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REACTION TO STIMULUS FIGURES

IN CHIMPANZEE DRAWINGS

A Thesis

Presented to

The Graduate Faculty

Central Washington University

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

Primate Behavior

---

by

Alexandra Bobrinskoy Casti

December 2016

CENTRAL WASHINGTON UNIVERSITY

Graduate Studies

We hereby approve the thesis of

Alexandra Bobrinskoy Casti

Candidate for the degree of Master of Science

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Dean of Graduate Studies

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ABSTRACT

REACTION TO STIMULUS FIGURES

IN CHIMPANZEE DRAWINGS

by

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December 2016

Seven captive chimpanzees (*Pan troglodytes*) produced drawings at the University of Oklahoma between November 1971 and November 1972. Chimpanzees drew on sheets of paper that were either blank or had a stimulus. The stimulus was located in the center or offset from the center. These drawings were scanned and digitized. Analysis tested whether chimpanzee mark placement was contingent on the location of stimulus figures. Centroid locations significantly changed between stimulus type for all drawing categories and among participants for free choice and central figure drawings. Participants drew in the empty space opposite offset figure drawings. Findings support previous studies that chimpanzee drawings show systematic patterns that vary between individuals. These findings have implications for motor play, aesthetics, and the ontogeny and phylogeny of art.

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CHAPTER I

INTRODUCTION

The establishment of captive chimpanzee (*Pan troglodytes*) breeding colonies for research purposes prompted the use of infant chimpanzees in comparative studies with human infants (Yerkes, 1943). Early studies (Kellogg & Kellogg, 1933; Kohts, 1935) compared various aspects of development between infant chimpanzees and humans. The emergence of drawing was one of the many observations early researchers recorded. Like humans, captive chimpanzees showed an intrinsic interest in drawing. Schiller (1951) was the first to systematically study chimpanzee drawing. Morris (1962) reviewed all known evidence of ape drawing and performed studies that added to Schiller's (1951) observations. Since then, multiple studies have extended Schiller (1951) and Morris' (1962) findings to show that chimpanzees are aware of their visual field and reacted to stimulus figures in formulaic ways (Boysen, Berntson, & Prentice; 1987; Smith, 1973). The current study aims to add to chimpanzee drawing research by quantitatively analyzing a collection of chimpanzee drawings obtained by researchers affiliated with the University of Oklahoma in 1971 and 1972. The following review first discusses developmental drawing stages in human children, summarizes key chimpanzee drawing studies in chronological order, and concludes by introducing the collection of chimpanzee drawings that will be analyzed for this thesis.

CHAPTER II

LITERATURE REVIEW

Children's Drawings

Piaget (1948) described three principal stages characteristic of children's drawing that begin after stage 0, where "pure scribbles" show no purpose or aim up until age two (p. 599). Stage I is divided into two substages. The first shows variations depending on the model being copied. The second substage begins around age three when children can talk about actual shapes and representational forms, but accuracy is not yet developed (p. 600). Stage II begins around age four and is marked by the progressive differentiation of Euclidean shapes at increasing levels of accuracy (p. 600). Children enter stage III around ages six or seven and can distinguish and independently represent shapes and concepts.

Kindler (1997) used the terms "Iconicity 1" through "Iconicity 5" to delineate the ranges of pictorial imagery development in Western children (p. 23). Iconicity 1 is the very beginnings of pictorial imagery, when children recognize their ability to produce icons of actions (p. 25). Uncontrolled drawing is an example of Iconicity 1. Human children begin scribbling as early as 12 months old. These initial drawings are uncontrolled and formless but become more contained as motor skills develop (Cox, 2005, p. 50). Kellogg (1969) described 20 basic scribbles (e.g., dot, single vertical/horizontal/diagonal/curved line, multiple vertical/horizontal/diagonal/curved line, roving open/enclosed line, zigzag/waving line, single/multiple loop line, spiral line, single crossed circle, imperfect circle) and 17 placement patterns (e.g., over-all, centered, spaced border, vertical/horizontal/diagonal half, one corner fan, across the paper, base-line fan). This provided descriptions for children's early drawings by the types of marks and the placement of those marks on the surface. Children transform basic forms and placement patterns into combinations of purposeful shapes as early as 24 months (Kellogg, p. 27).

Iconicity 2 is "when a child's attention shifts from causing an effect to the effect itself" (Kindler, 1997, p. 26). Shapes emerge and are encouraged by adults during this stage. This encouragement, as Kindler points out, could send the message that "organization, order, and predictability are the desirable outcomes of pictorial efforts" (p. 26). Iconicity 3 involves the vocal and gestural manifestations that accompany drawing in two to three year old children (p. 28). Children understand that imaginary actions can be represented pictorially in Iconicity 3. For example, in this stage, children draw pictures that simulate stories, games, and/or fantasies (p. 28).

Iconicity 4 is "when a child realizes the potential of graphic forms rather than graphic actions to stand for objects and things rather than dynamic events" (p. 28). Children attempt representation in the "Preschematic Stage" at 4 to 7 years old (Lowenfeld & Brittain, 1987, p. 39). Generalized shapes are used to represent complex forms such as a school bus or a portrait of the child's family in this stage.

Iconicity 5 is when children's drawings begin to heavily explore visual imagery. Lowenfeld and Brittain (1987) describe this stage as "The Stage of Dawning Realism" (p. 39). In teenage years, children enter the "Pseudo-Naturalistic Stage," also known as the stage of reasoning (p. 39). Self-criticism plays an important role, and this stage often marks the end of one's artistic development if no further motivation is present to develop these skills.

Chimpanzee Drawings

Like human children, chimpanzees show innate interest in drawing. Kohts documented the earliest evidence of ape drawing in 1913. Kohts (1935) compared drawings produced by Joni the chimpanzee from 1913 to 1916 with her son Roody's drawings, produced from 1925 to 1929. In comparison of two "first-stage" drawings, both drawings had stylistically similar simple scribbled lines. Kohts compared Roody's age 2 drawings to Joni's age 3-4 drawings. From this comparison she concluded "the predominance of round and circuitous drawing, while the chimpanzee at the age of 3-4 years, even after extensive exercises in drawing, did not go beyond drawing straight, sometimes crossing, lines haphazardly scattered on paper, which were so characteristic of the first two stages of the child's drawing" (p. 327).

Winthrop N. Kellogg and Luella D. Kellogg received infant chimpanzee Gua on loan from the Yerkes laboratory in 1931. At that time, the Kelloggs had a 10-month-old son, Donald, and agreed to raise Gua as their son's companion for nine months. The Kelloggs (1933) performed a drawing test during this experimental period, and both chimpanzee and human infants drew on the page when given a pencil. As with the Kohts (1935) study, Donald surpassed Gua's drawing abilities as he got older, and imitated the examiner's straight line while Gua failed to imitate the examiner (p. 266).

Schiller (1951) published the first study primarily focused on chimpanzee drawings. Alpha, an 18-year-old female chimpanzee at the Yerkes Laboratories of Primate Biology showed a keen interest in drawing. Researchers attached paper to a 12 x 15 in board and inserted it through a narrow space below the caging. Researchers pasted figures from colored paper onto sheets of contrasting colors and cut openings from paper sheets to paste contrasting colored sheets behind (p.101). Alpha received one or two pencils of different colors and drew on the paper from ten to 180 sec before the experimenter withdrew the board. The stimuli pasted on paper served to study color preference, figure formation, influence of form, position, size of figure or groups of figures, and tendencies to complete figures (p. 102). Alpha mainly used two strokes: short dashes and nearly parallel broad zigzag strokes.

When presented with a blank sheet of paper, Alpha usually made short marks in each corner, then along the margins, and lastly filled in the middle of the paper with coarser marks. In reaction to the various figures, Alpha placed her marks almost exclusively within a single figure, only diverging from this pattern three of the 25 large, single figures presented (p. 103). In reaction to the placement of single figures positioned off-center, Alpha drew in the largest open space, producing a “sort of balance between her markings and the presented figure” (p. 104). When presented with outlined figures, Alpha confined her drawing to the space within the outline in 22 out of 24 examples. Alpha reacted to spots scattered at random differently depending on the size of spots and the distance between them. If the spots were large and spread out, Alpha kept her drawing within each separate figure. If the spots were close together and small, she filled in the space between them or drew over the grouping as if they appeared as one large figure. When presented with a solid figure with a portion cut out, Alpha generally marked the figure and the left the open space blank, leaving the missing portion unmarked. In two of six cases, Alpha carefully filled in the missing portion with few marks made on the solid figure. Alpha did not complete incomplete triangles, squares, polygons, or circles. Alpha consistently completed the figure when presented with a space left amongst a circle of six or more dots. In reaction to symmetrical figures, Alpha responded to triangular outlines by centering her marks along each side of the triangle five out of seven times. Schiller stated “the location of the scribblings indicates the dominant aspect of the total configuration presented, and this dominance is quite evidently determined by the physical proportions and arrangement of the elements of the situation and not by selective conditioning" (p. 111). Alpha's drawings in reaction to various stimuli presented a strong argument for inclinations of balance, symmetry, and a self-motivated eagerness to draw, but these results were not quantitatively analyzed.

