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Age-Related Changes in Learning Across Early Childhood: A New Imitation Task

ABSTRACT: *Imitation plays a critical role in social and cognitive development, but the social learning mechanisms contributing to the development of imitation are not well understood. We developed a new imitation task designed to examine social learning mechanisms across the early childhood period. The new task involves assembly of abstract-shaped puzzle pieces in an arbitrary sequence on a magnet board. Additionally, we introduce a new scoring system that extends traditional goal-directed imitation scoring to include measures of both children's success at copying gestures (sliding the puzzle pieces) and goals (connecting the puzzle pieces). In Experiment 1, we demonstrated an age-invariant baseline from 1.5 to 3.5 years of age, accompanied by age-related changes in success at copying goals and gestures from a live demonstrator. In Experiment 2, we applied our new task to learning following a video demonstration. Imitation performance in the video demonstration group lagged behind that of the live demonstration group, showing a protracted video deficit effect. Across both experiments, children were more likely to copy gestures at earlier ages, suggesting mimicry, and only later copy both goals and gestures, suggesting imitation. Taken together, the findings suggest that different social learning strategies may predominate in imitation learning dependent upon the degree of object affordance, task novelty, and task complexity.* Dev Psychobiol 55: 719–732, 2013.

Keywords: *social learning; imitation; early childhood; preschool; puzzles*

INTRODUCTION

Imitation, the ability to reproduce a set of observed actions while using the observed gestures, plays a critical role in social and cognitive development, but the social learning mechanisms contributing to the development of imitation are not well understood (Want & Harris, 2002; Zentall, 2012). This is partly because many imitation tasks are restricted in their application to only a small range of ages: there is currently no single imitation task that can be used to assess learning and memory across the early childhood period (1.5–3.5 years of age). The available tasks are typically designed to test infants and toddlers (6–24 months; e.g., Barr, Muentener, & Garcia, 2007) or preschool-aged children (3- to 5-year-olds; e.g., Flynn & Whiten, 2008).

In addition to restrictions on age, many tasks are designed to examine only one aspect of social learning, the copying of either goals or gestures. There is a consensus among researchers that imitation is the reproduction of both observed goals and gestures (Huang & Charman, 2005; Longo, Kosobud, & Bertenthal, 2008;

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Lyons, Damrosch, Lin, Macris, & Keil, 2011; Lyons, Young, & Keil, 2007; Nielsen & Blank, 2011; Nielsen & Tomaselli, 2010; Want & Harris, 2002; Zentall, 2012). This means that both the ends and the means must be reproduced for imitation to occur. Each of these components—goals and gestures—map onto definitions of other social learning strategies. The reproduction of goals (copying the observed outcome) can be defined as goal emulation, while gestural copying can be defined as mimicry. The developmental trajectory from mimicry through imitation and goal emulation is well documented, but controversial (Jones, 2009; McGuigan & Whiten, 2009; Nielsen, 2006; Want & Harris, 2002), with researchers failing to agree on whether mimicry is present in early infancy, or something that emerges later in development. Want and Harris suggest that mimicry is a less complex social learning strategy as it involves replicating the observed gestures in the absence of any recognition of the goals of those actions. Thus it is likely that mimicry emerges earlier in development than imitation and emulation. Imitation, involving veridical copying of goals and gestures, emerges next by this argument, as the child develops a somewhat tenuous understanding of the goal. Finally performance progresses to goal emulation, in which goals are copied without gestural fidelity and the task is fully understood in terms of the goal. Adult observers frequently emulate; however, other reports (Flynn & Smith, in press; McGuigan, Makinson, & Whiten, 2011) have shown that adults can modify their strategy depending on task demands. However, questions regarding this progression are difficult to address because most imitation tasks designed for infants and toddlers do not separately measure goals and gestures (e.g., Barr, Dowden, & Hayne, 1996). Most tasks therefore lack the sensitivity to address the trajectory of social learning development. Thus, the tasks traditionally used to assess ‘‘imitation’’ in early childhood may only measure goal emulation, as researchers did not report the fidelity of gestural copying behavior (but see Huang & Charman, 2005; Nielsen, 2006). The goal of the present study was to develop a new imitation task that is able to distinguish between different social learning strategies (i.e., mimicry, imitation, and goal emulation) and that could be used across a wide range of ages in early childhood.

EXPERIMENT 1: DEVELOPMENT OF THE TASK

In order for age-related comparisons to be made, imitation tasks intended for use across a wide age range must first have a low and age-invariant baseline: Baseline performance must be at or near zero across ages (e.g., Barr et al., 1996; Meltzoff, 1990; Piaget, 1962; Uzgiris & Hunt, 1975). For example, Barr et al. (1996) developed a puppet imitation task with both a low probability and age-invariant baseline appropriate for 6- to 24-month-olds; infants across the age range rarely produced any of the target actions without first seeing a demonstration. The task was replicated both internally (e.g., Barr et al., 2007; Hayne, Boniface, & Barr, 2000) and by other laboratories (e.g., Elsner, Hauf, & Aschersleben, 2007; Haley, Grunau, Weinberg, Keidar, & Oberlander, 2010; Heimann & Nilheim, 2004; Horne, Erjavec, & Lovett, 2009; Learmonth, Lamberth, & Rovee-Collier, 2005) to answer questions about age-related changes in memory and social learning. Similarly, a primary goal of the present work was to develop a more general task that would be easily adaptable across toddlerhood and preschool development.

To ensure that our imitation task was sufficiently difficult, we developed a magnetic puzzle task, which included four puzzle pieces, three of which were relevant to the task, plus a distractor piece. Prior imitation research has shown that including a distractor during demonstrations makes it significantly more difficult for 20- and 27-month-olds to retrieve the demonstrated information at test (Bauer & Fivush, 1992; Wiebe & Bauer, 2005).

