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Precocious Hand Use Preference in Reach-to-Eat Behavior versus Manual Construction in 1- to 5-Year-Old Children

ABSTRACT: *The variation in hand use as a function of task and developmental age poses a problem for understanding how and when "handedness," preferred use of one hand, develops. The present cross-section study is the first to contrast hand preference use for the natural and frequently used reach-to-eat movement with a constructional task that requires a very similar reach-to-grasp movement. Thirty children between the ages of 1 and 3 years completed an eating task, in which they grasped small food items (Cheerios™ or Froot Loops™) that they brought to the mouth for eating. Thirty children between the ages of 3 and 5 years completed the construction task, in which they grasped LEGO® pieces to construct 3D models. Hand use preference for grasping in the eating and construction tasks was calculated by comparing the percentage of grasps made by the right hand and by the left hand. There were two main findings: First, right hand preference for grasping in the eating task is present as early as 1 year of age, whereas right hand preference for grasping in the construction task does not develop until 4 years of age. Second, right hand preference for grasping is greater in the eating than in the construction task. The results are discussed in relation to the idea that a consideration for task constraints (e.g., unimanual vs. bimanual; eating vs. construction; natural vs. praxic) should be incorporated into the experimental design when measuring hand use in children.* © *2012 Wiley Periodicals, Inc.* Dev Psychobiol 55: 902–911, 2013.

Keywords: *hand use preference; children; food items; left hand; right hand; bimanual task; unimanual task; cross-section; LEGO®*

INTRODUCTION

The reach-to-eat movement, grasping an object that is then placed in the mouth, is one of the earliest forelimb movements made by human infants (Piaget, 1952; Rochat, 1989; Lew & Butterworth, 1997). Therefore, it might be expected that it would also be the earliest lateralized movement, and substantial evidence supports this view. Right hand preference has been reported for face touching and thumb sucking in the fetus (Hepper, Shahidulllah, & White, 1990; Hepper, McCartney, & Shannon, 1998), grasp strength and duration in

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Research Highlights

- A right hand use preference is detected in children as young as 1 year of age for an eating task.
- A right hand use preference is not detected in children until 4 years of age in a construction task.
- Right hand use preference is greater for an eating task than a construction task.

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newborns (Ramsay, 1980) and for reaching and grasping objects that are placed in the mouth in infants younger than 1 year of age (Coryell & Michel, 1978; Hawn & Harris, 1983; Sacrey, Karl, & Whishaw, 2012). There is also evidence that the reach-to-eat movement is distinguishable with respect to hand preference from other tasks that have been presented to infants. Right hand preference in performing tasks such as unscrewing a bottle, removing objects from a bottle (Fagard & Marks, 2000; Vauclair & Imbault, 2009), and removing rings from a column do not develop until 21 months of age (Cochet, 2011; Vauclair & Imbault, 2009), and much later for a wide range of other manual tasks (Cornwall, Harris, & Fitzgerald, 1991; Hopkins & Ronnqvist, 1998; Lewkowicz & Turkewitz, 1982; Peters, 1983).

This heterogeneity in hand preference presents a puzzle; is it developmental age or is it task features that results in heterogeneity? Infants are adept at putting objects in the mouth at very young ages but can only engage in constructional tasks, such as unscrewing a bottle, when they are older. One way of reducing the confounding effects of task differences is to present tasks to younger and older infants in such a way the reach-to-grasp movement and the target are similar. Reaching for a small item to grasp with the hand and bring to the mouth can be performed by children as young as 6 months of age. Using this task, infants show a right hand use preference by 11 months of age when picking up Cheerios™ that will be brought to the mouth to eat (Sacrey et al., 2012). A task that presents almost similar grasping demands is to present children with a LEGO® construction task that requires that a child grasp for small objects that they are then required to assemble (Gonzalez, Whitwell, Morrissey, Ganel, & Goodale, 2007). Thus, for both tasks, the target objects have similar size, similar color, require a similar grasping movement, and only the purpose to which they are used is different. If eating and constructional tasks are indeed different with respect to hand preference, it would be expected that hand use preference will develop earlier in the food eating task than in the construction task.

A cross-section of children were filmed as they ate small food items (Cheerios™ or Froot Loops™; ages 1-, 2-, and 3-years-old; eating task) or constructed LEGO® models using big and small pieces (ages 3-, 4-, and 5-years-old; construction task). The films were analyzed off-line and hand use for picking up the objects was recorded to determine the presence of a right-, left-, or no hand preference for grasping in the eating versus construction grasping tasks.

MATERIALS AND METHODS

Research Participants

Fifty children (27 males and 23 females) participated in the study. The children were divided into five groups ($n = 10$ per group) based on age. Three age groups completed the ''eating task''; (1) 1-year-olds (five females); (2) 2-year-olds (six females); and (3) 3-year-olds (four females). Three age groups completed the ''construction task''; (1) 3-year-olds (four females); (2) 4-year-olds (four females); and (3) 5-year-olds (four females). The 1- and 2-year-olds completed only the ''eating task'' and the 4- and 5-year-olds completed only the ''construction task.'' The 3-year-olds completed both the ''eating'' and ''construction'' tasks ($n = 10$ in all three groups).

