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Gorilla Life-Stage Comparison of Head Orientation

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GORILLA LIFE-STAGE COMPARISON OF HEAD ORIENTATION

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by

Lisa Kay Wilding

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ABSTRACT

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Staring by primates, as well as other species of animals, can be perceived as a threat and averting that gaze can minimize potential conflict. Given that gorillas are highly sexually dimorphic, they may use this staring and gaze aversion strategy more than physical contact. Due to the shape of the eye and the pigmented sclera in some primates, eye gaze can be difficult to determine, whereas, head orientation may be a more salient cue. The current study documents developmental differences among age-sex classes of captive western lowland gorillas (*Gorilla gorilla gorilla*) in six head orientation categories (Head Toward Other, Head Toward Other Aversion, Continuous Head Orientation >= 2 secs, Continuous Head Orientation >= 3 secs, Mutual Head Toward Other, and Head Not Toward Other) toward conspecifics. Individuals were grouped into eight age-sex classes: infant females, infant males, juvenile females, juvenile males, subadult females, subadult males, adult females, and silverback males. In Head Toward Other, juvenile males oriented toward others significantly more than the expected frequency compared to other age-sex classes, whereas subadult females oriented toward others significantly less. In Continuous Head Orientation >= 2 secs, infant males and silverbacks oriented toward others significantly more than the expected frequency compared to other age-sex classes;

whereas juvenile males oriented toward others significantly less. In Continuous Head Orientation >= 3 secs, juvenile males oriented toward others significantly more than the expected frequency compared to other age-sex classes. These findings indicate that staring, as denoted by head orientation, is not inversely proportional to age, but tends to be related to sex and maturity of the individual. No significant differences between observed frequencies and expected frequencies of the population were detected in Head Toward Other Aversion, Mutual Head Toward Other, and Head Not Toward Other.

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CHAPTER I

INTRODUCTION

Gorillas, the largest living primate, are native to tropical and subtropical forests in Africa and are distributed in Equatorial Guinea, Gabon, parts of Angola, Nigeria, Cameroon, Central African Republic, Uganda, Rwanda, and the Democratic Republic of the Congo (Robbins, M. M., 2011). Experts of the International Union for Conservation of Nature (IUCN) list all gorilla subspecies (*Gorilla beringei graueri, Gorilla beringei beringei*, *Gorilla gorilla diehli*, and *Gorilla gorilla gorilla*) as Critically Endangered with populations declining (IUCN, 2017). There are 861 captive gorilla populations residing in European, American, African, and Asian institutions (International Studbook for the Western Lowland Gorilla, 2015).

Gorillas form cohesive, stable troops typically led by a dominant male, the silverback, named for the silver band of hair on the back that develops when the male matures (Robbins, M. M., 2011). Troops are most often comprised of one or more silverback males with several females and their immature offspring, but could also consist of several males in an all-male bachelor group. New social groups form when either females transfer to lone silverbacks or when immature males (known as blackbacks) emigrate. Average group size of western gorillas is 8-10 individuals (Robbins, M. M., 2011).

Gorillas have a long maturation, are dependent on mothers for nourishment and locomotion for 4 years (Breuer, Hockemba, Olejniczak, Parnell, & Stokes, 2009), and reach adulthood and sexual maturity at >10 years (Robbins, M. M., 2011). In wild and captive gorilla groups, mothers are very vigilant with infants at birth (Hoff, Nadler &

Maple, 1981) and under 6 months of age, infants are in constant contact with their mother; but time in contact and in proximity decreases as the infant ages (Hedeen, 1980; Maestripieri, Megna, & Ross, 2002; Maestripieri & Ross, 2004). Except for assistance in locomotion and taking away non-food items, mothers do not use direct instruction or scaffolding to teach the infant (Maestripieri et al., 2002; Schaller, 1963). Infants rely on the mother to learn feeding behaviors and how to collect food (Chance & Jolly, 1970). Reproductive success is nearly guaranteed for surviving infant females; whereas, not all males become the alpha male (Eckhart & Lanjouw, 2008). Mothers may prolong weaning in infant males to improve the infant's chances at becoming the alpha male with high reproductive success (Eckhart & Lanjouw, 2008).

The mother's vigilance relaxes toward the end of the infant's first year, and she allows the infant's social play with others (Hoff, Nadler, & Maple, 1981). After a year, infants begin to leave the close proximity of the mother and spend more time near the alpha male (Hoff et al., 1981; Maestripieri et al., 2002; Rosenbaum, Silk & Stoinski, 2011; Rosenbaum, Hirwa, Silk, Vigilant, & Stoinski, 2016). Unless intervention is required, mothers are generally uninvolved in their 2-4 year-old infant's activities and develop a more "hands off" rearing approach with less maternal control (Maestripieri et al., 2002). However, until offspring reach maturity, mothers serve as an important social partner. Older infants encourage mothers to follow or engage in play by a combination of eye gaze, gestures, and body postures (Maestripieri et al., 2002; Maestripieri & Ross, 2004). Despite the lesser involvement by the mother, 2-4 year-old infants will still observe their mothers during feeding (Maestripieri et al., 2002).

As the offspring mature, time near the alpha male will increase, as time near their mother decreases (Harcourt, 1979; Robbins, M. M., 2011; Rosenbaum et al., 2011); and juveniles, without the presence of their mother, will spend as much time near adult males as near other immatures (Rosenbaum et al., 2011). Female immatures spend more time grooming with the alpha male and male immatures spend more time playing with adult males (Rosenbaum, et al., 2011). Since the alpha male is likely the father to all immatures in the troop, watching over young offspring could ensure survival of his genes (Robbins, M. M., 2011) and discourage female transfer (Harcourt, 1979).

Due to emigration, most adult females within wild gorilla troops are unrelated and; female coalitions and alliances are few, with few affiliative relationships among females (Harcourt, 1979; Harcourt & Stewart, 2007; Robbins, M. M., 2011; Schaller, 1963; Scott & Lockard, 1999; Stokes, 2004; Watts, 2012; van der Dennen, 2013). Unlike males, dominance among adult females is weak (Eckhart & Lanjouw, 2008; Robbins, A. M., 2011) and based on the time they have spent in that particular troop or on their reproductive success, not on their age (Robbins, A. M., 2011; Rosenbaum et al., 2016; Scott & Lockard, 1999; Stewart & Harcourt, 1987; Stokes, 2004; van der Dennen, 2013).

Adult females do, however, form strong relationships with males for mating opportunities and protection for themselves and offspring (Harcourt & Stewart, 2007; Rosenbaum et al., 2016; van der Dennen, 2013) and initiate close proximity to the alpha male (Eckhart & Lanjouw, 2008; Harcourt, 1979). Females with dependent offspring spend more time near the silverback than do other females (Harcourt, 1979; Rosenbaum et al., 2016), as he provides protection against infanticide from outside males (Robbins, M. M., 2011). Among the most sexually dimorphic primates, adult male gorillas with longer body lengths and larger sagittal crests attract more female mates (Caillaud, Levrero, Gatti, Menard & Raymond, 2008). Over twice the female's size, the silverback completely dominates females (Eckhart & Lanjouw, 2008; Watts, 2012) and will intervene in female-female disputes (Harcourt & Stewart, 2007; Stokes, 2004). Although male-female interactions are usually affiliative, adult males direct a higher frequency of mild, agnostic behavior toward adult females (Stokes, 2004; Watts, 2012) in the form of "move away" cough-grunt vocalizations and displays, usually without contact (Harcourt & Stewart, 2007; Robbins, M. M., 2011), as a means of sexual coercion (Stoinski, Lukas, & Kuhar, 2013). To minimize future aggression toward them, females initiate reconciliation following an agnostic behavior by a male (Watts, 2012).

Comparable to female-female relationships, silverback-blackback male social relationships are weak due to competition for mates, so males coexist predominately through avoidance rather than affiliative relationships and do not spend time in close proximity (Eckhart & Lanjouw, 2008). Even though silverbacks unequivocally dominate them, subordinate males behave aggressively toward the alpha male (Eckhart & Lanjouw, 2008).

Gorillas communicate through gesturing, body orientation, vocalizations, and olfactory cues (Genty, Breuer, Hobaiter, & Byrne, 2009; Klailova & Lee, 2014; Schaller, 1963). Adult male gorillas use these communication cues to mediate disputes, control group members, and ward off impending threats to the group (Klailova & Lee, 2014; Robbins, M. M., 2011; Steward & Harcourt, 1987); however, unlike other apes, gorillas do not make physical contact in greetings (Yamagiwa, 1992).

Gorillas, like all primates, use eyes to receive information from the environment and convey information to others. Nonhuman primates typically respond to gaze with fight or flight response (Schaller, 1963; van Hooff, 1967). In gorillas, a direct stare may suggest a mild form of threat (Redican, 1975; De Veer & van den Bos, 1999); however, prolonged eye contact or a social stare between adults within the same troop occurs in a number of nonaggressive social contexts including eliciting play, greeting, and mitigating conspecific conflicts (Maestripieri et al., 2002; Maestripieri & Ross, 2004; Yamagiwa, 1992). A stare often leads to physical displacement of the recipient, and adult males commonly do the staring (Redican, 1975; Schaller, 1963). The direct stare is a component of a threat, and gaze aversion is a frequent response to this threat among nonhuman primates (Redican, 1975). Gaze aversion, the act of averting the eyes by turning the head and/or body away from another individual, is a strategy for avoiding potential conflict. Gaze aversion can indicate a submissive response to a threatening stare or can indicate that aggression is not forthcoming, serving to reduce potential conflict (Coss, Marks, & Ramakrishnan, 2002; Schaller, 1963; Weisfeld & Beresford, 1982).

Nonhuman primates use head and body orientation to detect another's gaze more often than eye orientation, as the dark sclera (area surrounding the iris of the eye) of most nonhuman primates is not easily observed (Coss, 1978; Coss et al., 2002; Genty, Breuer, Hobaiter, & Byrne, 2009; Kobayashi & Kohshima, 2001; Tomasello, Hare, Lehmann, & Call, 2007). Gorillas use gaze orientation as a communicative strategy (Gomez, 1996; Kano et al., 2012; Yamagiwa, 1992); however, research on the development of gaze orientation is limited. The proposed research investigates the developmental changes in captive western lowland gorilla head orientation toward conspecifics.

The literature review that follows includes contemporary literature regarding primate communication by eye and head orientation. Initial sections discuss primate staring, mutual gaze, and gaze aversion. The last section delineates the methods used to analyze gaze following, further emphasizing the importance of head orientation in receiving and conveying information in primates.

CHAPTER II

LITERATURE REVIEW

Primate Staring

Staring occurs when an individual prolongs a look toward another and scientists have traditionally associated it with aggressive interactions (Marler, 1968; Schaller, 1963). A prolonged gaze may be suggestive of self-confidence (Andrew, 1965; Libby & Yaklevich, 1973; Rosa & Mazur, 1979; Weisfeld & Beresford, 1982) or used as a strategy for a dominant individual to establish and maintain position in the group hierarchy without the need for physical contact (Marler, 1968; Rosa & Mazur, 1979; Schaller, 1963; Weisfeld & Beresford, 1982). A prolonged gaze or direct stare may be received as a threat from the viewpoint of the recipient (Marler, 1968; Redican, 1975; Riess, 1988; Schaller, 1963; Weisfeld & Beresford, 1982) or a possible prelude to an attack (Coss, 1968).

While staring is often aggressive, Yamagiwa (1992) studied it in affiliative contexts in a well-habituated all-male bachelor troop of Virunga mountain gorillas (*Gorilla beringei*). Yamagiwa recorded each individual's activity and distances between individuals for 10 secs in 10-min scans. He used ad libitum sampling to record interactions when individuals were within 2-5 m of one another. He coded social staring when one individual looked at another's face within a distance of 30 cm for 5 secs or longer without making physical contact. Social staring occurred during feeding, play, displacement, homosexual interactions, and pre- and post-conflict contexts in 202 episodes. Silverbacks rarely stared, but received more than half of the total staring episodes. In pre-conflict context, the youngest male stared most frequently and the oldest male received the most stares. Gorillas rarely used staring to initiate play, but solicited play more often by chest-beating, ground-thumping, pushing, slapping, or touching. Social staring occurred in homosexual encounters when the mounter or the mountee made no response to a conspecific in close proximity. It was successful in eliciting homosexual mounting compared with copulatory pants, another form of initiating homosexual courtship. Social staring occurred in younger males when supplanting older males and during high-tension periods; however, silverbacks never stared while intervening in disputes. When approaching each other, younger subordinate males stared significantly more at older, dominant males than vice versa and this staring occasionally elicited gaze aversion from the dominant male. The youngest male stared the most and the oldest male received the most stares.

Primate Mutual Gaze

For most primate species, females invest heavily in pre- and post-natal parental care of offspring. Primates rely on vision to gain information regarding their environment, from both a predator and prey standpoint, to locate food, and as a means of communication with others. As young primates develop, they use gaze for these same reasons. Curtin, Hauber, and Moller (2011) researched mutual gaze and its relationship to age and dominance between six female Japanese monkeys (*Macaca fuscata*). Experimenters used focal animal instantaneous sampling methods recording 15-s intervals within a 10.5-min session for 10 sessions per monkey. They recorded distance between monkeys as near, when they could potentially touch, and far, when they were unable to touch. They recorded mutual gaze when both the focal and partner monkey oriented their faces toward the other. The frequency of mutual gaze increased as age decreased. Furthermore, the number of sessions of mutual gaze increased with a decrease in age. The frequency of mutual gaze increased significantly when the monkeys were near than when they were far. There was no correlation between dominance rank and frequency of mutual gaze.

Bard, Myowa-Yamakoshi, Tomonaga, Tanaka, Costall, and Matsuzawa (2005) examined mutual gaze in eight captive chimpanzee (*Pan troglodytes*) mother-infant dyads, during the infants' first 3 months of life. Experimenters videotaped chimpanzee dyads and coded videotapes for maternal and mutual gaze and simultaneous cradling and interactive contexts as they occurred during natural interactions. Cradling was any maternal behavior that provided physical support of the infant. Interactive context was any non-cradling context, mutually exclusive of cradling. Maternal gaze was when the mother looked at the infant's body or face. Mutual gaze was when the mother looked at the infant's face and the infant looked at the mother's face. Maternal and mutual gaze were independent of cradling and interactive contexts. Mutual gaze occurred in three infant age classes. Moreover, mutual gaze appeared as a function of the actions of the mother during the times when she looked at her infant's face. At 3 months of age, with reduced physical contact, mother-infant mutual gaze significantly increased, whereas when in constant physical contact, such as cradling, mothers and infants exhibited significantly less mutual gaze. The authors stated that eye gaze in chimpanzees was difficult to observe due to the dark sclera in the eye of chimpanzees and the small-sized infant, but three different coders achieved good-to-excellent inter-rater reliability agreement. While Curtin et al. (2011) found that mutual gaze increased when monkeys were near, Bard et al.'s (2005) findings indicate that when physical contact occurred, mutual gaze decreased in chimpanzees.

Tomonaga, Tanaka, Matsuzawa, Myowa-Yamakoshi, Kosugi, Mizuno, Okamoto, Yamaguchi, and Bard (2004) researched the developmental changes in the mutual gaze in three captive chimpanzee (*Pan troglodytes*) mothers-infant dyads. Experimenters videotaped chimpanzee dyads in this observational study. Researchers coded mutual gaze when both the mother and infant looked at each other's face. Mutual gaze increased as the infant aged from 0-2 months. This increase corresponded to a decrease in physical contact between mother and infant, supporting the findings of Bard et al. (2005).

Myowa-Yamakoshi, Tomonaga, Tanaka, and Matsuzawa (2003) tested the gaze sensitivity of three infant chimpanzees (*Pan troglodytes*) (one male and two females) once every few weeks between 10 and 32 weeks of age. Experimenters videotaped trials in which infant chimpanzees viewed photographs of humans. Faces in photographs were of frontal and angled orientation combined with open, closed, direct, or averted eye gaze. Two of the conditions revealed a frontal view with all features scrambled. They paired 12 human photographs into 6 conditions. At 0.33-s intervals, coders determined which photograph the infants looked at and the duration of the look. Infants looked significantly longer at the frontal face with the eyes open than at the frontal face with the eyes closed. In addition, infants looked longer at direct gazes than at averted gazes, irrespective of face angle. Although the male infant spent significantly more total time looking at the frontal orientation with direct and averted eye gaze condition as he aged, age had little effect overall on the infants' perception of gaze.

Tomonaga and Imura (2010) tested an adult female chimpanzee's (*Pan troglodytes*) ability to detect a direct gaze among averted gazes in photographs of humans. Experimenters presented the chimpanzee with a CRT touch screen displaying human photographs and gave the chimpanzee the task of selecting the odd picture, the target, out of an array of photographs. Half of the trials used the direct gaze photograph as a target, which was surrounded by averted gaze photographs. The other half of the trials used the averted gaze photograph for the target, surrounded by direct gaze photographs. The chimpanzee touched the CRT screen indicating a selection and an attached computer calculated timings of responses. The chimpanzee showed faster response times for selecting the direct gaze target than the averted gaze target. Other tests involved altering brightness contrast of the eye and sclera, manipulating the location of the iris, and manipulating face views in the photographs. When experimenters darkened the sclera, the chimpanzee selected direct gaze target photographs more than averted gaze target photographs. When experimenters placed irises at the center of the eye region, the chimpanzee chose direct or averted gazes significantly more often than other types of face, regardless of gaze orientation.

Gomez (1990) studied communication development in one female gorilla (*Gorilla gorilla*) from 6-22 months of age in her interactions with humans. Experimenters recorded goal-direct behaviors, communicative actions, and looks. Goal-direct behaviors were the persistence of behaviors toward the goal, the selection of alternative behaviors, and the cessation of behaviors when obtaining the goal. A look was a visual behavior directed at the researcher's eyes before, during, or after a communicative action. The gorilla looked alternatively between the goal and the human's eyes in goal-direct behaviors, whereas she looked only at the human's eyes in communicative actions.

In 1996, Gomez analyzed eye gaze observational data from the same female gorilla at the age of 12 months and then again at 20 months. Researchers spent 3 hours per day, 7 days per week with her for the first 4 months and 5 days per week after that, making handwritten notes of her behavior. He defined gaze as collecting information distally from the environment and orienting oneself to the source of that information. At 12 months of age, the gorilla touched the human recipient first, before making eye contact, in a request to be carried. At 20 months of age, she waited for a mutual gaze first and then touched the human recipient.

Kaplan and Rogers (2002) researched eye gaze and eye morphology in 38 free-ranging, rehabilitated, wild Bornean orangutans (*Pongo pygmaeus*) (1.5-28 years old) living at a rehabilitation center and 13 captive orangutans (5-35 years old). They classified infants as less than or equal to 4 years of age, juveniles between 4 and 8 years old, and adults greater than 8 years old. Using videotape, they compared duration of gaze between dyads of mother-to-infant, juvenile-to-juvenile, juvenile-to-infant, juvenile-to-adult, and adult-to-adult. A gaze sequence began with the initiation of gaze towards a conspecific and ended when the gaze averted. They classified direction of gaze into two categories, including exposed sclera in two directions of gaze: direct (iris in the center of the eye) and sideways (iris to the side of the eye), determining frequency and duration. Juveniles looked at infants significantly longer than mothers looked at infants. Almost all juveniles gazed directly at the face of other juveniles in short duration and at high frequency.

Kaplan and Rogers (2002) conducted a second study using the same participants and videotapes. Experimenters selected only frames in which orangutans were within 3 m with their faces oriented toward the camera, allowing a clear view of the eyes. They further selected only images that showed orangutan eyes fully open and either one of two directions of gaze: direct (iris in the center of the eye) and sideways (iris to the side of the eye). Orangutans faced the camera more using sideways gazing.