Morris (1962) devised a similar experiment with Congo, a 1-year-old male chimpanzee at the London Zoo. He obtained 172 black and white drawings, 40 were blank sheets of paper while the remaining 132 sheets were marked with one or more simple stimulus figures before presented to Congo. Congo followed several rules when presented a blank sheet of paper. He kept within the space (40 out of 40 tests), marked where he had not already marked (30 out of 40 tests), marked where he already marked (10 out of 40 tests), concentrated on the center (24 out of 40 tests), and marked in a series of radiating lines (15 out of 40 tests) (p.70). When presented with incomplete figures, Congo treated most figures as if complete and only marked inside the incomplete area once. Congo received a novel stimulus to test whether he would create intersecting lines when presented with a vertical line on the page. Congo only produced the intersecting response in one out of 18 tests. Like Alpha, Congo showed a strong tendency to mark a central figure and positioned marks in the blank space opposite an offset figure. Corner marking also occurred in Congo's drawings, but far less frequently than Alpha's strong inclination to do so. These results solidified Schiller's findings of central marking and an inclination to "scribble for scribbling's sake," but were only descriptive.

Smith (1973) first used quantitative methods to analyze chimpanzee drawings. He obtained approximately 100 drawings on paper from three young chimpanzees. Smith presented the chimpanzees with white 8.5 x 11 in sheets of paper with one of 15 different stimulus figure categories (e.g., blank sheet, central small square, central large square, central small circle, central large circle, small right offset square, large right offset square, small left offset square, large left offset square, slightly right small square, slightly left small square, two centered horizontal small squares close together, two centered horizontal small squares slightly further apart, two centered horizontal small squares far apart, offset complete circular array of squares, offset incomplete circular array of squares) printed on them. The blank sheets served as the control (p. 407). Researchers presented five sheets of paper to each chimpanzee per session with either a black or blue crayon. Smith analyzed the drawings by fitting a Plexiglas grid over the paper, dividing it into 10 rows and 10 columns, totaling 100 rectangular cells measuring 3 x 2.25 cm. Researchers placed the grid over each drawing and made a tally mark on the corresponding score sheet wherever a grid cell contained a crayon mark. All three chimpanzees marked significantly more in the lower half than the upper half on the blank sheets of paper, and the markings were concentrated in the central 16% of the paper. In categories with one stimulus figure in the center, all chimpanzees tended to mark the center of the sheet, which corresponded with earlier findings (Morris, 1962; Schiller, 1951). On sheets displaying one figure offset from the center, the chimpanzees marked the available space without attempting to balance the offset figure. In the separated figures category, two of the three chimpanzees practiced a space-filling tendency consistent with earlier findings (Morris, 1962; Schiller, 1951). When the multiple separated stimulus figures were close together, two of the chimpanzees marked each component separately. When a distance between 6.25 and 10 cm separated stimulus figures, two chimpanzees marked the space between the figures. When testing for completion of an incomplete figure, the chimpanzees concentrated their marks in the general area of the stimulus array, but these marks occurred closest to the center regardless of the location of the gap in the array. Smith concluded that chimpanzees respond to visible effects from the movements they make on paper with a drawing utensil in hand and concentrate their marks in the center of the paper.

Boysen et al. (1987) continued the stimulus-drawing test in chimpanzees by presenting 18 different figures to three chimpanzees. Researchers obtained a total of 618 black and blue ballpoint pen drawings on 8.5 x 11 in white paper and compared results to earlier studies. Categories one through 16 were synonymous with Smith's (1973), while categories 15a and 16a were mirror images of Smith's categories 15 and 16. Researchers analyzed the drawings with a computerized adaptation of Smith's (1973) approach by placing a 10 x 10 column Mylar grid over each drawing and recorded the marked cells with a graphics pen. Boysen et al. scored and averaged each drawing by stimulus category and created a summary matrix for each category. General results showed a tendency for all three chimpanzees to mark toward the bottom horizontal center of the page. In agreement with Smith's (1973) findings, Boysen et al. found that any presence of a stimulus figure on the page elicited more centralized markings than the blank sheet. There was no evidence of balance among offset figures or closure of incomplete figures. Results also supported Morris (1962), Schiller (1951), and Smith's (1973) observations of space filling. As in previous studies, the chimpanzees marked each component in a multiple-stimulus figure when components were close together, and marked the space in-between figures when further apart.

Beach, Fouts, and Fouts (1984) asked Moja, an 11-year-old chimpanzee, to draw six different objects in six different conditions. Moja was cross-fostered at the University of Nevada, Reno in the 1970s (Gardner & Gardner, 1989, p. 9). Cross-fostering is a methodological procedure when the adults of one species rear the offspring of another species (Stamps, 2003). The Gardners cross-fostered five chimpanzees, Washoe, Moja, Tatu, Dar, and Pili, and used only

American Sign Language (ASL) to communicate with them. The Gardners reared the infant chimpanzees in the cross-fostering laboratory and raised the young chimpanzees as if they were deaf human children. Like human children, the chimpanzees wore clothes, helped with chores, used utensils, sat in highchairs, and played games (Gardner & Gardner). Caregivers encouraged the cross-fosterlings to sign by expanding on their fragmentary utterances and asking questions (Gardner & Gardner). In this environment, the chimpanzees acquired ASL signs in similar patterns to those of human children (Gardner & Gardner, 1994).

Moja drew numerous drawings of six objects, cup, brush, ball, banana, bird, and boot. Each object was prompted in the following conditions: (a) vocally, (b) vocally and in ASL, (c) vocally, in ASL, and shown a line drawing of each object, (d) vocally, in ASL, and shown a color slide image of each object, (e) shown the actual object and asked vocally and in ASL, and (f) shown the object, watched the experimenter make a line drawing of the object, and asked to draw the object vocally and in ASL (p. 3). Moja produced drawings in each condition, and researchers observed Moja using a consistent visual concept in her drawings of brush, cup, and ball (p. 4).

Iversen and Matsuzawa (1996) used touch-sensitive monitors to study chimpanzee drawing in a method they called electronic finger-painting. Two captive female chimpanzees learned to create structured drawings guided by automated visual commands on a touch-screen monitor. The chimpanzees entered a room with a touch-screen monitor that displayed visual stimuli. The visual stimuli were categorized into four “training steps” (p. 127). Steps one through four displayed unfilled circles in alignment, steps five through seven displayed unfilled rectangles of various sizes, and steps eight through ten displayed two white dots (p. 129). Researchers assigned target locations for each step and visual feedback appeared on the screen when the chimpanzee correctly pressed the screen. When the chimpanzees touched the visual stimuli in the proper order and/or location, electronic ink appeared on the monitor at the location pressed. Results showed precise straight-line control after reinforcement step training, and both chimpanzees reliably demonstrated the ability to connect two dots on the monitor by placing a finger on one dot and moving their finger over the surface until it reached the second dot (p. 130).

Iversen and Matsuzawa (1997) performed three experiments with the same two chimpanzees from their 1996 study. In experiment one, the monitor displayed a bar and two dots separately aligned with the endpoints of the bar. A model of the completed figure was present on the monitor in a smaller version. The chimpanzees were to aim at one dot, sweep their finger across the surface to the second dot, lift their finger, and press a white key on the monitor to end the trial (p. 155). One chimpanzee drew parallel to the model while the other chimpanzee did not. In experiment two, one chimpanzee was trained to draw parallel lines to the model while the stop-dot gradually faded away. The chimpanzee drew a line parallel to the model when the stop-dot was removed, but this did not occur in every trial. Experiment three presented three model marks (one vertical and two diagonals) on the screen and one start-dot location. Both chimpanzees eventually traced the guided model. This fully automated recording and teaching method showed evidence of “elementary copying behavior” in chimpanzees without verbal instruction, demonstration, or manual assistance (p. 154).

Iversen and Matsuzawa (1998) later introduced complex figures to the touch-screen trained chimpanzees. Stimuli (e.g., a diamond, a square with diagonal lines intersecting inside, three lines intersecting to form a star) appeared one at a time on the screen. Participants then traced the stimulus figure and pressed a switch that enabled the computer to analyze the drawing.

If 95% of the stimulus was covered by ink and 95% of the ink covered the stimulus figure, the computer delivered a food reward. Both chimpanzees traced correctly on 90% of the trials. The chimpanzees also performed a color tracing trial with a stimulus figure (a blue outlined square with two intersecting yellow lines inside the square) and four-choices of colored ink at the bottom of the screen. Through gradual progressive automated training, the chimpanzees chose the correct colors and traced the stimulus figure presented.

Tanaka and Tomonaga (2003) studied the development of scribbling in infant chimpanzees. Researchers used a notebook computer with a 10.4-in touch-sensitive screen to record strokes produced by three pairs of mother and infant chimpanzees. Each pair entered into the experimental booth and accessed the screen for three min. A dot appeared on the screen with an arrow-type mouse pointer at the center of the white screen. Subjects touched the screen any way they chose for the three min. The monitor provided six colors (black, red, blue, green, yellow, and white) at different sessions for electronic ink. The white electronic ink served as the control condition since touching did not produce any visible traces on the already white screen. The computer recorded all touches to the screen and the ink color remained the same for each session, and changed per session to prevent familiarization.

