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Orientation-indifferent representation in children's drawings[1]

AYA SAITO[2]* and MISATO HAYASHI *Kyoto University*

ARI UENO and HIDEKO TAKESHITA *University of Shiga Prefecture*

Abstract: Young children occasionally draw rotated figures such as an inverted face; however, little is known about the details of this phenomenon. In this paper, we addressed when and how rotated drawing emerges in normal child development. Study 1 reported that rotated drawings appeared spontaneously in a longitudinal observation of 33 children. The rotation occurred in 6.3% of all representational figures in free drawing trials, whereas 12.5% of representational drawing occurred in imitation task trials, among children 2 years and 11 months to 4 years and 11 months old. To clarify the developmental process in which rotated figures emerge, Study 2 investigated the different ages of children as to whether triggering stimuli cause them to draw rotated images. Rotation occurred more frequently in younger children who begin to produce representational drawing, and they seem to be indifferent to the orientation used in drawing representations. We discuss the reflection of the development of the concept to represent an object as well as the development of spatial cognition by the "viewer-centered" and "viewpoint-independent" referential frame in representational space on a picture-plane.

Key words: children's drawings, representation, orientation independent, conceptional development, spatial cognition.

When you draw figures on a table, it is quite natural to settle the far side of the sheet as upwards and the near side as downwards. The figures are universally drawn in a canonical upright orientation, for example, a face is drawn with the eyes in the upper part, the nose in the middle, and the mouth in the lower. Adults have a robust preference for viewing pictures in their canonical orientation and show better recognition for upright than for inverted pictures, particularly faces (Valentine, 1988; Yin, 1969).

However, this orientation preference is not shared by young children. They often hold a picture book upside down and seem unperturbed by it. Young children have at best a weak preference for viewing pictures right side up (DeLoache, Uttal, & Pierroutsakos,

*Correspondence concerning this article should be sent to: Aya Saito, Kumamoto Sanctuary, Wildlife Research Center, Kyoto University, 990 Ohtao, Misumi-machi, Uki 869-3201, Japan. (E-mail: ayams@wrc.kyoto-u.ac.jp)

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2000; Pierroutsakos & DeLoache, 2003). One-and-a-half year old children typically looked at an inverted picture book without reorienting it, and have been shown to be equally accurate in identifying depicted objects in upright and inverted pictures, while 2.5 year-old children consistently preferred the canonical orientation. However, this orientation indifference in young children only appeared for 2-D pictures, and not for real objects. Pierroutsakos, DeLoache, Gound, and Bernard (2005) reported that whereas 1.5 year-old children show no sensitivity to picture orientation on preference and processing measures, they do pay attention to the orientation of objects when interacting with them.

The orientation indifference of children appears not only in the recognition process but also in the representational process. Although not frequent, some parents and nursery teachers may have seen children draw a figure in an inverted or horizontal orientation. However, to our knowledge, there is no study that describes the details of rotated drawing in children's normal development. It is difficult to notice the rotation of the products because the whole object is drawn in a different orientation, and seems normal when the paper is reoriented. At this point, this phenomenon is different from multiple viewpoints drawing, when older children draw the different parts of an object or rotate objects in to an arrangement that looks like "cubism." In such cases, the parts or objects are drawn from each canonical view to represent its structure or function, which reflects "what they know." In a clinical study of adults, rotated drawing has been investigated as an unusual neuropsychological phenomenon. There are patients who copy complex figures (e.g. Rey Complex Figure) accurately, but in a rotated orientation relative to the model figure, which has been regarded as a reliable sign of brain injury (Royer & Holland, 1975). More recently, the interest in this phenomenon has focused on the implications for theories of object recognition (Solms, Turnbull, Kaplan-Solms, & Miller, 1998; Turnbull, Beschin, & Della Sala, 1997). It is indicated that spontaneous rotation in copying appears as part of a more general lack of awareness of the canonical orientation of objects. Turnbull et al. (1997) demonstrated that two patients who show rotation in copying also show difficulties in recognizing the canonical orientation of known objects. It has therefore been suggested that this disorder might indicate isolated access to visual representations of "viewpoint-independence." Such rotation in copying complex figures was also observed in children in a case report of Martin, Turnbull, and Venneri (1999). Two children aged 8 and 10 years rotated the Rey complex figures by 90 deg during copy and recall without other cognitive deficit.

The present study focused on the phenomenon in which children drew representational figures entirely rotated 90 deg to 180 deg from the canonical orientation. We aimed to address the questions of when, how, and why this emerges in normal development. In Study 1, we described the emergence of spontaneous rotated drawing in detail through the longitudinal observation of children. In Study 2, we investigated the developmental background concern with this phenomenon by analyzing the age differences at which stimuli triggered drawing of rotated face images.