Maestripieri et al. (2002) observed interactions in 11 mother-infant gorilla (*Gorilla gorilla*) dyads (infants between 2-42 months old). Experimenters recorded ad libitum during focal observation sessions of communication and social interaction. Variables of interest included any attempts by the infant to encourage the mother to follow, move to another location, or obtain food. Infants encouraged their mothers to follow them with eye gaze, alternating gaze from the mother to another location while walking, or tactile interactions, including pulling their mother's arm or hand.

In a similar study, Maestripieri and Ross (2004) investigated maternal influences, such as encouragement and discouragement, in the development of six captive western lowland gorilla (*Gorilla gorilla*) infants from birth to 5 years of age. Experimenters observed infants 1 hr every week for 22 months and recorded the infant's proximity to the mother at 60-s intervals. Experimenters coded maternal influences in locomotion, food sharing, object manipulation, and communication and social interaction. Food sharing maternal influences included any attempts by the mother at directing the infant’s attention to food with eye gaze, facial expressions, vocalizations, tactile interactions, offering of food, helping to process the food, or not letting the infant obtain food from her. Time in contact with mother and maternal influences generally decreased with infant age. Infants initiated food sharing significantly more than mothers did. Infants more frequently solicited food from their mothers when they observed and repeated their mother's food manipulation.

Research in primate mutual gaze showed a significant negative correlation between mutual gaze and age (Bard et al., 2005; Curtin et al., 2011; Gomez, 1990, 1996; Libby & Yaklevich, 1973; Maestripieri et al., 2002, Maestripieri & Ross, 2004; Tomonaga et al., 2004; Yamagiwa, 1992). However, proximity to the mother also had a significant affect, as young chimpanzee infants who were cradled and in close body contact with their mother showed less mutual gaze than infants who were in less physical contact (Bard et al., 2005; Tomonaga et al., 2004). In other words, at birth and while mothers cradled infants, mutual gaze occurrences were low, then spiked as the infant spent less time in contact with the mother. After this initial increase, mutual gaze and maternal influences gradually decreased as gorillas aged (Maestripieri & Ross, 2004). Hierarchy or dominance status did not have an effect on mutual gaze, at least with monkeys (Curtin et al., 2011). Duration of gaze increased when the recipient was facing the partner with a direct gaze versus an averted gaze in young chimpanzees (Myowa-Yamakoshi et al., 2003; Tomonaga & Imura, 2010; Tomonaga et al., 2004); however, the opposite was true when the orangutans were older (Kaplan & Rogers, 2002).

Primate Gaze Aversion

Libby and Yaklevich (1973) researched eye contact and gaze aversion in 70 human participants who had completed the Edwards Personality Preference Schedule. This test measured abasement, the need to accept blame for problems and confess errors to others, and nurturance, the need to be of assistance to others. Experimenters interviewed participants using 54 questions. There were six neutral questions at the onset followed by 24 alternating embarrassing and non-embarrassing questions. Experimenters asked the participant to maintain eye contact with the interviewer. Concealed researchers recorded if the participant maintained eye contact with the interviewer throughout, broke eye contact before the interviewer finished speaking, looked up or down after the interviewer finished speaking, and looked right or left after the interviewer finished speaking. Those that scored high in abasement (indicative of low self-esteem) looked significantly more to the left than individuals with low abasement scores, who looked equally to the left and right. Those that scored high in nurturing made significantly more eye contact than individuals rated with low nurturance.

In an attempt to understand gaze aversion in nonhuman primates, Coss (1978) studied 28 captive mouse lemurs (*Microcebus murinus*) in their peak activity period. During 30-s trials, experimenters placed the lemur in a dimly-lit box apparatus. Displayed inside of the box were 0-4 concentric black spots within two separate circles. One circle contained two black spots displayed horizontally within the circle. The other circle contained one of four models: blank circle, one black spot in the center of the circle, three black spots in a triangular arrangement within the circle, or four black spots in a square arrangement within the circle. Experimenters recorded head orientation to either visual model. Glances that require large movements accompanied turning of the head toward the source; therefore, head orientation provided a relatively accurate measurement of the direction of gaze. They measured frequency and duration of each gaze behavior as indicated by head orientation. Two horizontal concentric spots, more representative of a fixed stare, elicited less visual inspection than the other models.

A second experiment examined mouse lemur responses to the spatial position of two spots within three models (Coss, 1978). Participants consisted of 50 captive mouse lemurs. Experimenters recorded behaviors in varying degrees of activity periods (peak, natural torpor, and artificially induced torpor). Frightened mouse lemurs are more likely to freeze during trials, so experimenters separated lemurs into two distinct groups. Lemurs with slightly rotated or completely flattened ears, indicative of fear in mouse lemurs, were in a fear-motivated group and those with erect or un-rotated semi-erect ears were in a calm group. Experimenters exposed lemurs to the same box apparatus as the first experiment. Displayed inside of the box were two concentric black spots within two separate circles. One circle contained two black spots displayed horizontally within the circle. The other circle contained one of two models: two black spots positioned vertically within the circle or two black spots positioned in a 45-degree diagonal plane within the circle. Two horizontal concentric black spots, more representative of a fixed stare, elicited significantly fewer bouts of visual inspection by the calmer mouse lemur group than the other models.

Observational studies of conspecific interactions also can reveal patterns in gaze aversion. Coss et al. (2002) researched wild bonnet macaque (*Macaca radiata*) gaze aversion in two urban troops (88 individuals) and seven forest troops (212 individuals), including juveniles, subadults, and adult males. Only males were included in the analysis due to the easily-detected male dominance hierarchy. Researchers videotaped macaques for 3 min at feeding stations. Resolution of video image limited analysis to the change in a macaque's head orientation only when the individual looked up from feeding to face another individual. Researchers coded gaze aversion and latency during a gaze event. A gaze event occurred when an individual oriented the head toward another individual. Gaze aversion occurred when the head and/or body turned away from a conspecific following eye contact. They measured latency to gaze avert after establishing eye contact with conspecifics. Latency to gaze avert was the time between the start of directing the head toward another to the start of directing the head away from the other. In the forest troops, latency to gaze avert decreased in older monkeys, meaning glances became quicker over time. Juveniles exhibited a significantly longer latency to gaze avert than adult and subadult males. There was no significant difference in latency to gaze avert between subadults and adults.

Shillito, Gallup, and Beck (1999) state that gaze aversion may be a contributing factor for gorillas, as a whole, to fail the behaviors indicative of mirror self-recognition (MSR), namely the mark test, which consists of inconspicuously applying a mark to the body that is only visible through a mirror. Shillito et al. (1999) angled the mirrors to by-pass gaze aversion issues, but still gorillas failed to pass the MSR. Posada and Colell (2007) found that an adult male gorilla, given time to be comfortable with the mirror, showed no aversion and passed the MSR. Conversely, Povinelli (1994) argues that gorillas failing the MSR are not failing due to aversion to make eye contact with their image. Povinelli (1994) hypothesizes that since chimpanzees, bonobos, humans, and orangutans, who share a more distant ancestor have all been successful at passing the MSR, that gorillas have undergone a secondary loss of an ancestral trait preventing them from self-recognition.

There has been very little research conducted on primate gaze aversion, as eye direction is difficult to detect in some nonhuman primates. Although turning of the head is a submissive behavior in gorillas (Schaller, 1963), few studies have been conducted researching gaze aversion behavior in gorillas, outside of the mirror self-recognition tests. Within the limited nonhuman primate studies that have been done, there is a definite developmental pattern of gaze aversion in macaques (Coss et al., 2002) as occurs in mutual gaze. Juveniles engage in more mutual gaze and longer delays in gaze aversion than do subadults and adults.

Head and Eye Cues

Direction of gaze may be particularly important in guiding interactions with others. Although the eyes receive information from the surrounding environment, conspecifics, and other species, a question is whether nonhuman primates use eyes to convey information to others. Hasselmo, Rolls, Baylis, and Nalwa (1989) examined neuron activity within the superior temporal sulcus (STS) region of the brain, involved in the perception of where others are gazing, in three alert rhesus macaque monkeys (*Macaca mulatta*). Monkeys with permanently implanted microelectrodes sat in a restraint chair. In trials, an experimenter facing a monkey performed a set of dorsal and ventral head movements and eye/eyelid/eyebrow movements. Researchers converted neuron activity of the monkeys' STS into digital pulses and recorded them on a computer. STS neurons responded to closing the eyelid and lowering of the eyebrows in the human. The cells were not responsive to the human's eyes or the direction of gaze, but fired strongly when the back of the human's head moved forward.

Primates convey social information through the face and eyes. Kano, Call, and Tomonaga (2012) studied facial scanning of five gorillas, 10 orangutans, and 12 humans exposed to colored whole body and facial pictures of conspecifics and allospecific individuals (half of the pictures were familiar to the participant). Gaze movement of the participant was noninvasively recorded using a table-mounted infrared eye-tracker camera. All participants showed similar scanning paths and viewed the eye area predominantly, regardless of the type of picture. No significant differences in facial scanning were detected between gorillas and orangutans; however, humans viewed whole-body faces and eyeballs of facial pictures longer than gorillas and orangutans.

Humans exhibit a large, white sclera surrounding the iris colored part of the eye, as well as a wider eye opening; whereas, nonhuman primates typically express a darker pigmented sclera surrounding the eye (Kobayashi & Kohshima, 2001). Kobayashi & Kohshima (2001) deduced the drastic contrast in the white sclera to the iris of the eye makes eye gaze orientation of humans easier to determine than the eye gaze orientation of nonhuman primates. Expanding on Kobayashi and Kohshima's (2001) research, Mayhew and Gomez (2015) measured gorilla eye openings, the amount of sclera exposed, and noted the varying degrees of depigmentation of the sclera. Mayhew and Gomez (2015) findings differ in that gorillas do have depigmentation of the sclera occurring and the amount of sclera exposed is comparable to human eyes; however, gorillas have a less horizontally elongated eye compared to a human eye. The smaller elongated eye, not the lack of sclera depigmentation, is what makes eye gaze orientation more difficult to determine (Mayhew & Gomez, 2015). With uncertainty of detecting eye gaze orientation in nonhuman primates, researchers frequently associate gaze with head orientation (Anderson, Sallaberry, & Barbier, 1995; Bania & Stromberg, 2013; Brauer, Call, & Tomasello, 2005; Burkart & Heschl, 2007; Genty et al., 2009; Ruiz, Gomez, Roeder, & Byrne, 2009; Wilson, Wilkinson, Lin, & Castillo, 2000). With nonhuman primate eye morphology making eye gaze more difficult to discern, head orientation may be a more accurate cue.

Direct staring, mutual gaze, and gaze aversion studies have received relatively little attention in comparison to gaze following research. Gaze following is typically associated with looking in the same direction as the partner. Methodologies used to investigate gaze following support the premise that nonhuman primates use head orientation as an indirect means for determining eye gaze. Genty et al. (2009) states that eye gaze in gorillas cannot be precisely determined, but notes that gaze generally follows head orientation. Emery (2000) asserts that when the eyes are not visible, nonhuman primates extrapolate cues from head or body orientation of conspecifics. Researchers use head orientation as cues and assess gaze orientation from participants' head orientation responses (Anderson et al., 1995; Bania & Stromberg, 2013; Brauer et al., 2005; Burkart & Heschl, 2007; Ruiz et al., 2009; Wilson et al., 2000).

Only a few studies of primates involve gaze following of conspecifics in a naturalistic setting (Bethell, Vick, & Bard, 2007; Genty et al., 2009). Most gaze following experiments involve a human experimenter providing cues in trials (Anderson et al., 1995; Brauer et al., 2005; Burkart & Heschl, 2006, 2007; Flombaum & Santos, 2005; Okamoto, Tomonaga, Ishii, Kawai, Tanaka, & Matsuzawa, 2002; Peignot & Anderson, 1999; Povinelli & Eddy, 1996; Rolls, 2000; Tomasello et al., 2007; Vick & Anderson, 2000, 2003; Wilson et al., 2000). Fagot and Deruelle (2002) used a cartoon-type drawing as a cue. Lorincz, Baker, and Perrett (2000) used a drawing of a conspecific, whereas Ruiz et al. (2009) used a photograph of a conspecific.

Brauer et al. (2005) compared gaze following skills in 6 orangutans (*Pongo pygmaeus*), 6 gorillas (*Gorilla gorilla*), 4 bonobos (*Pan paniscus*), and 11 chimpanzees (*Pan troglodytes*) of various ages. At the start of each 10-s trial, the experimenter offered the ape 1-4 pieces of food. Then the experimenter held a food item in front of the ape during two human-cued conditions: the experimenter raised her head and looked at the ceiling above the ape or the experimenter kept her head and eyes oriented toward the ape (the control condition). Experimenters coded gaze following when the ape's eyes or head moved in the same direction as the experimenters. They defined double looks as looking up, looking at the experimenter, and looking up again. Apes looked up significantly more in the look-at-ceiling condition compared to the look-at-participant condition. Age had a significant effect on look-at-ceiling performance and double looks, with adults more likely to look up and produce more double looks than infants.

Ferrari, Kohler, Fogassi, and Gallese (2000) assessed the capacity to use eye cues only in gaze following in two adult southern pig-tailed macaques (*Macaca nemestrina*). Macaques sat in a restraint chair with heads restrained during three human-cued conditions: head-and-eyes, eyes-only, and a control. In the head-and-eyes condition, the experimenter turned his head together with eyes 70 degrees up, down, left, or right. In the eyes-only condition, the experimenter oriented the eyes up, down, left, or right. The control condition was a box that rotated on horizontal and vertical axes. For each stimulus, experimenters administered 12 trials during a 20-min videotaped session. Gaze following responses were the monkey's movement of eyes only in the direction of where the experimenter was oriented. Direction of macaque eye movements was coded as up, down, left, or right. Results show significantly more gaze following responses in the head-and-eyes and eyes-only conditions compared to the control condition.

A second experiment tested 11 juvenile and adult macaques individually in an enclosure with the experimenter seated in front of them (Ferrari et al., 2000). They used the same conditions with an additional condition of the experimenter turning their upper torso. Gaze following responses in this experiment consisted of the amount of time the monkey's body was oriented toward the experimenter and the time spent looking at the experimenter. Adult monkeys showed a significantly higher percentage of gaze following responses with head-and-eyes and eyes-only cues than torso turn or control conditions. Juveniles showed significantly more gaze following with head-and-eyes cues than with the control condition. In addition, adult gaze following responses were significantly higher during head-and-eyes and eyes-only cues than were juveniles.

Okamoto et al. (2002) researched the ability of an infant chimpanzee (*Pan troglodytes*), 6-17 months of age, to follow experimenter-given cues. In videotaped trials, there was a tray with a pair of objects, the target and the non-target. Experimenters gave one of four types of cues toward toy targets: tap, point, head turn, or glance. A tap cue was tapping on the target object with a finger. The point cue was pointing to the target object with a finger. A control condition for the tap and point cue was a passive face with hands forming fists between the two objects. The head turn cue was gazing at the target with head oriented toward it. A control condition for the head turn condition was a passive face while jiggling the head from side to side. The glance cue was glancing at the target object without head orientation. A control condition for the glance condition was a passive face gazing at the center and blinking repeatedly. Chimpanzee responses were looking at the target, looking at the experimenter's face, looking on the opposite side of the target, or looking at something other than the target, the experimenter's face, or the opposite side of the target. Experimenters coded looking at the target as a follow response and all other looking as a no-follow response. The chimpanzee gave significantly more follow responses in the glance condition compared to the glance control condition between 11-13 months of age.

When the chimpanzee was 17 months of age, experimenters conducted a second study (Okamoto et al., 2002). They used four conditions: the point and head turn conditions as in the first study, the incongruent point, and incongruent head turn. The incongruent point cue was pointing to the target object with a finger that originates from the non-target object. The incongruent head turn cue was orienting head and eyes toward the target object from the side of the non-target object. Chimpanzee responses were coded the same as in the first experiment. The chimpanzee showed highly accurate performance on all conditions averaged across sessions: 100% for the point and incongruent point, 96.9% for the head turn, and 83.3% for the incongruent head turn.

Peignot and Anderson (1999) researched the ability of five parent-reared captive western lowland gorillas (*Gorilla gorilla*) to use human manual and facial cues in an object-choice task. Experimenters placed three black plastic containers in front of a gorilla with a handheld cardboard screen between the container and gorilla. Experimenters placed a peanut under one of the containers, removed the screen, and demonstrated one of nine experimenter cues. Cues included pointing at container with index finger, tapping on container with index finger, head and eyes oriented toward container, eyes only oriented toward the hidden food object, and various combinations of these cues. A choice was determined when the gorilla picked up a stick and oriented it through the bars in the direction of the object they chose. If gorillas made the correct choice, they received a peanut. If gorillas made an incorrect choice, experimenters revealed the empty contents. Gorillas chose the object with the peanut most often with tapping and pointing cues. Performance remained good on eye and head orientation, however, performance dropped with only eye orientation. Moreover, none of the gorillas used the eye-only cue to discover the hidden food and instead agitatedly left the experimental area sometimes throwing objects in the direction of the experimenter.

Povinelli and Eddy (1996) investigated chimpanzee (*Pan troglodytes*) gaze following responses to head and eye movement and eye movement alone. Experimenters videotaped seven captive chimpanzees in eight sessions of 10 trials. After chimpanzees received a food reward, the experimenter looked at the chimpanzee's eyes. After making eye contact, the experimenter cued either by moving his or her head and eyes to look at a predetermined location above and behind the chimpanzee either to the left or right or by just looking with the eyes at the same predetermined location without movement of the head. The control condition was not executing any cue. Chimpanzee responses included turning their head more than 90 degrees from center to look either up, behind, or directly above themselves. Chimpanzees turned their heads significantly more often with head-and-eyes and eyes-only cues than during the control.

Tomasello et al. (2007) researched the effect of human head and eye movements on redirecting gaze in primates. Participants were 11 chimpanzees (*Pan troglodytes*) (4-27 years old), four gorillas (*Gorilla gorilla*) (5-25 years old), four bonobos (*Pan paniscus*) (6-20 years old), and 20 human infants (12 and 18 months old). An experimenter sat opposite participants using six conditions of cues toward the ceiling: head-only, eyes-only, head-and-eyes, neither-head-or-eyes, back-of-head, and back control. The head-only cue was closing the eyes and orienting the head toward the ceiling. The eyes-only cue was keeping the head stationary and glancing at the ceiling. The head-and-eyes cue was looking to the ceiling with head and eyes. The neither-head-or-eyes cue was staring straight ahead at the participant. The back-of-head cue was sitting with his back to the participant and looking up to the ceiling. The back control condition was sitting with their back to the participant and staring straight ahead. Researchers videotaped participants during the trials. They scored a trial as a non-trial if the participant did not acknowledge the cue. Non-trials were not included in analysis. Gaze following responses occurred whenever a participant looked to the ceiling either by orienting his head or eyes upward so that the underside of the chin was visible on videotape. Researchers coded any other direction of gaze as not gaze following. All participants looked to the ceiling when both the experimenter's head and eyes cued toward the ceiling. Tomasello et al. found that nonhuman primates followed the experimenter's head direction (viewed from the front or the back) even if the experimenter's eyes were closed and more likely to follow open eyes to the ceiling if the head oriented upward also, showing that head cues were clearly an important factor. Conversely, eye cues influenced human infants more than head cues. Unfortunately, the non-trial data was not included and test rooms were obviously different between the apes and human children. In fact, the human infants sat on their parent's lap, so parents could have inadvertently cued infants.

Vick and Anderson (2000) researched eye gaze in three captive capuchin monkeys (*Cebus apella*). The experimenters presented a tray with two opaque brown containers, one containing food and the other empty, in front of the monkey. The experimenter used the following cue conditions toward the baited container: tap, point, head-and-eyes, eyes-only, and glance. The tap cue was the experimenter tapping on the top of the baited container with her or his index finger and the experimenter's head and eyes oriented toward the container. The point cue was the experimenter looking with her or his head and eyes toward the baited container and pointing to it. The head-and-eyes cue was experimenter's head and eyes were oriented toward the baited container. The eyes-only cue was only the experimenter's eyes were oriented toward the baited container. The glance cue was the experimenter making three to-and-fro eye movements between the baited container and a central point between the two containers with her or his head facing straight ahead. Experimenters recorded a response when a monkey physically contacted a container. All monkeys chose baited containers significantly above chance in the tap, point, and head-and-eyes cues. Two of the monkeys chose baited containers significantly above chance in the eyes-only cue.

