a complex process. It is also the case that children may intend to communicate with a drawing but are not always successful in their goal because of immaturity in required perceptual-motor skills (Gardner, 1973). Although we know a great deal about the processes responsible for verbal symbol formation, we still know relatively little about those involved in the emergence of graphic symbols.

Sometime around their third birthday, well after they have uttered their first words, children begin to produce simple representational drawings—the

graphic equivalent of first words (Cox, 1992; Golomb, 1981, 1992; Winner, 1982). But what leads to these early graphic symbols? Before they produce their first representational drawings, infants and toddlers take great delight in scribbling. The developmental precedence of scribbling has led some researchers to propose that it is a necessary precursor to representational drawing. For example, Kellogg (1969) suggested that complex forms emerge from the combination of simple scribbles. However, her assumption is challenged by cross-cultural studies (Alland, 1983) and experiments with blind children (Kennedy, 1983), which show that children produce representational drawings with little or no scribbling experience. From a different perspective, Golomb (1992) argued that the emergence of representational drawing depends on the ability to produce enclosed forms, such as the circles and ovals that begin to appear in scribbles during the third year. Until a shape can be produced, there can be no graphic representation (Arnheim, 1974; Golomb, 1992). Although the logic of this argument is clear, we are still left with the question of how and when these enclosed forms become linked to intentional graphic symbols produced by the child.

Researchers have attempted to explore this question with training studies. They have found that children will draw representational human figures at 2 years of age when parts of the figure are dictated to them, when they complete an incomplete figure, or when they assemble the figure from precut parts (Bassett, 1977; Cox & Parkin, 1986; Golomb, 1973). At first glance, these results imply that experimenters have tapped a latent ability to produce graphic symbols early in the third year; however, I would argue that none of these tasks require intentional graphic symbol production. When parts of a figure are dictated, the verbal symbolic system may scaffold performance. When an incomplete figure is presented as a cue, the child has not independently generated a symbol. When all of the parts are presented for assembly, the child is solving a spatial perceptual problem. Thus, although the training studies show a sensitivity to incomplete symbols early in a child's third year, they do not reveal an ability at this age for intentional production of marks that can be interpreted by others as a message about the world.

The emergence of graphic symbol production and understanding is explored here in two experiments by using a task that requires children to produce symbols on their own and to respond to the experimenter's symbols. Three empirical questions underlie the research. First, when do children begin to generate graphic symbols? Most researchers agree that this occurs sometime around their third birthday (Cox, 1992; Golomb, 1992; Winner, 1982). Earlier "romancing" of form, as when children label their scribble productions, is not genuine symbolization in that children typically divulge what they have intended to portray only after the fact, and may change their earlier announced intention when their marks more closely resemble some other object (Golomb, 1992; Winner, 1982). Nevertheless, romancing of form does indicate an awareness that, from our culture's perspective, pictures typically share a graphic equivalence with their referents. Another type of study that asks children to draw from a model, rather than imagination, pushes the estimate of effective symbolization forward to middle childhood. Reith (1990, 1997) asked children between the ages of 5 and 11 years to draw from a model, and reported that they do not demonstrate a concern for accurate portrayal until 7 years of age (Reith, 1990). However, his stimuli were complex (e.g., a sculpture of a kangaroo), leaving open the possibility that children can produce unambiguous symbols when asked to draw simpler objects. We asked children to draw objects that could be portrayed with circles and lines, and expected them to be able to make the marks needed to depict the objects because circles and lines are evident in children's scribbles during the second year (Golomb, 1992). Whether their marks were effective symbols was the question of interest.

A second question is whether there are any experiences that can facilitate the onset of graphic symbol production. My perspective is that drawing, like language, can be facilitated by social experience. The facilitative effect of social interaction has been repeatedly shown in language research (Tomasello, 1992). For example, following children's attentional lead in object naming facilitates verbal symbol acquisition (Baldwin, 1991; Bruner, 1983b; Tomasello & Farrar, 1986). In contrast, direction of children's attention away from their object of focus impairs acquisition of verbal symbols. Whether the production of graphic symbols is also influenced by social learning was explored in Experiment 1. Children played a game where they were instructed first to use their drawings as symbols to indicate which object the experimenter was to put down a tunnel, and then to switch roles so that they used the experimenter's drawings as a guide for their own choice in a match-to-symbol task. Drawings of the objects were collected before and after the game. The question of social factors was also explored in Experiment 2, by giving children feedback when their drawings were not effective symbols. This manipulation was designed to determine whether failure to communicate would facilitate children's graphic symbol production as it has been found to in language research (Golinkoff, 1986; Marcos & Chanu, 1992).