Study 1

To clarify when the rotated drawing appears in children's spontaneous drawing, the orientations of representational figures in free drawing and imitation task trials were analyzed from the longitudinal observation.

Methods

Participants. The participants were a total of 33 children (14 male and 19 female) aged from 11 months to 2 years and 6 months at the beginning of the observation period. They were members of the "Umikaze" Infant Laboratory at the University of Shiga Prefecture, Japan. Their development in drawing behavior was longitudinally followed by using the test on imitating model drawing, which was standardized as a developmental scale for children (Kyoto

Table 1 The orientations of the representational figures observed in a total of 285 sessions

Trial	Number of representational figures	Mean age (*SD*)	Orientation		
			Upright	Rotated	Others
Free drawing	63	4 years and 1 month (9 months)	55 (87.3%)	4 (6.3%)	4 (6.3%)
Imitation task	56	3 years and 6 months (9 months)	34 (60.7%)	7 (12.5%)	15 (26.8%)

Scale of Psychological Development, Ikuzawa, 1985; Saito, 2008, 2010). The experiments were conducted at intervals of 2–3 months during the period from September 2005 to April 2009, with other tasks of object manipulation in the same experimental day (Hayashi, 2007; Hayashi & Takeshita, 2009).

Procedure. The experiments were carried out individually in a quiet room at the laboratory. The children were sitting beside their parents or on their lap while a tester sat in front of them across a low table. The materials were pieces of B4-sized plain paper (257 × 364 mm) and water paint markers.

In the first free drawing trial, the tester asked the child to draw freely on a piece of blank paper. We used eight different figures for the imitation task trials: horizontal lines, vertical lines, a circle, a cross, a square, a rhombus, an upright triangle, and an inverted triangle; the tasks grew increasingly difficult in that order. In front of the child, the tester drew one of the model figures on the upper or left side of the page using a pale orange colored marker. Then the tester passed a blue marker to the child and asked him or her to draw the same figure on the same paper. If the child did not succeed in imitating within 30 s, the tester then demonstrated the model drawing again by tracing the model figure. On any given experimental day, children received one session consisting of a free drawing trial and two to five out of eight imitation trials, depending on their concentration and their former success in imitation.

Data analysis. The drawing behavior was recorded using two video cameras set at different view angles. We analyzed all the free drawing trials to find clear representational figures, which have recognizable parts and could be subjectively identified. For example, a product with recognizable parts of eyes and mouth was identified as a face representation. Even in the imitation task trials, children sometimes drew representational figures during or after their attempt at imitation of simple figures. Those representational drawings were also considered for the second analysis. The orientations of the figures with the canonical orientation which had more than two distinguishable parts needed to be identified as to their orientation, such as a face with eyes and a mouth, a body with a head of a human/animal, a vehicle with tires, a house with a roof, and a flower with a stem, were judged using criteria as to whether they were either "upright" or "rotated." The other figures without a clear canonical orientation, such as a rail line or the petals of a flower, were judged as having "others" orientation.

Results

The average age for the first appearance of representational figures in the longitudinal observation was 3 years 0 months (*SD* = 7 months) and 13.0% of these were in rotated orientations. Moreover, 47.8% of those representational figures were observed in model drawing trials without any clear representations in the former free drawing trials in the same sessions. Within a total of 285 sessions (mean age = 2 years and 9 months, *SD* = 13 months, range = 11 months to 5 years and 9 months), the representational figures were observed in 63 of 285 free drawing trials (*M* = 4 years and 1 month, *SD* = 9 months, 2 years and 1 month to 5 years and 9 months). Within a total of 1025 imitation task trials, the representational figures were

observed in 56 trials by children whose age averaged 3 years and 6 months (SD = 9 months, 2 years and 1 month to 5 years and 2 months), which was significantly younger than in the free drawing trials, $t(117) = 3.34$, $p < .001$. The ratios of orientations for all the representational figures are shown in Table 1 and there was a significant difference between the two trials, $p < .01$ using two-tailed Fisher's exact test. The residual analysis indicated a more frequent occurrence in the free drawing trials and a less frequent occurrence in imitation trials for the upright orientation (87.3% vs. 60.7%, $p < .01$), whereas a less frequent occurrence in the free drawing trials and a more frequent occurrence in the imitation trials for others (6.3% vs. 26.8%, $p < .01$). The rotation appeared in 6.3% of the representational figures in the free drawing trials by an average of 3 years and 5 months (2 years and 11 months to 4 years and 0 months) and in 12.5% of the imitation task trials by an average of 3 years and 5 months (2 years and 4 months to 4 years and 10 months), but there was no significant difference by residual analysis. All the products of the rotated drawing are shown in Figure 1. In the case of 10 and 11, the rotated figures were drawn with the independent upright figures on the same page without reorientation of the sheet. None of the children commented on the orientation while they drew the rotated figures.