Researchers divided touches between mother and infant based on time-stamped data from the computer and video monitoring. Researchers used “strokes” as the unit analysis, and defined them as “a series of consecutive dots, where each dot was recorded less than 100 ms after the one immediately preceding it. When an interval of more than 100 ms passed between the recording of one dot and the next, the first dot became the end of the previous stroke and the second dot the beginning of the next stroke” (p. 247). Researchers calculated the number of strokes in each session per subject and classified each stroke into six types: dot, straight line, curve, hook, loop, and miscellaneous.

All three infants drew on the screen without food reward. Two of the three mothers also touched and drew on the screen. Infant chimpanzees drew on the screen for much shorter durations than the adult chimpanzees. Researchers classified a total of 1,460 strokes and all infants produced each type of stroke. Chimpanzees made more strokes when the ink color was visible on the screen. Results supported previous studies (Boysen et al., 1987; Morris, 1962; Schiller, 1951; Smith, 1973) by showing that chimpanzees possessed an intrinsic motivation to draw. Chimpanzee infants in the age-period of 13-23 months demonstrated motor-control to produce a variety of strokes with their finger. Infant chimpanzees drew with their fingers before they used a mark-making instrument on paper. The same infant chimpanzees showed rapid development at the age of 20-23 months when drawing with a marker on paper (Tanaka & Tomonaga, p. 251).

Martinson (2007) recruited 77 human participants to sort the 35 drawings created by Moja in the Beach et al. (1984) study. Moja completed each drawing on 9x12 in black construction paper with white pastel chalk. The researcher chose an exemplar drawing from each of six categories (apple, ball, boot, brush, cup, banana, and bird), and instructed human participants to sort a packet of 28 drawings into categories according to similarity of form to each exemplar. The researcher calculated the probability of sorted drawings with the corresponding exemplar and compared the probabilities with the participants' performances. Multidimensional scaling provided a visual representation of similarities of dissimilarities among the categories through a pattern of proximity. It also provided the researcher with a determination of perceived similarity and dissimilarity between Moja's drawings (p. 12). Humans perceived similarities in Moja's drawings of cup, boot, and banana.

Zeller (2007) conducted a study of similarities and differences in a collection of 396 non-representational paintings made by human children, chimpanzees, gorillas, and orangutans. The researcher analyzed the number of colors used, first and last color preferences, use of novel colors, respect for boundaries, negative space, and placement pattern to see whether there was any evidence of choice in the production of marks to disprove a null hypothesis of random concatenations of color and placement (p. 185). All species demonstrated centralized mark placement; chimpanzees placed their marks in the lower central area of the page in agreement with previous studies (Boysen et al., 1987; Schiller, 1951; Smith, 1973). There was evidence of respect for boundaries, with human children showing most respect for boundaries with 52.6% of their marks placed within the edges of the paper, and chimpanzees with 29.2% of their marks within the boundaries of the page (pp. 198-200).

Current Study

Researchers at the former Institute of Primate Studies (IPS) at the University of Oklahoma collected chimpanzee drawings analyzed for the current study. They collected drawings from seven captive chimpanzees from January 1971 to November 1972. Researchers used stimulus figures from previous studies (Morris, 1962; Schiller, 1951; Smith, 1973) and added additional categories for a total of 31 potential stimulus tests. The objective of the current study is to analyze the collection of chimpanzee drawings. Previous work shows that chimpanzees respond in particular patterns to particular stimuli (Boysen et al., 1987; Morris; Schiller; Smith). This allows us to make predictions about the chimpanzees' responses to the stimuli in this dataset. Completing further chimpanzee drawing analyses contributes to the growing awareness and understanding of the cognitive and biological traits that chimpanzees possess.

The researcher hypothesized that mark placement was contingent upon the presence of the stimulus figure. For free choice and central figure drawings, the researcher hypothesized results similar to previous studies with mark placement located in and around the physical center of the page with shifts between categories and participants. The researcher hypothesized to find evidence of space filling and/or balance for offset figure categories with marks located in the space absent of the stimulus figure.

CHAPTER III

METHOD

Participants

Seven captive chimpanzees (*Pan troglodytes*), Ally, Booee, Bruno, Cindy, Lucy, Thelma, and Washoe, participated in the drawing study conducted by researchers affiliated with the University of Oklahoma between November 1971 and November 1972. Background information for each chimpanzee is provided in Table 1.

Ally was born in 1969 at the Institute for Primate Studies (IPS) in Norman, Oklahoma. Dr. William Lemmon, the director of IPS, sent Ally to be raised in the private home of Sheri Roush when he was six weeks old. Ally's home environment was very similar to those of human infants, including toilet training, table manners, brushing teeth, and discipline (Fouts, 1973b, p. 46). Roger Fouts began teaching Ally American Sign Language (ASL) around his first birthday and his vocabulary included more than 70 signs at the time of the drawing study (Fouts, 1997, p.161; Fouts, 1973b, p. 48). Fouts described Ally's painting method as "explosive" and reminiscent to 1950s action painting by the artist Jackson Pollack (p.161).

Booee was born in 1967 at the National Institutes of Health (NIH) research facility in Bethesda, Maryland. NIH surgeons subjected Booee to a split-brain operation as a newborn and left him with a severed corpus callosum (Fouts, 1997, p. 133). An NIH doctor, Fred Schneider, took Booee home and his family nursed him back to health. Booee lived with the Schneiders for more than 30 months before he was relocated to IPS in early 1970. Booee began ASL lessons with Fouts at 36 months old and acquired 10

Table 1

Background Information for Each Chimpanzee

Name/Sex	Year born/location	Early rearing	Age in years during study	Evidence of art experience	Location during study
Ally/M	1969/IPS	Home-reared in private residence	2-3	Painting	Private Residence
Booee/M	1967/NIH	Home-reared for more than 30 months in private residence after experimental split-brain operation	4-5	Drawing/painting	IPS
Bruno/M	1968/IPS	Home-reared for 24 months then partially home-reared for 8 months in private residence	3-4	No reports found	IPS
Cindy/F	1966/Wild	Readily handled by humans in laboratory setting	5-6	No reports found	IPS
Lucy/F	1964/Circus	Cross-fostered in private residence	7-8	Drawing/painting	Private Residence
Thelma/F	1967/Wild	Readily handled by humans in laboratory setting	4-5	No reports found	IPS
Washoe/F	1966/Wild	Cross-fostered in Gardner laboratory	5-6	Drawing/painting	IPS

selected signs (Fouts, 1973a, p. 978). Prior to the drawing study, Fouts described Booee's drawing and painting marks as always occurring in two opposite corners of a page, perhaps as an "enduring effect" from his split-brain surgery (Fouts, 1997, p. 134)

Bruno was born in February of 1968 at IPS and given to Dr. Herbert Terrace, a psychology professor at Columbia University in New York, when he was six weeks old (Hess, 2008, p. 56). Terrace brought Bruno to New York to test whether a chimpanzee could survive the city's cold winter climate. Bruno was home-reared by the family of Stephanie Lee, one of Terrace's former students. Terrace attempted to teach Bruno basic ASL during his time in New York, but was unsuccessful. Bruno returned to IPS in June of 1969. Bruno began sign language lessons with Fouts when he was 36 months old and acquired 10 selected signs (Fouts, 1973a, p. 978).

Cindy was born in 1966 in Africa and carried back to the United States by a Peace Corps volunteer (Fouts, 1997, p. 132). Soon after her arrival, Cindy arrived at IPS and was readily handled by humans. Cindy began sign language lessons with Fouts at an estimated age of 45-51 months and acquired 10 selected signs (Fouts, 1973a, p. 978).

Lucy was born in 1964 into a colony of circus chimpanzees and sold at two days old to Dr. Lemmon, who then gave her to Maury and Jane Temerlin (Hess, 2008, p. 35; Fouts, 1997, p. 150). Maury was a psychotherapist and psychology professor at the University of Oklahoma, and he and his wife were former students of Lemmon as well as longtime patients and protégés. The Temerlins wholly embraced Lucy as their daughter and provided her with the same enriched environment as they provided for their human son (Temerlin, 1975, p. xxi). Lucy was six years old when Fouts began making house calls to teach her ASL, and she had a growing vocabulary of nearly 90 signs at the time of the drawing study (Fouts, 1973b, p. 47). Prior to the drawing study, Lucy had experience in drawing and finger painting (Temerlin, 1975, p. 123).

Thelma was born in 1967 in Africa and carried back to the United States by a Peace Corps volunteer (Fouts, 1997, p. 132). Soon after her arrival, Thelma arrived at IPS and was readily handled by humans. Thelma began sign language lessons with Fouts at an estimated age of 33-39 months and acquired 10 selected signs (Fouts, 1973a, p. 978).