In an attempt to separate head and eye cues, researchers conducted a second experiment with the same two monkeys (Vick & Anderson, 2000). Using the same test procedure as the first study, they used the following cue conditions: head-only, head-and-eyes, eyes-only, and head-versus-eyes. The head-only cue was the experimenter's head was oriented toward the baited container, but her or his eyes were closed. The head-and-eyes cue was the experimenter's head and eyes were oriented toward the baited container. The eyes-only cue was the experimenter's head was facing forward and only her or his eyes were oriented toward the baited container. The head-versus-eyes cue was the experimenter's head was oriented toward one container, while her or his eyes were fixated on the other container, and both containers contained food. Experimenters recorded a response when a monkey physically contacted a container. Both monkeys chose baited containers significantly above chance in head orientation cues over eye cues. In fact, with the eyes-only condition, the performance of the monkeys was not significantly above chance. In all other conditions that contained head orientation, performance was significantly above chance.

Bethell et al. (2007) researched chimpanzee eye gaze as it relates to head movement in ten captive chimpanzees (*Pan troglodytes*). Researchers videotaped chimpanzees while they were feeding, resting, and grooming and coded for three movements at 1-s intervals: congruent, incongruent, and out-of-view. Congruent movements were head movements and eye movements orientating in the same direction. Incongruent movements were whenever the eyes moved, but the head did not move or when head movement occurred with no eye movement. Out-of-view was when either the eyes or head were obscured from view. Researchers further categorized congruent and incongruent behaviors into glance, scan, and fixation. A glance was a horizontal or vertical shift of the eyes to break a gaze for less than a second and then returning to gaze again. Scans were vertical or horizontal movements of the eyes that occurred continuously when the chimpanzee did not fixate on any particular target for more than 1 sec. Fixations were instances when the eyes did not move from a target for at least 1 sec. Glances were highly incongruent (70-100%) and fixations and scans occurred independently of head movement.

In a related study, Tsutsumi, Ushitani, Tomonaga and Fujita (2012) researched the role of eyes and the concept of animacy, a characteristic of life, in 22 captive Japanese macaque (*Macaca fuscata*) infants, including ten one-month-olds and 12 three-month-olds. These parent-reared macaques had been exposed to living creatures such as insects, conspecifics, and wild birds. Researchers presented three objects to these infants on a conveyor-type belt while the belt was moving and when it was still: a stone, a stone with eyes facing perpendicular to the macaque, and a stone with fur. Caretakers wrapped the macaque in a blanket and held them in their lap during six trials each 5 secs in duration. Researchers videotaped trials and the coder and caretaker holding the infant were blind to the stimuli. They coded macaque responses as a look or not-look. A look occurred when the macaque's eyes directed to the object. One-month-olds did not differentiate among the six conditions (3 morphological x 2 motion). Three-month-olds looked longer when the object was in motion then when it was still. Interestingly, the stone and stone-with-eyes received less visual attention than the stone-with-fur.

Nonhuman primates attend to paired head and eye orientation in most research testing of gaze following behaviors (Brauer et al., 2005; Burkart & Heschl, 2006, 2007; Call & Tomasello, 2008; Flombaum & Santos, 2005; Lorincz et al., 2000; Peignot & Anderson, 1999; Povinelli & Eddy, 1996; Ruiz et al., 2009), as well as head orientation alone (Genty et al., 2009; Okamoto et al., 2002; Rolls, 2000; Tomasello et al., 2007; Vick & Anderson, 2000, 2003; Wilson et al., 2000). However, not all researchers found head and/or eye cues used exclusively by nonhuman primates. Capuchin monkeys required cues of pointing, head rotation, and eyes combined to display gaze following behaviors

(Anderson et al., 1995), and monkeys responded to some eye movements independently of head movements (Bethell et al., 2007).

From the current research, gaze orientation shows definite changes between and within age classes in orangutans (Kaplan & Rogers, 2002), chimpanzees (Bard et al., 2005; Myowa-Yamakoshi et al., 2003; Tomonaga et al., 2004), gorillas (Maestripieri et al., 2002; Maestripieri & Ross, 2004; Yamagiwa, 1992), and macaques (Coss et al., 2002; Ferrari et al., 2000). Past the cradling stage, chimpanzee infant mutual gaze increases (Bard et al., 2005; Tomonaga et al., 2004) and forest-dwelling macaque juveniles' latency to gaze avert is significantly longer than adult and subadult males (Coss et al., 2002).

This literature review exposes gaze orientation commonalities and trends that exist between these primates. However, social structure, the nature of the competitive and cooperative relationships between individuals within groups, differs greatly in orangutans, chimpanzees, macaques, and gorillas. Using avoidance and tolerance as relationship strategies, gorillas may respond more acutely in refined studies of gaze orientation, such as the ontogeny of head orientation, which has not yet been evaluated.

The hypothesis in this study is that captive western lowland gorillas (*Gorilla gorilla gorilla*) within eight age-sex classes (infant females, infant males, juvenile females, juvenile males, subadult females, subadult males, adult females, and silverback males) will differ in direct head orientation duration toward a conspecific. A Chi-Square (X^2) goodness-of-fit test compared observed HTO proportions from focal age-sex classes against expected HTO proportions in the population. In this design, focal age-sex class had eight groups (see Table 2) and head orientation had six categories: *Head Toward Other, Head Toward Other Aversion, Continuous Head Toward Other > = 2 secs,* *Continuous Head Toward Other > = 3 secs, Mutual Head Toward Other,* and *Head Not Toward Other* (see Table 4). The categories are not mutually exclusive, meaning that any given gorilla could be included in one or more categories in a single instance.

CHAPTER III

METHODS

Participants

There were 41 western lowland gorillas videotaped between 2009 and 2010. The gorillas, reared by wild or captive gorilla parents or by humans, resided in zoos. LKW categorized gorillas into age-sex classes according to the western lowland gorilla classification of Breuer, Hockemba, Olejniczak, Parnell, and Stokes (2009): infants (birth to 4 years old: 3 males, 2 females), juveniles (4-7.5 years old: 2 males, 1 female), subadult females (7.5-10 years old: 2), subadult males (7.5-11 years old: 3), adult females (>10 years old: 22), and old silverbacks (>18 years old: 6). Sex was not pooled as western lowland gorillas older than four years have distinct behaviors and should be categorized separately (Hutchinson & Fletcher, 2010). The James R. Davis Studbook provided additional biographical data on each gorilla participant including stud number, name, date and place of birth, sex, rearing, parents, siblings, and offspring (Gorilla Haven Org., 2010) (see Table 1).

Procedure

Participating zoos and videotaping. LKW videotaped from 2009 to 2010 at six zoos in the United States that housed western lowland gorillas. Participating zoos and the year data collection occurred appears in Table 3. On the first day of data collection, zoo personnel provided access to the zoo, identified gorillas and their unique morphological and/or behavioral characteristics, and suggested locations for placement of equipment.

The videotape used was from a previous study by LKW and focused on interactions between gorillas or a gorilla who appeared to gesture. Infants and juveniles were typically more gregarious than older conspecifics within the group, so there was an emphasis to videotape them.

Continuous videotaping occurred, with the exception of changing batteries and saving data from Secure Digital (SD) non-volatile memory cards, from early morning until zookeepers brought the gorillas off exhibit and/or the zoo closed for the day. Recordings occurred a minimum of three days at each zoo.

Equipment. LKW used a SANYO VPC-HD1 video recorder (SANYO North America Corporation, San Diego, CA) powered by small SANYO DB-L40 rechargeable batteries to record video. Ten battery packs were generally required in an 8-hour period of videotaping. A Tv-SHQ video quality setting provided the highest quality videotape while still maximizing the memory usage. A sturdy tripod with a joystick provided more stable videotaping, even though this video recorder had image stabilization features. This camcorder was limited to 2 GB SD memory cards, such that transferring data after the SD reached capacity required storing accumulated data onto a laptop periodically throughout each day of videotaping. After successful transfer of the data, SDs were formatted in the camcorder and recording resumed.

ELAN software. ELAN (EUDICO Linguistic Annotator) software allows for complex annotation encoding to accompany individual video frames of video recordings. Annotations are textual in nature and can describe features observed in the media. LKW and JPW coded video files and made detailed annotations requiring the use of ELAN to identify times when two or more gorillas were within the same frame (see Phase 1 below) and when gorillas were "in range" of each other within each frame (see Phase 2 below).

Gorilla identification. Zoo personnel spent time with LKW pointing out physical features of each gorilla within their zoo for identification purposes. LKW spent a minimum of three days at each zoo and was familiar with all gorillas and their names (see Table 1). Each gorilla was assigned to an age class, depending on their age at the time of recording. See Table 2 for definitions of age classes. The biographical information, gorilla group members, and individual physical attributes of the gorilla participants from each zoo were available to coders and discussed before inter-rater reliability testing started.

A random number of screenshots of all gorilla participants from all video data were used as test criteria for gorilla identification at each zoo. Each screenshot contained enough physical depiction to correctly identify each gorilla. Inter-rater reliability analysis with LKW and JPW was achieved at a high level of agreement in identifying gorillas by name (CMZ = 100%, SFZ = 100%, SDZ = 92%, WAP = 100%, RGZ = 93%, WPZ = 100%). Since each gorilla had an assigned age class, identification by name also established the age class (see Table 1).

Table 1

Gorilla Age Class and Sex Composition

Gorilla Stud #	Age (Year-Month)		Name	Zoo	Rearing	Age Class and Sex
			INFANT (birth-4 years)			
8120	1	0	Hasani	SFZ	human	IM
1933	2	7	Uzumma	WPZ	gorilla	IF
1908	2	9	Tumani	CMZ	gorilla	IF
1871	3	9	Bouendje	SDZ	gorilla	IM
1870	3	9	Ekuba	SDZ	gorilla	IM
			JUVENILE (4-7.5 years)			
1824	5	6	Hasani	RGZ	gorilla	JM
1822	6	10	Tulivu	RGZ	human	JF
1720	7	5	Mandaazi	SDZ	gorilla	JM
			SUBADULT FEMALE (7.5-10 years)			
1699	7	9	Calaya	WPZ	gorilla	SF
1578	9	7	Naku	WPZ	gorilla	SF
			SUBADULT MALE (7.5-11 years)			
1686	8	9	Mashudu	RGZ	gorilla	SM
1577	9	2	Ajari	WAP	gorilla	SM
1681	9	4	Pierre Pont (Jack)	RGZ	gorilla	SM
			ADULT FEMALE (> 10 years)			
1650	10	1	Jamani	WAP	human	AF
1501	11	2	N'Neka	SFZ	gorilla	AF
1502	11	11	Monifa	SFZ	gorilla	AF
1423	13	9	N'Djole	SDZ	gorilla	AF
1408	14	3	Hope	RGZ	unknown	AF
1261	16	11	Kwisha	CMZ	gorilla	AF
1262	17	1	Asha	CMZ	human	AF
1113	20	5	Tusa	RGZ	human	AF
0889	25	26	Jumoke	WPZ	gorilla	AF
0775	28	3	Zura	SFZ	human	AF
0788	28	3	Matadi	RGZ	gorilla	AF
0742	29	2	Jessica	SDZ	gorilla	AF
0733	29	5	Bawang	SFZ	human	AF
0745	29	29	Juju	CMZ	human	AF

Table 1 (Continued)

Gorilla Age Class and Sex Composition

Gorilla Stud #	Age (Year-Month)		Name	Zoo	Rearing	Age Class and Sex
			ADULT FEMALE (> 10 years) continued			
0692	30	9	Alberta	WAP	human	AF
0661	32	27	Kamilah	WAP	gorilla	AF
0624	33	2	Roxie	CMZ	gorilla	AF
0474	37	1	Huerfanita	RGZ	human	AF
0473	37	4	Lina	RGZ	human	AF
0549	40	5	Amanda	WPZ	wild	AF
0223	44	6	Alvila	SDZ	human	AF
0080	52	0	Vila	WAP	wild	AF
			OLD SILVERBACK (> 18 years)			
0900	24	7	Marcus	RGZ	human	SB
0848	25	8	Rafiki	CMZ	gorilla	SB
0770	28	4	OJ	SFZ	human	SB
0687	31	4	Vip	WPZ	gorilla	SB
0439	38	0	Winston	WAP	wild	SB
0442	40	11	Memba	SDZ	wild	SB

Note. Gorilla participants showing identification stud number, age, name, zoo (see Table 3 for zoo abbreviations), rearing, and age class and sex. Rearing classifications include "wild" indicating the gorilla was wild born and reared in the wild, "gorilla" indicating rearing occurred in captivity by conspecifics, and "human" indicating the gorilla was hand-raised by humans. Age class and sex abbreviations are: IM = infant male; IF = infant female; JM = juvenile male; JF = juvenile female; SM = subadult male; SF = subadult female; AF = adult female; BB = adult blackback male; and SB = old silverback male.

Table 2

Gorilla Age-Sex Class Definitions

Age-Sex Class	*Definition*	*Abbr.*
Infant Females	Birth-4 yrs old	IF
Infant Males	Birth-4 yrs old	IM
Juvenile Females	4-7.5 yrs old	JF
Juvenile Males	4-7.5 yrs old	JM
Subadult Females	7.5-10 yrs old	SF
Subadult Males	7.5-11 yrs old	SM
Adult Females	> 10 yrs old	AF
Old Silverbacks	> 18 yrs old	SB

Table 3

Participating Zoo Information

Zoo	Location	Zoo ID	Year
Cheyenne Mountain Zoo	Colorado Springs, CO	CMZ	2009
San Francisco Zoo	San Francisco, CA	SFZ	2009
San Diego Zoo	San Diego, CA	SDZ	2009
Wild Animal Park (currently San Diego Zoo Safari Park)	Escondido, CA	WAP	2009-2010
Rio Grande Zoo	Albuquerque, NM	RGZ	2010
Woodland Park Zoo	Seattle, WA	WPZ	2010

Note. Participating zoos, location, zoo identification abbreviation, and the year videotaping occurred.

Analysis

The first two hours of video data at each zoo was analyzed for a total of 12 hours of data. The two-hour segments were coded in three phases of selection. Each subsequent phase narrowed the number of video frames for final analysis. For instance, the input for Phase 1 was the entire two hours of video at each zoo. The output of Phase

1, which was the input for Phase 2, was the frames consisting only of two or more gorillas. The output for Phase 2, which was the input for Phase 3, was the frames where two or more gorillas were "in range" of each other (see Phase 2 below). LKW and JPW coded all phases in 1-sec intervals.

Phase 1. Phase 1 identified the video frames in 1-sec intervals that contained two or more gorillas. There were specific instructions for the coders to clarify ambiguous areas in the video, for example, when a gorilla was partially or fully obscured behind an enclosure obstacle (e.g., a tree or boulder) or another gorilla, and how to record the start and stop times using ELAN software (see Appendix A). The first 20% of the two hours collected at each zoo was double-coded by a second coder. Inter-rater reliability analysis was achieved in Phase 1 (89%).

Phase 2. Neck rotation in gorillas is limited to 90-degree movement from the midline of the body toward both the left and right shoulders (180-degree rotational arc total). Phase 2 identified when two or more gorillas were "in range" of each other. The definition of "in range" was when two or more gorillas were each within this 180-degree rotational arc, capable of turning their heads toward each other given their body position. Therefore, for example, if one gorilla was oriented toward another's backside they were not "in range." Not only did gorillas need to be "in range" of each other, but also enough of the focal needed to be visible from the camera's perspective to make a determination on head orientation. See Appendix A for guidelines on determining when gorillas were "in range" and how coders recorded the start and stop times for this selection phase using ELAN software. The first 20% of the 2 hours analyzed at each zoo was independently coded by a second coder. Inter-rater reliability analysis was achieved in Phase 2 (93%).

Phase 3. Phase 3 coded the camera angle in relation to each focal, the spatial relationship between gorillas, and the head orientation between gorillas as appeared from the camera's perspective. Each frame represented a snapshot in time. In Phase 3, experimenters replicated this snapshot onto a flat table, with each focal represented by a properly positioned circle divided into sixths. These circles determined orientations between focals and to the camera. It is important to note that the circle placements needed to reflect the proportional distance between the focal and the camera and between focals. Experimenters used an Excel spreadsheet to record the coding of head orientation frequency in 1-sec interval frames for this phase. Appendix A (Phase 3, Page 95) contains detailed coding, instructions, and a sample spreadsheet to code this phase.

When coding data on an individual gorilla within a frame, that gorilla's identity was coded and was designated as "focal." Any other gorilla's identity, "in range" of the focal, was coded and designated as "target." In each frame, there was one designated focal and one or multiple targets. Each gorilla was coded as a focal once and depending on the number of gorillas within a frame, could be coded as a target more than once. For instance, if three gorillas (Gorilla 1, Gorilla 2, and Gorilla 3) were "in range" of each other within a frame, the coder would code that frame three times, each using a different focal gorilla. The first time, Gorilla 1 would be the coded as the focal and Gorilla 2 and Gorilla 3 would be coded individually as targets in relation to the focal. The second time, Gorilla 2 would be the coded as the focal and Gorilla 1 and Gorilla 3 would be coded individually as targets in relation to the focal. Finally, the third time, Gorilla 3 would be coded as the focal and Gorilla 1 and Gorilla 2 would be coded individually as targets in relation to the focal.

With each gorilla individually coded, experimenters made no determination during the coding of this phase about whether gorillas were orientating their heads toward another. By using software formulas later, a determination of head orientation was made. The first 20% of the two hours analyzed at each zoo was independently coded by a second coder. Inter-rater reliability analysis was achieved in Phase 2 (92%).

Phase 4. Finally, in Phase 4, Excel algorithms analyzed the coder input from Phase 3 (see Appendix B) to determine head orientation. When coder input from Phase 3 was entered into the Excel spreadsheets, the algorithms calculated the results. The Excel algorithms determined a categorical code for each frame for each focal. The categories were *Head Toward Other, Head Toward Other Aversion, Continuous Head Toward Other > = 2 secs, Continuous Head Toward Other > = 3 secs, Mutual Head Toward Other,* and *Head Not Toward Other* (see Table 4 below for definitions of each category).

In each *Mutual Head Toward Other* instance, only unique combinations of identified gorillas engaged in MHTO were included to avoid duplicate entries. For instance, if Gorilla 1 and Gorilla 2 were engaged in MHTO, the only instance analyzed would be when Gorilla 1 was the focal and Gorilla 2 was the target, but not vice versa, i.e., when Gorilla 2 was the focal and Gorilla 1 was the target, this interaction was not scored (see Appendix B).

EXCEL software. An Excel spreadsheet contained the coding from all phases. Algorithms in the spreadsheet analyzed the codes and determined head orientation between age classes, including and excluding sex. See Appendix A (Phase 3) for detailed coding instructions and sample input. See Appendix B for Excel variables, definitions, algorithms, and sample output. LKW wrote all algorithms.

Statistics

The prediction was that captive western lowland gorillas (*Gorilla gorilla gorilla*) within eight age-sex classes (infant females, infant males, juvenile females, juvenile males, subadult females, subadult males, adult females, and silverback males) will differ in direct head orientation duration toward a conspecific. A Chi-Square (X^2) goodness-of-fit test compared observed HTO proportions from focal age-sex classes against expected HTO proportions in the population. Proportion formulas used the average observed HTO per individual for each age-sex class with expected frequencies controlled for unequal observation times across age-sex classes, resulting in expected proportions of non-whole numbers. In this design, focal age-sex class had eight groups (see Table 2) and head orientation had six categories: *Head Toward Other, Head Toward Other Aversion, Continuous Head Toward Other > = 2 secs, Continuous Head Toward Other > = 3 secs, Mutual Head Toward Other,* and *Head Not Toward Other* (see Table 4). The categories are not mutually exclusive, meaning that any given gorilla could be included in one or more categories in a single instance.