Discussion

The first representational figures were observed at approximately 3 years of age and nearly half of the children who scribbled on a blank page drew representational figures in subsequent imitation tasks in the same session. Also, the average age of the children who drew representational drawings was younger in the imitation trials than in the free drawing trials. The children often drew representational figures inspired by the models or their own imitated lines. For example, some of them drew

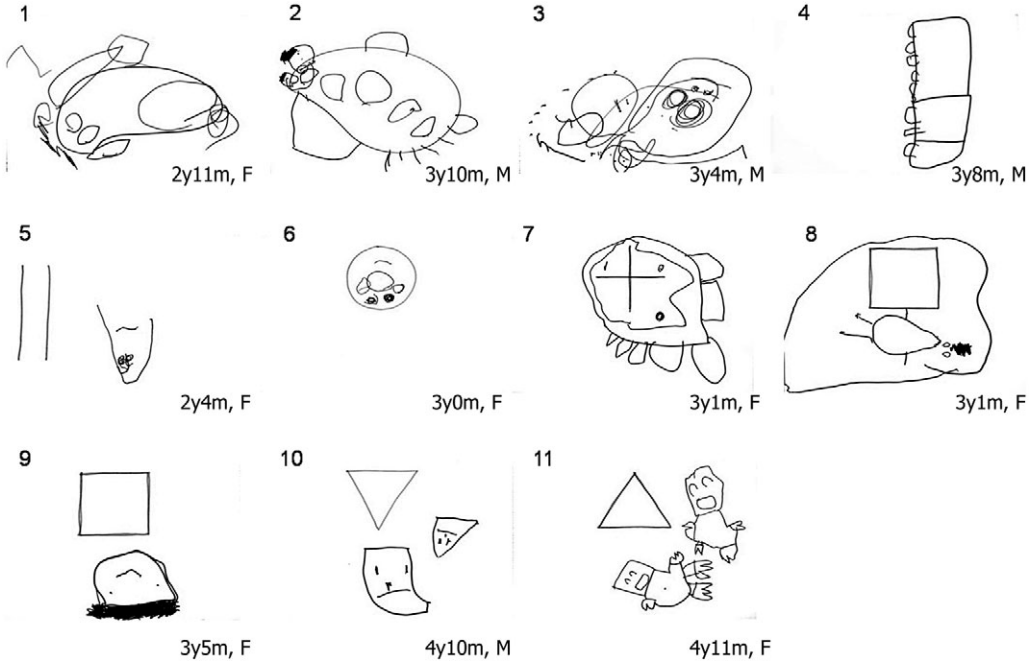

Figure 1 Rotated drawings observed in Study 1. The upper digit refers to the case number and the bottom text refers to the age (m = months; y = years), and sex (F = female; M = male). Figures 1–4 were observed in free drawing, and 5–11 were used in the imitation task trials. The geometric shapes were the models formerly drawn by the tester.

small circles within the drawn model circle to make a face. The rotation also appears in this process, for example, the girl of case 6 in Figure 1 declared "Anpanman" (a cartoon character) and drew a nose, eyes, cheeks, and a mouth inside the model circle in a perfectly inverted position. In case 9, the girl first tried to imitate a square, but failed to make the four angles, with the upper side being rounded. Then she added hair, two eyes, and a smiley mouth with an inverted orientation, using the rounded side as the jaw of a face. These results suggest that the figures on the paper may trigger the child's imagination, particularly those of a younger age, and assist them in making representational drawings. Furthermore, it can be considered that the inspired image may not depend on orientations and sometimes leads them to draw rotated figures.

Study 2

To address how and why rotated drawing emerges in the developmental process, we examined how this phenomenon was induced. As Study 1 shows the possibility that the stimuli in the imitation tasks may have triggered the drawing of representational figures and their rotation, we prepared stimulus figures resembling the heads of humans and animals in different orientations to trigger the rotated image. Children often draw a human or an animal face in spontaneous drawing and it is easy to judge the orientation by the position of the facial parts. We also prepared conflict stimuli, which combined both upright and inverted stimuli to judge the dominance of the orientation. The spontaneous drawing on these stimuli was examined as to whether the children used the stimuli in the upright or the rotated orientation to draw representational figures, and the frequency of the behavior was compared in respect to the different ages of the children. Some of the children, even those who could not draw clear representational figures, reoriented the rotated stimuli or named their products. We analyzed these behaviors with regard to in which direction did they recognize the stimuli or products as pointing.

Methods

Participants. The participants were also members of the "Umikaze" Infant Laboratory. A total of 31 children (12 male and 19 female) aged from 1 year and 10 months to 5 years and 9 months participated in Study 2. Each child was tested one to five times during August 2009 to July 2010 with at least 1-month intervals.