Children were recruited from acquaintances of the authors, private day homes, the University of Lethbridge Daycare, and a local Montessori preschool. The daycare, preschool, and day homes provided only the age of the child in years to the experimenters. Informed consent was obtained from the parent(s) prior to the their child participating in the study. The University of Lethbridge Human Subjects Research Committee approved the study. All participants were naïve to the purpose and hypothesis of the study.

Stimuli and Apparatus

Eating Task. Children performed a natural reach-to-eat movement. Children were seated in a high chair with the tray table attached, with the hands and arms free to grasp and manipulate objects, see Figure 1. The experimenter placed small food items (Cheerios™, 0.4 cm × 1.0 cm; or Froot Loops™, 0.9 cm × 1.2 cm) at a comfortable reaching distance (within 2/3 the length of the extended arm) on the high chair tray. The child reached towards a food item, grasped it with one hand, and withdrew it to the mouth for eating. The task was video-recorded using an HD Everio camera, positioned in front of the infant, approximately 150 cm away from the child and 50 cm above the tray top to capture a full view of both hands.

Construction Task. Children sat comfortably in a chair placed in front of a table. Both the chair and table were small and designed for preschooler children. Two identical prebuilt LEGO® models (built by the experimenter) were shown to the child. The experimenter disassembled one of the models and randomly placed the LEGO® pieces to the left, center, and right of the child (see Fig. 2) at a comfortable reaching distance (within 2/3 the length of the extended arm).

Two different sized LEGO® pieces were used for the models to determine any influence of dexterity in handedness (i.e., the smaller the LEGO®, the more dexterity needed to build the models). Small-size LEGO® pieces ranged in size from 0.6 cm × 0.7 cm × 0.9 cm to 0.5 cm × 0.5 cm × 0.3 cm (Fig. 2A) and big-size LEGO® pieces ranged in size from 6.5 cm × 3.2 cm × 2.0 cm to 3.0 cm × 3.0 cm × 2.0 cm (see Fig. 2B). The complexity of the models (i.e.,

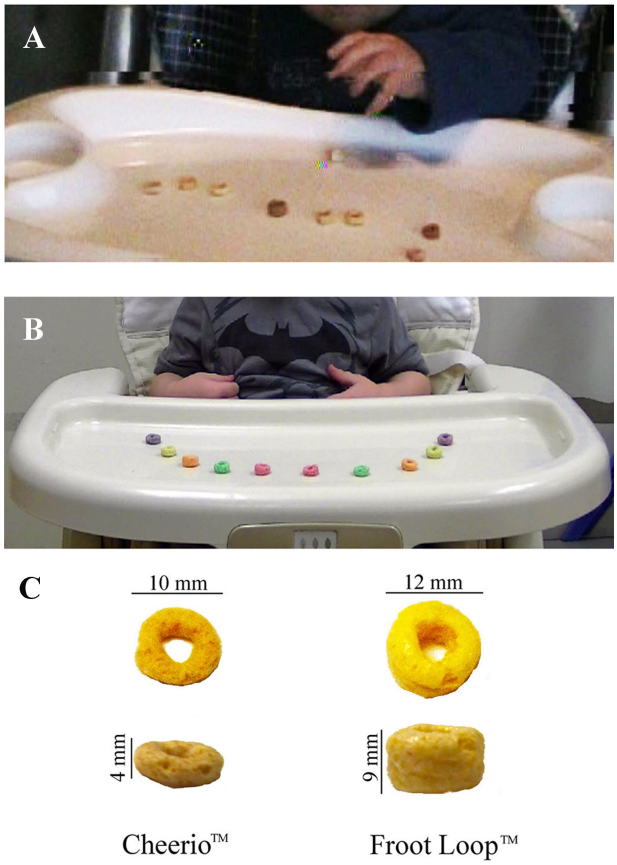

FIGURE 1 Experimental set-up for the (A) Cheerios™ and (B) Froot Loops™ eating tasks. (C) Size comparison for Cheerios™ and Froot Loops™ pieces.