We increased task complexity through two additional design choices. First, the puzzles consisted of an arbitrarily ordered sequence. Arbitrary sequences limit or eliminate the use of logical inference or top-down knowledge derived from previous experience to accomplish the goal (Bauer, Hertsgaard, Dropik, & Daly, 1998; Flynn & Whiten, 2008). Second, we designed the puzzle pieces as flat abstract magnetic shapes. This sets the current task apart from many imitation tasks used in the literature, in which the (meaningful) objects in a task sequence afford a restricted range of possible orders to which the actions can be applied to the objects (see also Horne et al., 2009; Zentall, 2012). Memory demands increase when task objects are chosen or created to avoid resembling specific objects familiar to the child observers. We assembled the arbitrary puzzle sequence using actions that were likely to lack any previously learned affordances (Gibson, 1979) to the objects involved. Further, the puzzle pieces themselves should be unfamiliar in that they are only semantically meaningful as shapes (e.g., triangle, rectangle) and do not symbolically represent other objects. To increase the ecological validity of the task, and in keeping with typical tasks designed for children in this age range, the puzzles were assembled to make objects. When correctly assembled the puzzles resembled either a boat or a fish.

The primary objective in developing a new imitation task was to enable a more fine-grained examination of social learning components. The new task provides a framework with which to test the predicted developmental progression from simple to complex social learning strategies, using a single task. Specifically, based on Want and Harris (2002) we predicted a developmental trajectory from mimicry (copying gestures) through imitation (copying both goals and gestures) to goal emulation (copying goals). We examined this question by measuring age-related changes in the patterns of goal and gesture reproduction.

Methods

Participants. This study included 126 typically developing children (60 boys) from two metropolitan areas. Independent groups of children were tested at each of the following ages: 1.5 years ($N = 23$, M age = 18 months 4 days, $SD = 16$ days), 2 years ($N = 31$, M age = 24 months 5 days, $SD = 17$ days), 2.5 years ($N = 24$, M age = 30 months 1 days, $SD = 12$ days), 3 years ($N = 24$, M age = 36 months 6 days, $SD = 39$ days), and 3.5 years ($N = 24$, M age = 42 months 2 days, $SD = 20$ days). Participants were primarily Caucasian (71%) and from college-educated families (100% of families that reported education, 70% of sample). SES scores (Nakao & Treas, 1994) captured the diversity of the sample more effectively than ethnicity and education (SES range = 29.2–97.2, $M = 76.9$, $SD = 13.8$) with 67% of families reporting. Ten additional children were excluded from the analysis: three due to experimenter error, five for failure to interact with the experimental stimuli for at least 60 s, and two due to parental interference.

Apparatus. The apparatus enclosure was made of a black plastic material; it was 35.5 cm tall, 42 cm wide, and 23.3 cm deep. The front of the enclosure contained a metal board, oriented vertically and painted school bus yellow (see Fig. 3C). The apparatus was placed on a child-sized table throughout the procedure.

Stimuli. The stimuli consisted of small plastic geometric pieces painted in different colors. There were two sets of objects, a "boat" and a "fish." Each test object was composed of three smaller component pieces (see Fig. 1 for a photo of the stimulus board pre- and post-assembly). A magnetic backing held the pieces on the metal board, but was sufficiently weak that the pieces could be easily slid around on the board. All puzzle pieces were .5 cm thick. The three pieces that made up the final puzzle object (fish or boat) were located in three of the four corners of the metal board; the last corner contained an additional distractor piece that was not moved during the demonstration.

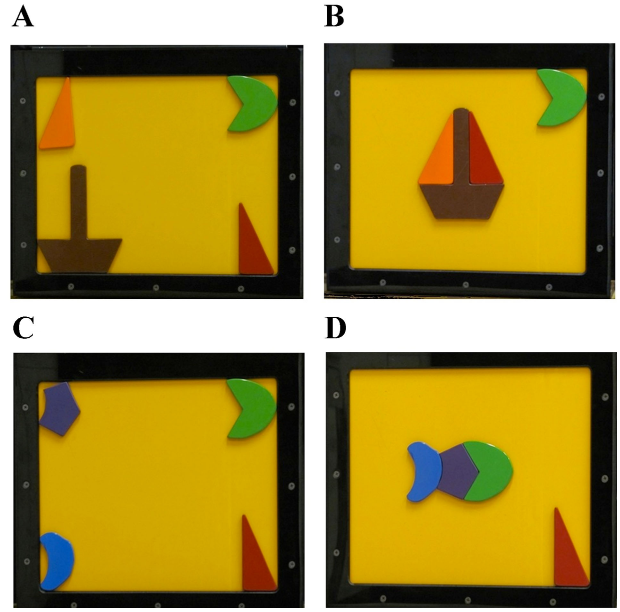

FIGURE 1 Stimuli. *Boat*. The top row depicts the beginning (A) and ending (B) position for the boat puzzle. The boat when fully assembled measured 15.2 cm high at the center by 12.1 cm long at the widest point. *Fish*. The bottom row depicts the beginning (C) and ending (D) position for the fish puzzle. The fish when fully assembled measured 8.9 cm high at the widest point and 15.2 cm long from the end of the green piece to the end of the blue piece.

Boat: The boat puzzle was comprised of two triangles and a larger trapezoid with a long rectangle (the "mast") attached (see Fig. 1A,B).

Fish: The fish puzzle was comprised of three small geometric components (see Fig. 1C,D).

Distractor piece: For the boat puzzle, the distractor was the green geometric component from the fish puzzle. For the fish puzzle, the distractor was the red triangle from the boat puzzle. The distractor was placed at either the top right or the bottom left corner of each puzzle and was counterbalanced across subjects.

Design. Independent groups of children at 1.5, 2, 2.5, 3, and 3.5 years of age were randomly assigned to either a *live demonstration* or *baseline* group. The placement of the boat or fish puzzle pieces was counterbalanced across participants into one of two configurations on the board. Each participant was tested with only one configuration of one test object. Children in the baseline group did not participate in a demonstration session. Rather, they were shown the stimuli for the first time at the start of the test period.

Procedure. Testing primarily occurred in the home (a small subset—$n = 10$—were tested in the laboratory). All of the children in the study were given a brief (5–10 min) warm up play session to ensure that they were familiar and comfortable with the experimenter.