Apparatus. Pieces of A4-sized (594 × 841 mm) paper and black markers were used for drawing. The upper half of an oval (90 × 78 mm) was drawn in the center of the sheet as a base, to which were added a few parts to make three basic schematic stimuli that resembled the ears of a cat (c), the ears of a bear (b), and a hat (h). Each basic stimulus was printed on a paper in different orientations: upright, left/right horizontal, inverted, and conflict, which combined two different basic stimuli of upright and inverted (Figure 2). They were printed in 2-mm wide gray lines, which were of a similar width to the marker lines. We arranged two series of sessions with the different types of stimuli: a rotation session and a conflict session. A rotation session consisted of a piece of blank paper, an inverted stimulus, a horizontal stimulus, and an upright stimulus. A conflict session consisted of a piece of blank paper, an inverted stimulus, and two or three conflict stimuli in order to counterbalance the orientations of the stimulus prototypes. The stimuli were prepared as a series, and assigned to the children so as to prevent the same orientation of each prototype overlapping within a session.

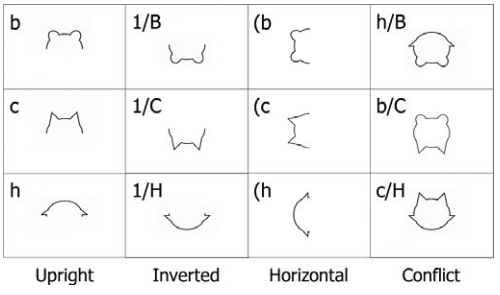

Figure 2 Examples of the stimulus figures used in Study 2.

Procedure. The experiments were carried out individually in a quiet room. A tester was sitting in front of them in the rotation stimuli series and at the right side of them in the conflict stimuli series. The tester put a sheet of paper on the low table, and handed a marker to the child, saying "Let's draw on this as freely as you like" (in Japanese). In that way, the drawings in each trial were observed one by one. During the whole session, neither the tester nor the parents commented on the orientations of the stimuli or the drawings of the children. The self-explanation about the drawings was recorded during the observation, and at the end of each trial, the tester asked the children what they drew.

Data analysis. The drawing behavior of the participants was recorded using two video cameras. We checked whether they reoriented the sheet before drawing, whether they drew representational figures using the stimuli, and, if so, which orientation was triggered by the stimuli. We identified five patterns of behavior: (a) mark the stimuli – scribbling to mark the stimuli; (b) draw a scrambled face – drawing imperfect face parts within the stimuli, that is, drawing too many eyes or indistinct parts; (c) draw a rotated figure – using the stimuli to draw a representational figure in a rotated orientation; (d) reorient the sheet and draw upright figure – rotating the sheet before using the stimuli to draw an upright representational figure; and (e) draw an upright figure – using the stimuli to draw a representational figure without reorienting the sheet. Every other behavior was categorized as "others," that is, unresponsive scribbling, just tracing, nonclear representations, representations without canonical orientation, and independent representations without using the stimuli. The frequencies of these categorized behaviors for each type of stimuli were calculated in each of four age groups (1 year and 10 months to 2 years and 9 months; 2 years and 10 months to 3 years and 9 months; 3 years and 10 months to 4 years and 9 months; and 4 years and 10 months to 5 years and 9 months) and examined using a 1-*d.f.* Cochran-Armitage trend test.

Results

The frequency of the representational drawing in the upright stimuli was 73.1%, which was higher than in the free drawing trial on a piece of blank paper (65.6%, $p < .01$ using the chi-square test). In the free drawing trial, a rotated figure was observed in only one case among 97 trials (1.0%), by a girl aged 2 years and 10 months. In contrast, rotated figures were more frequently observed in the rotated stimuli sessions (7.0%, $p < .01$ using Fisher's exact test). Figure 3 shows the frequencies of the categorized behavior for each type of stimuli in the different age groups. The examples of the products of each behavior are shown in Figure 4. The number of cases includes the duplications of the same participants with more than 1-month intervals. Only for conflict stimuli, the duplications contained two or three trials for the participant in the same session for the day.

Age differences in the frequencies of categorized behavior on each stimulus: Upright stimuli. In the youngest group, the most frequent behavior was "mark the stimuli" (38.5%), which was less frequently observed in older groups ($\chi^2 = 16.7$, $p < .01$ using the Cochran-Armitage trend test). The "scrambled face" was also observed in 15.4% of the youngest, but in 5% or less of the older groups ($\chi^2 = 4.9$, $p < .05$). In contrast, representational figures in the "upright" orientation rose with age and were most frequent in the oldest group (80.0%, $\chi^2 = 17.7$, $p < .01$).