The third question of our research is whether production of graphic symbols is linked to the understanding of these symbols. I argue that the intention to produce a graphic symbol necessarily rests on the understanding that pictures can serve as symbols of particular things. Reith (1990, 1995) found that children do not attempt to match their productions to the reality of the model until 7 years of age. However, this does not preclude the possibility that children understand this link even though they are not aware of it or able to verbalize about it. That this link may be evident earlier than middle childhood is especially likely given the findings of DeLoache and her colleagues (DeLoache, 1987, 1991, 1995a, 1995b; DeLoache & Burns, 1994; DeLoache, Kolstad, & Anderson, 1991; DeLoache et al., 1997), who show that sometime between the second and third birthday children can use photographs and line drawings to facilitate retrieval in a memory task. Also, children's labeling of their scribbles and early forms, whether before or after they produce them, indicates at least an incipient awareness of the link between symbol and referent, and a step toward the intention to capture the link in their drawing. To the extent that graphic symbol production depends on an understanding of the symbolic function of pictures, the earliest children should be able to produce effective symbols is shortly after they achieve this understanding (i.e., sometime in their third year). In Experiment 1, the relation between production and understanding of graphic symbols was assessed by comparing performance on drawing and matching-to-symbol tasks.

EXPERIMENT 1

The drawing task in this study required children to create graphic symbols on their own. The drawings were collected before and after a game, allowing the question of the potentially facilitative effects of social interaction to be examined in the graphic domain. It was expected that drawing ability would improve only insofar as the child had a concept of a picture as a symbol, sometime during the third year (DeLoache, 1995a).

Method

Participants

A total of 48 children participated in this study, 16 from each of three age groups: 2-year-olds (M = 2,4, *range* = 2,1–2,8), 3-year-olds (M = 3,3 *range* = 2,11–3,6), and 4-year-olds (M = 4, *range* = 3,9–4,4). There were 11, 7, and 8 girls at ages 2, 3, and 4 years, respectively. The children were recruited through letters sent to parents from the daycare center or through phone contact after consulting the birth announcements of a local weekly newspaper. The resulting sample was predominantly white and middle class.

Materials

A soft drawing pencil 1 cm in diameter and 11 cm in length was used by all children and by the experimenter to produce the drawings. All children's drawings were rendered on unruled index cards (10 × 15 cm). The experimenter's drawings were made on index cards and then mounted on matte board (5.5 × 7.7 cm) and covered with clear adhesive plastic for durability.

A box (50 × 25 cm) having one high (18.5 cm) and one low (7 cm) end and a tunnel (8 cm diameter, 30 cm length) placed on a vertical incline were used to provide the children with an interesting activity to perform with the objects. One end of the tunnel was placed on the high end of the box at shoulder height for children of this age and the other terminated in the middle of the floor of the box so that when an object was dropped through the tunnel it was caught by the box. The entire apparatus was made from cardboard and covered in heavy colored paper.

The objects to be drawn and used in the game were: a plain ball (5.5 cm diameter), a "spider" ball that was identical to the first except for long black rubber "legs" sprouting from all over the ball (average length = 9.6 cm), a small plain ball (3.8 cm diameter), a group of 3 small plain balls (each diameter = 3.8 cm), and a black stick (0.6 cm diameter, 13.5 cm length). The balls were identical in color (neon orange with spots of neon green and purple) and the plain balls were produced by pulling out the black rubber legs from spider balls. These objects were specially chosen because they can all be depicted using either a circle or a line, or both, as indicated in Figure 1, which presents the experimenter's drawings of the objects.

Note that in order to be an effective symbol, object

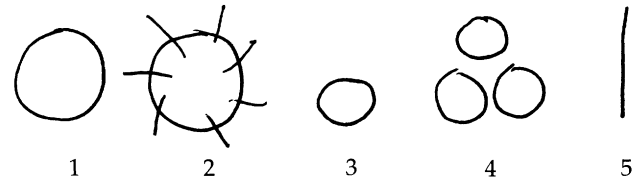

Figure 1 Experimenter's drawings of objects used in Experiments 1 and 2.