Table 4

Head Orientation Categories Defined

Head Orientation	Definition
Head Toward Other (HTO)	The number of 1-sec interval frames (not necessarily consecutive) an identified gorilla orients his or her head toward another identified gorilla
Head Toward Other Aversion (HTOA)	The number of 1-sec interval frames an identified gorilla engaged in HTO for a short duration (data was analyzed for one 1-sec interval frame)
Continuous Head Toward Other (CHTO)	The number of 1-sec interval consecutive frames an identified gorilla engages in HTO (data was analyzed for > = two 1-sec interval consecutive frames and > = three 1-sec interval consecutive frames)
Mutual Head Toward Other (MHTO)	The number of 1-sec interval frames (not necessarily consecutive) two identified gorillas engage in HTO with each other
Head Not Toward Other (HNTO)	The number of 1-sec interval frames (not necessarily consecutive) an identified gorilla did not engage in HTO with another identified gorilla

CHAPTER IV

RESULTS

Table 5 presents the expected and observed frequencies of head orientation in 1-sec interval frames in eight age-sex classes in six head orientation categories. Overall, juvenile males engaged in HTO and CHTO > = 3 secs significantly more than the expected frequency and significantly less in CHTO > = 2 secs than the expected frequency at $p < .0001$. Subadult females engaged in HTO significantly less than the expected frequency at $p < .0001$. Infant males and silverbacks engaged in CHTO > = 2 secs significantly more than the expected frequency at $p < .0001$.

Figures 1, 2, and 3 show the results of Table 5 as a bar chart for each head orientation category where significance was found (HTO, CHTO > = 2 secs, and CHTO > = 3 secs), respectively.

Table 5

Age-Sex Class: Head Orientation Focal Expected and Observed Frequency of 1-sec Interval Frames

		HTO	HTOA	CHTO>=2	CHTO>=3	MHTO	HNTO
IF	Exp	20.9	4.3	11.7	13.2	3.3	59.6
	Obs	25.5	5.5	14.5	12.5	6.0	51.5
IM	Exp	237.1	48.8	132.0	149.4	37.3	675.8
	Obs	235.7	54.7	***178.7	140.7	33.3	645.0
JF	Exp	7.0	1.4	3.9	4.4	1.1	19.9
	Obs	5.0	3.0	2.0	0.0	2.0	15.0
JM	Exp	132.5	27.3	73.8	83.5	20.1	377.7
	Obs	***190.5	34.0	***6.5	***123.5	31.5	361.5
SF	Exp	20.9	4.3	11.7	13.2	3.3	59.6
	Obs	***6.5	4.5	2.0	0.0	1.5	56.5
SM	Exp	83.7	17.2	46.6	52.7	13.2	238.5
	Obs	66.3	10.7	52.3	45.7	8.7	271.7
AF	Exp	69.7	14.4	38.8	43.9	11.0	198.8
	Obs	59.0	13.9	44.6	37.9	8.9	208.8
SB	Exp	125.5	25.8	69.9	79.1	19.7	357.8
	Obs	108.8	17.3	***87.7	79.0	17.7	377.7

Note. Each table entry represents the expected and observed frequency in secs of each focal age-sex class for each of the six head orientation categories. ***Indicates differences that are significant at $p < .0001$.

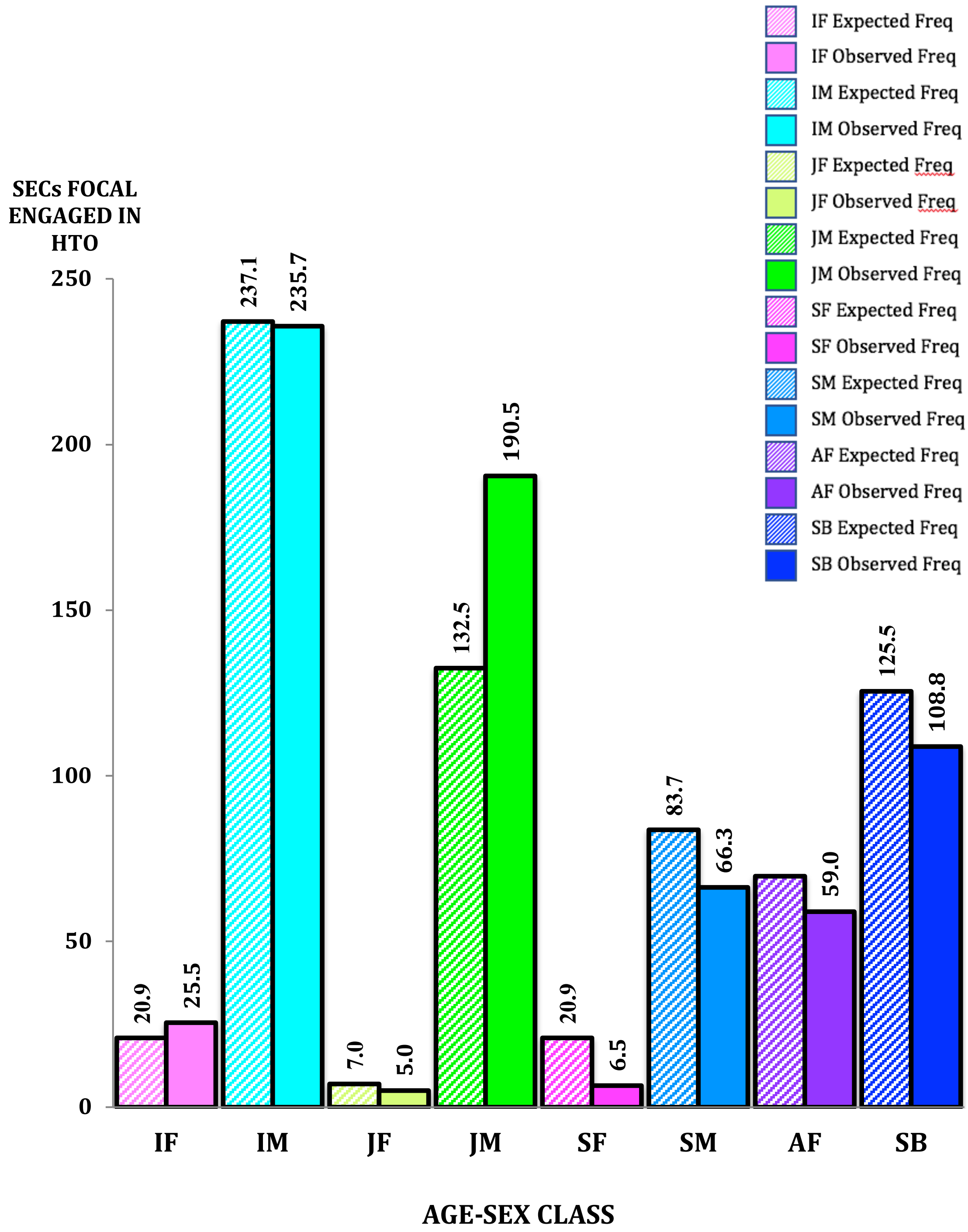

Figure 1. Age-Sex Class: Expected and Observed HTO Focal Frequency in 1-sec Interval Frames. A Chi-Square (X^2) goodness-of-fit test showed focal head orientation (HTO) in eight age-sex classes was not equally distributed in the population, X^2 (7, N = 697.28) = 44.39, $p < .0001$. Results suggest that focal age-sex classes are significantly different and JMs engaged in HTO more than the expected frequency compared to other age-sex classes. Conversely, SFs engaged less than the expected frequency in HTO compared to other age-sex classes.

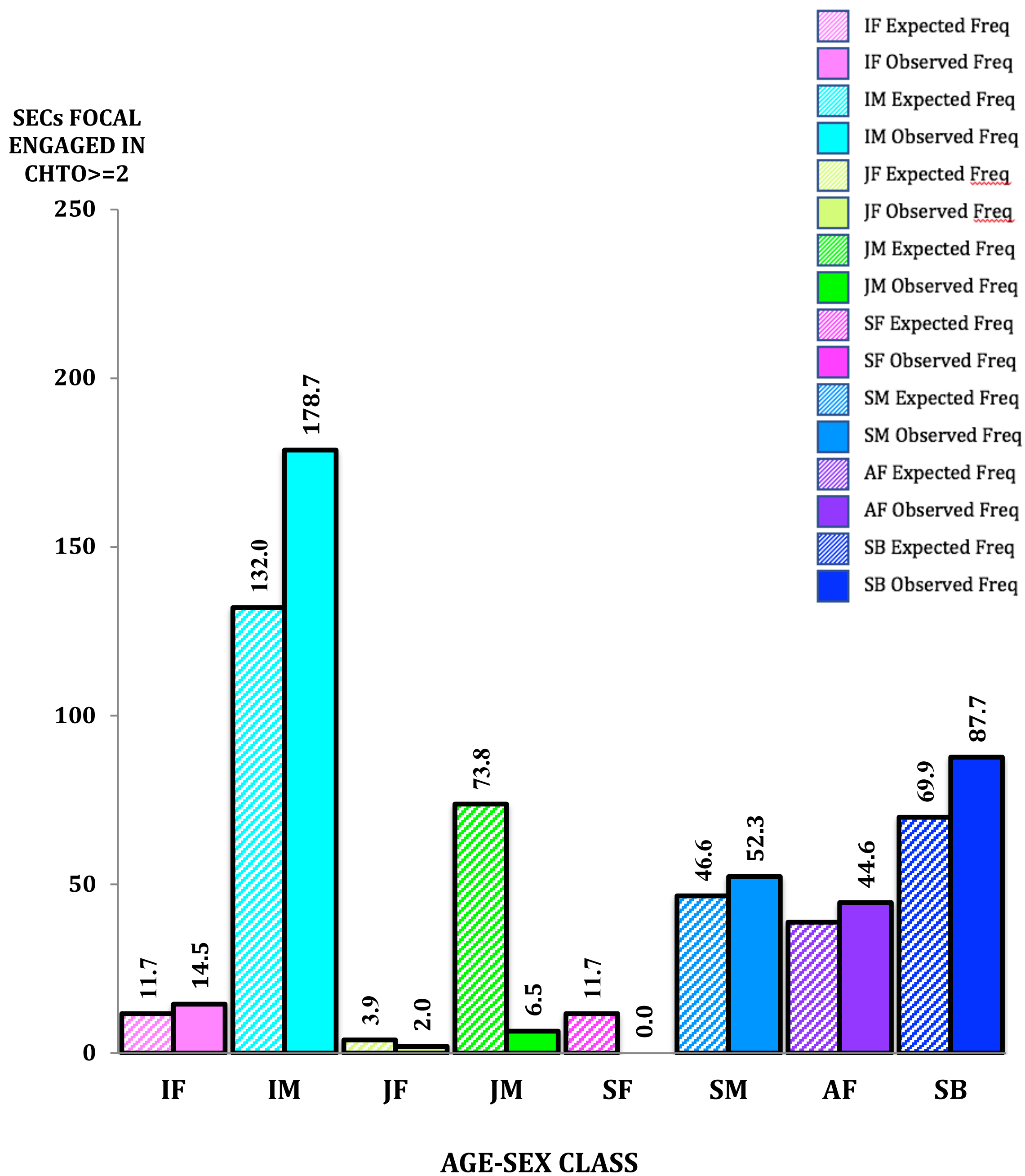

Figure 2. Age-Sex Class: Expected and Observed CHTO >= 2 secs Focal Frequency in 1-sec Interval Frames. A Chi-Square (X^2) goodness-of-fit test showed focal head orientation (CHTO >= 2 secs) in eight age-sex classes was not equally distributed in the population, X^2 (7, N = 388.31) = 93.53, $p < .0001$. Results suggest that focal age-sex classes are significantly different and IMs and SBs engaged in CHTO >= 2 secs more than the expected frequency compared to other age-sex classes. Conversely, JMs engaged less than the expected frequency in CHTO >= 2 secs compared to other age-sex classes.

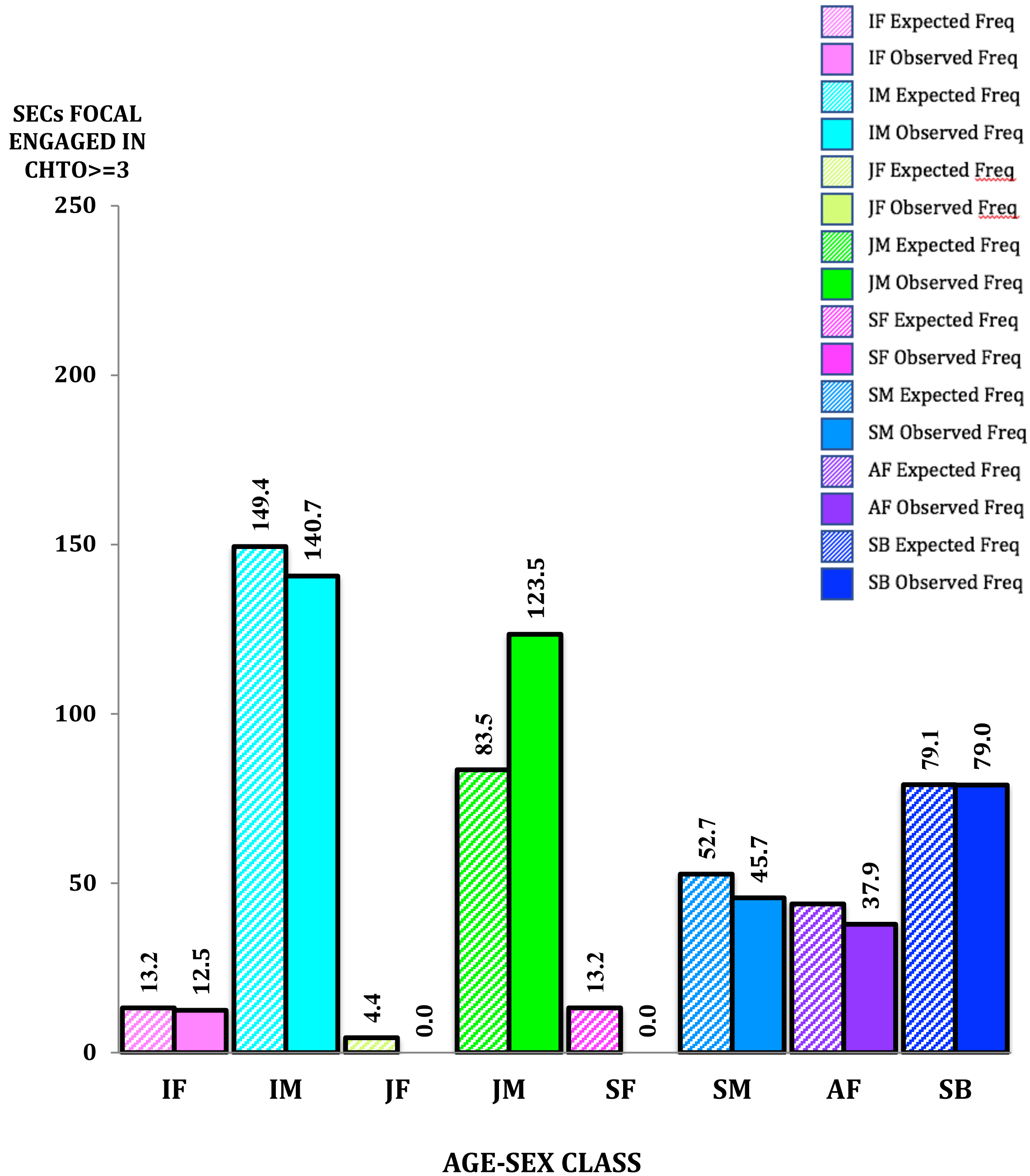

Figure 3. Age-Sex Class: Expected and Observed CHTO >= 3 secs Focal Frequency in 1-sec Interval Frames. A Chi-Square (X^2) goodness-of-fit test showed focal head orientation (CHTO >= 3 secs) in eight age-sex classes was not equally distributed in the population, X^2 (7, N = 439.25) = 39.08, $p < .0001$. Results suggest that focal age-sex classes are significantly different and JMs engaged in CHTO >= 3 secs more than the expected frequency compared to other age-sex classes.

Head toward other. Table 5 (Column 1) shows the expected and observed frequencies of time in secs each focal age-sex class spent in HTO and Figure 1 graphs the expected and observed frequencies. A Chi-Square (X^2) goodness-of-fit test showed focal head orientation (HTO) in eight age-sex classes was not equally distributed in the population, X^2 (7, N = 697.28) = 44.39, $p < .0001$. Results suggest that focal age-sex classes are significantly different and JMs engaged in HTO more than the expected frequency compared to other age-sex classes. JMs spent the largest percentage of time oriented toward AFs. Conversely, SFs engaged less than the expected frequency in HTO compared to other age-sex classes.

Head toward other aversion. Table 5 (Column 2) shows the expected and observed frequencies of time in secs each focal age-sex class spent in HTOA. A Chi-Square (X^2) goodness-of-fit test showed the data was consistent in focal head orientation aversion (HTOA) in eight age-sex classes and was equally distributed in the population, X^2 (7, N = 143.53) = 9.72, $p = .205$. Results suggest that within the HTOA category, the null hypothesis cannot be rejected.

Continuous head toward other > = 2 secs. Table 5 (Column 3) shows the expected and observed frequencies of time in secs each focal age-sex class spent in CHTO > = 2 secs and Figure 4 graphs the expected and observed frequencies. A Chi-Square (X^2) goodness-of-fit test showed focal continuous head orientation (CHTO > = 2 secs) in eight age-sex classes was not equally distributed in the population, X^2 (7, N = 388.31) = 93.53, $p < .0001$. Results suggest that focal age-sex classes are significantly different and IM and SB engaged in CHTO > = 2 secs more than the expected frequency compared to other age-sex classes. IM and SB spent the largest percentage of time oriented toward AFs. Conversely, JMs engaged less than the expected frequency in CHTO > = 2 secs compared to other age-sex classes did.

Continuous head toward other > = 3 secs. Table 5 (Column 4) shows the expected and observed frequencies of time in secs each focal age-sex class spent in CHTO > = 3 secs and Figure 6 graphs the expected and observed frequencies. A Chi-Square (X^2) goodness-of-fit test showed focal continuous head orientation (CHTO > = 3 secs) in eight age-sex classes was not equally distributed in the population, X^2 (6, N = 439.25) = 39.08, $p < .0001$. Results suggest that focal age-sex classes are significantly different and JMs engaged in CHTO > = 3 secs more than the expected frequency compared to other age-sex classes. JMs spent the largest percentage of time oriented toward AFs.

Mutual head toward other. Table 5 (Column 5) shows the expected and observed frequencies of time in secs each focal age-sex class spent in MHTO. A Chi-Square (X^2) goodness-of-fit test showed the data was consistent in mutual head orientation (MHTO) in eight age-sex classes and was equally distributed in the population, X^2 (7, N = 109.58) = 11.97, $p = .1015$. Results suggest that within the MHTO category, the null hypothesis cannot be rejected.

Head not toward other. Table 5 (Column 6) shows the expected and observed frequencies of time in secs each focal age-sex class spent in HNTO. A Chi-Square (X^2) goodness-of-fit test showed the data was consistent in head not toward other (HNTO) in eight age-sex classes and was equally distributed in the population, X^2 (7, N = 1987.66) = 10.79, $p = .148$. Results suggest that within the HNTO category, the null hypothesis cannot be rejected.