Inverted stimuli. Rotated figures were found in all age groups and were most frequent in the 2 years and 10 months to 3 years and 9 months group (15.0%). All of them were in an inverted orientation. Similar to the upright stimuli trials, "mark the stimuli" and "scrambled face" were highest in the youngest group and declined with age ($\chi^2 = 14.4$, $p < .01$ and $\chi^2 = 8.5$, $p < .05$). Following all the four children who showed both behaviors, "marking" always appeared before that of "scrambled face," which needed more control to draw

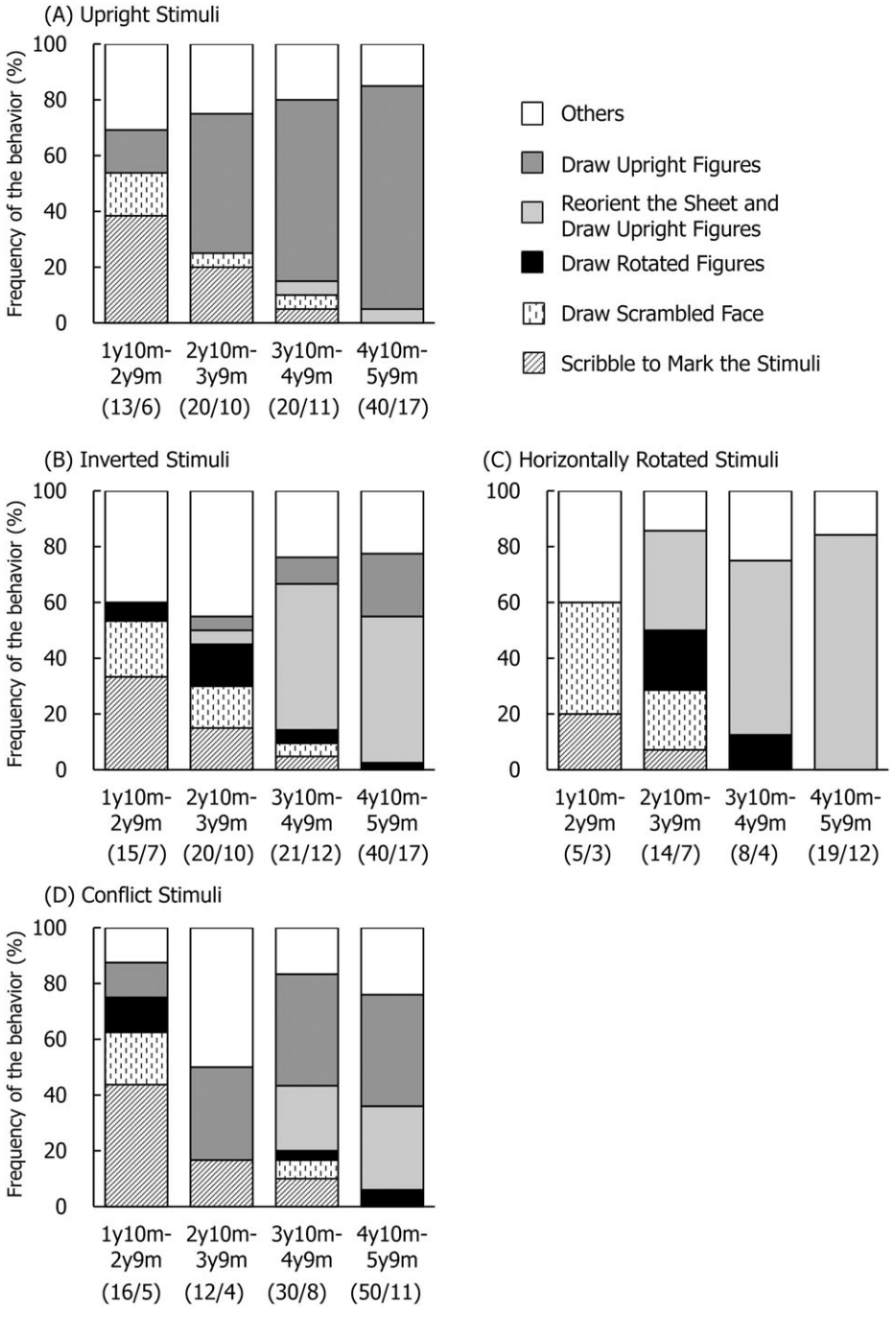

Figure 3 The frequency of the behavior for different types of stimuli in each age group (number of the cases/number of the participants). y = years; m = months.