Baseline group. The baseline group began with the magnet board covered with the black cloth. At the start of the session, the experimenter removed the cover and invited the children to play using the words, ''now it's your turn.'' The baseline lasted 60 s from the first time the child touched the magnet board or puzzle pieces. The purpose of the baseline was to ensure that spontaneous production of the target behaviors (sliding, connecting the pieces) was low and age-invariant. During baseline children readily interacted with the pieces, picking them off the board, showing them to the parent, and rotating them. In contrast, spontaneous production of target behaviors (the actions presented during demonstration) was rare, and did not vary across age (see Results Section below). Following the 60 s measurement period, the experimenter conducted a manipulation check. The experimenter demonstrated the target actions and gave the child the opportunity to reproduce the target actions. If the child did not immediately reproduce the target actions, the experimenter demonstrated again and then gave the child the puzzle pieces. The manipulation check demonstrated that children of all ages were physically capable of reproducing the gestures and connecting the puzzle pieces.

Demonstration group. Children in the demonstration group observed a live demonstration of the construction of (one) puzzle and then participated in a test phase.

Live demonstration phase. Participants were seated approximately 50 cm away from the apparatus and experimenter. The experimenter, while facing the child, lifted a black cloth covering the display, placed two fingers (index and middle digit) on the center of each of the three target pieces and then slid each to its final location (see Fig. 1 for an illustration of the stimulus board pre- and post-assembly). The cloth was lowered over the display while the pieces were returned to the start position so that the child did not observe the experimenter moving the pieces back to the pre-demonstration positions. Using this procedure, the demonstration was repeated for a total of three demonstrations (overall exposure time $M = 52$ s, $SD = 5.1$ s). During the demonstration phase the experimenter made non-specific, fully scripted comments in order to keep the child engaged in the task (e.g., ''Look at this!'', ''Isn't that fun?''). Children were required to look toward the demonstration at least two-thirds of the time in order to be included in the final sample.

Test phase. A delay averaging 2.32 s ($SD = 1.9$ s) separated the start of the test phase from the end of the demonstration phase. The test phase began with the magnet board covered with a black cloth. The experimenter lifted the cover to reveal the magnet board and the four puzzle pieces placed in their original, pre-demonstration positions. The experimenter then invited the child to play by stating, ''Now it's your turn.'' Each child was given 60 s from their first contact with the puzzle board or the pieces to freely play with the items. Following the 60 s measurement period, the experimenter conducted a manipulation check as in the baseline group.

Coding. Imitation is operationally defined as group performance significantly above baseline. Mimicry, imitation, and goal emulation were assessed using the following dependent measures: gesture and goal reproduction. Success on the gestural component of a task, coupled with poor performance on the goal component, would indicate mimicry. Conversely, success on the goal component of the task coupled with poor performance on the gestures would be indicative of goal emulation (Nielsen, 2006; Tomasello, 1990; Want & Harris, 2002; Zentall, 2012). If children succeed in copying the goals using the demonstrated gestures, this would be indicative of imitation (Nielsen, 2006; Tomasello, 1990; Want & Harris, 2002; Zentall, 2012).

Gesture score. Children received one point for each target puzzle piece that they slid using the demonstrated sliding action. If at any point during the 60 s test they slid one of the three target pieces they received a point. The maximum number of points was 3, meaning that if the children slid each of the target pieces they would receive all three points. If they slid only one or two pieces they would receive scores of one and two, respectively. Children did not receive additional points for multiple attempts at sliding one piece. They did not receive a point for grasping and removing a piece from the board in order to move it. Children had to start and end an action with the sliding motion (if they picked up the piece at any time during the slide, no point would be scored for that action). A slide was scored as a correct gesture, however, if the child used any open-handed gesture in which the surface and not the edges of the object were touched. Copying the sliding gesture was considered to index mimicry, as it could be completed regardless of whether the goal was also completed successfully.

Goal score. Children received one point for each of the puzzle pieces that they connected to the central object in the correct orientation within approximately 1–2 mm of touching (two possible points). The goal score is completely separate from the gesture score in that if a child used an incorrect gesture to correctly connect two puzzle pieces they still received a point for the goal. Thus, the goal score is a measure of emulation, as it does not assess how the children connected the pieces, merely whether they were connected correctly (in terms of the goal) or not.

Puzzle interaction. Because this is the first study using this task we measured the amount of time each child spent interacting with each of the puzzle pieces. Average time spent interacting with the puzzle pieces was calculated within and across experimental group, as well as within and across age group.

Interrater reliability. Thirty percent of all of the test sessions were rescored by a second coder and kappa was calculated. Interrater agreement on each of the subscales ($k_{\text{gesture}} = .96$, $k_{\text{goal}} = .81$) was very good.

Results

Preliminary Results. Gesture and goal scores were converted to proportions to permit direct comparison of the two measures. The individual influences of age, sex, stimulus type and group were assessed with an analysis of variance (ANOVA) on each dependent measure. There was no main effect or interaction involving sex for either gestures or goals, so this variable was not included in subsequent analyses. All goal reproduction baselines were zero; therefore we conducted this analysis using only data from the demonstration group to avoid a violation of homogeneity. There was a significant main effect of stimulus type (fish, boat), $F(1, 86) = 5.59$, $p = .02$, partial $\eta^2 = .06$ for *gestures* (demonstration group: boat $M = .62$, $SD = .38$; fish $M = .76$, $SD = .34$; baseline group: boat $M = .16$, $SD = .08$; fish $M = .25$, $SD = .13$), and $F(1, 48) = 7.34$, $p = .009$, partial $\eta^2 = .13$ for *goals* (demonstration group: boat $M = .72$, $SD = .43$; fish $M = .43$, $SD = .46$; baseline group: boat $M = .00$; fish $M = .00$), which shows that the boat puzzle was easier than the fish puzzle. Stimulus type did not enter into any significant interactions for group or age for either gesture or goal score. Given that stimulus did not interact with the main variable of interest (age), subsequent analyses were also collapsed across stimuli (see Discussion Section below).