CHAPTER V

DISCUSSION

Researchers have studied gaze aversion in other primates (Kaplan & Rogers, 2002; Myowa-Yamakoshi et al, 2003; Tomonaga et al., 2004; Tomonaga & Imura, 2010) and this trait occurs in gorillas (Peignot & Anderson, 1999; Yamagiwa, 1992), so one might expect that all age classes would be homogeneous in their head orientation responses. However, this data revealed a heterogeneous head orientation response in which certain age-sex classes have different responses. Using a set of specific rules and algorithms during coding of videotaped gorilla data, this study yielded an unbiased interpretation of head orientation with precision. Results of this study demonstrate three important findings in direct head orientation duration of eight age-sex classes (infant females, infant males, juvenile females, juvenile males, subadult females, subadult males, adult females, and silverback males) of captive western lowland gorillas toward a conspecific in six head orientation categories (HTO, HTOA, CHTO > = 2 secs, CHTO > = 3 secs, MHTO, and HNTO). First, the juvenile males spent more time than the expected frequency in HTO, while the subadult females spent less time in HTO than the expected frequency. Second, infant males and silverbacks spent more time than the expected frequency engaged in CHTO >= 2 secs, while the juvenile male spent less time in CHTO >= 2 secs than the expected frequency. Third, juvenile males spent more time than the expected frequency in CHTO >= 3 secs. Keep in mind, these categories overlap and are not mutually exclusive; for example, HTO contains data associated with every instance of HTO, continuous or not. HTO results are a superset of CHTO >=2 secs and

CHTO >=3 secs. Furthermore, CHTO >= 2 secs results is a superset of CHTO >= 3 secs. These findings will be further discussed in detail.

The first finding is juvenile males engaged in HTO more often than the expected frequency of the population. This category included all data of head orientation, be it one-instance durations or continuous durations. Juvenile males, engaged in HTO, oriented toward adult females 48%, infant males 29%, and silverbacks 23%. Contrarily, subadult females engaged in HTO less often than the expected frequency of the population. This finding supports Kaplan & Roger's (2002) conclusion that orangutan juveniles looked more than adults or infants. Additionally, this finding supports Coss et al.'s (2002) conclusion that juvenile male macaques spent more time watching older macaques, especially adults, and had a longer latency to avert.

The second finding is infant males and silverbacks engaged in CHTO >= 2 secs more often than the expected frequency of the population. This category included shorter and longer continuous durations of head orientation. Infant males, engaged in CHTO >=2 secs, oriented toward adult females 71%, silverbacks 12%, juvenile males 10%, and other infant males 7%. Older infants engage in head orientation toward adult females to solicit play or observe feeding (Chance & Jolly, 1970; Maestripieri et al., 2002; Maestripieri & Ross, 2004). As stated earlier, mothers may prolong the weaning stage in infant males (Eckhart & Lanjouw, 2008). Silverbacks, engaged in CHTO >= 2 secs, oriented toward adult females 63%, infant males 19%, subadult males 11%, juvenile males 6%, and infant females 1%. Adult male non-contact aggression directed toward adult females (Robbins, M. M., 2011; Stokes, 2004) could affect head orientation. Contrarily, juvenile males engaged in CHTO >= 2 secs less often than the expected frequency of the population. Juvenile males, engaged in CHTO >= 2 secs, oriented toward adult females 52%, infant males 25%, and silverbacks 23%. CHTO >= 2 secs may be associated with a delay or latency to gaze avert. This finding conflicts with Yamigawa's (1992) conclusion that silverbacks stared the least; however, only males were included Yamigawa's (1992) study, which could influence results. As mentioned, minimal research has been conducted with regard to gaze aversion in great apes.

The third finding is juvenile males engaged in CHTO >= 3 secs more often than the expected frequency of the population. This category only included data of longer duration head orientation. Juvenile males, engaged in CHTO >= 3 secs, oriented toward adult females 60%, silverbacks 23%, and infant males 17%. These results are consistent with a previous study that examined social staring behavior (>= 5 secs) in an all-male mountain gorilla group (Yamagiwa, 1992). Yamagiwa (1992) used a different age-class system more appropriate for mountain gorillas, as they mature slightly earlier than western lowland gorillas. Consistent with Yamagiwa's (1992) finding is the youngest male, corresponding to this study's juvenile male age-sex class, stared most frequently; and subordinate gorillas will direct staring toward older, dominant gorillas more frequently than vice versa. Stoinski et al. (2013) observed male western lowland gorillas similar in age to juvenile males initiating significantly more affiliative behavior than older males (both in all-male and mixed sex groups). Typically associated with aggressive interactions, staring or continuous head orientation toward another is a strategy to establish and maintain position (Marler, 1968; Redican, 1975; Rosa & Mazur, 1979; Schaller, 1963; Weisfeld & Beresford, 1982). There are several differences between the present study and Yamagiwa (1992). Yamagiwa (1992)'s subjects were all male (the youngest individual was 7 years old), where more conflict is expected as competition drives hierarchies. Also, Yamagiwa (1992) defined and coded a prolong stare for 5 secs and beyond and limited proximity to within 12 inches. In contrast, this study included both sexes (the infant was the youngest age class), continuous orientation included anything equal to or longer than 2 secs, and proximity included any distance that was within visual range of the focal, as defined previously. Yamagiwa (1992) denoted ages, but this research designated age and sex, noting that there is a marked difference in age classes and sex within age class (Hutchinson & Fletcher, 2010).

Juvenile males were above the expected frequency of the population in both HTO and CHTO >= 3 secs, but below the expected frequency of the population in CHTO >= 2 secs. Since these three categories are hierarchical, juvenile males engaged in quick 1-sec durations as well as longer continuous durations, but did not engage in shorter 2-sec durations of head orientation. The HTOA category specifically included only 1-sec duration head orientations, but results were insignificant, placing more emphasis on the longer duration head orientations of greater or equal to three seconds. Additionally, in each of these three head orientation categories, infant males, juvenile males, and silverbacks spent the majority of time oriented toward the adult female age-sex class. The adult female fulfills several roles within the troop of either a future mate, mother, or subordinate member and comprises the largest age-sex class in numbers.

Many researchers agree that head orientation is associated with gaze (Anderson, Sallaberry, & Barbier, 1995; Bania & Stromberg, 2012; Brauer, Call, & Tomasello, 2005; Burkart & Heschl, 2007; Genty et al., 2009; Ruiz, Gomez, Roeder, & Byrne, 2009; Wilson, Wilkinson, Lin, & Castillo, 2000) and could be a more reliable cue due to the variation in pigmentation of sclera in nonhuman primates. Furthermore, it is also agreed that gaze generally follows orientation (Genty et al., 2009). Nevertheless, this research does not assume that subtle eye shifting is not occurring, thus delineating head orientation as orienting toward and not looking toward. Due to the anatomy of the gorilla head, with its larger crest and mandible, an orientation of the head toward another, even though they may not be looking directly at another, could convey the same information to a conspecific who cannot detect eye direction.

Although ad libitum sampling data was used from an unrelated study, it is beneficial in the sense that the collection of data is impartial toward the behavior patterns researched in this study. This form of data collection offers no systematic constraints on what is recorded or when. Although habituated to a zoo environment, a captive setting could affect behaviors. Moreover, zoos do not necessarily reflect a typical wild lowland gorilla nuclear family configuration, for instance, not all troops contained all age classes and rearing varied. Having all age-sex classes available in one troop could shed even further light on the dynamics of a natural troop. Ideally, data would be collected in a natural setting equally amongst all age-sex classes.

The methodology and coding in this study is unique and incorporates a more scientific, unbiased approach to determining orientation given the angles from the camera and between subjects. Given the large amount of data to code, importance was placed on a systematic approach focusing on accuracy, replication, and impartiality toward the outcome. Achieving a high inter-rater reliability in all four phases speaks to the strength of the research design and to the scientific integrity of the study. Furthermore, this methodology could be applied to the study of all animal communication, both in captive and wild settings.

This research did corroborate with some primate age-class stare findings, associated with both short and long continuous head orientation. Methodology, inclusion of age class with sex, and an expansion of categories of orientation differed compared to other primate stare research. Additionally, age classes including sex are critical in this study of head orientation, as infant females mature at a different rate and fulfill a completely different role than their male counterparts. Finally, the six head orientation categories researched provide an all-encompassing picture of how gorillas use head orientation. This study incorporates these areas of study that are missing from past research.

The major conclusion of this research is that a difference in age-sex classes in three head orientation categories does emerge. Moreover, it is not linear as one might surmise, meaning head orientation is not directly or inversely proportional to age. Unlike a linear progression of diminished orientation, this study revealed that a variety of higher than expected frequencies occur across separate age-sex classes. Sex is a critical factor in gorilla species where differences in roles and behavior can clearly be seen. A female's existence and future position within the troop is very different from that of a male. Most females will have successful reproductive lives; however, not every male will become an alpha male with access to female mates. Alpha males will encourage females to stay with them by providing protection, while in turn passing on his genes; and adult females, wanting protection for themselves and offspring, will be motivated to stay with a powerful alpha male. The sexual dimorphism in gorillas further substantiates the difference in roles. This finding suggests that the unique role each age-sex class has and the ultimate rank and position one might fulfill, as stated earlier, is vital to deepening our understanding of this form of nonverbal communication.

Moreover, orphan infant gorillas rescued in the wild are reared in sanctuaries with some limited reintroduction back to the wild. Research in communicative development can be valuable for the acceptance of orphaned zoo infants into a captive troop and successful reintroduction of orphaned gorillas back to the wild. Without fully understanding how gorillas use gaze and/or orientation, humans can jeopardize the welfare and social behavior in young, high-risk gorilla orphans (Maple, 1980), further diminishing the chances for acceptance by future conspecifics (Porton & Niebruegge, 2006).

All species of gorillas are critically endangered (IUCN, 2012), meaning they are all facing a very high risk of extinction in the wild. Gorillas are close relatives to humans and we should care about their existence. The more we learn about them, the more we can increase their odds of survival. Most of the knowledge we have of gorillas comes from the small population of habituated Virunga Mountain gorillas in Rwanda (Robbins, 2007); however, maturation is slower in western lowland gorillas and comparing age classes needs to account for this difference (Nowell & Fletcher, 2007; Breuer et al., 2009). This study exposes a non-linear response in head orientation to conspecifics by not only the age class, but sex as well. In the future, all age-sex classes should be filmed equally and activities recorded, as eating or grooming could alter results. The methodology used in this research is rigorous and can be used in all primate studies of gaze both in captivity and the wild. Most importantly, more research needs to be conducted in areas of direct stare, mutual gaze, and gaze aversion with captive gorillas and wild counterparts. It is imperative to understand as much as we can about gorilla communication, both verbal and nonverbal, to increase the survival rate of these critically endangered species, before it is too late.

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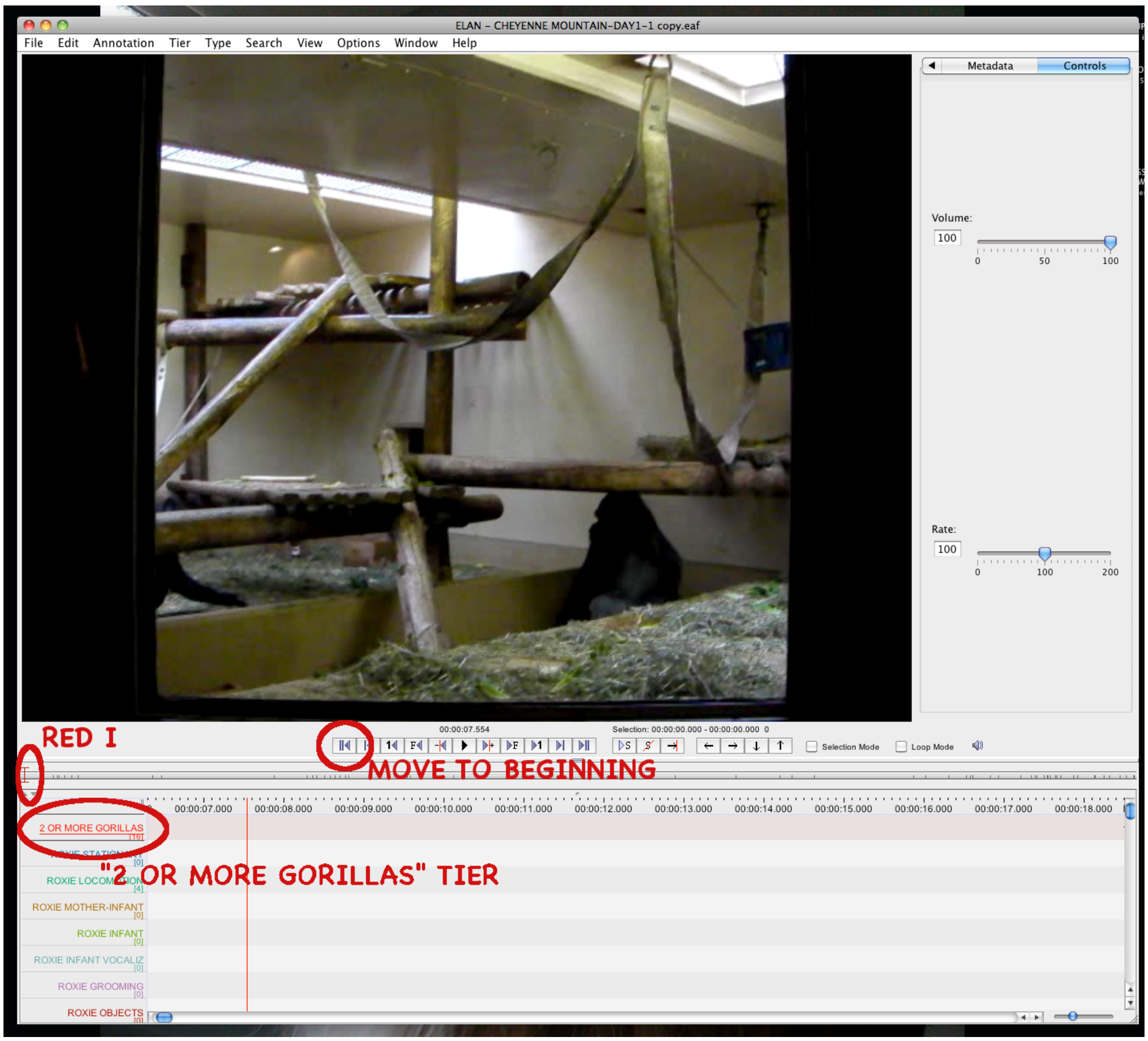
Appendix A

Instructions for Coding Head Orientation
(Phase 1, 2, and 3)

Phase 1

ELAN Software

The film will be viewed through the software ELAN. A data sheet will be used to record the times. Enter the file name of the *.eaf file on the data sheet.



Double-click on the *.eaf file given to you to code.

Start at the beginning of the video by pressing the  button (*circled in red above*).

Move the film as fast as you want by clicking on the *red* **I** (located on a horizontal hashed bar just below the media control buttons...*circled in red above*), holding the mouse down and dragging to the right

Start timing by writing down the number of gorillas and the start time, found at the top of the media control buttons (*see example below*) on the data sheet (see Page 69 for starting criteria).

Stop timing by writing down the stop time, found at the top of the media control buttons (*see example below*) on the data sheet (see Page 85 for stopping criteria).

For example, if there were two gorillas in this video segment, the data sheet entry would be look like this:

FILE NAME	HOW MANY GORILLAS?	START TIME								END TIME						
CHEYENNE MOUNTAIN-DAY1-1 copy.eaf	*2*	*00*	*:*	*07*	*:*	*55*	*.*	*908*	*TO*	*00*	*:*	*10*	*:*	*11*	*.*	*882*

The "head" is defined as any part of the cranium, including the skull, sagittal crest, eyes, ears, nose, and mouth.

The "shoulder" is defined as the rounded outside curvature where the arm is connected with the torso.

A "sliver" is defined as the visibility of the wall or surrounding enclosure environment placed vertically on the left or right of the subject or horizontally above or below the subject.

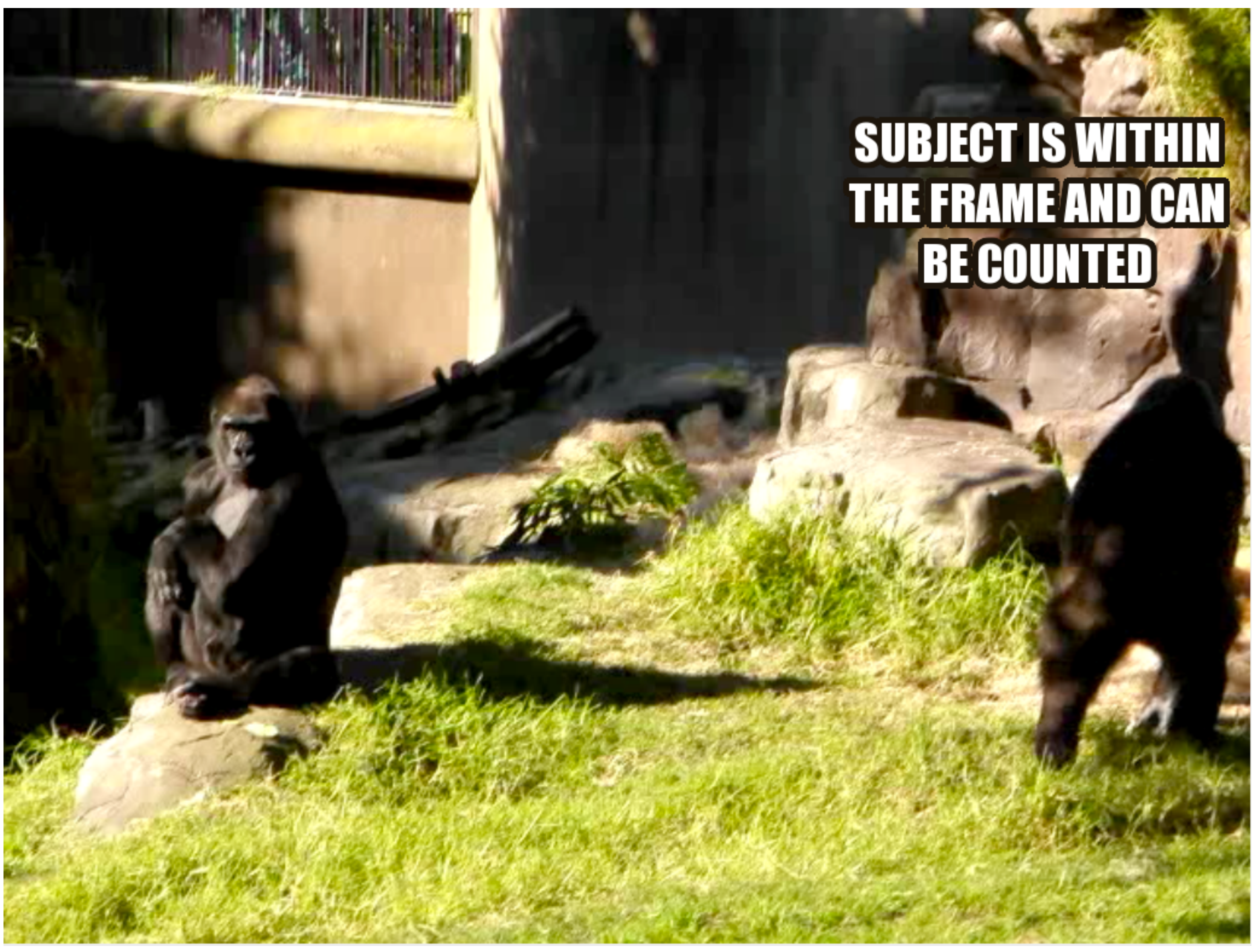
START

In order to start, there has to be a minimum of 2 gorillas in the frame (defined below). As soon as that occurs, write down the number of gorillas counted and the start time (found at the top of the media control buttons pictured above) on the data sheet.

The following rules are defined in order for a gorilla to be counted or "in the frame."