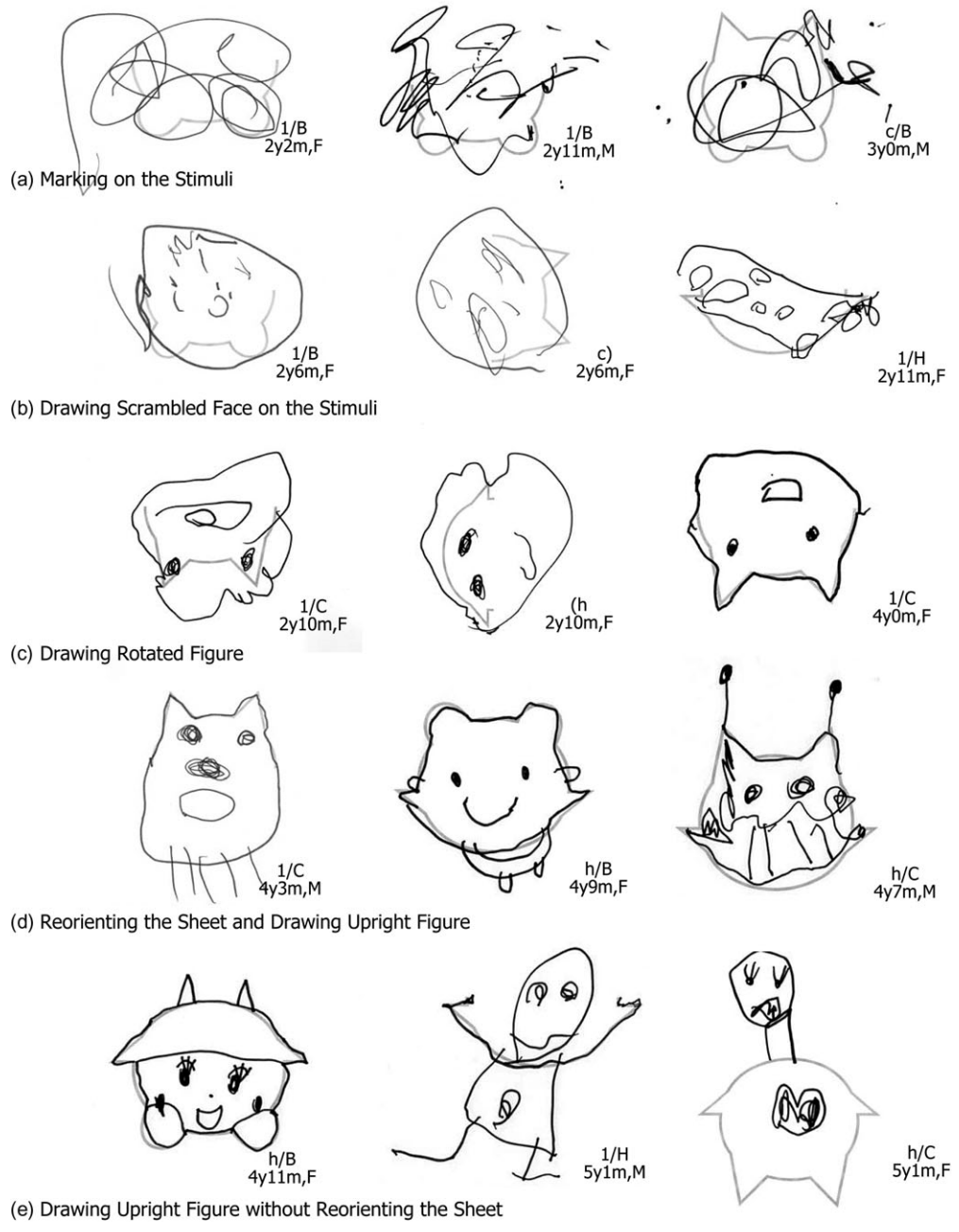

Figure 4 Examples of the drawing of children to the rotated/conflict stimuli. The attached texts refer to the type of stimuli, age (y = years; m = months), and sex (F = female; M = male).

distinct parts, for example, a girl who marked the stimuli at 2 years and 2 months (left in Figure 4) drew a scrambled face at 2 years and 5 months and 2 years and 11 months (right in Figure 4). Older children often reoriented the sheet to draw upright figures (52.4% of the 3 years and 10 months to 4 years and 9 months group and 52.5% of the 4 years and 10 months to 5 years and 9 months group, $\chi^2 = 20.5$, $p < .01$). Some of the children drew representational figures in an upright orientation using the inverted stimuli without reorientation, the frequency of which was highest in the oldest group (22.5%, $\chi^2 = 6.6$, $p < .05$). Note that in these cases, the stimuli were used in "unintended ways" by the authors, for example, the inverted "cat" stimulus (1/C) used as the legs of a monster, and the inverted "hat" stimulus (1/H) used as the arms of a boy (the bottom center of Figure 4).