Washoe was born in 1966 in Africa and presumably captured after several months of care by her natural mother (Gardner & Gardner, 1971, p. 125). Washoe arrived in Reno, Nevada, at the cross-fostering laboratory of Allen and Beatrix Gardner when she was about 10 months old. The Gardners began Project Washoe and immersed Washoe in a stimulating and linguistic environment with a human foster family that used only ASL to communicate with Washoe and each other (Gardner & Gardner, 1989, p. 5). Washoe acquired at least 132 signs in Reno by the time she went to the University of Oklahoma with Fouts in October of 1970. Washoe lived in IPS with other chimpanzees inside a laboratory building with complex interconnected enclosures (Gardner & Gardner, 1989, p. 280). Prior to the drawing study, Washoe had experience with drawing and finger painting (Fouts, 1997, p. 36; Gardner & Gardner, 1989, p. 2)

Drawing Set

Experimenters obtained a total of 593 drawings from chimpanzee participants between November 1971 and November 1972. Chimpanzees completed drawings on 8.5x11 in sheets of white paper with pencil. During drawing sessions, experimenters familiar with the chimpanzees provided them with stimulus sheets and/or blank sheets of paper. See Figure 1 for stimulus categories. The experimenter noted the top of each

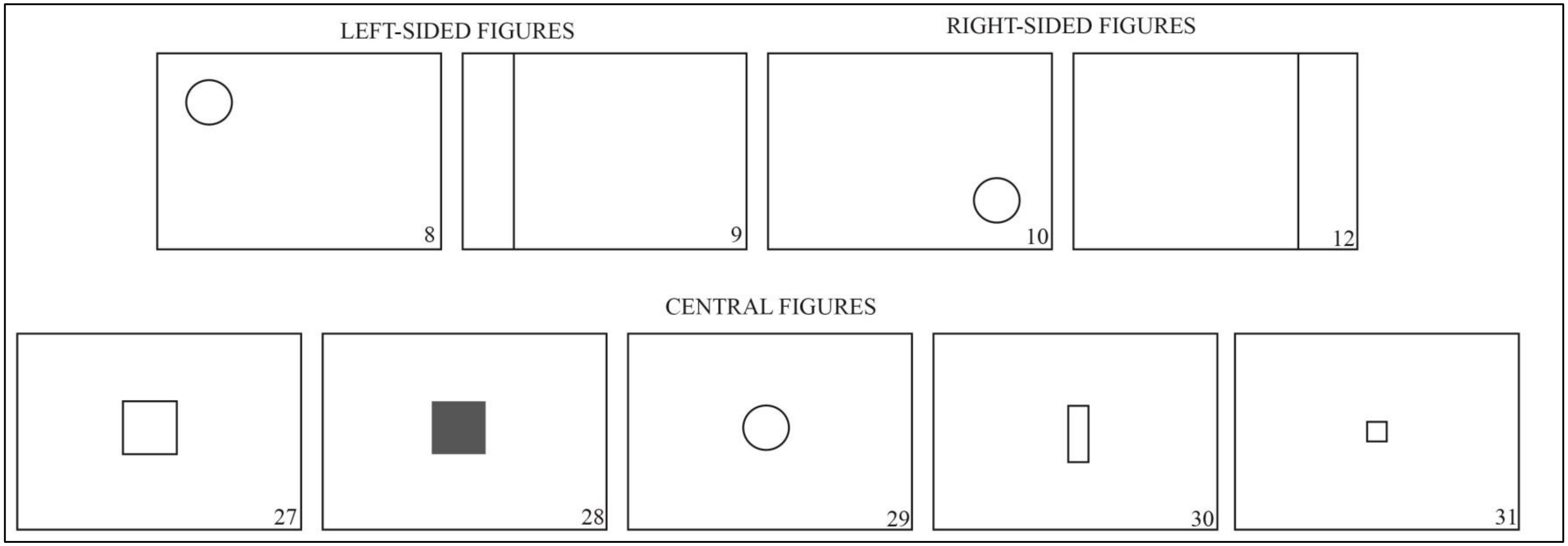

Figure 1. Presented stimulus categories for drawing. Free choice (blank sheet) is not depicted.

drawing, chimpanzee name, date, and stimulus category on the back of each sheet. Upon completion, the experimenter placed drawings in the chimpanzee's designated folder. Experimenters also recorded on "Chimpanzee Art Test" sheets, specifying the chimpanzee tested, chimpanzee sex/age, human tester/sex, place tested, date tested, session start/finish time, number of free choice drawings, hand positions, and additional remarks. There were 81 completed drawings from Ally, 88 from Booee, 47 from Bruno, 70 from Cindy, 96 from Lucy, 70 from Thelma, and 141 from Washoe. Experimenters presented stimulus categories 1-22 to four of the participants (Ally, Booee, Lucy, and Washoe) and presented stimulus categories 23-31 to all seven participants. All participants produced drawings in the free choice (blank sheet) category. The researcher analyzed categories with adequate sample sizes and similar stimulus figures from previous studies. Table 2 provides the number of drawings produced by each chimpanzee for the stimulus categories analyzed in this study. The researcher combined categories 8, 9, 10 and 12 to represent left-sided and right-sided offset stimulus figure drawings and combined categories 27-31 to represent central figure drawings. A research assistant for the current study scanned drawings and data sheets in PDF format.

Analysis

The researcher initially adapted techniques from Smith (1973) and Boysen et al. (1987) to analyze the drawings. The researcher and a research assistant placed a clear lamination sheet with a 10x10 grid on a tablet computer displaying each drawing. They notated each cell containing a mark with a tally on the lamination sheet. They recorded the total number of marks per cell for each drawing on a score sheet per participant. The researcher reevaluated and made adjustments if the research assistant obtained a different

Table 2

Number of Drawings Completed by Each Participant per Stimulus Category

Stimulus Figure Category	Number of drawings per category per chimpanzee						
	Ally	Booee	Bruno	Cindy	Lucy	Thelma	Washoe
8	2	2	0	0	2	0	1
9	2	1	0	0	2	0	2
10	2	2	0	0	2	0	2
12	2	2	0	0	2	0	2
27	10	8	7	10	10	10	10
28	4	5	5	5	5	5	5
29	5	5	5	5	5	5	5
30	3	2	2	3	3	3	3
31	3	3	3	3	3	3	3
FC	8	23	14	34	11	34	59
Total	41	53	36	60	45	60	92

total from the researcher. The researcher completed summary matrices to show overall distribution of marks.

The researcher converted all drawings into JPEG files and inputted them into a Python code programmed to provide the mean *x* and mean *y* coordinates (centroids) for each drawing in relation to the physical center of the image. Python is a programming language widely used in scientific and numeric computing ("General Python FAQ," 2015).

Statistical evaluations were based on a two-way analysis of variance (ANOVA) that independently compared mean *x* and *y* coordinates versus participants and stimulus categories. Since not all participants produced offset figures drawings, the researcher analyzed them separately from the free choice and central figures. Post hoc Tukey's honest significant difference (HSD) tests examined differences between stimuli and participants' centroids. Results were considered significant if $p = \leq .05$.

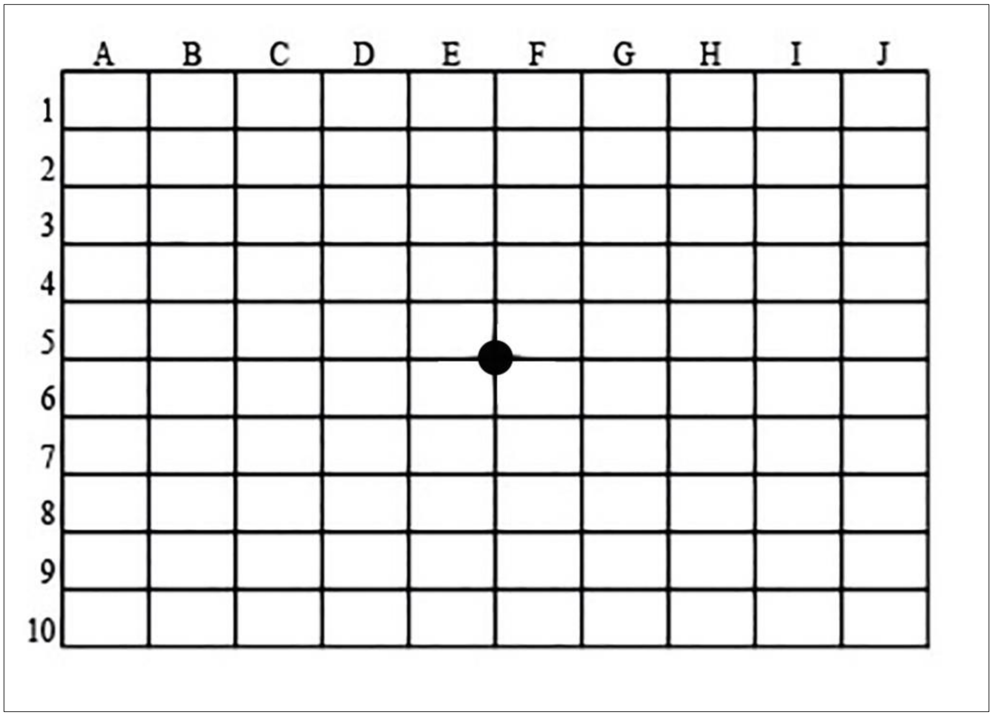

Figure 2. Column and row labels with minimum/maximum *x* and *y* coordinates used in summary matrix tally mark analysis. Letters A – J labeled cells on the *x-axis*. Numbers 1 – 10 labeled cells on the *y-axis*. Physical center (black circle): *x* = 825, *y* = 636; top left: *x* = 0, *y* = 0; top right: *x* = 1650, *y* = 0; bottom left: *x* = 0, *y* = 1272; bottom right: *x* = 1650, *y* = 1272.