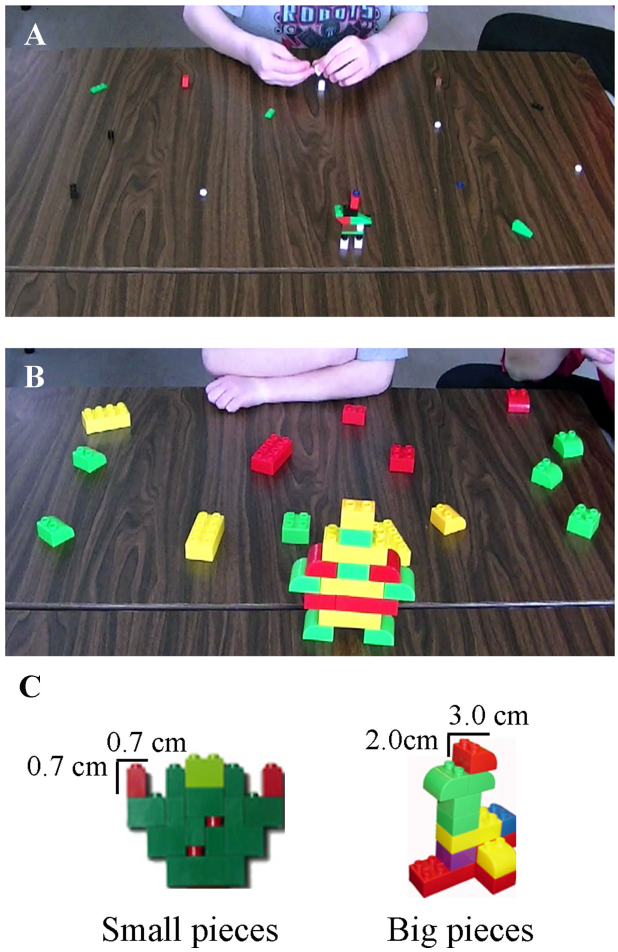

FIGURE 2 Experimental set-up for the (A) small LEGO® and (B) big LEGO® tasks. (C) Size comparison for small and big LEGO® pieces.

number of LEGO® pieces) varied by age, with 3-year-olds having 8 pieces in the small LEGO® task and 9 pieces in the big LEGO® task, 4-year-olds having 9 pieces in the small LEGO® task and 11 pieces in the big LEGO® task, and 5-year-olds having 15 pieces in both the small and big LEGO® tasks. In preliminary studies, we found that complexity affected performance of the children. If the model had too many pieces (i.e., complex), the youngest group became frustrated and did not want to continue. In contrast, for the older ages, we found that if the models were too simple, the children were uninterested in completing them. A similar effect was seen with the size of the LEGO® pieces themselves. Because the smaller LEGO® are more difficult to place together, the number of smaller LEGO® pieces were tailored to the age of the child. Because each child had to complete a number of models, we tailored the number of pieces in each model to the age of the child to ensure enough complexity and interest to continue participation.

The task was video-recorded using an HD Everio camera, positioned in front of the table, approximately 150 cm away from the child and 50 cm above the tabletop to capture a full view of both hands.

Procedure

The procedure was adapted to the age of the child and the task performed.

Eating Task. Children were filmed at their place of residence, day home, or daycare (each child was filmed individually). Testing took approximately 15 min per child. The procedure was adapted to the age of the child:

(1) *One-year-old*: At snack time, children were seated in their high chair. Cheerios™ were placed on the high chair tray, ensuring equal numbers to the left, right, and center of the child. The child was then uninterrupted as he/she grasped and ate the Cheerios™.

(2) *Two- and 3-year-olds*: At snack time, children were seated in a high chair. Froot Loops™ were placed on the high chair tray, ensuring equal numbers to the left, right, and center of the child. The child was asked to pick up a food target according to its color (i.e., "can you eat a green one next?") to ensure the food targets

were grasped in a random order, thus allowing comparability between the food and small LEGO® tasks.

Construction Task. Children were seated at the midpoint of the table and presented with two identical LEGO® models. The experimenter showed the two models to the child and explained that they were going to play a ''game''. The experimenter picked up one of the identical models and dissembled the pieces. The pieces were spread across the table, ensuring an equal number of pieces to the child's left, right, and center. The second identical model was placed in the middle of the table, out of reach of the child. Each child built three consecutive models using big LEGO® pieces, and three consecutive models using small LEGO® (size presentation was randomized across subjects). Each child was tested individually at his or her preschool or day home. Testing took approximately 30 min per child. The experimenter encouraged the child to reassemble the LEGO® model using the scattered pieces. No other instructions were given to the child, nor interrupted as they constructed the models.

Hand Use Preference

Eating Task. The video record was analyzed offline to determine the total number of grasps made by the right and left hands during the eating task. The total number of grasps was calculated to determine a percent right-hand use (number right hand grasps/total number of grasps × 100) for each child. Bimanual grasps were also coded from the videos, however were quite rare in occurrence, comprising less that 5% of all grasps. When they did occur, they were coded as a ''left'' and ''right'' grasp.

Construction Task. The video record was analyzed offline to determine the total number of grasps made by the right and left hands for the small LEGO® pieces and the big LEGO® pieces. Two separate hand use scores were measured for the small LEGO® and big LEGO® pieces. The total number of grasps was calculated to determine a percent right-hand use (number right hand grasps/total number of grasps × 100) for each child. Bimanual grasps were also coded from the videos, however were quite rare in occurrence, comprising less that 3% of all grasps. When they did occur, they were coded as a ''left'' and ''right'' grasp. There were no instances of using one LEGO® piece to ''grasp'' (stick to) another.