Puzzle Interaction. The average amount of time children spent interacting with the three target puzzle pieces compared to the distractor piece did not vary as a function of age or group (*ps* > .10). The average amount of time children interacted with the puzzle pieces was 46.42 s ($SD = 32.02$ s) in the baseline group and 36.17 s ($SD = 23.46$ s) in the demonstration group. The amount of time children spent interacting with the distractor did vary as a function of group, $F(1,106) = 4.37$, $p = .039$, partial $\eta^2 = .040$. Children in the baseline group spent slightly more time with the distractor ($M = 10.79$ s, $SD = 10.88$ s) than children in the demonstration group ($M = 7.28$ s, $SD = 8.21$ s). This is to be expected because of stimulus enhancement to the three target pieces for the live demonstration group (Zentall, 2012). For children in the baseline group, however, there is no reason for children to avoid the distractor as it lacks ‘‘distractor’’ status. Time spent with the distractor did not vary as a function of age ($p = .77$). Differences in group performance on the gesture and goal scores could not be accounted for by failure to interact with the puzzle pieces as a function of group or age.

Does Performance Exceed Baseline?

Gesture Score. Figure 2 illustrates gesture score by group across all ages. A 2 (group) × 5 (age) ANOVA on gesture score yielded a main effect of age, $F(4, 116) = 7.81$, $p < .001$, partial $\eta^2 = .21$, and group, $F(1, 116) = 164.06$, $p < .001$, partial $\eta^2 = .59$. These main effects were qualified by a significant Age × Group interaction, $F(4, 116) = 5.55$, $p < .001$, partial $\eta^2 = .16$. A contrast across age for the baseline group showed no effect ($F < 1$), such that comparisons across age did not require an adjustment of baseline. With the exception of 1.5-year-olds, children at each age in the demonstration group performed significantly above baseline. For 1.5-year-olds there was a trend toward above-baseline performance (simple effects test on group—baseline compared to demonstration—at 1.5 years; $p = .085$) (see Fig. 2).

Goal Score. Figure 2 illustrates goal score by group across all ages. Baseline was zero at all ages: a hallmark of a good imitation task (see Barr & Hayne, 2000). Consequently, however, baseline data could not be included in further analyses because this would constitute a violation of homogeneity. A one-way ANOVA across age on goal score for the demonstration group yielded a main effect of age, $F(4, 67) = 10.71$,

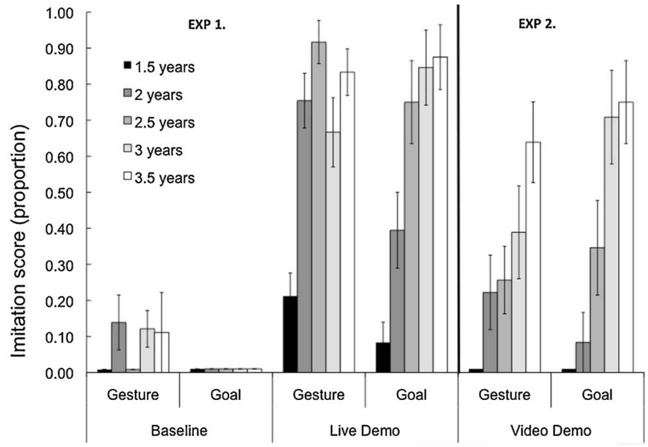

FIGURE 2 Gesture score (±1 *SE*) and goal score (±1 *SE*) for the baseline group, live group (Exp. 1), and video group (Exp. 2) at each age tested.

$p < .001$, partial $\eta^2 = .40$. To assess whether any individual age group was above baseline, a one-sample *t*-test against zero was conducted at each age ($p < .01$—Bonferroni correction for multiple *t*-tests). These tests indicated that goal score was significantly above zero for all age groups except 1.5 years: 1.5 years, $t(11) = 1.48$, $p = .17$; 2 years, $t(18) = 3.75$, $p = .001$; 2.5 years, $t(11) = 6.51$, $p < .001$; 3 years, $t(11) = 8.12$, $p < .001$; and 3.5 years, $t(11) = 9.75$, $p < .001$ (see Fig. 2).

Age-Related Changes in Social Learning Strategies

A primary goal of the study was to determine whether learning differed in terms of gesture and goal performance as a function of age. The baseline for all age groups was virtually zero, permitting age-related comparisons to be made without adjusting for baseline differences (Barr et al., 1996; Barr & Hayne, 2000; Meltzoff, 1990). Given that we had established that the task has an age-invariant baseline, we were able to examine gesture and goal scores further using follow-up analyses to investigate age-related changes in the production of gestures and goals.

Gesture Score. Gesture scores are depicted in Figure 2 as a function of age and group. A Helmert contrast testing 1.5-year-olds against the mean of all older participants was significant, $p < .001$, but the same test comparing 2-year-olds to all older participants was not ($p = .92$). These follow-up analyses suggest that there were no differences in age groups tested between 2.0 and 3.5 years, in which children reproduced approximately equal numbers of gestures.

Goal Score. Goal scores are depicted in Figure 2 as a function of age and group. A Helmert contrast testing 1.5-year-olds against the mean of all older participants was significant, $p < .001$, and the same test comparing 2-year-olds to all older participants was also significant ($p = .001$). The Helmert contrast testing 2.5-year-olds against the mean of all older participants was not significant ($p = .40$), suggesting that there were no differences in age groups tested between 2.5 and 3.5 years (see Fig. 2).

Discussion

This new imitation task enables age-related comparisons of social learning mechanisms to be made across early childhood. The baseline for the boat and fish puzzle was virtually zero, suggesting that the children tested did not see any connection between the puzzle pieces and a familiar object; that is, the pieces prior to demonstration did not afford construction of the puzzles to make either a boat or a fish. Overall, however, children successfully copied the boat puzzle more than the fish puzzle. While both puzzles included arbitrary sequences, we speculate that the boat puzzle was less challenging than the fish puzzle because it was segmented along part boundaries, making the components and the assembled puzzle more readily identifiable and thus more likely to be correctly recalled.