CHAPTER IV

RESULTS

Free Choice Versus Central Figure Drawings

Mean *x* coordinates were significantly different between stimulus type $F(1,340) = 7.09$, $p = .008$ and participants $F(6,340) = 2.61$, $p = .017$. Figure 3 displayed the central stimulus figure mean (865.15) farther to the right on the *x*-axis than the free choice drawing mean (820.91). There was a significant interaction between stimulus type and participants $F(6,340) = 2.46$, $p = .024$. Tukey's HSD tests showed individual differences between Ally versus Booee and Ally versus Thelma (see Table 3). Figure 4 shows the distribution of means between stimulus types for each chimpanzee. In this figure the interaction is apparent in that on the *x*-axis, Ally's centroids are farthest from Booee and Thelma's centroids.

Mean *y* coordinates were significantly different between participants $F(6,340) = 3.78$, $p = .0012$. Tukey's HSD tests showed individual differences between Cindy versus Booee and Lucy versus Cindy (see Table 4). Figure 4 shows the distribution of means between stimulus types for each chimpanzee. In this figure the interaction is apparent in that on the *y*-axis, Cindy's centroids are farthest from Booee and Lucy's centroids. Mean *y* coordinates were not significantly different between stimulus type $F(1,340) = .12$, $p = .73$. There was a significant interaction between stimulus type and participants $F(6,340) = 5.05$, $p = <.0001$.

Offset Figure Drawings: Left-Sided Versus Right-Sided Figures

Mean *x* coordinates were significantly different between stimulus type $F(1,30) = 4.67$, $p = .03$. Figure 3 displayed the right-sided figure mean (852.61) farther right on the

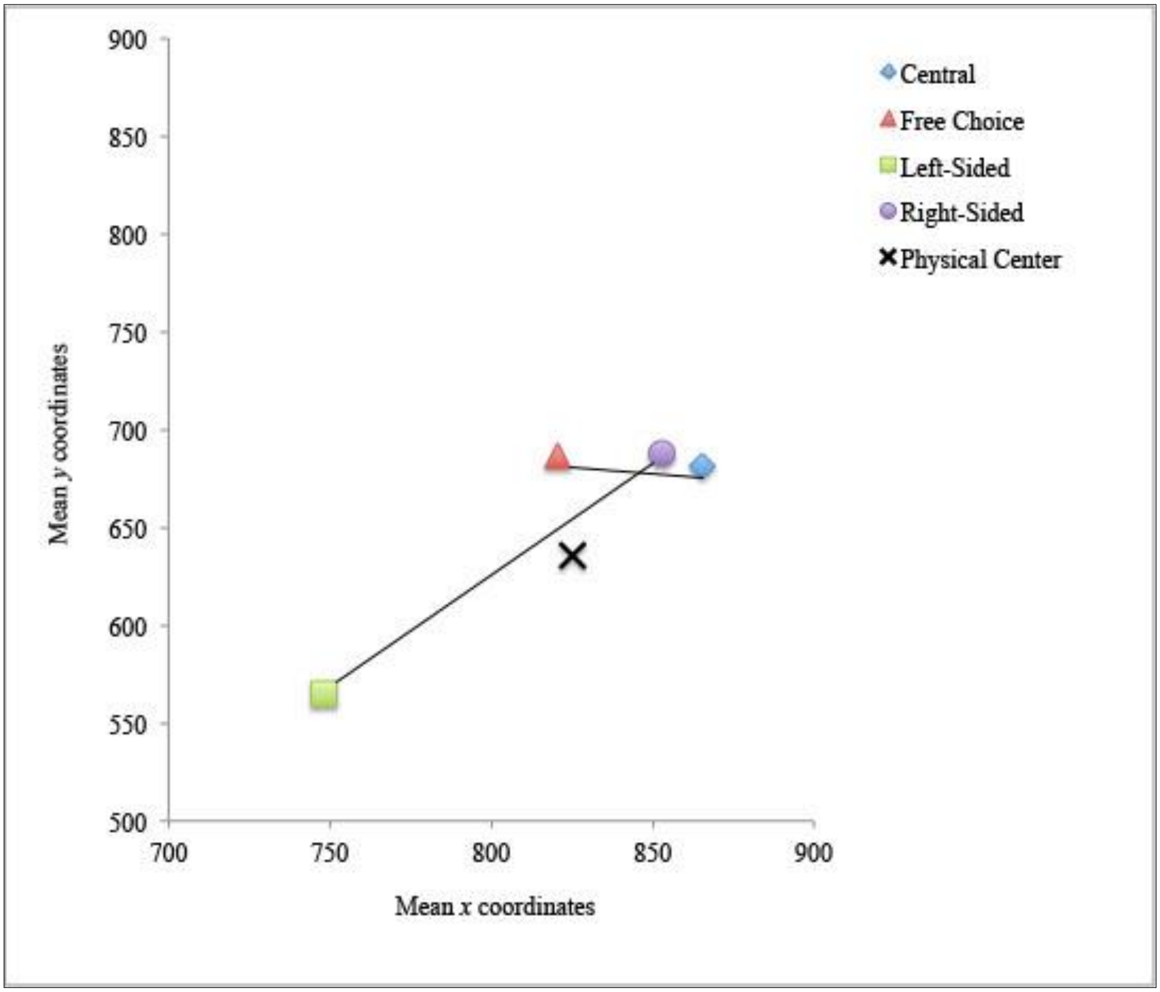

Figure 3. Scatter plot displaying mean *x* and *y* coordinates per stimulus type. Lines connect central figures versus free choice and left-sided versus right-sided figures. The X represents the physical center of the page.

Table 3

Tukey Simultaneous Tests for Differences of Mean x Coordinates in Free Choice and Central Figure Categories

Difference of Levels	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
BOOEE-ALLY	-128.05	32.43	-3.95	0.0015
BRUNO-ALLY	-59.52	35.2	-1.69	0.6222
CINDY-ALLY	-46.67	30.92	-1.51	0.7394
LUCY-ALLY	-88.09	34.22	-2.57	0.1339
THELMA-ALLY	-94.77	30.92	-3.07	0.0354
WASHOE-ALLY	-81.12	29.33	-2.77	0.0827
BRUNO-BOOEE	68.53	32.71	2.09	0.3556
CINDY-BOOEE	81.38	28.06	2.9	0.0573
LUCY-BOOEE	39.96	31.66	1.26	0.8691
THELMA-BOOEE	33.28	28.06	1.19	0.8996
WASHOE-BOOEE	46.92	26.29	1.78	0.5586
CINDY-BRUNO	12.85	31.22	0.41	0.9996
LUCY-BRUNO	-28.57	34.49	-0.83	0.9821
THELMA-BRUNO	-35.25	31.22	-1.13	0.9193
WASHOE-BRUNO	-21.6	29.64	-0.73	0.9909
LUCY-CINDY	-41.42	30.11	-1.38	0.815
THELMA-CINDY	-48.1	26.3	-1.83	0.5282
WASHOE-CINDY	-34.46	24.41	-1.41	0.7958
THELMA-LUCY	-6.68	30.11	-0.22	1
WASHOE-LUCY	6.96	28.47	0.24	1
WASHOE-THELMA	13.64	24.41	0.56	0.9979