1 can be depicted with a simple circle but object 2 must have lines emanating from the circle to distinguish it from object 1. Object 3 needs to be smaller than object 1 to be distinguished from it, and object 4 needs to show a number of circles. Object 5 can be distinguished from object 1 by use of a line instead of a circle. Thus, with these five objects there are four possible distinctions: Added Feature (object 1 versus 2), Size (object 1 versus 3), Number (object 1 versus 4), and Figure/Line (object 1 versus 5).

Procedure

All children were tested individually in a quiet room (25 in their daycare centers, 19 in a psychology laboratory, and 4 in their own homes). Parents who observed were told that it was important that they not intervene in any way, including giving their children verbal prompts or expressing pleasure or disappointment. Following a 10-min period where children became familiar with the two experimenters, they were asked to draw a picture of anything they liked. This was designated as the Free Drawing and was used to establish whether children were already making representational drawings and whether they could produce circles and lines. The data regarding the representational nature of these drawings is presented later. All but one child produced circles and lines in their Free Drawings; this three-year-old child did not make any enclosed forms in any of the drawings made during the experiment. Thus, with this one exception, the children in this study could make the marks needed to produce an effective graphic symbol of the objects of this study.

Phase 1. In Phase 1, the experimenter told children that they were ". . . going to play a game with some toys. First I'll get you to make some drawings of the toys and then we'll play a game with those drawings." The experimenter gave the objects to the child one at a time for a brief period of tactile exploration because this has been found to improve drawing ability (Bremner & Moore, 1984; Cox, 1986). Because children would have the opportunity to handle objects during the game before their second drawings, it was important to control for this potential confound. The experimenter then placed the objects in front of the child so that they formed a horizontal line and then picked up the objects one at a time, in a predetermined random order, and held them approximately 10 cm from the table surface and 25 cm from the child's midline on the side opposite to their drawing hand, so that they could be easily viewed while being drawn. After the child made a drawing of an object the experimenter coded which object had been drawn on the back of the index card. Once all the drawings were completed, the experimenter placed each drawing on a stand just behind the object it was intended to represent, and noted explicitly for each drawing that ". . . this is your drawing for this one." These instructions were so worded in order to emphasize that each of the drawings went with a particular object. The stand screened the drawings and objects from a second experimenter who now joined the game.

Phase 2. At the beginning of Phase 2, the second experimenter was told to put on "ear plugs," an archaic set of stereo headphones that looked like they would screen out all sound. Children were told that, in the game, the first experimenter would place two toys in front of the second experimenter and the children should indicate, by showing a picture, which of those toys they wanted the second experimenter to drop down the tunnel. These instructions emphasized that the nature of the game was to use pictures to communicate about objects. Each child was told to ". . . use your pictures to show him which one to choose, and you can't use words to tell him, because he can't hear since he has on those ear plugs." Very few of the children ever said anything to the second experimenter during this phase of the game. The child's objects were always in the same order when the child was choosing the pictures, so that the second experimenter could tell which one the child was asking to have dropped down the tunnel even if that drawing was not an effective symbol. The experimenter always chose the correct one so that the child would have a positive experience of the game. Also, failure in this case might lead the children to acquire a problematic task philosophy, such as "pictures aren't good symbols, so I had better point." Such a consequence would have significantly reduced the effectiveness of the game and introduced failure as a potential cause of poor performance. Children occasionally tried to indicate the target either verbally or gesturally early in this phase, and when they did, the first experimenter pointed to the appropriate pictures after the two objects had been placed on the other side of the screen for the choice task, indicating that the child should ". . . pick this one or this one and show it to Mike." All of the 2-year-olds, half of the 3-year-olds, and none of the 4-year-olds needed this prompting at the beginning of the game. Although they were not explicitly told to do so, almost all of the children held up their picture until a choice had been made.

In this phase, the first experimenter presented eight choice trials to the second experimenter, and each time the child held up the picture of one of the objects, indicating which one the second experimenter was to choose. The choice trials represented four dis-

tinctions (Added Feature, Size, Number, and Figure/Line), each presented twice. The order of presentation of the distinctions was randomized within a set of four across children, as was the position of the correct choice.