Ipsilateral Versus Contralateral. The video record was analyzed offline to determine the total number of grasps made by the right and left hands in ipsilateral (i.e., right hand grasps in right space; left hand grasps in left space) and contralateral (i.e., right hand grasps in left space; left hand grasps in right space) space. The surface (tray for ''eating'' task and table for ''construction'' task) was divided down the middle, ensuring that 50% of the pieces (food or LEGO®) were in right space and 50% of pieces (food or LEGO®) were in left space. The total number of grasps were subdivided into four categories; (1) right contralateral; (2) right ipsilateral; (3) left contralateral; and (4) left ipsilateral. The total number of grasps was calculated to determine the percentage of grasps made in each of the four categories (i.e., number right hand grasps in right space/total number of grasps × 100). A separate score was calculated for the small and big LEGO® pieces for the 3-, 4-, and 5-year-olds.

Handedness

The 1- and 2-year-olds were followed until their second (1-year-olds) or third (2-year-olds) birthdays, at which time the parents identified their children as right-handed. Parents and teachers identified all the 3-, 4-, and 5-year-old children as right-handed.

Statistics

Data were analyzed using Statistical Package for the Social Sciences (SPSS) v. 19 with an alpha of 0.05 as significant. Bonferroni corrections were applied to all post hoc comparisons. Right hand use in the eating task was compared across ages 1–3 years. Right hand use in the construction task was compared across ages 3–5 years. The 3-year-old children ($n = 10$) performed both the eating and construction task and were analyzed using a paired t-test to compare right hand use for grasping.

RESULTS

The children were always able to reach out and grasp either the small food items or LEGO® pieces using the right and left hands. One-, 2-, and 3-year-old children show a right hand preference for grasping small food items in the eating task, whereas only the 4- and 5-year-olds showed a right hand preference for grasping the small and large LEGO® pieces in the construction task. The results will be fully described below.

Eating Task

Right Versus Left. Children used both their right and left hands to grasp the small food items. As shown in Figure 3A, 1-, 2-, and 3-year-old children used their right hand more often for grasping small food items. Overall, 1-year-olds used their right hand 62.62% (±7.032) of the time to grasp the Cheerios™, 2-year-olds used their right hand 81.86% (±5.009) of the time to grasp the Froot Loops™, and 3-year-olds used their right hand 81.22% (±5.39) of the time to grasp the Froot Loops™.

These findings are supported by a one-way ANOVA on right hand use using Age (1, 2, 3 years old) as the between subjects factor and right hand use as the within subjects factor. Although close, there was no significant

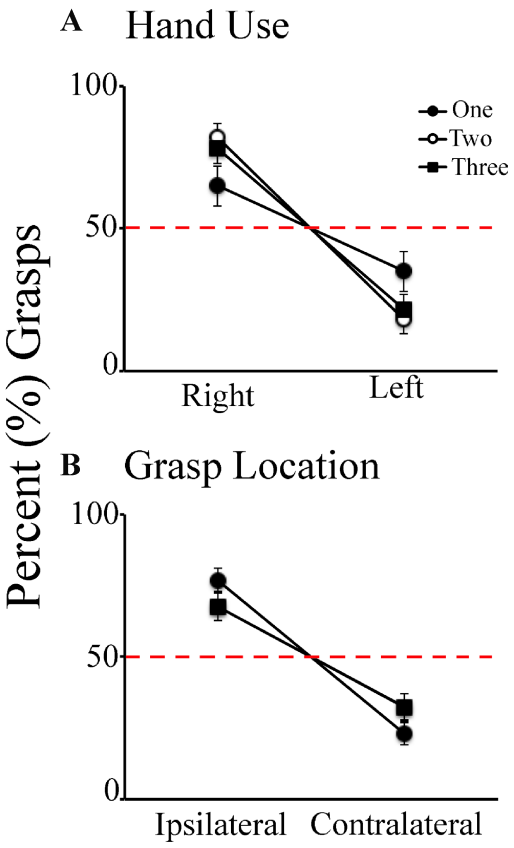

FIGURE 3 Mean ± standard error for (A) percentage of right and left hand use in 1-, 2-, and 3-year-olds when grasping small food items; (B) percentage of grasps made in ipsilateral and contralateral space for 1-, 2-, and 3-year-olds when grasping small food items. The red line denotes 50%. Note the increase in contralateral grasps in 3-year-olds.

effect of Age for right hand use ($F(2, 27) = 3.09$, $p = 0.06$, $\eta^2 = 0.19$).