There were age-related changes in gesture score between 1.5 and 2 years, but not thereafter. Reproduction of goals did not exceed baseline at 1.5 years. This combination of outcomes is suggestive of mimicry at 2 years (Tomasello, Kruger, & Ratner, 1993; Want & Harris, 2002). Goal reproduction was significantly higher at age 2.5 than at 2 years, and did not increase thereafter. Goals and gestures were reproduced at approximately equal levels by children 2.5 years of age and older. The combination of gesture and goal reproduction is suggestive of imitation from 2.5 to 3.5 years. These findings suggest that given a highly novel task, where the initial affordances of the objects are not strong and the demonstrated order of actions is arbitrary, the youngest children mimicked, while older children imitated the demonstration (see Want and Harris, 2002; Zentall, 2012, for discussion). These data do not show a pattern indicative of goal emulation in the age range tested. We are currently testing older children with a more complex puzzle and will examine whether emulation or overimitation emerges in the tested age range (McGuigan, Whiten, Flynn, & Horner, 2007; Nielsen, 2006; Tomasello, 1990; Want & Harris, 2002; Zentall, 2012).

There were no age-related differences in performance between children 2.5 and 3.5 years of age under optimal imitation conditions (when the demonstration was presented by an engaged adult and test occurred immediately following demonstration). In Experiment 2, the new task is used to examine children's social learning strategies in a situation where the learning conditions are known to be suboptimal—a video demonstration lacking social contingency.

EXPERIMENT 2: A TEST CASE OF THE VIDEO DEFICIT

Young children *consistently learn less from television than from a face-to-face interaction*, a finding termed the video deficit effect (Anderson & Pempek, 2005). The deficit may be partly due to the fact that, as opposed to learning during face-to-face interactions, learning from television involves transfer of learning. Transfer, according to Barnett and Ceci (2002), is the process of applying information in situations that are featurally and or contextually distinct from the conditions where learning occurred. In this context, transfer involves relating information between a 2-dimensional (2D) source and a 3-dimensional (3D) target (Barnett & Ceci, 2002; Barr, 2010; Klahr & Chen, 2011). Transfer of information across dimensional changes involves generalizations across shape, size, color, depth, and social context (Barnett & Ceci, 2002; Barr, 2010; Hayne, 2006; Klahr & Chen, 2011; Troseth, 2010).

Although the existence of a video deficit in young children's learning is now well-documented using multiple different procedures (for reviews see Anderson & Hanson, 2010; Troseth, 2010), imitation has been used most extensively to investigate the video deficit effect (for review see Barr, 2010). For example, Hayne and coworkers (Barr & Hayne, 1999; Hayne, Herbert, & Simcock, 2003) examined imitation from television using a 3-step sequence and demonstrated that goal reproduction by 15- to 30-month-olds was significantly lower following a video demonstration than following a live demonstration. As is common in the literature, these studies did not measure gesture reproduction. One exception is Whiten and coworkers, who developed a 9-step procedure to investigate older (3- to 5-year-old) children's imitation of gestures and goals from live (McGuigan et al., 2007) and video (Flynn & Whiten, 2008) models. The task was difficult for children: While both ages exhibited some evidence of gestural and goal imitation from the live demonstration (McGuigan et al., 2007), only 5-year-olds reproduced the goals from video (Flynn & Whiten, 2008). That is, the 3-year-olds demonstrated the typical video deficit effect and copied the goal less frequently. Both 3- and 5-year-olds were less likely to copy gestures following video as compared to live demonstration (Flynn & Whiten, 2008; McGuigan et al., 2007). The authors concluded that idiosyncratic social behaviors or gestures might be less likely to transfer from a video than a live demonstration, thus decreasing overall fidelity (see also Huang & Charman, 2005, for a similar argument). They did not test children younger than 3 years of age.

The age of a video deficit offset is unclear from previous studies because no single study has tested ages spanning the range from emergence to offset of the deficit. Furthermore, researchers have not consistently measured how different social learning mechanisms are deployed. For example, studies with children under 2 years of age (e.g., Barr et al., 2007) have typically measured only goal reproduction, while studies including children over 3 years of age (e.g., Flynn & Whiten, 2008) have examined both goal and gesture reproduction. It is possible that there is simply a lag in both gesture and goal reproduction following a video demonstration; but it is also possible that gesture and goal reproduction may improve at different rates between 1.5 and 3.5 years of age.

The goal of Experiment 2 was to examine goal and gesture reproduction following a video demonstration between 1.5 and 3.5 years using the magnet board task developed in Exp. 1. Overall, the video deficit should be most pronounced for 1.5-year-olds and decline across development, with 2- to 3.5-year-olds showing progressively less extreme differences in performance between the live demonstration and video demonstration groups. Flynn and Whiten's (2008) findings suggest that both goal and gestural reproduction from video might lag behind goal and gestural reproduction from a live demonstration, but that the lag may be more pronounced for gesture than for goal reproduction.

Methods

Participants. This study included 61 typically developing children (32 boys) from two metropolitan areas. Independent groups of children were tested at each of the following ages: 1.5 years ($N = 12$, M age = 18 months 1 day, $SD = 13$ days), 2 years ($N = 12$, M age = 24 months 2 days, $SD = 14$ days), 2.5 years ($N = 13$, M age = 30 months 4 days, $SD = 27$ days), 3 years ($N = 12$, M age = 36 months 6 days, SD = 39 days), and 3.5 years ($N = 12$, M age = 42 months 3 days, $SD = 26$ days). The majority of participants were Caucasian (56%) and from college-educated families (100% of families that reported education, 65% of sample). The SES scores (Nakao & Treas, 1994) more effectively captured the diversity of the sample than education and ethnicity (range = 43.4–97.2, $M = 76.9$, $SD = 14.7$), with 64% of the sample reporting. Seven additional children were excluded from the analysis: three due to experimenter error, three for failure to interact with the experimental stimuli for over 60 s, and one due to parental interference.

Apparatus and Stimuli. The apparatus and stimuli in Exp. 2 were the same as those used in Exp. 1. A computer screen with a resolution of 1024×768 (17″ diagonal extent; NEC display) was located behind the magnet board and built into the enclosure (see Fig. 3); the apparatus was oriented vertically throughout the experiment. The computer screen was used to play the demonstration movie in the video groups using a Java program created specifically for this task. The apparatus was placed on a child-sized table, which was used as the demonstration and test surface during the demonstration and test phases.