Phase 3. In Phase 3 the children were told "It's your turn to put the toys down the tunnel. Now I'm going to use my pictures." They were instructed to ". . . be sure to look carefully at the picture I show you so you know which one to drop down the tunnel." If necessary, children were given prompts such as "Put this one down the tunnel," or "Here's the one for the tunnel," as experimenter-drawn pictures were held up. No reinforcement was given, but children were generally encouraged throughout the game. The experimenter presented eight trials, two for each of the four distinctions, as in the previous phase, and recorded the child's choices. Without pausing, the experimenter then presented five new trials where each of the five objects was paired with its picture. The experimenter held up a picture and the child chose between a duplicate of that picture and the object. These trials were included as an additional measure of whether young children treat pictures as objects rather than symbols. If so, they may be inclined to put the picture of the object down the tunnel, and not the object, when the experimenter held up a picture. On all trials the experimenter's picture of the object was in view until the child made the choice. As in Phase 2, order of presentation of distinctions and position of correct object was randomized across children.

Phase 4. Following a 5-min break, Phase 4 began. Children were asked to make a second set of drawings. All of the objects were lined up and the experimenter held them one at a time, in random order, as for the original drawings. After a 10-min break, children were asked to help the experimenter organize their pictures by placing each picture with the appropriate object. They were free to make changes from their original arrangement during this process. The task (Phases 1–4) lasted approximately 20 min, excluding the break.

Scoring and Analysis

Children made three types of drawings in this experiment: free drawings, first drawings of the objects (after handling but before the game), and second drawings of the objects (following the game). Children's free drawings were first classified by two independent judges (agreement = 100%) as either prerepresentational or representational. Drawings were presented to the judges along with the label provided by the child and classed as representational if the judge could discern what was being portrayed in the picture and as prerepresentational if the judge was unable to tell the subject of the drawing. In only 3 of 48 cases was the representational status of the drawing ambiguous and the label provided by the child necessary to disambiguate the subject of the drawing. In all other cases the drawing was a scribble that did not at all resemble the label (prerepresentational) or the subject of the drawing was evident even without the label (representational). Children's first and second sets of object drawings were judged according to whether they exhibited the four possible distinctions between the objects (Added Feature, Size, Number, and Figure/Line). To make the judgments, pairs of drawings relevant to each distinction (e.g., object 1 versus object 2 for the Added Feature distinction) were compared by two judges. Interrater reliability was high (mean agreement = 89%, $\kappa = .85$).

Results and Discussion

To explore when children make effective graphic symbols and whether these productions were contingent on an understanding of the symbolic function of pictures, children's drawings and their success at the tunnel task were examined. Thus, production was compared to understanding.

Children's Production of Graphic Symbols

All 16 of the 2-year-olds, 13 of the 3-year-olds, and 3 of the 4-year-olds were classified as prerepresentational drawers according to their free drawing; the difference between the two younger groups and the older group was significant, $\chi^2(2, N = 48) = 26.07, p < .001$. When children were asked to make specific drawings of the balls and stick, their drawings became more representational. Separate χ^2 tests were performed for each age group comparing the number of representational drawers in free versus first and free versus second sets of drawings for both lenient (at least one distinction) and strict (all four distinctions) criterions of the latter two sets. These data are presented in Table 1. The number of two-year-olds making representational drawings did not change from free to first or second sets using either the lenient or strict criteria. There were more 3-year-olds classed as representational drawers when a lenient criterion was applied to both first, $\chi^2(1, N = 32) = 8.13, p < .01$, and second, $\chi^2(1, N = 32) = 10.16, p < .01$, sets of drawings, but there was no change in number when a strict criterion was applied. The only change noted for 4-year-olds was that *fewer* children were classed as representational drawers when a strict criterion was

Table 1 The Number of Children Making Representational Drawings in Experiment 1

Age (Years)	Free	Lenient Criterion		Strict Criterion	
		Set 1	Set 2	Set 1	Set 2
2	0	3	4	0	0
3	3	11	12	3	5
4	13	16	16	3	8

applied to the first set of drawings, $\chi^2(1, N = 32) = 12.50$, $p < .001$. The finding that some children who had been prerepresentational in their free drawings shifted to a representational mode with the instruction to draw a particular object supports Golomb's (1981) claim that children will often successfully represent a simple object when the task directs them to do so, even if they do not spontaneously produce this type of drawing.