Ipsilateral Versus Contralateral. Children grasped small food items from both the ipsilateral and contralateral space. As shown in Figure 3B, 1-, 2-, and 3-year-old children grasped small food items from ipsilateral space more often than contralateral space. Overall, 1-year-olds completed 77.00% (±3.96) of all grasps in ipsilateral space (46.00% with right hand and 31.00% with left hand) and 23.00% (±3.96) of all grasps in contralateral space (19.00% with right hand and 4.00% with left hand). Overall, 2-year-olds completed 66.78% (±4.84) of all grasps in ipsilateral space (49.54% with right hand and 17.24% with left hand) and 32.32% (±4.84) of all grasps in contralateral space (all with right hand). Overall, 3-year-olds completed 67.55% (±4.76) of all grasps in ipsilateral space (47.33% with right hand and 20.22% with left hand) and 32.45% (±4.76) of all grasps in contralateral space (30.89% with right hand and 1.56% with left hand).

These findings are supported by a repeated measures ANOVA on right hand use using Age (1, 2, 3 years old) as the between subjects factor and Hand (Right, Left) and Space (Ipsilateral, Contralateral) as the within subjects factor. There was a significant effect for Hand ($F(1,27) = 54.57$, $p < 0.001$, $\eta^2 = 0.38$) and Space ($F(1,27) = 60.82$, $p < 0.00$, $\eta^2 = 0.26$), but no significant effects for Age ($F(2,27) = 1.00$, $p > 0.05$, $\eta^2 = 0.00$), Hand × Age ($F(2,27) = 2.35$, $p < 0.05$, $\eta^2 = 0.033$), Age × Space ($F(1,27) = 1.47$, $p > 0.05$, $\eta^2 = 0.012$), or Age × Hand × Space ($F(2,27) = 0.33$, $p > 0.05$, $\eta^2 = 0.00$).

A repeated measures ANOVA on Space using Age (1, 2, 3 years old) as the between subjects factor and Space (Ipsilateral, Contralateral) as the within subjects factor was ran to remove any influence hand use (Right, Left) had on grasping in ipsilateral versus contralateral space. There was a significant effect of Space ($F(1,27) = 60.815$, $p < 0.001$, $\eta^2 = 0.67$), but no Age ($F(2,27) = 1.00$, $p > 0.05$, $\eta^2 = 0.00$) or Age × Space ($F(2,27) = 1.47$, $p > 0.05$, $\eta^2 = 0.032$) interaction.

Construction Task

Right Versus Left. Children grasped the LEGO® pieces using both their right and left hands. As shown in Figure 4A, the percentage of right hand use varied as a result of age but not as a result of LEGO® size. Three-year-olds used their right and left hands equally when grasping both the small and big LEGO® pieces, whereas 4- and 5-year-olds used their right hand more than their left hand when grasping both the small and big LEGO® pieces. Overall, 3-year-olds used their right hand 52.05 (±1.83) % of the time to grasp small LEGO® and 47.19 (±1.69) % of the time to grasp big LEGO®; 4-year-olds used their right hand 65.86 (±4.43) % of the time to grasp small LEGO® and 61.80 (±2.20) % of the time to grasp big LEGO®; and 5-year-olds used their right hand 68.20 (±4.55) % of the time to grasp small LEGO® and 64.92 (±3.91) % of the time to grasp big LEGO®.

These findings are supported by a repeated measures ANOVA on right hand use using Age (3, 4, 5 years old) as the between subjects factor and size (small, big) as the within subjects factor. There was a significant effect of Age for right hand use ($F(2,27) = 13.02$, $p < 0.001$, $\eta^2 = 0.41$) but no effect of Size ($F(1, 27) = 0.32$, $p > 0.05$, $\eta^2 = 0.015$) or Age × Size interaction ($F(2, 27) = 3.12$, $p > 0.05$, $\eta^2 = 0.029$). Follow-up comparisons showed that 3-year-olds use