Individual confidence level = 99.66%

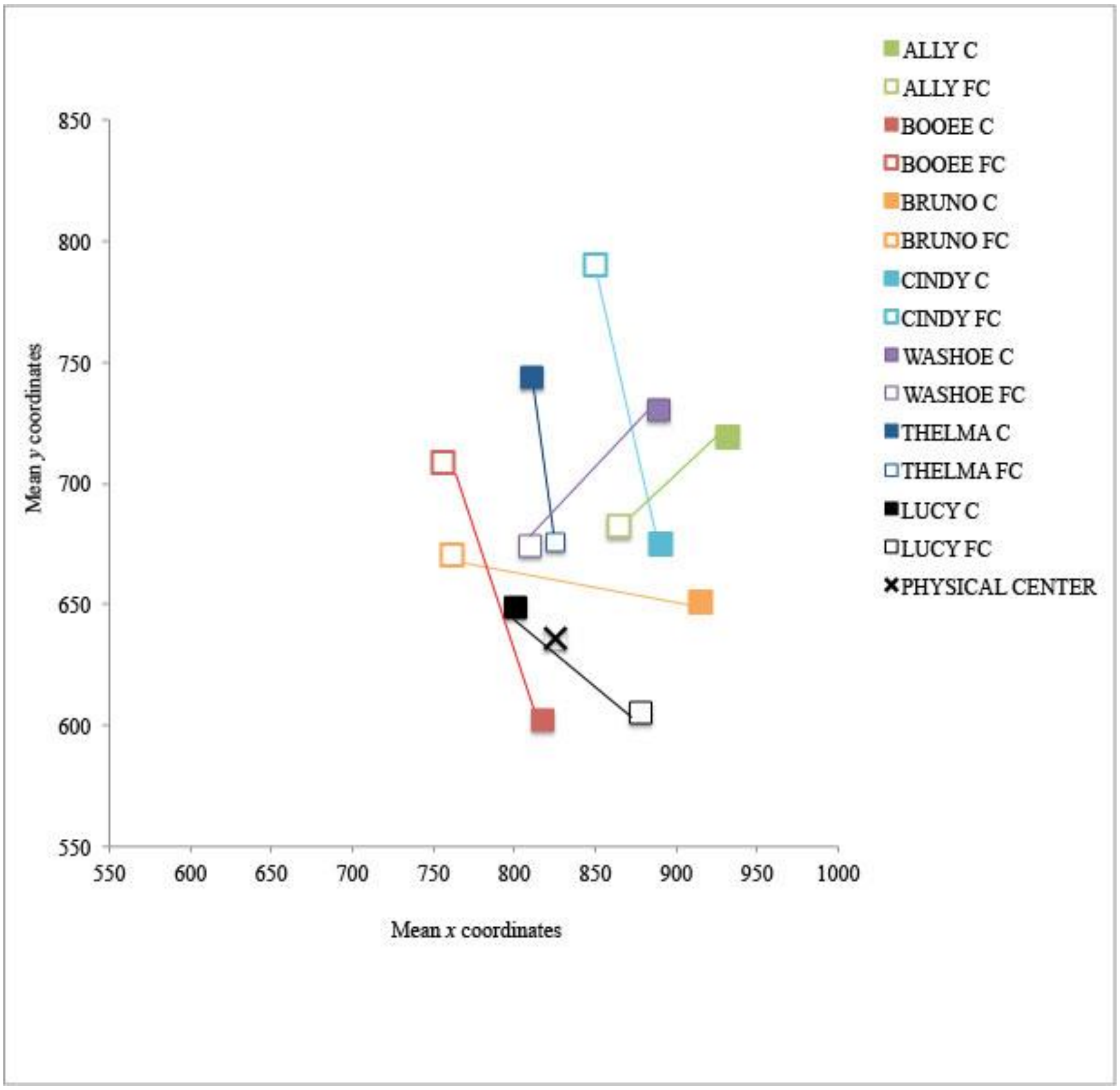

Figure 4. Scatter plot displaying free choice and central figure mean *x* and *y* coordinates per participant. Free choice coordinates are outlined squares and central figure coordinates are filled in. Lines connect each individual's free choice and central figure coordinates to illustrate interactions.

Table 4

Tukey Simultaneous Tests for Differences of Mean y Coordinates in Free Choice and Central Figure Categories

Difference of Levels	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
BOOEE-ALLY	-52.79	29.13	-1.81	0.5397
BRUNO-ALLY	-50.99	31.62	-1.61	0.6743
CINDY-ALLY	30.95	27.78	1.11	0.924
LUCY-ALLY	-74.76	30.74	-2.43	0.1853
THELMA-ALLY	-4.21	27.78	-0.15	1
WASHOE-ALLY	-19.08	26.35	-0.72	0.9912
BRUNO-BOOEE	1.81	29.39	0.06	1
CINDY-BOOEE	83.75	25.21	3.32	0.0156
LUCY-BOOEE	-21.96	28.44	-0.77	0.9876
THELMA-BOOEE	48.58	25.21	1.93	0.462
WASHOE-BOOEE	33.71	23.62	1.43	0.7873
CINDY-BRUNO	81.94	28.04	2.92	0.0539
LUCY-BRUNO	-23.77	30.98	-0.77	0.988
THELMA-BRUNO	46.78	28.04	1.67	0.6376
WASHOE-BRUNO	31.9	26.63	1.2	0.8952
LUCY-CINDY	-105.71	27.05	-3.91	0.0018
THELMA-CINDY	-35.16	23.63	-1.49	0.752
WASHOE-CINDY	-50.03	21.93	-2.28	0.2527
THELMA-LUCY	70.54	27.05	2.61	0.1234
WASHOE-LUCY	55.67	25.58	2.18	0.3083
WASHOE-THELMA	-14.87	21.93	-0.68	0.9938

Individual confidence level = 99.66%

x-axis than the left-sided figure mean (748.43). Mean *x* coordinates were not significantly different between participants $F(3,30) = .70$, $p = .55$. There was not a significant interaction between stimulus type and participants $F(3,30) = 1.79$, $p = .17$.

Mean *y* coordinates were significantly different between stimulus type $F(1,30) = 24.17$, $p = <.0001$ and participants $F(3,30) = 32.02$, $p = <.0001$. Figure 3 displayed the left-sided figure mean (687.55) lower on the *y*-axis than the right-sided figure mean (565.16). There was also a significant interaction between stimulus type and participants $F(3,30) = 3.91$, $p = .01$. Tukey's HSD tests showed individual differences between Booee versus Ally, Lucy versus Ally, Washoe versus Booee, and Washoe versus Lucy (see Table 5). Figure 5 shows the distribution of means between stimulus types for each chimpanzee. In this figure the interaction is apparent in that on the *y*-axis, Ally and Washoe's centroids are farthest from Lucy and Booee's centroids.

Table 5

Tukey Simultaneous Tests for Differences of Mean y Coordinates for Offset Figure Categories

Difference of Levels	Difference of Means	SE of Difference	T-Value	Adjusted P-Value
BOOEE-ALLY	-264.08	49.25	-5.36	<0.0001
LUCY-ALLY	-270.18	47.94	-5.64	<0.0001
WASHOE-ALLY	-46.89	49.25	-0.95	0.7771
LUCY-BOOEE	-6.11	49.25	-0.12	0.9993
WASHOE-BOOEE	217.18	50.53	4.3	0.0008
WASHOE-LUCY	223.29	49.25	4.53	0.0004

Individual confidence level = 98.93%

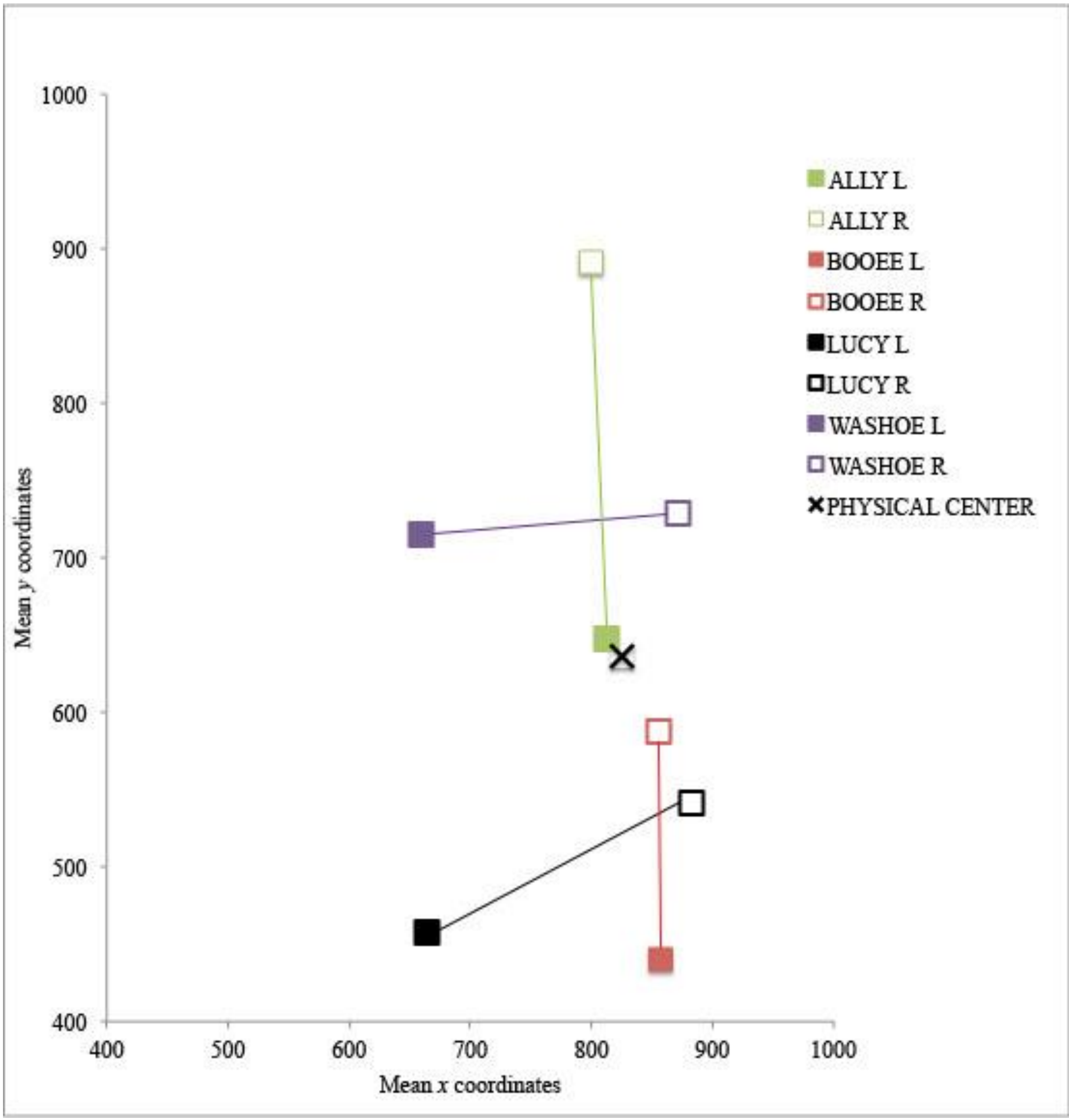

Figure 5. Scatter plot displaying offset figure mean *x* and *y c*oordinates per participant. Coordinates from right-sided figures are outlined squares and coordinates from left-sided figures are filled in. Lines connect each individual's right-sided and left-sided figure coordinates to illustrate interactions.