To assess whether the social-communicative experience helped children to produce more effective symbols, children's number of distinctions (*range* = 0–4) in their second as compared to their first set of object drawings were analyzed using a 3 × 2 (Ages × Drawing Set) repeated measures analysis of variance (see Table 2 for relevant means). This analysis revealed significant main effects of age, $F(2, 45) = 34.02$, $p < .001$, and drawing set, $F(1, 45) = 9.23$, $p < .004$. The age effect indicated that 2-year-olds made significantly fewer distinctions than 3-year-olds, who in turn made fewer than 4-year-olds. The drawing set effect revealed that more distinctions were made in the second as compared to the first sets of drawings. Inspection of the data presented in Table 2 suggests that there was no improvement from first to second drawings for 2-year-olds (*mean* difference = .06), but there was improvement for 3- and 4-year-olds (.50 and .61, respectively). A χ^2 analysis confirmed that improvement was predominantly found in the older groups. Two, 7, and 9 of 16 children improved in the 2-, 3-, and 4-year-old groups, respectively, $\chi^2(2, N = 48) = 6.94$, $p < .05$. Frequency data also indicated that types of distinctions varied in difficulty, $\chi^2(3, N = 384) = 7.85$, $p < .05$. Summing across all ages and both sets of drawings, 57% of children distinguished the ball and stick (Figure/Line), 43% of children distinguished both the ball and spider ball (Added Feature) and the single compared to three balls (Number), and only 39% of children distinguished the large and small balls (Size).

Thus, it appears that the social-communicative game employed in this study helped older children to produce more effective symbols. The major aim of the task was to help children learn that pictures can be used to denote particular objects and that these pictures could then be used to communicate about which object was to be placed in the tunnel. In short, the goal was to enlighten children about the symbolic function of drawings in this context. My interpretation of the findings is that the game served to do this. However, there are a number of other, uninteresting, possible explanations of the findings. One is that the additional handling of the objects during the game was responsible for improvement. Another explanation of the improvement would be that merely drawing the objects a second time resulted in improvement. As neither of these explanations could be definitively ruled out, a second study was conducted and is reported later.

Children's Understanding of the Experimenter's Symbols

The percent of correct choices out of a total of eight trials was calculated for each child. This data were then analyzed with correlated *t* tests to assess whether performance was above chance, and then with a one-way analysis of variance to assess age effects. The 2-year-olds were performing at chance (50% for this two-choice task), $t = .79$, *ns*, while both the 3-year-olds, $t = 5.71$, $p < .001$, and 4-year-olds, $t = 8.49$, $p < .001$, were well above chance. The age effect was significant, $F(2, 45) = 23.44$, $p < .001$, and indicated that

Table 2 Mean Number of Distinctions[a] Made in First and Second Sets of Drawings in Experiment 1

Age (Years)	First Set		Second Set		Overall	
	M	*SD*	*M*	*SD*	*M*	*SD*
2	.25 (6)	.58	.31 (8)	.48	.28 (7)	.52
3	1.69 (42)	1.58	2.19 (55)	1.68	1.94 (49)	1.63
4	2.81 (70)	.83	3.42 (85)	.63	3.13 (78)	.79
	1.58 (40)	1.50	1.98 (50)	1.67		

[a] Total possible number of distinctions is four and percentage of distinctions is given in parentheses.

2-year-olds (47%) performed less well than 3- and 4-year-olds, who did not differ (71% and 82%, respectively). Thus, in a task where the graphic symbol is present while children make their choices between two objects, children 3 years and older use a simple graphic image as a symbol to guide their behavior, but younger children do not.

There was evidence that the youngest children treated the pictures as objects and not as symbols, as in DeLoache (1995a) and DeLoache and Burns (1994). On average, 2-year-olds put 2.38 (of a total possible of 5) pictures down the tunnel when they were paired with their objects at the end of Phase 3, whereas the 3-year-olds put only .25 pictures down, and none of the 4-year-olds did so. This age effect was significant when the number of children putting at least one picture down the tunnel (15, 2, and 0 at the three age groups, respectively) was compared, $\chi^2(2, N = 48) = 37.9$, $p < .001$. Thus, the failure of the youngest children in responding to the experimenter's symbols and in producing their own symbols may be driven by the dual representation failure.