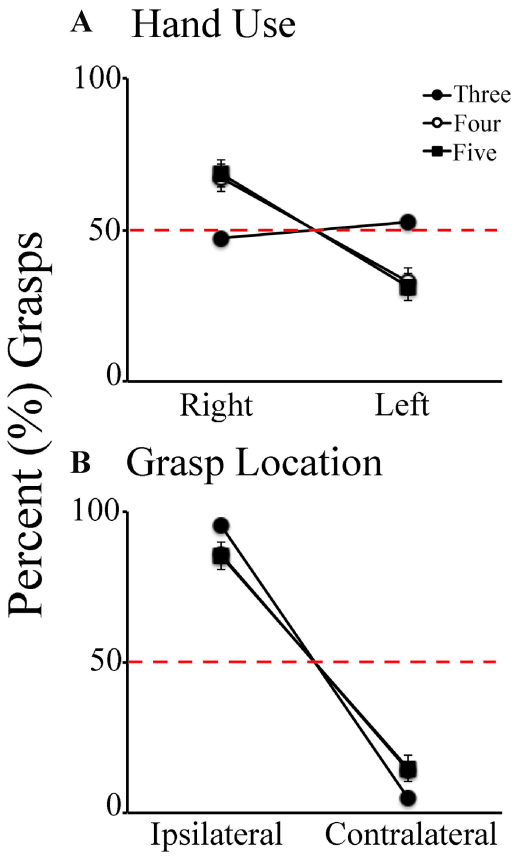

FIGURE 4 Mean ± standard error for (A) percentage of right and left hand use in 3-, 4-, and 5-year-olds when grasping big and small LEGO® pieces; (B) percentage of grasps made in ipsilateral and contralateral space for 3-, 4-, and 5-year-olds when grasping LEGO® pieces. The red line denotes 50%.

fewer right hand grasps than 4- and 5-year-olds ($ps < 0.0015$).

Ipsilateral Versus Contralateral. Children grasped small and big LEGO® pieces from both the ipsilateral and contralateral space. There was no effect for size of LEGO®, thus they were combined for the following analysis. As shown in Figure 4B, 3-, 4-, and 5-year-old children grasped LEGO® from ipsilateral space more often than contralateral space. Overall, 3-year-olds completed 95.08 (±1.81) % of all grasps in ipsilateral space (49.63% with right hand and 45.45% with left hand) and 4.92 (±1.81) % of all grasps in contralateral space (2.31% with right hand and 2.61% with left hand). Overall, 4-year-olds completed 84.62 (±1.87) % of all grasps in ipsilateral space (54.50% with right hand and 30.12% with left hand) and 15.38 (±1.87) % of all grasps in contralateral space (13.81% with right hand and 1.57% with left hand). Overall, 5-year-olds completed 85.23 (±4.46) % of all grasps in ipsilateral space (56.00% with right hand and 29.33% with left hand) and 14.77 (±4.46) % of all grasps in contralateral space (12.72% with right hand and 2.05% with left hand).

These findings are supported by a repeated measures ANOVA on right hand use using Age (3, 4, 5 years old) as the between subjects factor and Hand (Right, Left) and Space (Ipsilateral, Contralateral) as the within subjects factor. There was a significant effect for Hand ($F(1,49) = 107.95$, $p < 0.001$, $\eta^2 = 0.072$), Space ($F(1,49) = 2530.87$, $p < 0.001$, $\eta^2 = 0.79$), Hand × Space ($F(1,49) = 47.224$, $p < 0.00$, $\eta^2 = 0.015$), Age × Hand ($F(2,49) = 19.64$, $p < 0.001$, $\eta^2 = 0.026$), Age × Space ($F(2,49) = 14.89$, $p < 0.001$, $\eta^2 = 0.017$), and Age × Hand × Space ($F(2,49) = 4.40$, $p < 0.01$, $\eta^2 = 0.0033$), but no significant effect for Age ($F(2,49) = 1.67$, $p > 0.05$, $\eta^2 = 0.00$).

A repeated measures ANOVA on Space using Age (3, 4, 5 years old) as the between subjects factor and Space (Ipsilateral, Contralateral) as the within subjects factor was ran to remove any influence hand use (Right, Left) had on grasping in ipsilateral versus contralateral space. There was a significant effect of Space ($F(1,49) = 1253.15$, $p < 0.001$, $\eta^2 = 0.95$) and an Age × Space ($F(2,49) = 6.18$, $p < 0.01$, $\eta^2 = 0.0094$) interaction, but no effect of Age ($F(2,49) = 0.89$, $p > 0.05$, $\eta^2 = 0.00$). Follow-up tests showed that 3-year-olds were less likely to grasp LEGO® from contralateral space than 4- and 5-year-olds ($p < 0.017$).

Comparison of Right Hand Use in Eating Versus Construction Tasks

The 3-year-olds ($n = 10$) who completed both the eating and construction tasks were compared for right hand use during the eating task and small and big LEGO® construction task. As illustrated in Figure 5A, there is a significant increase in use of the right hand for grasping in the eating task when compared to the small ($t(9) = 6.21$, $p < 0.001$) LEGO construction task. There was also a significant difference for right hand grasping in the eating versus big LEGO® construction tasks ($t(9) = 4.16$, $p < 0.01$). There was no difference between right hand use for grasping in the small versus big LEGO construction task ($t(9) = 2.05$, $p > 0.05$).

A comparison for grasp location (Fig. 5B) showed that 3-year-olds performed more ipsilateral grasps in the small LEGO task versus the eating task ($t(9) = 6.26$, $p < 0.001$), and performed more contralateral grasps in the eating task versus the small LEGO task ($t(9) = 5.72$, $p < 0.001$).