Procedure. **Video group.** Other than the change from a live to a video demonstration the procedures for Exp. 2 were identical to Exp. 1.

Video demonstration phase. Viewing conditions during the video demonstration phase were the same as those in the live demonstration. The experimenter demonstrating the target behaviors on the video assembled the puzzle three times in the same manner as in the live demonstration (see Fig. 3, panel A). The video demonstration was 60 s in duration. The exact same phrases (e.g., "Look at this", "Isn't that fun") were used during the live and video demonstrations.

Test phase. A delay averaging 26 s ($SD = 17$ s) separated the start of the test phase from the end of the video demonstration phase. During this time, the child was turned around while the experimenter placed the magnet board in front of the screen, covered the magnet board with the black cloth and placed the puzzle pieces in the starting position. The test phase was identical to Exp. 1 (see Fig. 3C). Following the 60 s measurement period, the experimenter conducted a manipulation check as in the baseline group.

Results

Gesture and goal scores were converted to proportions to permit direct comparison of the two measures. The individual influences of age, sex, stimulus type and group were assessed with an analysis of variance (ANOVA) on each dependent measure. There was no main effect or interaction involving sex for either gesture or goal score, so this variable was not included in subsequent analyses. All goal reproduction baselines were zero; therefore we conducted this analysis using only data from the demonstration group to avoid a violation of homogeneity. There was no effect of stimulus

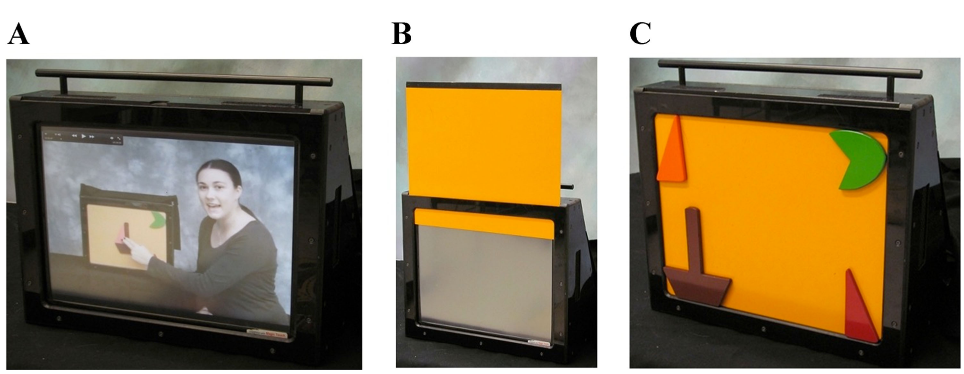

FIGURE 3 (A) Depicts computer screen during the video demonstration of the target actions. (B) Depicts how the magnet board slides in front of the computer screen. (C) Depicts the starting position for the boat stimuli during the test session.

type (fish, boat) for either gestures or goals, nor did it enter into any significant interactions, thus, subsequent analyses were collapsed across stimuli.

Puzzle Interaction. Children did not differ in the amount of time spent with the individual puzzle pieces as a function of age ($p = .17$; overall mean time = 45 s) after observing the video demonstration. Additionally, time spent with the distractor did not vary as a function of age ($p = .20$). That is, children interacted with the puzzle pieces at all ages in the video group.

Does Performance Exceed Baseline?

Gesture Score. A cross-experiment analysis was conducted and data from Exp. 2 was compared to the baseline control group data collected in Exp. 1. Figure 2 illustrates gesture score by group across all ages. A 2 (group: video, baseline) × 5 (age) ANOVA on gesture score yielded a main effect of age, $F(4, 98) = 5.50$, $p < .001$, partial $\eta^2 = .18$ and group, $F(1, 98) = 17.26$, $p < .001$, partial $\eta^2 = .15$. These main effects were qualified by a significant Age × Group interaction, $F(4, 98) = 2.58$, $p = .048$, partial $\eta^2 = .05$. Younger children (1.5- and 2-year-olds) failed to perform significantly above baseline after observing the video demonstration. Older children (2.5- to 3.5-year-olds) did perform significantly above baseline (see Fig. 2).

Goal Score. Figure 2 illustrates goal score by group across all ages. Because the baseline means from Exp. 1 were zero at all ages they could not be included in further analyses because this would constitute a violation of homogeneity. A one-way ANOVA across age on goal score for the demonstration group yielded a main effect of age, $F(4, 56) = 10.59$, $p < .001$, partial $\eta^2 = .43$. To assess whether any age group was above baseline, a one-sample t-test against zero was conducted at each age ($p < .01$—Bonferroni correction for multiple *t*-tests). Children 1.5 and 2 years of age did not perform significantly above baseline and will not be considered further; 1.5 year olds scored zero in both the baseline and video demonstration conditions and thus were not tested, 2 years, $t(11) = 1.00$, $p = .16$. Children 2.5–3.5 years of age performed significantly above baseline: 2.5 years, $t(12) = 1.48$, $p = .022$; 3 years, $t(11) = 5.45$, $p < .001$; 3.5 years, $t(11) = 6.51$, $p < .001$ (see Fig. 2).

Age-Related Changes in Social Learning Strategies

We examined gesture and goal scores further to investigate age-related changes in learning from video across the tested age range. Due to the fact that all 1.5 year olds scored zero on both the gesture and goal measures following a video demonstration, their data were not considered in this analysis.

Gesture Score. Gesture score by group and age is depicted in Figure 2. A Helmert contrast comparing 2-year-olds (whose performance was not above baseline—see above) to all older groups trended toward significance ($p = .07$), the Helmert contrast comparing 2.5-year-olds to the mean of all older participants was significant ($p = .03$), and the contrast comparing 3- to 3.5-year-olds trended toward significance ($p = .08$). Based on the contrast findings, we calculated a regression function to illustrate the age-related change in more detail. The slope of the best fitting line from 2.5- to 3.5-years showed a reliable age-related increase of .57 gestures every 6 months ($r = .38$, $p = .01$).