CHAPTER V

DISCUSSION

Mean *x* and *y* coordinates were significantly different between stimulus type for free choice and central figures, which showed that drawings were contingent on figures versus a blank page. For free choice drawings, Ally, Booee, Bruno, Thelma and Washoe's centroids were slightly above the physical center of the page while Cindy and Lucy's centroids were well above or slightly below the physical center (see Figure 4). For central figure stimuli, all centroids were located slightly above the physical center of the page, except Booee with a centroid below the physical center (see Figure 4). This shows that chimpanzees tend to mark in the center of the blank page, but the centroid changes with the addition of a central stimulus figure. Numerous other studies (Boysen et al., 1987; Morris, 1962; Schiller, 1951; Smith, 1973; Zeller, 2007) also showed patterns of central marking.

Figure 4 displayed individual differences in centroid placement. There were significant differences between Ally's versus Booee's pattern and Ally's versus Thelma's pattern (see Table 3). Figure 4 illustrated these differences by showing the distance between centroids per participant.

The centroids for left versus right-sided stimuli were located significantly different from each other. Centroids averaged below and to the left of the physical center of the page for left-sided figures and above and to the right of the physical center of the page for right-sided figures (see Figure 3). All offset centroids were located in areas absent of stimulus figures, which provided evidence for space filling and balance. Figure 6 shows examples of offset figure drawings. Results also supported previous findings of space filling/balance for offset stimulus

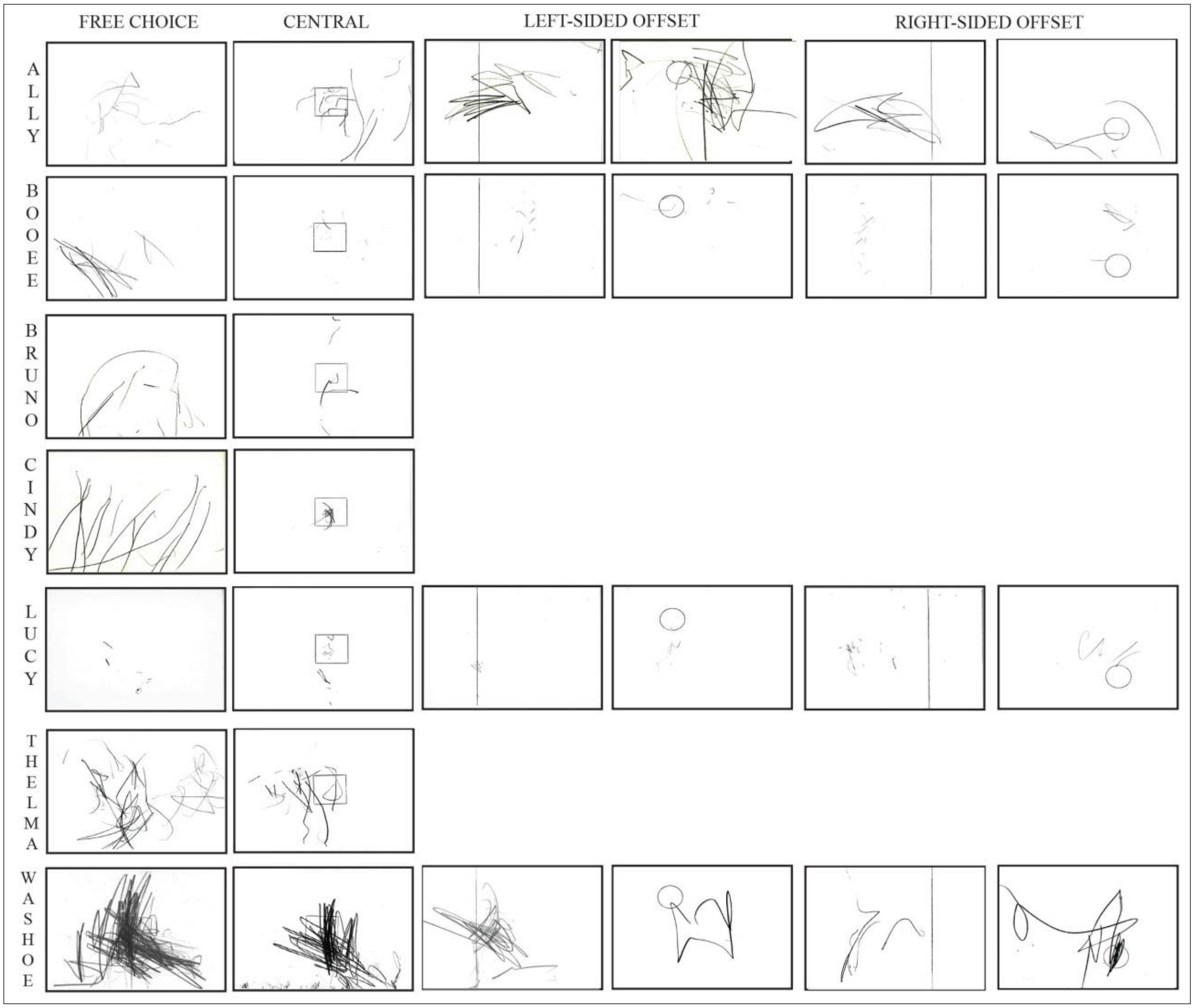

Figure 6. Selected drawing examples from all chimpanzees per category. Bruno, Cindy, and Thelma did not produce drawings for offset figure categories.

figures (Morris, 1962; Schiller, 1951; Smith, 1973). There were individual patterns in centroid placement with lines connecting left-sided versus right-sided centroid pairs per participant. There were significant differences between Ally's versus Lucy's pattern, Ally's versus Booee's pattern, Washoe's versus Lucy's pattern, and Washoe's versus Booee's pattern (see Table 4). Figure 5 illustrated these differences by showing the distance between centroids per participant.

All participants showed visible pattern shifts across stimulus figure categories and free choice drawings. Summary matrices from the researcher's tally mark analysis provided visual representations of overall mark frequency and distribution (see Figure 7). Free choice and central figure summary matrices showed cells in and around the physical center filled 75-100 percent for all participants. Offset summary matrices showed a visible shift in mark distribution. Ally, Booee, and Washoe distributed their marks across more cells than Lucy in both offset categories. Booee and Lucy's left-sided summary matrices showed a tendency to mark towards the upper left side of the page, while Ally and Washoe's offset summary matrices showed central distribution. Figure 6 shows examples of drawings per stimulus category.

This study was the first of its kind to analyze drawings from an archival database with modern image analysis technology. Digitizing and analyzing this collection of drawings added to the body of research showing central mark distribution and provided new data on how chimpanzees respond contingently to stimulus figures. The researcher first adapted Smith (1973) and Boysen et al.'s (1987) procedures to provide visual summaries of mark distribution per participant. The researcher then created a custom Python program that digitally analyzed the drawing, producing dependent variables to achieve powerful statistical analysis. This method allowed for extremely detailed results on the pixel level and will aid in future drawing studies.