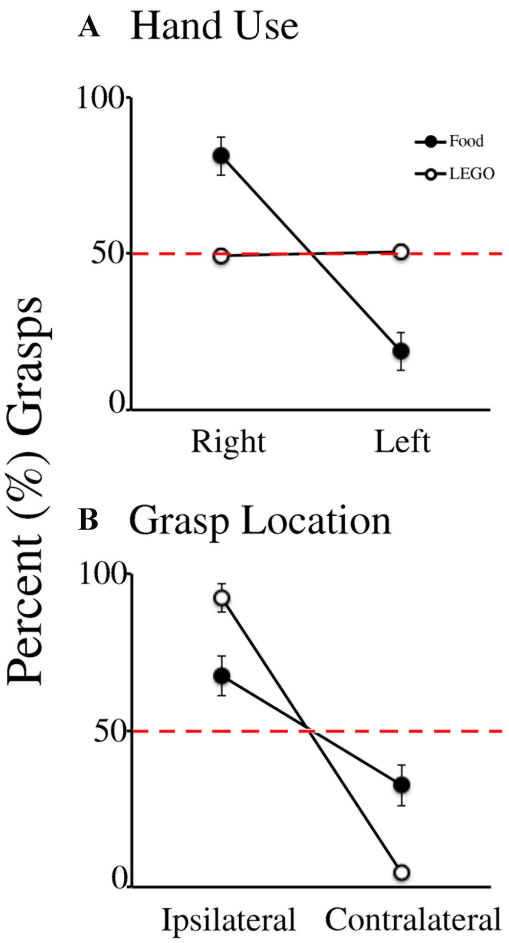

FIGURE 5 Mean ± standard error of percentage of (A) right and left hand grasps and (B) ipsilateral and contralateral grasps in 3-year-olds on the food eating (black circles) and construction (white circles) tasks.

DISCUSSION

While many studies have documented hand-use preference in young children, this study provided the first cross-sectional description of right hand use preference in a natural, eating task versus a praxic, construction task. One-, 2-, and 3-year-old children were video-recorded as they reached for small food items to grasp and place in the mouth for eating and 3-, 4-, and 5-year-old children were video-recorded as they reached for big and small LEGO® pieces to grasp and construct different models. Hand use preference was determined by calculating the percent of right and left hand use for grasping either the small food items (1-, 2-, and 3-year-olds) or LEGO® pieces (3-, 4-, and 5-year-olds). Examination of hand use preference for grasping showed: (1) children as young as 1 year of age show a right hand preference for grasping in the eating task; (2) children as young as 4 years of age show adult-like, right hand preference for grasping in the construction task; and (3) 3-year-old children show no hand preference when grasping in the construction task but show a strong right hand preference when grasping in the eating task. Taken together, the findings demonstrate the importance of task characteristics (i.e., eat vs. construct) when measuring hand use preference in children.

One-, 2-, and 3-year-old children show a right hand use preference when grasping small food items to eat. That is, they reach towards the food item, grasp it, and transport it to the mouth for eating with their right hand. The robust right hand use in young children reported here is in contrast to other literature (Seth, 1973; Shirley, 1931). For example, Fagard & Marks (2000) report negligible right hand use in 18-month-olds and equitable right and left hand use in 30-month-olds when performing a remote control switch-pressing task. The lack of a right hand use may be due to the task features, in that the experimenter was holding the remote control that had two switches that could be manipulated (praxis). When given a more naturalistic task to complete, such as pointing to one animal in an array of animals (Cochet, Jover, & Vauclair, 2011) or grasping small toys (Ramsay, 1980), children as young as 9 months of age show a consistent preference for right hand use (Sacrey et al., 2012). Indeed, a preference for right hand use is also observed in Chimpanzees (*Pan troglodytes*) who are grasping small food items to eat (Hopkins, Cantalupo, Wesley, Hostetter, & Pilcher, 2002; Hopkins, Russell, Hook, Braccini, & Schapirp, 2005).

The construction task demonstrated a right hand use preference for grasping in the 4- and 5-year-olds but did not show hand use preference for the 3-year-olds. Four- and 5-year-olds were more likely to use their left hand to hold the model (passive role) as their right hand grasped and manipulated the LEGO® pieces (active role), as seen in adults (Gonzalez et al., 2007). In contrast to the 4- and 5-year old children, 3-year-olds showed no hand preference for picking up the LEGO® pieces, nor did they show any preference for which hand performed the passive, holding role or the active, manipulative role. This was surprising, as previous research has shown a right hand preference in 2- and 3-year-old children for holding and manipulating objects (i.e., getting a toy out of a tube; Cochet, 2011; Cochet et al., 2011; Fagard & Lockman, 2005). It could be argued that pointing to an object or extracting a toy from a tube is "simpler" than constructing models with LEGO® pieces. In fact, 3-year-olds found the task difficult and/or uninteresting, as some of the children did not complete the task or verbally expressed that it was

"too hard." More importantly, the 3-year-olds made very few grasps in contralateral space, whereas the 4- and 5-year-olds did grasp LEGO pieces from contralateral space, using their right hand, accounting for the difference in right hand use for grasping in the construction task. This finding is in line with other research (Leconte & Fagard, 2006; Ralf, Cox, & Smitsman, 2006), which shows that the likelihood of crossing over the midline to grasp an object (i.e., contralateral grasps) increases with age. Taken together, these factors affecting the 3-year-old children's performance in the task could have also affected their hand preference for grasping.