Goal Score. Goal score by group and age is depicted in Figure 2. A Helmert contrast testing 2.0-year-olds (whose performance did not exceed baseline) against the mean of all older participants was significant ($p < .001$). The same contrast comparing 2.5 year olds to the mean of all older participants was also significant ($p = .004$), but the contrast comparing 3- to 3.5-year-olds was not significant. A regression analysis further illustrated age-related changes between 2 and 3.0 years of age, the range reflecting significant change as indicated by the contrasts. The slope of the best fitting line for 2- to 3-year-old children indicated an age-related increase of .62 goals every 6 months ($r = .53$, $p = .001$). This difference suggests a gradual age-related increase in performance through 3 years of age.

Cross-Experiment Comparisons

We conducted a planned cross-experiment comparison to examine differences in performance by the live demonstration and video demonstration groups following Exp. 2.

Gesture Score. Differences in gestural copying from live (Exp. 1) and video (Exp. 2) demonstrations were compared directly across ages. Planned *t*-tests revealed a significant video deficit in comparison to gesture production from the live demonstration for the 1.5-year-olds: $t(22) = 2.59$ $p = .017$; 2-year-olds: $t(29) = 4.23$, $p < .001$; and 2.5-year-olds: $t(23) = 5.82$, $p < .001$. There was a trend toward a video deficit for the 3-year-olds: $t(23) = 1.77$, $p = .09$; and by 3.5 years there was no indication of a significant difference between the live and video groups, $t(22) = 1.50$, $p = .14$. Taken together, these findings suggest that learning gestures from video was more difficult than learning gestures from a live demonstration at each age tested up until 3.5 years of age (see also Flynn & Whiten, 2008; Hopper, Lambeth, & Schapior, 2012 for similar findings).

Goal Score. Goal-directed behavior was not above baseline performance at 1.5 years following either a live or video demonstration. Planned *t*-tests revealed that a significant deficit in learning goal-directed behavior from video as compared with a live demonstration was present at 2 and 2.5 years of age; 2-year-olds: $t(29) = 2.09$, $p = .045$; 2.5-year-olds: $t(23) = 2.29$, $p = .031$. There was no evidence of a video deficit in goal-directed behavior at 3 or 3.5 years of age, t's < 1. It is important to note in particular that goal score following a *live* demonstration was above baseline relatively early (1.5–2.5 years), while increases following a *video* demonstration were not observed until 2.5–3.0 years, suggesting a lag in reproduction of goal scores by at least 6 months.

Discussion

Taken together, these findings are consistent with previous imitation studies (e.g., Barr & Hayne, 1999; Hayne et al., 2003); during the toddler period a video learning deficit for goals is present at 2.0 and 2.5 years of age. These results extend previous findings by demonstrating an offset of deficit performance; reproduction of goals was equivalent from live and video demonstrations by 3–3.5 years of age on a single 3-step task. The goal of Exp. 2 was to determine if the mode of presentation (live vs. video) influenced the type of social learning strategy observed. That is, do children copy relatively more gestures or goals from video than from a live demonstration? Children's overall imitation performance revealed that a video learning deficit is present for the puzzle task until approximately 3 years of age. Consistent with Flynn and Whiten (2008), the results of our study using the new subscales of goal and gesture reproduction indicate that the video deficit effect may not be a simple reduction in the total amount of information learned, but may actually represent a fundamental change in the type of information that is encoded.

Children's gesture score was lower following a video demonstration than following a live demonstration (from no imitation at 1.5 years) throughout the tested age range. Goal-directed actions were not imitated in the live or video demonstration groups at the earliest age tested, and children's goal score in the video group (Exp. 2) was significantly less than that of children in the live group (Exp. 1) until 3 years of age. The 1.5-year-olds show a pattern of mimicry following a live demonstration, imitating above baseline for gestures, but not for goals, and this is the same pattern that 2 year-olds exhibit following a video demonstration. Not until 3.5 years were both goal and gesture imitation at approximately equal levels across the live and video demonstration groups, indicative of imitation (following Want & Harris's, 2002 definition). This is despite the fact that gesture imitation emerged early in development in the context of a live demonstration.

Current Explanations for the Deficit. Several potentially interrelated explanations for the video deficit include an account based on representational flexibility (Eichenbaum, 1997; Hayne, 2006; Jones & Herbert, 2006), another invoking symbolic competence (DeLoache, Pierroutsakos, Uttal, Rosengren, & Gottlieb, 1998; Troseth & DeLoache, 1998), a perceptual impoverishment account (Barr et al., 2007; Carver, Meltzoff, & Dawson, 2006) and one based on social contingency (Nielsen, Simcock, & Jenkins, 2008). Each account suggests that both memory- and attention-based factors contribute to the video deficit effect. In general, the representational flexibility and symbolic competence accounts suggest that young children lack the capacity to represent information in a way that leads to effective transfer across dimensional change. Conversely, the perceptual impoverishment and social contingency accounts suggest that the 2D stimulus is of poorer quality (either perceptually or socially) and thus, the representation of this information is less detailed. If there is less or lower quality information available at the time of encoding it stands to reason that there would be insufficient matching cues to facilitate effective retrieval.

The present study is unique in that it measures both the onset and offset of the video deficit within a single task and suggests that the deficit is not linked to a particular developmental milestone in perceptual or memory skill (see Barr, 2010; Troseth, 2010 for an extended discussion of theoretical explanations of the deficit). For example, Barr and Hayne (1999, Exp. 2a) found that 15-month-olds show no video-learning deficit when tested immediately after viewing three demonstrations of a 3-step enabling sequence, yet on the more difficult puzzle imitation task tested in the present study, the deficit persists until after 2.5 years. Factors such as the type of information to be transferred, how learning is measured (goals or gestures), the amount of exposure prior to test, and the delay duration are all likely to play a role in children's success at transferring information across dimensional changes. Further studies with both adults and children are needed to assess the contribution of these factors (see also Brito, Barr, McIntyre, & Simcock, 2012; Klahr & Chen, 2011; Triona & Klahr, 2003; Zack, Barr, Gerhardstein, Dickerson, & Meltzoff, 2009).