Horizontally rotated stimuli. Rotated figures on the horizontal stimuli were observed in the 2 years and 10 months to 3 years and 9 months group (21.4%) and the 3 years and 10 months to 4 years and 9 months group (12.5%), and all of them were of horizontal orientation. Marking and the scrambled face were found only in the two youngest groups. The older children often reoriented the sheet by rotating 90 deg to draw figures in an upright position, the practice of which increased with age and was most frequently found in the oldest group (84.2%, $\chi^2 = 14.8$, $p < .01$). This reorientation behavior was more observed for horizontal stimuli than for inverted stimuli ($\chi^2 = 6.3$, $d.f. = 1$, $p < .05$) particularly in the 2 years and 10 months to 3 years and 9 months group (35.7%, $\chi^2 = 5.3$, $d.f. = 1$, $p < .05$).

Conflict stimuli. Rotated figures were observed in three age groups other than those of the 2 years and 10 months to 3 years and 9 months group. All of them were in an inverted orientation. In the youngest group, "rotated figures" were observed in 12.5% of the cases, which is almost an equal frequency with that of the "upright figures." However, the frequency of "upright", together with and without reorientation, increased with age ($\chi^2 = 18.1$, $p < .01$). The older children tended to draw figures in canonical orientations, by using the inverted stimulus as part of an upright figure, for example, the inverted ears of a bear are used as the paws of a cat on stimulus (c/B; Figure 4, bottom left). Those children often reoriented the sheets to find a better way to draw an upright figure. One girl aged 4 years and 11 months commented on stimulus (h/B) as follows: "It seems like a hat from here (and reoriented the sheet), but a bear from here." Such an acknowledgement about the stimuli's ambiguity was also observed in two boys (aged 5 years and 2 months).

Early recognition of geometric orientation. Table 2 shows the reorientation behavior on the stimuli and oral explanations from the children about the products when they scribbled to mark the stimuli or drew scrambled faces. When the children marked the rotated stimuli, 45.5% reoriented the sheet in advance. In contrast, when children drew scrambled faces, reorientation was only observed in 25.0% of the cases. The difference was not significant using Fisher's exact test. In contrast, there was a significant difference in the occurrence of accompanied behavior by which children named the products in the rotated orientations without reorienting the sheet (e.g. an inverted stimulus (1/C) was named "cat") between these two groups (9.1% of whom marked the stimuli whereas 58.3 % of whom drew scrambled faces, $\chi^2 = 6.13$, $d.f. = 1$, $p < .05$).

Discussion

How rotation occurs? The frequency of the representational drawings was increased by presenting upright stimuli. The frequency of the rotated drawings differed according to the types of stimuli and the ages of the children, which suggests the extent to which the presented stimuli triggered the children to draw representational and rotated figures. Younger children tended to be inspired by the image of the stimuli to draw representational figures and were indifferent about the representation orientations.

Table 2 Frequency of reorientation and naming rotated image while marking or drawing scrambled face

Type of drawing	*N*	Mean age (*SD*)	Sheet reorientation	Without reorientation	
				Naming rotated image	Naming upright image
Marking on:					
Rotated stimuli	11	2 years and 10 months (7 months)	5 (45.5%)	1 (9.1%)	0 (0.0%)
Conflict stimuli	12	2 years and 10 months (11 months)	1 (8.3%)	2 (16.7%)	1 (8.3%)
Drawing scrambled face on:					
Rotated stimuli	12	3 years and 1 month (6 months)	3 (25.0%)	7 (58.3%)*	0 (0.0%)
Conflict stimuli	5	3 years and 0 months (11 months)	0 (0.0%)	2 (40.0%)	1 (20.0%)

They sometimes drew upright figures on upright stimuli, horizontal figures on horizontal stimuli, and inverted figures on inverted stimuli, without commenting on their orientations.

The frequency of the rotated (inverted) and the upright figures on the conflict stimuli was almost equal only in the 1 year and 10 months to 2 years and 9 months age group, despite their being able to use the upright orientations. It indicates that there is little dominance of inverted and upright orientations in these representations of younger children, while older children obtain the dominance to choose upright orientations. There were a few older children who tried to draw figures in an inverted orientation, but in such cases, the rotation produced seemed to be deliberate. A girl aged 5 years and 6 months declared: "I will draw upside down," and drew an inverted face on stimulus (h/C). The girl also drew two faces of upright and inverted orientations within a stimulus (c/B). This type of integration of the different orientations of the faces was also observed in a boy aged 4 years and 7 months. "Reorient to draw upright figures" was more observed for horizontal stimuli than for inverted stimuli. In face recognition, there is a linear relationship between the angle of rotation and the accuracy of recognition (Valentine & Bruce, 1988). Our stimuli were merely illustrations of a half outline of a head without facial parts, but it may also be easy for children to become aware of the canonical orientation when the stimuli are presented in a horizontal rather than in an inverted orientation.

Why rotation occurs? Now, let us consider why rotated drawing emerges in normal child development. There is no reason to think that children intended to draw rotated figures in order to show pictures in the upright from the viewpoint of others. The orientation did not depend on the sitting position of the tester or the parents, and some children even drew figures in a different orientation corresponding to the presented stimuli in a series of sessions.