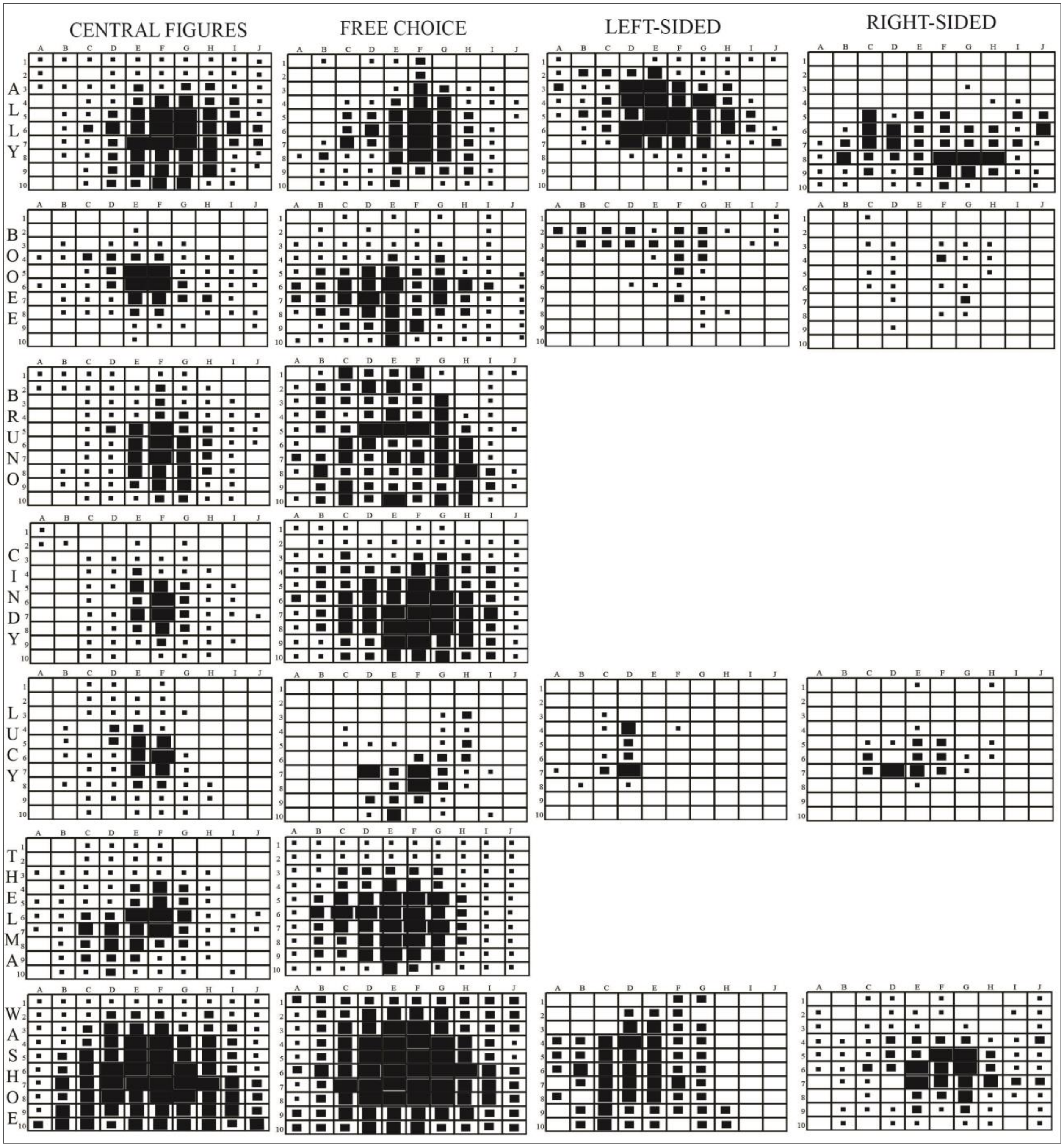

Figure 7. Summary matrices graphically depicted for proportion of same cells marked across each drawing category per chimpanzee. Bruno, Cindy, and Thelma did not produce drawings for offset figure categories. The relative size of the blackened area in each cell represents the proportion of the individual drawings in which the corresponding cell was marked (blank = 0% and completely filled = 100%).

The drawings were part of a data set created over 40 years ago. The original experimenters created 31 categories and issued categories 1-22 to four of the seven participants (Ally, Booee, Lucy, and Washoe). Categories 23-31 were issued to all seven participants, but these categories were all central stimulus figures of similar size and shape (see Figure 1). Drawings and the number of participants were low for all categories except central figures and free choice drawings. Future studies could collect drawings from more participants that reacted to stimulus figures of various size, shape, and location to provide additional evidence of mark placement patterns. Information on mark sequence could show the drawing process from beginning to end, providing information about when and how participants reacted to stimulus figures. It would be interesting to analyze how often participants' lines intersected stimulus figures or were placed inside the stimulus shape.

Convex hull is a mathematical term referring to the smallest bounded subset of points on a two-dimensional plane. Measuring convex hulls in chimpanzee drawings could provide additional quantitative information about mark distribution. As appears in Figure 8, the convex hull would show the boundaries of marks in each category per participant. A challenge with this analysis is the nuance of line weight and what analysis software constitutes as a registered mark.

The program built for this study inverted images and measured marked pixels only on a binary level. Some participants like Lucy and Booee barely touched the paper with the pencil, while others like Washoe pressed so hard that her pencil pierced through the paper. See Figure 6 for drawing examples. The Python program might have ignored very lightly drawn marks when inverting the drawings into black and white. Future studies could analyze drawings on an 8-bit gray scale instead of binary to ensure the analysis of all drawn marks.

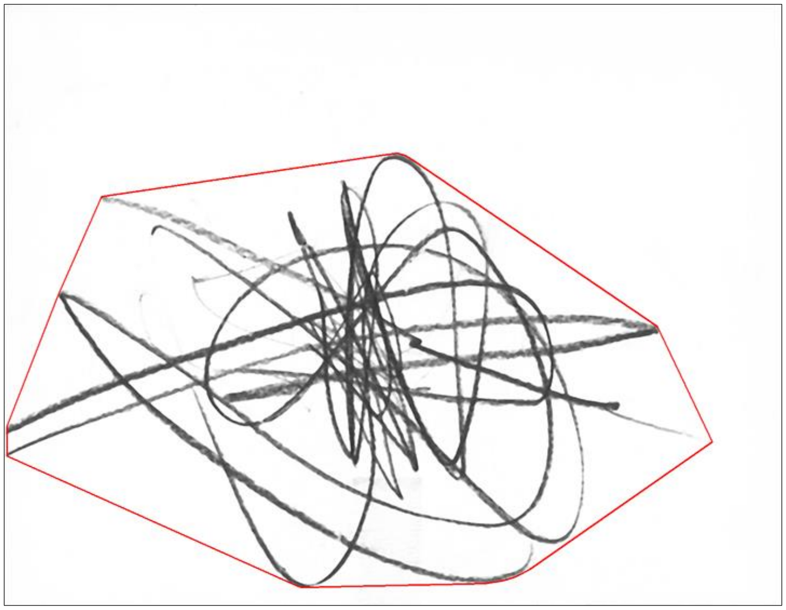

Figure 8. Convex hull example: Washoe, free choice

The main principle of Gestalt psychology is that the whole is other and/or different than the sum of its parts. Gestalten arises in young children during the scribble phase as an early visual discovery of motor play. Chimpanzees in drawing studies all participated in exploratory motor play while making marks for "mark's sake," suggesting an intrinsic motivation to draw. Human children begin making marks on paper as early as 12 months by first exhibiting the motor sensations of the drawing utensil on paper (Gardner, 1980, p. 10). Piaget (1948) describes this transition:

> Actually, the very first form of drawing does not seem imitative and has characteristics of pure play, but it is a play of exercise: this is the scribbling the child of two to two and a half engages in when he is given a pencil. Very soon, however, the subject thinks he recognizes forms in his aimless scribble, with the result that soon thereafter he tries to render a model from memory, however poor a likeness his graphic expression may be from an objective point of view. As soon as this intention exists, drawing becomes imitation and image. (p. 495)

Chimpanzees use drawing as exploratory motor play to express reactions to stimulus figures. Gestalt psychology claims, "organized units or structuralized configurations are the primary forms of biological reactions at least at the psychological level of [non-human] animal behavior, and that in the sensory field these organized units or gestalten correspond to configurations of the stimulating world" (Bender, 1938, p. 5). Chimpanzee drawings are structuralized configurations in reaction to the physical/emotional sensations of drawing and the stimulus figures on the page.

Researchers in West Africa recently observed chimpanzees habitually banging and throwing rocks against trees, or tossing them into tree cavities, resulting in "conspicuous stone accumulations" (Kuhl, Kalan, Arandjelovic, et al., 2016, p. 2). A possible explanation for this stone caching and throwing behavior is that the chimpanzees were "triggered by thoughts of awe, wonder" at magnificent natural features or events (King, 2016, p. 2). Meanwhile humans participate in aesthetic experiences when erecting Cairns or skipping rocks on water. Chimpanzees too may be creating an aesthetic experience by placing rocks in piles (Jensvold, 2016). Human artists practice personal aesthetics by choosing color, composition, balance, and subject matter. Chimpanzees in this study showed central marking and balance, which too may be a demonstration of aesthetic experience.

The findings in this study support previous conclusions that chimpanzee drawings are not random acts on paper, but are deliberate exploratory choices that vary across species and on an individual level (Boysen et al., 1987; Morris, 1962; Schiller, 1951; Smith, 1973; Zeller, 2007). Communicating intent behind the marks of a non-human species is fascinating to anthropologists, primatologists and art historians alike, for it provides further evidence for a continuity of species. Analyzing and interpreting these drawings enlighten us about the behavior of another species and possibly about the behavior of early humans, who began expressing themselves visually through symbols and figures tens of thousands of years ago (Bahn, 1998, p. xii).

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