The present study and other recent studies have demonstrated the utility of using video technology to standardize demonstrations and to titrate experimental variables (see also Hopper et al., 2012; Huang & Charman, 2005; Zmyj, Buttelmann, Carpenter, & Daum, 2010 for similar arguments). The extent to which studies can rely on video demonstrations, however, rests on precise measurement of similarities and differences between performance following live and video demonstrations. Developing a test such as the puzzle task that is not only appropriate for toddlers and preschoolers, but potentially also for adults, will be valuable to researchers interested in examining various age-related changes in social learning and memory.

GENERAL DISCUSSION

The key finding from these two experiments is the pattern of age-related social learning strategies used by children in this new task. The results suggest a timeline from mimicry to imitation (see also Flynn & Whiten, 2008; Jones, 2009; Nielsen, 2006; Want & Harris, 2002). The younger children (1.5- and 2-year-olds) tended to imitate more of the demonstrated gestures, but not goals. Older children (2.5- to 3.5-year-olds) tended to copy both goals and gestures with greater accuracy. This shift may be due to the changing role of social learning across development. Early in life children copy actions in order to learn about the physical world; mimicry of manual gestures is more conducive to this objective. Later, children appear to copy demonstrated actions in order to maintain a social interaction (a ''conversation'' of sorts; see Meltzoff, 2007; Nielsen, 2006; Nielsen & Tomaselli, 2010; Over & Carpenter, 2012; Uzgiris, 1981). The fact that gestural copying was poorer following the video demonstration suggests that children are sensitive to the lack of social contingency in the video presentation (see also Flynn & Whiten, 2008; Nielsen et al., 2008).

The high fidelity copying of the sliding gesture in older age groups may be a form of overimitation (Kenward, Karlsson, & Persson, 2011; Lyons et al., 2007, 2011; McGuigan et al., 2011; McGuigan & Whiten, 2009; Nielsen, 2006; Nielsen & Tomaselli, 2010). Overimitation is defined as completion of a task via imitation that could be more easily solved using a simpler strategy. Overimitation may be adaptive particularly in social or ambiguous learning situations or opaque imitation situations (e.g., Harnick, 1978; Nielsen & Blank, 2011; Zentall, 2012). If young children overimitate, then task completion time may be slower than if they had used goal-directed actions more directly afforded by the task objects; however, success would be *more* likely than if a process of goal emulation was always adopted. Task demands rather than age may actually be the most definitive factor in terms of deployment of social strategy (Over & Carpenter, 2012). The present study replicates and extends studies conducted by Whiten and coworkers (Flynn & Whiten, 2008; McGuigan et al., 2007) demonstrating differences in the social learning strategies as a function of whether the task was presented by a live model or a video model. When there was a live model, gestural imitation levels remained consistently high across development, suggesting a potential pattern of overimitation of gestures. In contrast, when target actions were demonstrated on video, overall fidelity was lower but this was particularly apparent for gesture score. Recall that during baseline children typically selected a different gesture, lifting the magnet pieces off the board rather than sliding them. Age-related changes, however, may not be static. When task familiarity is high, young children may not engage in mimicry (Jones, 2009). When the degree of motor difficulty and novelty are high and affordance is low, then 1.5- to 2-year-olds may adopt a mimicry strategy, as the present findings suggest. It is possible that older children may also adopt a mimicry strategy if the present task were made even more difficult. Thus, it is not the case that children at any particular age are incapable of deploying other strategies, but rather that demands imposed by a specific task may in part dictate which strategy is adopted (see also Nielsen, 2006). Specifically, 1.5-year-olds' performance in this task should not be taken to suggest that all tasks elicit similar performance at this age; there are findings in the literature clearly showing that with different tasks (e.g., Barr & Hayne, 1999, 2000), 1.5-year-olds exhibit goal-directed behavior.

We selected the 1.5- to 3.5-year-old age range for two reasons. First, this is a range in which there is currently no one task appropriate for testing such distinctly different developmental groups. This issue is not trivial as across the first few years of life children's interests and abilities change rapidly. Consequently, tasks that are appealing to 1.5-year-olds may not be appealing to 3-year-olds. Second, evidence from several studies (see Barr & Hayne, 2000; Bauer, 2007, for review) suggests that the memory demands (e.g., sequence length, exposure duration, and abstractness) of the puzzle task were appropriate for this age range. The results show, however, that the task was quite difficult for 1.5-year-olds in its current form.

The data produced by children in this task show that it is appropriate for 2- to 3.5-year-olds; however, task complexity could be manipulated by changing the number of puzzle pieces and distractors to examine strategy use in younger and older children and even adults. It is possible to design puzzle pieces such that construction of two different objects could be demonstrated using the same pieces, enabling a test of the direct (demonstration-encoded) goal and gesture learning; this simple modification would eliminate or control for any stimulus effects.

Further, we could devise a two-action procedure to control for emulation and social facilitation (Dawson & Foss, 1965; Whiten, Custance, Gomez, Texidor, & Bard, 1996). As described by Zentall (2012), the two-action procedure involves demonstrating two different responses that result in the same outcome. In Zentall's studies, for example, a bird can be shown to peck or step on a treadle in order to produce a food reward (these are low-probability actions in the absence of demonstration). Rather than emulating the actions to simply get to the goal, the birds imitated, stepping on the treadle following a stepping demonstration and pecking following a pecking demonstration. Following Flynn and Whiten (2008), the design of the puzzle task permits direct manipulation of the type of gesture demonstrated to complete the puzzle sequence. In the magnet puzzle task, for example, two different sliding actions, for example, one using two hands and the other using one hand, could be demonstrated to different groups of children.

Taken together, the findings from the present study demonstrate that young children first mimic demonstrated actions, and it is only later that an increase in imitation (gesture and goal reproduction) is observed (see Want & Harris, 2002, but see also Jones, 2009). This new imitation task has the potential to assess social learning under a wide array of conditions and across a broad age range in the early childhood period.

NOTES

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