Sliver Visible on All Sides

If the subject has their head and shoulders within the frame, indicated by a sliver of wall or surrounding enclosure environment visible on all sides of the subject (from top to bottom on both sides and from left to right above and below), this indicates the subject's body is completely within the frame and can be counted. *Both shoulders are defined as being within the frame, even if one is not visible due to the gorilla positioning itself perpendicular to the camera.*




A SLIVER EXISTS
AROUND THIS
GORILLA. SHE
WILL BE COUNTED.
<----------


THIS GORILLA ------------->
WILL NOT BE COUNTED AS
THERE IS NO SLIVER ABOVE
HIM

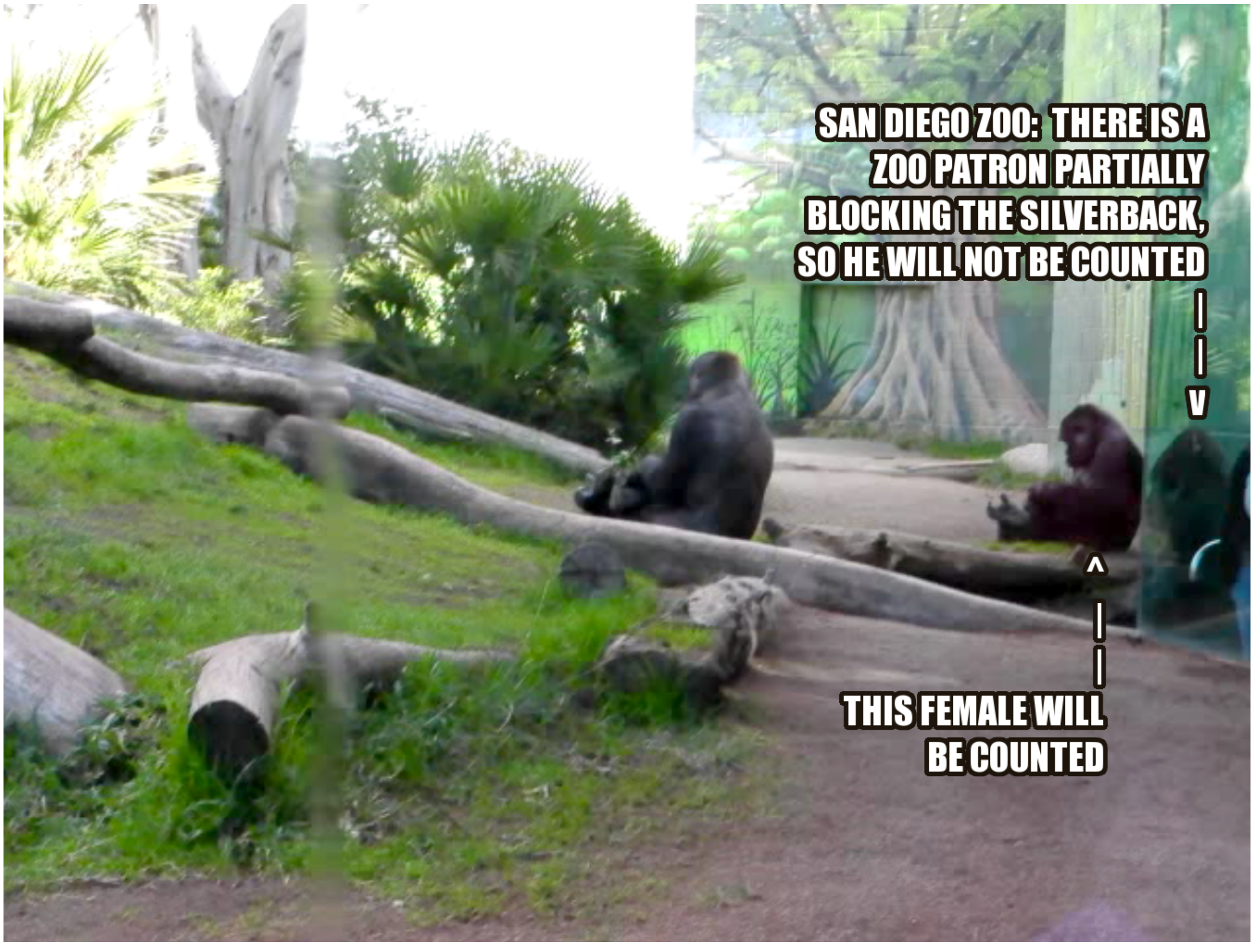

THIS GORILLA CAN BE COUNTED
|
|
V
THIS GORILLA CANNOT BE COUNTED
|
|
V

Sliver Visible on 3 Sides

If the subject has a sliver of wall or surrounding enclosure environment visible on three sides of the subject (from top to bottom on both sides and from left to right above) such that the subject's entire torso (the central part of the body from which extend the neck and limbs) and head are within the frame, this subject can be counted. This rule applies to gorillas who have extremities outside the bottom of the frame.

Touching Edge of Frame

If the subject has their head and shoulders within the frame and is standing or sitting touching the edge of frame, indicated by a sliver of wall or surrounding enclosure environment visible on three sides of the subject (from top to bottom on either the left or right side and from left to right above and below), this indicates the subject's body is completely within the frame and can be counted. *Both shoulders are defined as being within the frame, even if one is not visible due to the gorilla positioning itself perpendicular to the camera.*

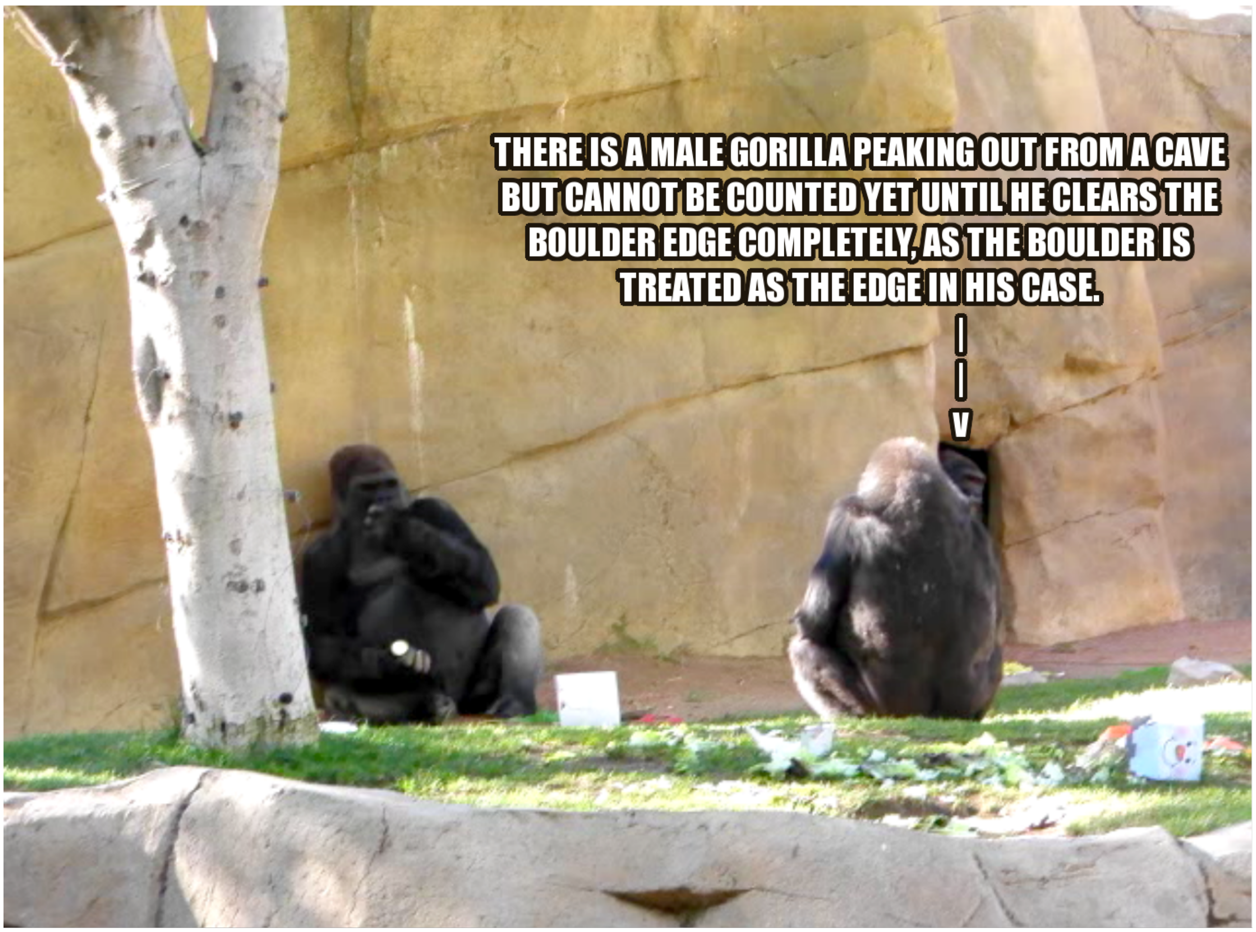

SAN DIEGO ZOO: THERE IS A
ZOO PATRON PARTIALLY
BLOCKING THE SILVERBACK,
SO HE WILL NOT BE COUNTED
|
|
V
^
|
|
THIS FEMALE WILL
BE COUNTED

Silhouette on Edge of Frame

If a gorilla is on the side edge of the frame **AND** only a black silhouette of the subject can be seen, timing will begin only when the subject moves into the frame and a vertical sliver of wall or surrounding enclosure environment is visible from top to bottom of the enclosure on both sides of the subject, indicating the subject's body is completely within the frame and can be counted.

Permanent Structure Jutting Out at Edge of Frame

If a permanent enclosure structure or foliage (like a bush or boulder which juts out from the edge of the frame), that obstruction will be considered the edge of the frame for that subject and timing will begin only when the subject moves into the frame and a vertical sliver of wall or surrounding enclosure environment is visible from top to bottom of the enclosure on both sides of the subject, indicating the subject's body is completely within the frame and can be counted.




THIS INFANT CAN NOW BE
COUNTED, AS THE FOLIAGE IS
TREATED AS THE EDGE OF THE
FRAME FOR HIM AND HE HAS A
SLIVER ON ALL SIDES.

Hidden Behind Another Gorilla on Edge of Frame

If a gorilla subject is on the side edge of the frame **AND** is hidden behind another gorilla, timing will begin only when the subject moves into the frame and a vertical sliver of wall or surrounding enclosure environment is visible from top to bottom of the enclosure on both sides of the subject, indicating the subject's body is completely within the frame and can be counted. In this instance, the vertical sliver of wall will be between the subject and the blocking gorilla. This does not include a gorilla that appears in the center of the frame, just the edge.

Disappeared from View in Center of Frame

If a gorilla subject is in the center of the frame and has previously disappeared entirely from view by an enclosure structure located in the center (thus, no longer counted), that subject will be counted as soon as the upper torso (above the waist) is visible.

Partially Visible in Center of Frame

If a gorilla subject is in the center of the frame and is now only partially visible (i.e., moved within the frame behind a structure) and was counted in the last count, he/she will be counted again in this count.

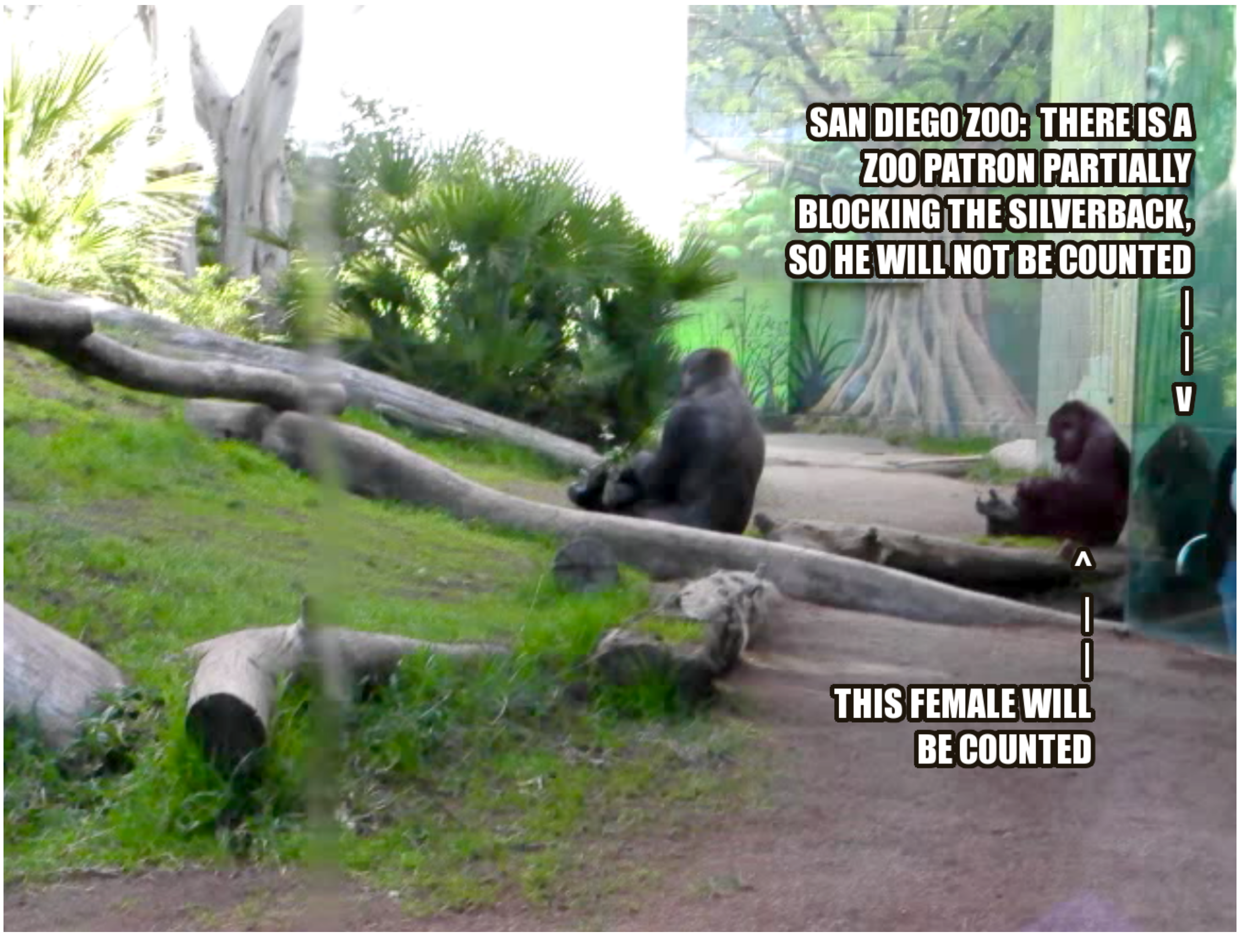
A gorilla in the center of the frame who is only partially visible (i.e., sitting in a trench) can be counted if a sliver of wall or surrounding enclosure environment is visible on three sides of the subject (from top to bottom on both sides and from left to right above)

Camera Movements

- If the camera is still and not moving, counting can begin.
- If the camera has moved to a partially hidden gorilla in the center of the frame that was not counted in the last count, that subject will be counted as soon as the upper torso (above the waist) is visible.
- If the camera pans and a gorilla that was previously counted is only now partially visible, that gorilla will no longer be counted and must enter in again under the rules for starting as described above.

Zoo Patrons

Typically, counting cannot begin if zoo patrons are in the camera's view. However, at the San Diego Zoo, the observation glass juts out into the enclosure. At this zoo, treat the edge of the zoo patrons within the observation glass as if it were a side wall (which will be shifting as patrons move about).




ZOO PATRON
WITHIN CAMERA'S
VIEW. DO NOT
START.


ZOO PATRON
WITHIN CAMERA'S
VIEW. DO NOT
START.

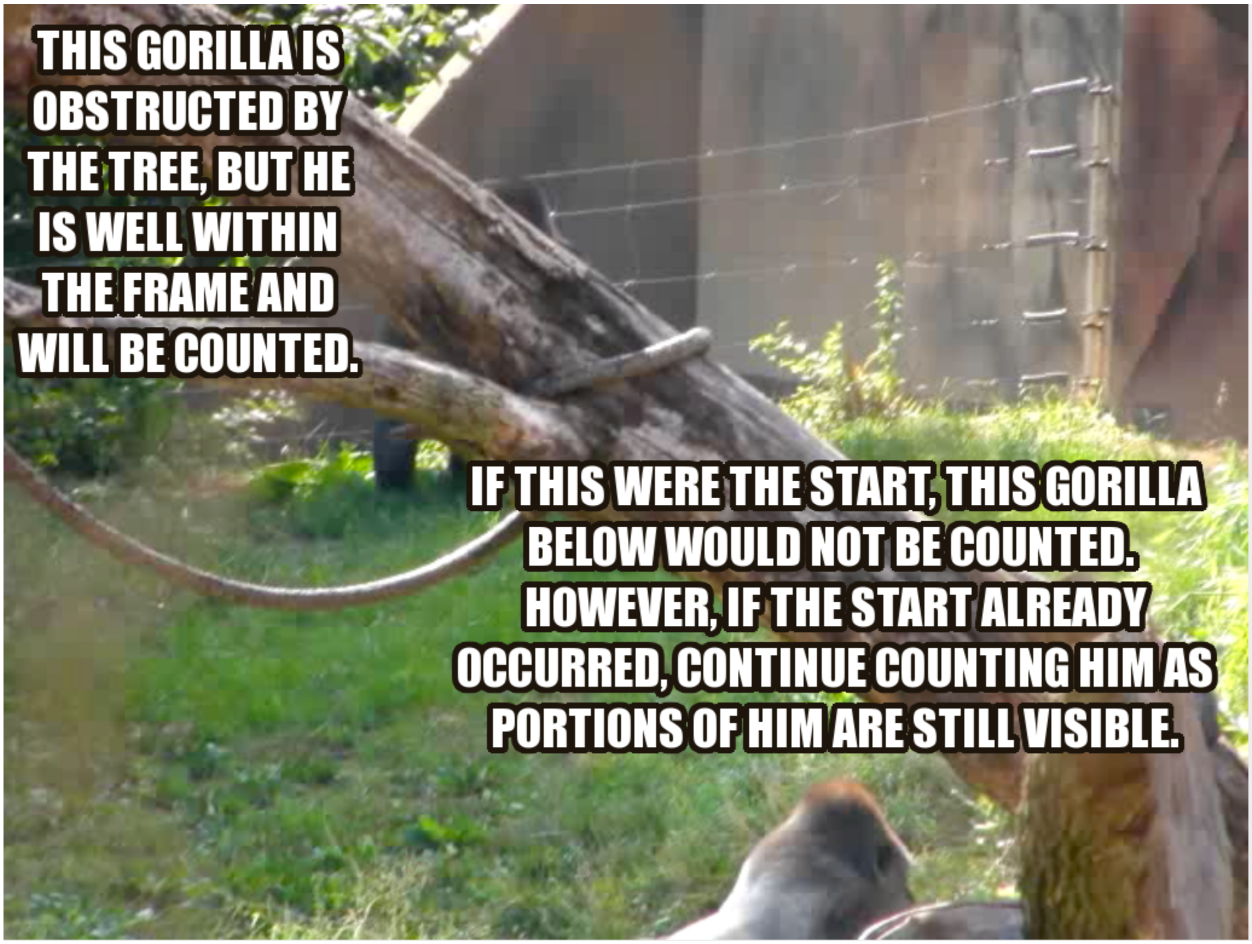
When to Continue or Stop

Leaving the frame is the moment when either a part of the head or a shoulder moves outside the edge of the frame and typically indicates when you should stop. However, there will be times when the head and shoulders may no longer be visible, but you should continue and not stop.