Although there were individual differences in the emergence age, generally five patterns of behavior were observed on the rotated stimuli: (a) marking on the stimuli, (b) filling in scrambled facial parts, (c) using the stimuli to draw a rotated figure, (d) reorienting the sheet and using the stimuli to draw an upright figure, and (e) using the stimuli to draw upright figures by giving another image. The frequencies of patterns (a) and (b) declined with age, whereas (d) and (e) increased with age.

Those drawing patterns may reflect the child's knowledge of concepts in attributing a face representation. For example, each drawing pattern on inverted stimuli (1/C) can be considered as follows: (a) "marking" behavior indicates that children recognized the stimuli as "a cat"; (b) a "scrambled face" indicates that

children know the constituent parts of a face and recognized the stimuli as "cat's ears" when filling in other parts, but were still indifferent to the number and the position of the parts; (c) a "rotated figure" indicates that children knew the position of the parts in their order but were still orientation-indifferent; (d) a "reoriented and upright figure" indicates their having knowledge of the position with regard to orientation so they could recognize the stimuli as "cat's ears in rotated orientation"; and (e) an "upright figure" indicates that children recognized the stimuli as "cat's ears in rotated orientation," but dared to find another object image. Extending this explanation to mirror writing, in which orientation indifference normally appears with regard to left and right between 3 and 7 years old (Schott, 2007), after the conventional orientation establishes the vertical axis from top to bottom, it may establish the horizontal axis from left to right.

Analysis of the reorientation behavior and the oral explanations suggested that younger children who scribbled to mark the stimuli prefer the upright orientation, whereas children who intended to draw a scrambled face or rotated figure seem more indifferent with regard to geometric orientation. This controversy may arise from the different developmental processes involved in recognition and representation. In the recognition tasks of DeLoache et al. (2000), 1.5-year-old children showed tendencies to orientation-indifference recognition and 2.5-year-old children showed preferences for the upright orientation. Because the average age of marking behavior in our experiments was older than that (2 years and 10 months), it is reasonable to think that most of the children already had orientation-dependent recognition, and therefore they reoriented the stimuli to an upright position. Although the children who drew scrambled faces ($M = 3$ years and 1 month) also have orientation-dependent recognition, this orientation may not apply to their own representational space. It shows that there is also an orientation-indifference period in representation when children begin to produce representational figures.

It has been suggested that the disorder of rotated drawing in adults might indicate isolated access to visual representations that are "viewpoint-independent" (Solms et al., 1998; Turnbull et al., 1997). In light of these arguments, drawing patterns on rotated stimuli may also reflect the development of spatial cognition. To mark the stimuli, children needed to have the viewer-centered referential frame to orient their pens on the stimuli. Drawing rotated figures may reflect the prior establishment of a viewpoint-independent referential frame on the picture-plane. Further, when older children predominantly draw upright figures, these two referential frames might properly connect and establish the orientation-dependent space on the picture-plane. It should be noted that Goodale and Milner claim that the dorsal stream, which is dedicated to the visual guidance of action, employs a viewer-centered means and the ventral stream, which is concerned with object recognition, might employ a viewpoint independent means (Goodale & Milner, 1992; Milner & Goodale, 1993). The results from our study indicated that both referential frames, properly connected, are needed in order to produce a representational figure in the canonical orientation.

General discussion

The comparative studies with chimpanzees have illuminated the human trait, which is to imagine nonexistent things on incomplete figures to draw representational figures (Saito, 2008, 2010). Human children tend to use something even as simple as an abstract shape and add missing parts to complete their inspired images. Note that the stimuli presented in Study 2 were simple and obscure, for example, the stimulus (c) is just a rounded line with two triangular projections. Nevertheless, most of the children, including those who just scribbled, recognized it as "a cat" even in the inverted orientation. Further, although the tester did not ask the children to use the stimulus to produce a figure, most of them sought to use the stimulus to produce a representational figure.

As reported in Study 1, rotated drawing is a rather rare phenomenon in children who are free drawing. However, in Study 2, the presentation of the stimuli brought out the rotated drawing more frequently, generally in young children who are beginning to produce representational drawing. Object representation starts after the period of scribbling to mark the existent parts of stimuli, when children establish their knowledge of the componential parts of an object to complete the missing parts. However, younger children who drew scrambled faces were still indifferent about the parts of a face in terms of their position and number. Later, children who drew rotated figures grasped the concept of position with regard to the parts of a face, but still showed orientation indifference. Lastly, children who always drew figures in an upright position grasped the concept of position with orientation, that is, orientation-dependent representation. Such a process of early development in representational drawing seems to be related to the establishment of spatial cognition of representational space with respect to the viewer-centered and viewpoint-independent referential frames.

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