Children's Classification of Their Own Symbols

A second measure of the effectiveness of children's symbols, in addition to determining the number of distinctions portrayed, lies in their ability to recognize their own symbols. Ten minutes after children drew their pictures, they were given them one at a time in random order and asked to place them with the appropriate object. Placements were scored as correct if children placed their drawing, coded on the back with the object drawn in Phase 1, with the appropriate object. They could change their placement as they proceeded, and all children were asked if they wanted to change any pictures following their placement; thus, chance level was .20 (5 object/picture matches). Correlated t tests, all $p < .001$, revealed that 2-year-olds were at chance (.15) and that 3-year-olds performed less well (.53) than 4-year-olds (.79), although both were performing above chance. The proportion of correct matches was calculated for each child and analyzed using a one-way analysis of variance of age. The main effect of age, $F(2, 45) = 32.03$, $p < .001$, stemmed from a pattern similar to that found for children's use of the experimenter's symbols, with the exception that here 3-year-olds were poorer than 4-year-olds at matching their symbols with objects, whereas they had been equivalent to the 4-year-olds in using the experimenter's symbols. This suggests that production of 3-year-olds may lag somewhat behind their understanding of graphic symbols, even with simple objects. This idea was tested more directly by measuring the relation between performance on the drawing task and the choice task.

Table 3 Values for the Spearman Rank Correlations for Comparisons of Distinctions Made in Drawings with Correct Responses in Matching to Symbol Task of Experiment 1

Age (Years)	First Set	Second Set
2	.66***	.89***
3	.61**	.46*
4	.80***	.85***

*$p < .05$; **$p < .01$; ***$p < .001$.

Relation between Drawing Production and Understanding

To compare the mean proportion of distinctions made in the first and second sets of drawings with the mean proportion of correct responses on the choice task, separate Spearman rank correlations were calculated at each of the three ages. The results are presented in Table 3.

All of the correlations were positive and significant. In order to further explore this relation, contingency analyses were conducted. Quite stringent criteria were used. Children were classed as passing the symbol understanding task if they scored at least 6 out of 8 on the matching-to-symbol task using the experimenter's pictures, and as passing the symbol production task if they produced three or four distinctions between the objects. For the first set of drawings, 40 (83%) children either passed or failed both understanding and production tasks, $\chi^2(1, N = 48) = 22.49$, $p < .01$. Only 1 out of 48 children failed the understanding and passed the production test. In the second set of drawings, 41 (85%) of the children were consistent across tasks; only four out of 48 children failed understanding and passed production, $\chi^2(1, N = 48) = 24.71$, $p < .001$. Taken together, the correlation and contingency results support the claim made earlier that children's ability to produce an effective symbol is related to their ability to understand drawings as symbols.

EXPERIMENT 2

This study was designed to verify that the facilitation of performance attributed to the game in Experiment 1 was indeed due to the social use of graphic symbols and not due to extraneous variables, such as repetition. The design and procedure were identical to Experiment 1, with two important exceptions. First, in

the game of Experiment 1 children denoted the object to be placed in the tunnel by showing a picture, while in Experiment 2 they pointed to the object. This was to control for the possible facilitative effects that handling and drawing two pictures may have had. A second change in Experiment 2 was the addition of Phase 5, in which the experimenter attempted to match the child's drawings to the objects. For all ambiguous drawings, the experimenter indicated there was trouble matching, and asked the child to draw a third set of pictures so as to be sure where they went. This manipulation was added to explore whether failure to communicate with their drawings facilitated graphic symbol production for children of this age. Sitton and Light (1992) reported that, when children draw human figures and the gender of those figures is misinterpreted by another child, 5-year-olds improve their second drawings by rendering a more differentiated figure, whereas 4-year-olds do not. Because even preverbal infants will sometimes refine their communication signals when they fail to elicit the right response from the listener (Golinkoff, 1986; Marcos & Chanu, 1992), perhaps these young preschoolers would as well. Exploration of this possibility is relevant to the question of domain specificity.