In order to determine if you should continue timing and advancing the film or stop, refer to the following:

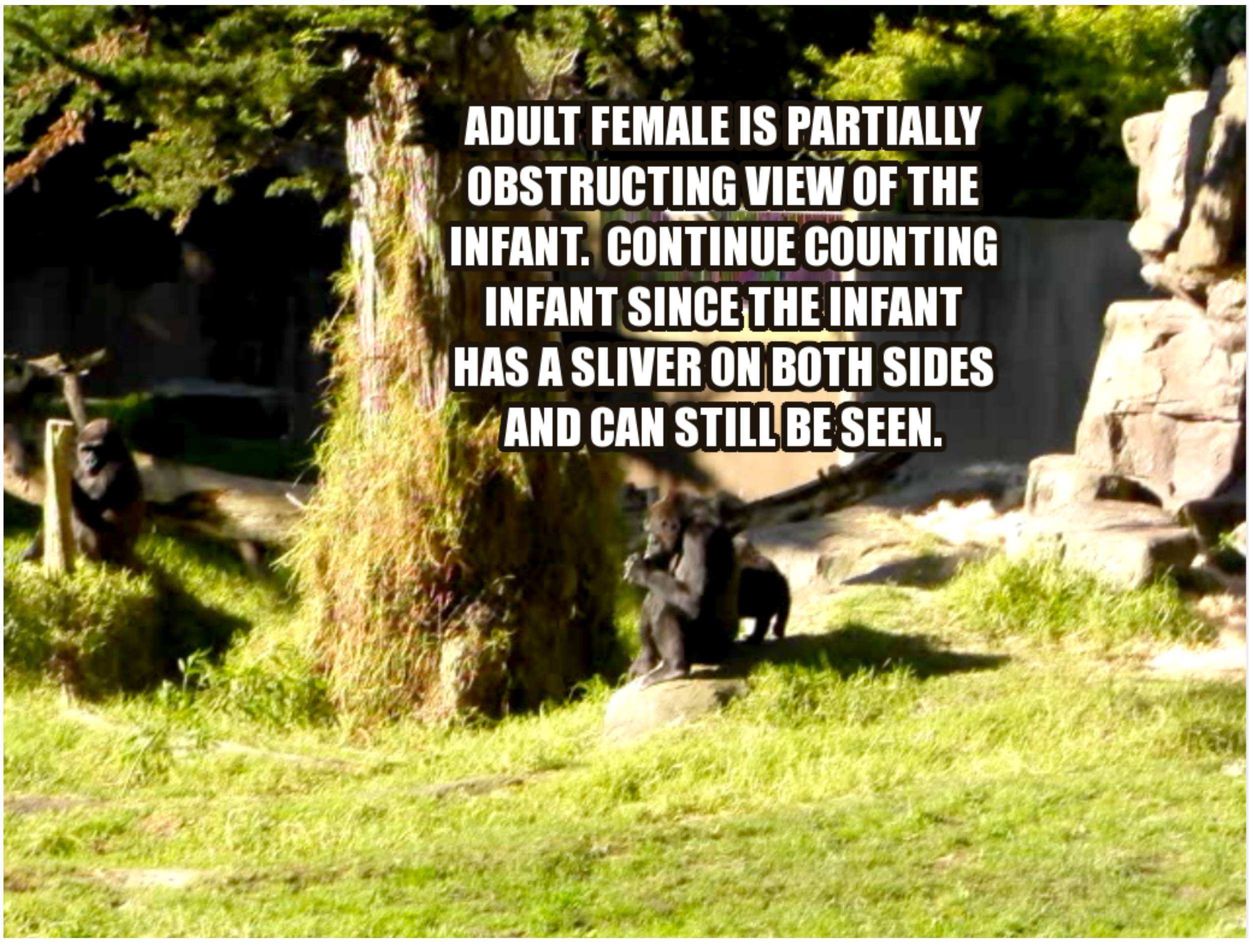
Obstructions that Block Part of a Subject

If obstructions in the enclosure block part of a gorilla and a vertical sliver of wall or surrounding enclosure environment is visible from top to bottom of the enclosure on both sides of the subject, **CONTINUE**.


THIS GORILLA IS OBSTRUCTED BY THE TREE, BUT HE IS WELL WITHIN THE FRAME AND WILL BE COUNTED.
IF THIS WERE THE START, THIS GORILLA BELOW WOULD NOT BE COUNTED. HOWEVER, IF THE START ALREADY OCCURRED, CONTINUE COUNTING HIM AS PORTIONS OF HIM ARE STILL VISIBLE.

Partially Obstructed by Another Gorilla

If one gorilla is partially obstructed from view by another gorilla and a vertical sliver of wall or surrounding enclosure environment is visible from top to bottom of the enclosure on both sides of the obstructed gorilla, **CONTINUE**. The key is that the subject is only partially obstructed and some part of their body can be seen.

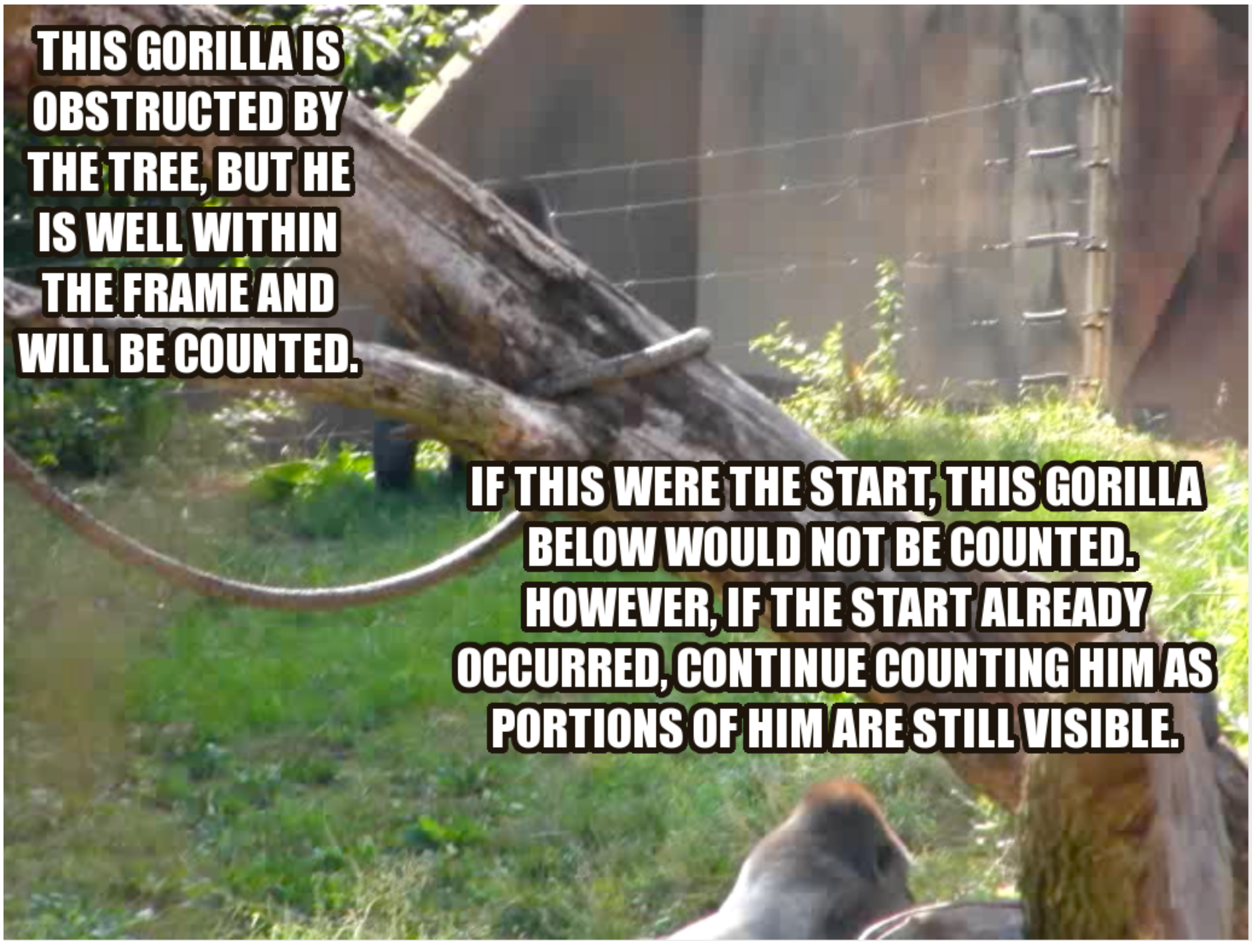


Totally Obstructed by Another Gorilla

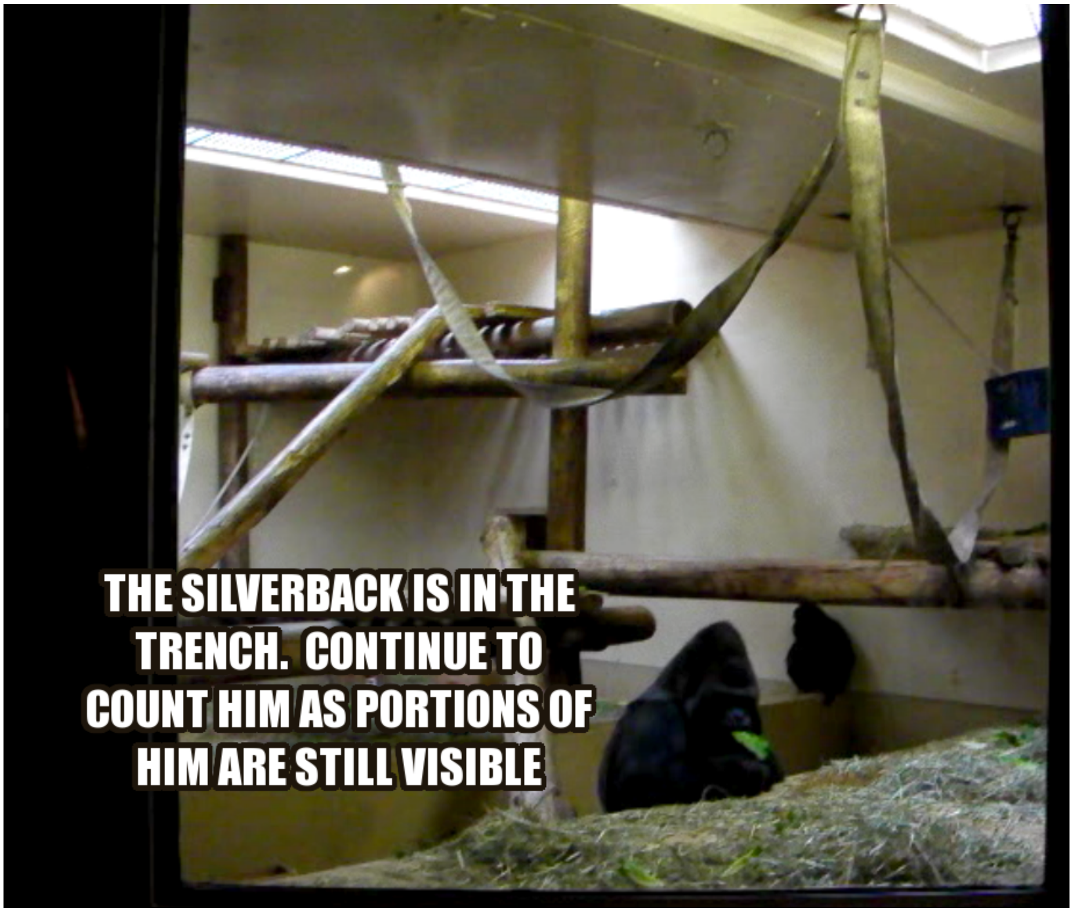
If one gorilla is totally obstructed from view by another gorilla, **STOP** by writing down the stop time (found at the top of the media control buttons pictured above) on the data sheet.

Only Part of the Subject is Visible

If a gorilla climbs down into a cement trench, behind a wall or other structure, or is at the bottom edge of the frame and only a portion of the gorilla is visible (for instance, just the top line, head, foot, arm, etc.), **CONTINUE**.



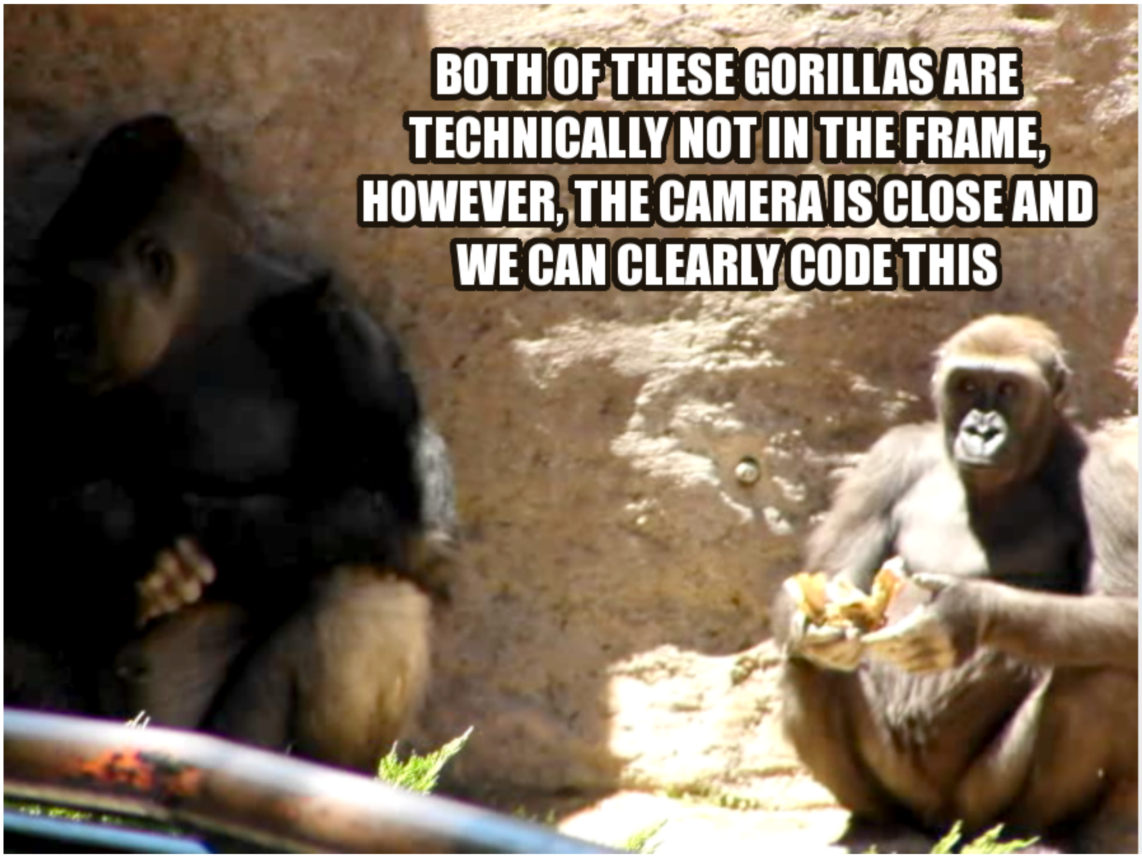

CONTINUE COUNTING THIS GORILLA.
SHE WALKED BEHIND THE TREE, BUT
HER HIND END IS STILL VISIBLE.



Shoulder or Back Not Completely Within Edge of Frame

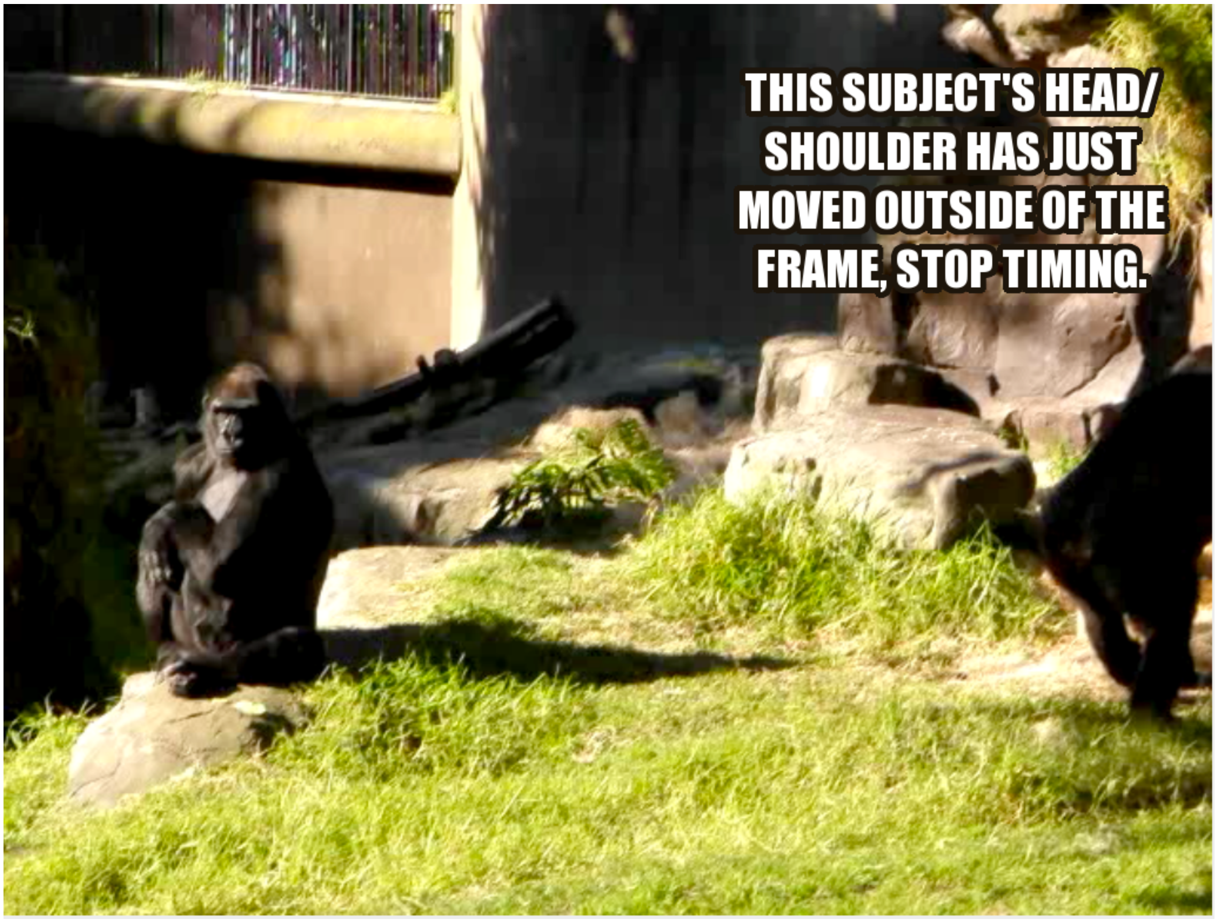
If a subject is on the edge of the frame and a shoulder or back is not completely within the frame (there is no vertical sliver of wall or surrounding enclosure environment visible), but the majority of the body is visible and you can clearly see the gorilla enough to code head orientation, **CONTINUE**.


THIS INFANT'S BACK IS NOT COMPLETELY WITHIN THE FRAME, BUT WE CAN CLEARLY CODE FOR HEAD ORIENTATION. CONTINUE COUNTING HIM.


BOTH OF THESE GORILLAS ARE
TECHNICALLY NOT IN THE FRAME,
HOWEVER, THE CAMERA IS CLOSE AND
WE CAN CLEARLY CODE THIS

Leaving the Frame

If the count of the gorillas in the frame changes, denoted by a gorilla leaving or a new gorilla entering the frame, **STOP** by writing down the stop time (found at the top of the media control buttons pictured above) on the data sheet.