There was no significant increase in right hand use for precision grasping of small LEGO® pieces compared to whole hand grasping of big LEGO® pieces in any of the age groups. This was a surprising finding as previous literature has noted the increased use of the right hand for precision grasping. For example, Gonzalez and Goodale (2009) showed that adults increase use of their right hand by 10% when grasping small LEGO® pieces when compared to big LEGO® pieces. Increase right hand use when precision is required has also been shown in young children (Fagard & Lockman, 2005). In the current study, although not significant, 4- and 5-year olds displayed a 4% increase in right hand use for grasping the small LEGO® pieces when compared to the big ones. It could be argued that the 4- and 5-year-old children's nervous system has not fully matured to support the increase of right hand use when precision is needed or, more likely, that the complex characteristics of the construction task occluded this effect. It has been reported that items that require exploration, such as multi-colored or multi-textured objects increase left-hand use in children (Fagard & Lockman, 2005). It is likely that this affected the children's hand use as the LEGO® pieces varied in shape and color.

It is striking that the 3-year-old children did not show a hand use preference when grasping LEGO® pieces but did show a very robust (82%) right hand preference for grasping food items. This is a surprising finding given that the targets in both tasks were of similar size and color. There are a number of possible explanations for the performance of the 3-year-olds. First, the construction task may have been too difficult (praxis) or "not fun" for the 3-year-olds, as many of the children commented that the task was "too hard." Second, the different end goal of the two tasks may have affected the results. The eating task required the grasped object to be placed in the mouth for eating, whereas the construction task required the grasped object to be incorporated into a model with other objects. Because the Froot Loops™ and small LEGO® pieces both varied by color and were similar in size, requiring precision grasping for purchase, it is likely that the manipulatory component of the task (eat versus construct) influenced right hand use. Third, the increase in right hand use for the food items may be related for the increased frequency of grasping food items from contralateral space with the right hand, which rarely occurred for the LEGO® pieces. Fourth, task complexity has been shown to affect hand use in children (Bryden, Mayer, & Roy, 2011). That is, tasks that require precision grasping reduce variability (i.e., show more right hand use) and objects that encourage exploration, such as multi-colored or multi-textured objects, increase variability (i.e., show an increase in left hand use; Fagard & Lockman, 2005). Finally, there appears to be a special relationship between the right hand and eating. Gonzalez and coworkers have noted that when picking up small food items, the right hand is more accurate when scaling the digits to target size if the grasped item is to be eaten versus placed in a bib under the chin (Gonzalez et al., unpublished data). Therefore, it is likely that the different task characteristics affected the selection of right hand use for the 3-year-olds.

It is possible that the unimanual/bimanual demand was different for the two tasks. It can be argued that the eating task is largely a unimanual task, whereas the construction task is a bimanual task. It has been postulated that bimanual skills are more likely to reveal stability in hand use preference than unimanual tasks because the two hands play different and complementary roles (passive, holding hand, vs. the active, grasping hand; Fagard & Lockman, 2005; Fagard & Marks, 2000). Yet, it has also been demonstrated that children do not show a difference in right hand use for both unimanual tasks (e.g., pointing) and bimanual tasks (e.g., removing toy from small bottle) between 15 and 25 months of age (Cochet, 2011; Cochet et al., 2011). Although the eating task is largely unimanual, the children could grasp food using both the right and left hands simultaneously, suggesting bimanual dexterity for the eating task. Similarly, although the construction task is largely bimanual, many of the children grasped the LEGO® pieces using only one hand, either the left or right, suggesting a level of unimanual dexterity for the construction task. Therefore, it is more plausible that the early presentation of right hand preference for grasping in the eating task is due to the innate nature, rather than unimanual dexterity, of the task over the praxis, bimanual nature of the construction task.

In conclusion, this cross-sectional study using eating and construction grasping tasks to measure the development of right hand use preference in children shows that a right hand use preference can be detected in children as young as 1 year of age. The results of the

present study illustrate the importance of considering task constraints when measuring hand use preference in children. When given an eating task, 1-, 2-, and 3-year-old children show a robust right hand use preference for grasping food items to eat. When considering only the results of the construction task, a stable hand use preference does not appear before 4 years of age, suggesting that 3-year-old children do no display hand preference. Taken together, these results suggest that a consideration for task constraints (e.g., unimanual vs. bimanual; eating vs. construction; natural vs. praxic) should be considered and incorporated into the experimental design when measuring hand use in children.

NOTES

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