Method

Participants

A total of 32 children participated in this study, 16 from each of two age groups: 3-year-olds (M = 3,2, *range* = 2,10–3,7), and 4-year-olds (M= 4,1, *range* = 3,11–4,5). These are the ages where a facilitation effect was found in Experiment 1. There were 9 and 7 girls, respectively in the two age groups. The children were recruited in the same manner as in Experiment 1, and the sample was similar.

Materials

Materials were the same as those in Experiment 1.

Procedure

The two exceptions noted above necessitated the following changes in instructions. In Phase 2, children were told to indicate, by *pointing*, which of the two toys put out by the first experimenter they wanted the second experimenter to drop down the tunnel. In Phase 3, the experimenter announced that it was the child's turn to put toys in the tunnel, and proceeded to *point* to one of the two objects presented in each trial. To assess the impact of failure to communicate, Phase 5 was added as soon as the child had finished lining up the second set of drawings under the objects they portrayed. It was then announced that it was the experimenter's turn to try to match the drawings. The drawings were randomly matched, with the exception that the experimenter always chose and placed any unambiguous drawings first. Then the experimenter dramatically claimed "Uh oh, I can't tell where these ones go, they kind of look the same to me," while randomly laying out whichever drawings were ambiguous. In all cases the ambiguous drawings involved the balls. A typical ambiguity was that all, or some subset of, the balls were drawn with the same sized circular form. The experimenter then picked up one of the balls that needed to be redrawn and said to the child, "When I look at these pictures I can't tell which one goes with this. Can you draw me another one so that I can be sure that it goes with this one and not one of the others?" The experimenter picked up all of the objects that needed to be redrawn, one by one, and asked the child to redraw them in random order. The particular objects redrawn varied across children according to which drawings in the child's second set were ambiguous.

Results and Discussion

The questions of interest in Experiment 2 relate to the production task. Do children's drawings improve in the second as compared to the first set even though the game did not involve the use of graphic symbols? If children are given feedback that their symbols are not effective, will they improve their drawings? Understanding was not measured because objects were indicated by pointing and not by showing graphic symbols. No children made any errors in placing the objects in the tunnel when they were indicated by pointing.

Is Pointing as Effective as Graphic Symbols?

Independent judges counted the number of distinctions (*range* = 0–4) each child made in the first and second set of drawings. Interrater reliability was high (*mean* agreement = 98%). These data were analyzed using a 2 × 2 (Ages × Drawing Set) repeated measures analysis of variance. The relevant means are presented in Table 4. The analysis revealed significant main effects of age, $F(1, 30) = 5.51$, $p < .03$, and drawing set, $F(1, 30) = 6.00$, $p < .02$. Three-year-olds made significantly fewer distinctions (1.81) than did 4-year-olds (2.88), and fewer distinctions were made in the second as compared to the first sets of drawings (2.47 versus 2.22 for the first and second sets, respec-

Table 4 Mean Number of Distinctions[a] Made in First, Second, and Third Sets of Drawings in Experiment 2

Age (Years)	First Set		Second Set		Third Set[b]	
	M	*SD*	*M*	*SD*	*M*	*SD*
3	1.94 (49)	1.61	1.69 (42)	1.54	2.20 (55)	1.66
4	3.00 (75)	.97	2.75 (69)	1.00	3.69 (92)	.63
	2.47 (62)	1.41	2.22 (56)	1.39	2.95 (74)	1.47

[a] Total possible number of distinctions is four and percentage of distinctions is given in parentheses.
[b] These means were calculated from data for 15 3-year-olds and 13 4-year-olds.

tively, a change of .25). Out of 32 children, 8 made fewer distinctions on their second set of drawings, 1 made more, and 21 stayed the same. Thus, the children's improvement in Experiment 1 is not likely to be due to simple repetition of drawings or noncommunicative experience with the objects.

The Positive Effects of Negative Feedback

Out of a total of 32 children, 15 of the 3-year-olds and 13 of the 4-year-olds completed a third set of drawings. The remaining four children had produced an unambiguous second set of drawings. The number of distinctions (*range* = 0–4) in the children's second and third sets of object drawings were analyzed using separate correlated *t* tests for each age group. Both 3-year-olds, $t = 3.16$, $p < .01$, and 4-year-olds, $t = 5.33$, $p < .01$, produced significantly more distinctions in their third as compared to their second set of drawings (see Table 4). This contrasts with the findings of Sitton and Light (1992), who did not find improvement in 4-year-olds' drawings of the human figure when other children were the communicative partners. There are a number of differences between the studies that could account for this discrepancy, including the type of drawing and the age of the communicative partner. When compared to Experiment 1, the change that occurred as a result of negative feedback was equivalent to that produced by the communicative game (see Tables 2 and 4).

GENERAL DISCUSSION

In Experiment 1, children's ability to produce and respond to simple graphic symbols was explored. The ability to produce effective symbols was found to emerge toward the end of the third year and to improve through the fourth year. The effectiveness of these symbols as communicative tools was facilitated following a game that had children using their drawings as symbols and responding to an experimenter's drawings. The game facilitated symbol effectiveness only for 3- and 4-year-olds; the 2-year-olds were unable to make the most simple distinction (circle versus line) between objects used in the study. It is very likely that the 2-year-olds failed to produce representational drawings both before and after the game because they did not yet have a concept of a drawing as a symbol. This reasoning is supported by the finding in Experiment 1 that many of the 2-year-olds put pictures of objects down the tunnel when given the choice between pictures and their referents, even though they had completed eight trials where they had to choose between two objects and so presumably were used to putting objects down the tunnel. In addition, these children performed at chance when the experimenter-drawn symbols were used to indicate which of two objects should be put down the tunnel by the child. Thus, it appears that in the present context, 2-year-oles neither respond to simple graphic symbols nor produce them. That this production failure is conceptual and not due to an inability to make the appropriate marks is supported by the fact that circles and lines were present in the free drawings of all but one child across Experiments 1 and 2.

These findings support DeLoache's (1995b) model of symbol understanding and use, in particular the notion of a dual representation failure in young children. They also fit with the developmental trajectory DeLoache predicts for the emergence of understanding of the role of pictures-as-symbols. DeLoache et al. (1997) argue that the difficulty with young children's use of pictures as symbols stems primarily from their dual nature and suggest that, until sometime in the second year, infants look through pictures to their referents and respond as they would to the object (e.g., trying to grasp the object portrayed in a picture). Toward the end of the second year, infants begin to acquire the concept of a picture as a two-dimensional object in its own right, a concept that undergoes significant refinement during the following months. Sometime

around the middle of their third year, children begin to grasp the relation between a picture and its referent, an appreciation that allows them greater flexibility in their use of pictures.This developmental sequence may be characterized as the child having first the concept that the picture is the same as the referent (i.e., picture-as-referent), then that the picture is an interesting object (i.e., picture-as-object), and finally that the picture stands for an object (i.e., picture-as-symbol).

The use of a social-communicative game as an attempt to promote effective symbol production was inspired by studies that explore the social bases of language (Baldwin, 1991; Bruner, 1983b; Tomasello, 1992; Tomasello & Farrar, 1986). The results of Experiment 1 suggest that the facilitative effects of social interaction are not restricted to the domain of verbal language, but can also promote the acquisition of symbols in the graphic domain. Experiment 2 confirmed that the effects of Experiment 1 were due to social interaction with graphic symbols, and further suggested that another facilitative social cue is failure to communicate. When told the experimenter couldn't tell which picture went with which object, over half of the children improved their drawings.

A major question addressed by these experiments is whether the understanding of graphic symbols is related to the emergence of representational drawing ability. Certainly there is a correlation between the two when one considers the results of Experiment 1. Only when children consider that pictures can function as symbols can they intentionally create a graphic symbol. Reith (1990) has shown that children's understanding of the dual nature of pictures is correlated with the accuracy of their drawings of three-dimensional models. With far simpler objects that require only circles and lines for their depiction, Experiment 1 indicated a relation between symbol understanding and production at 3 years of age. I believe this suggests that the first representational drawings of young children emerge from the significant shift in cognitive understanding that accompanies the acquisition of the concept that pictures can function as symbols. The finding that social interaction facilitates symbol acquisition in the graphic domain, as it does in the verbal domain, has implications for the debate of domain specificity in symbolic processing. Social interaction may be a general mechanism that promotes symbolic functioning across domains; however, as Karmiloff-Smith (1992) argues, the finding of domain-general mechanisms does not preclude the possibility that domain-specific mechanisms may also constrain symbolic development. Further research is needed to explore the extent to which the understanding and production of graphic symbols is related to understanding and production in other symbolic domains.

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