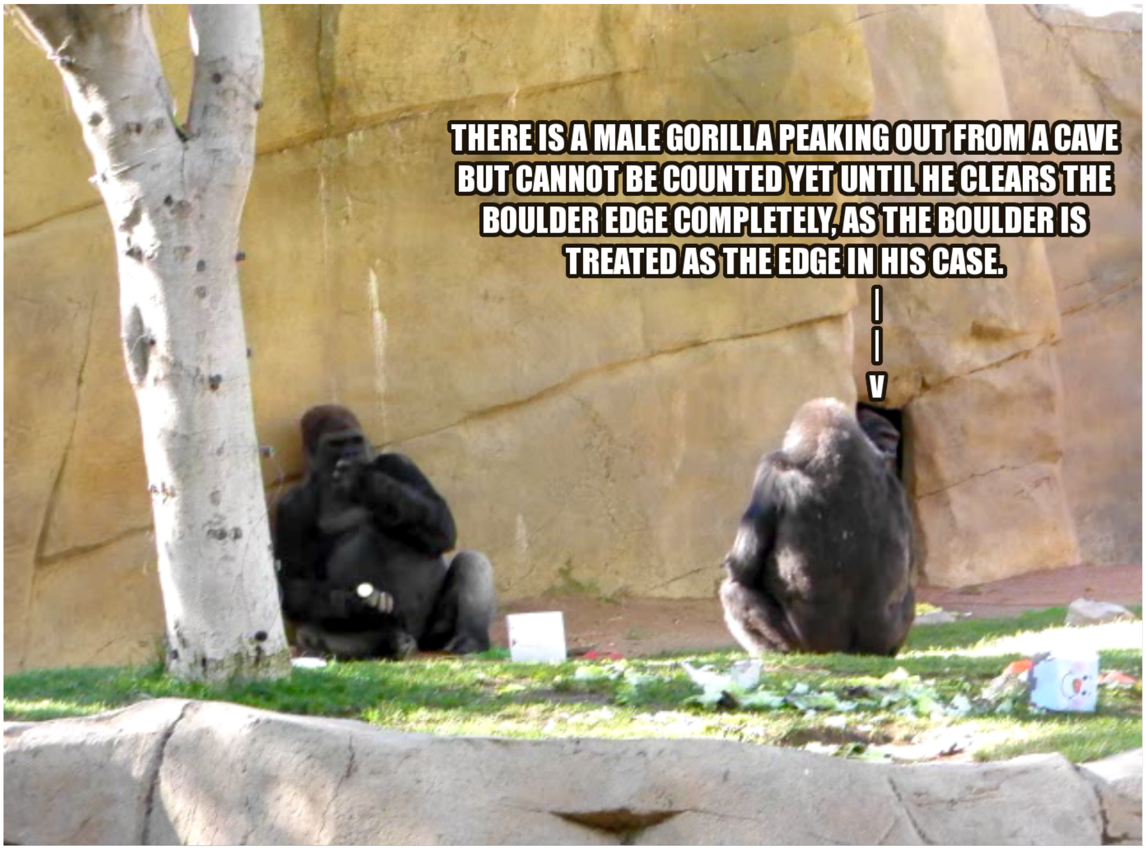

THIS SUBJECT'S HEAD/
SHOULDER HAS JUST
MOVED OUTSIDE OF THE
FRAME, STOP TIMING.

Disappears Entirely From View

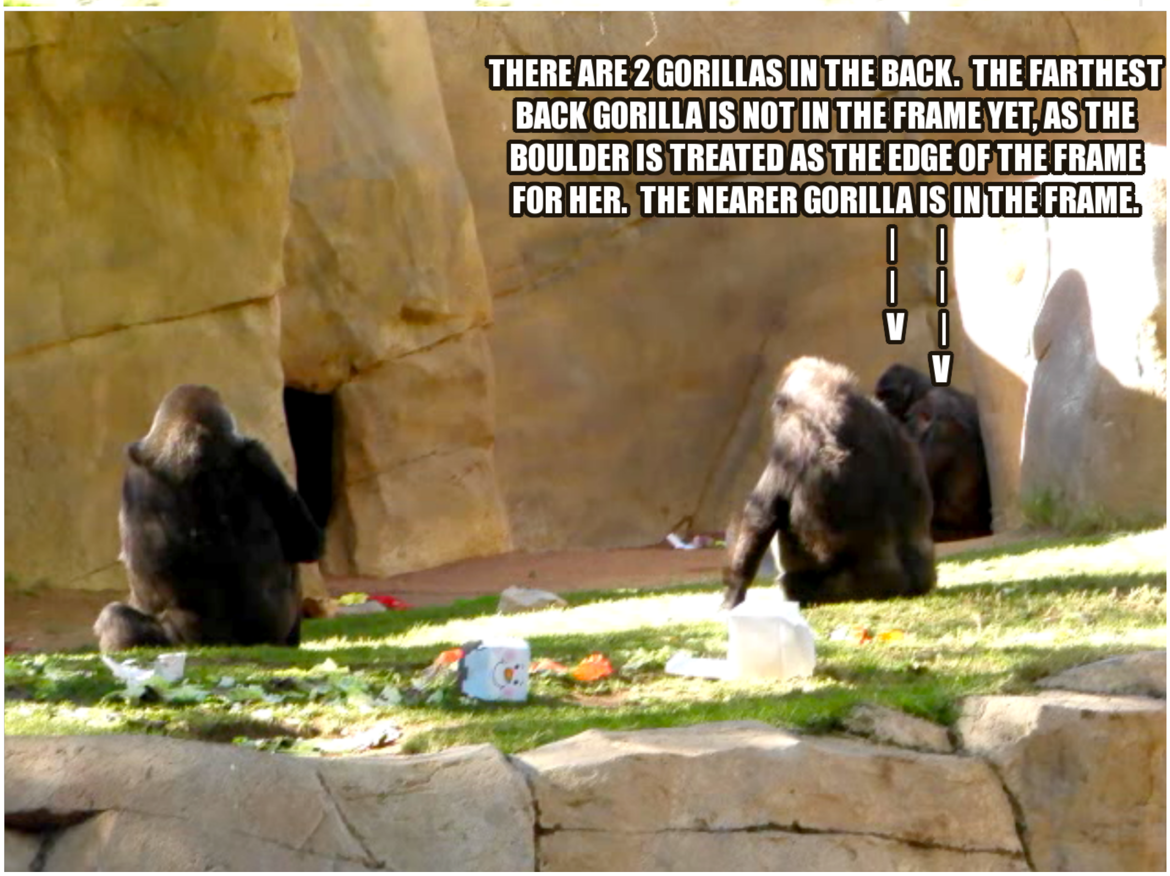
If a gorilla enters into the cement trench, behind a wall or tree, or other structure and disappears entirely from view, **STOP** by writing down the stop time (found at the top of the media control buttons pictured above) on the data sheet.

Permanent Structure Jutting Out From Edge of Frame

If there is an opaque permanent obstruction (like a bush or boulder) jutting out from the edge of the frame such that a gorilla walking behind it would not be seen exiting the other side, that obstruction will be considered the edge of the frame for that gorilla. As soon as part of the head or a shoulder moves behind that permanent obstruction, **STOP** by writing down the stop time (found at the top of the media control buttons pictured above) on the data sheet, as that gorilla will no longer be counted.


THERE IS A MALE GORILLA PEAKING OUT FROM A CAVE
BUT CANNOT BE COUNTED YET UNTIL HE CLEARS THE
BOULDER EDGE COMPLETELY, AS THE BOULDER IS
TREATED AS THE EDGE IN HIS CASE.


THIS GORILLA IS NO LONGER IN THE FRAME
|
|
V


THERE ARE 2 GORILLAS IN THE BACK. THE FARTHEST BACK GORILLA IS NOT IN THE FRAME YET, AS THE BOULDER IS TREATED AS THE EDGE OF THE FRAME FOR HER. THE NEARER GORILLA IS IN THE FRAME.
| |
| |
V |
V

Camera Movement

If movement or panning of the camera does not change the count and the same subjects are being filmed and the video is relatively focused (for instance, following a subject or zooming in), **CONTINUE**.

Camera Out of Focus

The camera itself is moving or panning and out of focus and blurred, **STOP** by writing down the stop time (found at the top of the media control buttons pictured above) on the data sheet.

Zoo Patrons

The moment a zoo patron is visible, with the exception of the San Diego Zoo described on Page 83, **STOP** by writing down the stop time (found at the top of the media control buttons pictured above) on the data sheet.

Phase 2

Using the start-stop times from Phase 1, you will be making further refinement to the video, which will be called "In Range" (Phase 2). This phase will determine if there is visible evidence that two or more gorillas in the frame have the potential or capability of looking at each other.

See Page 105 for an explanation on how to advance the video in ELAN.

"N" will be defined as the number of gorillas in the frame (determined in Phase 1).

The criteria for refinement in Phase 2 to qualify for "In Range" will require the following **2** statements to be both be ***TRUE***:

Statement 1: Using the POSITIONAL CIRCLE (see Page 34), at least 2 of the gorillas in the frame are in the 0, 1, 2, 4 or 5 zone in relation to the other. In other words, one gorilla is obviously not sitting or standing directly behind another gorilla.

Statement 2: At least 2 of the gorillas meeting Statement 1 above meet **ONE** of the following criteria (each gorilla needs to meet one of the following):

- Front, back, or side torso [the main part of the body in which the neck, arms, and legs are attached] fully visible and not shadowed
- Silhouetted outline of the ear(s) or muzzle **<u>and</u>** shoulder(s) detectable
- Head and shoulder(s) completely visible and distinguishable (not in shadow) and not obstructed
- Head or shoulder slightly obstructed (such as the top of the crest), but visibility still allows you to determine head and shoulder orientation
- Head and/or shoulder is temporarily obstructed, but scanning slightly before the clip, during the clip, or slightly after the clip shows the head and/or shoulder(s) completely visible and enough is visible during the clip to reveal that the subject did not shift their torso (shoulders)

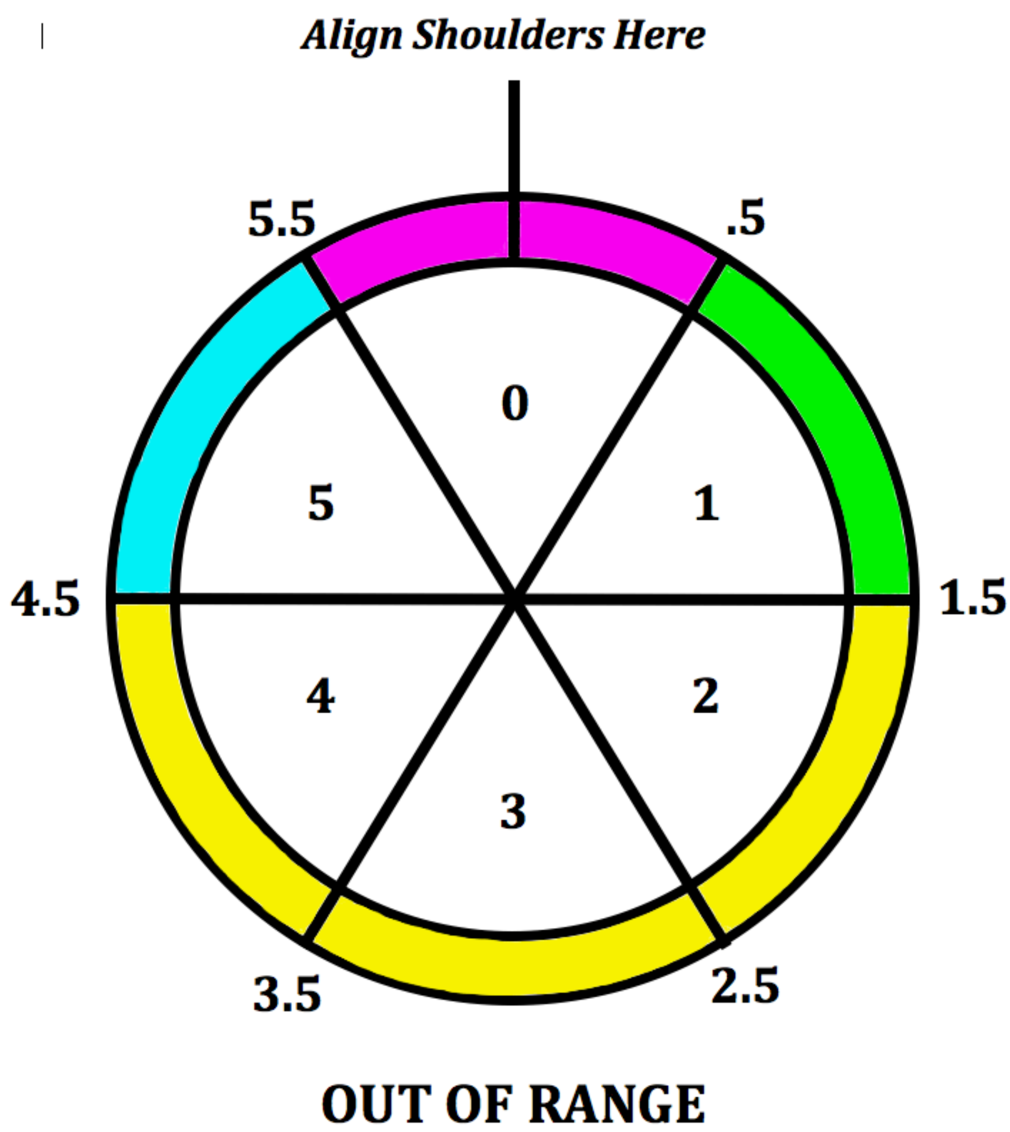
If any of the following occur, Statement 2 is false:

- *A tree or obstruction blocks the view of one gorilla to another, disregard and don't count*

- *The gorilla is all black, disregard and don't count*

Viewing the video between the Phase 1 start-stop times, write down the start time when the above 2 statements are met (both are ***true***). Continue through the film until one of the statements is ***false*** or the end of the Phase 1 stop segment occurs and write down that stop time. NOTE: If an infant is spinning around in play, you don't need to start and stop each time their back is to another.

Instructions for Using Positional Circle



Place Gorillas on POSITIONAL CIRCLES

Line up each gorilla so as his/her shoulders are perpendicular to 0 (zero) and his/her shoulders are placed in the center of his/her POSITIONAL CIRCLE

Assign Numbers to Each Gorilla

ID each gorilla and assign each gorilla to numbers 1-4 (if two gorillas 1-2 and if three gorillas 1-3)

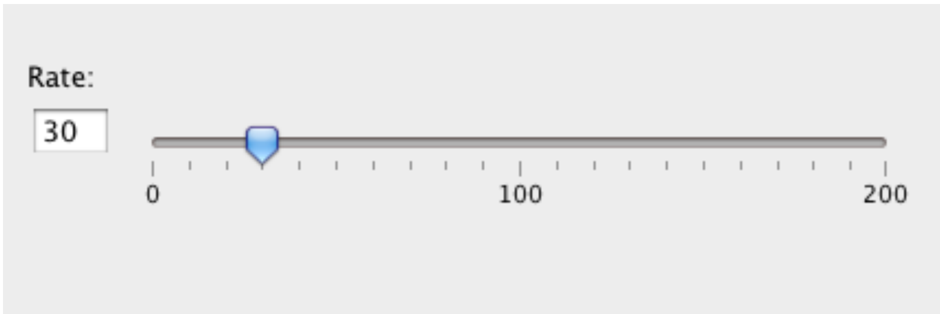
Gorilla Zones

Using the POSITIONAL CIRCLE for Gorilla 1, determine the orientation to Gorilla 2

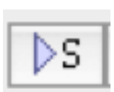
Using the POSITIONAL CIRCLE for Gorilla 2, determine the orientation to Gorilla 1

Advancing the Video

Moving this bar, located on the right-hand of the ELAN screen will alter the playback speed. The setting for normal speed is 100 and half speed is 50. A playback speed of 30 slows things up so that muzzles, ears, etc., can be seen more easily.



The media control buttons below the Selection times will be useful in this exercise.

 will play the selected interval at the playback rate you set

 will take you to the next selection

 will move to the end of this selection (pressing it again will move you to the beginning of this selection)

Phase 3

In this final phase, you will be coding for "Head Orientation."

An example data sheet looks like this:

PHASE 3

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P1 #	PHASE 2 TIMES	G1 (G2)	G1 (G3)	G1 (G4)	G2 (G1)	G2 (G3)	G2 (G4)	G3 (G1)	G3 (G2)	G3 (G4)	G4 (G1)	G4 (G2)	G4 (G3)	G1: CAM	G2: CAM	G3: CAM	G4: CAM	G1: HEAD	G2: HEAD	G3: HEAD	G4: HEAD	G1 ID	G2 ID	G3 ID	G4 ID	G1 (G5)	G2 (G5)	G3 (G5)	G4 (G5)	G5 (G1)	G5 (G2)	G5 (G3)	G5 (G4)	G5: CAM	G5: HEAD	G5 ID
5	00:03:25.780																																			
5	00:03:26.780																																			
5	00:03:29.780																																			
4	00:03:38.420																																			
4	00:03:39.420																																			
4	00:03:40.420																																			
3	00:03:44.090																																			
3	00:03:45.090																																			
3	00:05:36.250																																			
2	00:05:37.980																																			
2	00:05:38.980																																			
2	00:05:39.980																																			
3	00:07:27.160																																			
4	00:07:27.340																																			
3	00:07:28.470																																			
2	00:07:30.050																																			

Column variables are defined as follows:

P1 #	Number of gorillas counted during Phase 1 coding
PHASE 2 TIMES	The video recording time (hh:mm:ss:sss) when 2 or more gorillas were within range of each other during Phase 2 coding
G1 (G2)	G1 represents the first designated gorilla within the frame. G2 represents the second designated gorilla within the frame. G1(G2) represents the orientational relationship between G1 and G2, as displayed on G1's Positional Circle. Values include: 0, .5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5, or 5.5.
G1 (G3)	G1 represents the first designated gorilla within the frame. G3 represents the third designated gorilla, if one exists, within the frame. G1(G3) represents the orientational relationship between G1 and G3, as displayed on G1's Positional Circle. Values include: 0, .5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5, or 5.5.
G1 (G4)	G1 represents the first designated gorilla within the frame. G4 represents the fourth designated gorilla, if one exists, within the frame. G1(G4) represents the orientational relationship between G1 and G4, as displayed on G1's Positional Circle. Values include: 0, .5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5, or 5.5.
G2 (G1)	G2 represents the second designated gorilla within the frame. G1 represents the first designated gorilla within the frame. G2(G1) represents the orientational relationship between G2 and G1, as displayed on G2's Positional Circle. Values include: 0, .5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5, or 5.5.
G2 (G3)	G2 represents the second designated gorilla within the frame. G3 represents the third designated gorilla, if one exists, within the frame. G2(G3) represents the orientational relationship between G2 and G3, as displayed on G2's Positional Circle. Values include: 0, .5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5, or 5.5.
G2 (G4)	G2 represents the second designated gorilla within the frame. G4 represents the fourth designated gorilla, if one exists, within the frame. G2(G4) represents the orientational relationship between G2 and G4, as displayed on G2's Positional Circle. Values include: 0, .5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5, or 5.5.
G3 (G1)	G3 represents the third designated gorilla, if one exists, within the frame. G1 represents the first designated gorilla within the frame. G3(G1) represents the orientational relationship between G3 and G1, as displayed on G3's Positional Circle. Values include: 0, .5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5, or 5.5.

G3 (G2)	G3 represents the third designated gorilla, if one exists, within the frame. G2 represents the second designated gorilla within the frame. G3(G2) represents the orientational relationship between G3 and G2, as displayed on G3's Positional Circle. Values include: 0, .5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5, or 5.5.
G3 (G4)	G3 represents the third designated gorilla, if one exists, within the frame. G4 represents the fourth designated gorilla, if one exists, within the frame. G3(G4) represents the orientational relationship between G3 and G4, as displayed on G3's Positional Circle. Values include: 0, .5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5, or 5.5.
G4 (G1)	G4 represents the fourth designated gorilla, if one exists, within the frame. G1 represents the first designated gorilla within the frame. G4(G1) represents the orientational relationship between G4 and G1, as displayed on G4's Positional Circle. Values include: 0, .5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5, or 5.5.
G4 (G2)	G4 represents the fourth designated gorilla, if one exists, within the frame. G2 represents the second designated gorilla within the frame. G4(G2) represents the orientational relationship between G4 and G2, as displayed on G4's Positional Circle. Values include: 0, .5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5, or 5.5.
G4 (G3)	G4 represents the fourth designated gorilla, if one exists, within the frame. G3 represents the third designated gorilla, if one exists, within the frame. G4(G3) represents the orientational relationship between G4 and G3, as displayed on G4's Positional Circle. Values include: 0, .5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5, or 5.5.
G1: CAM	The camera angle in relation to the first designated gorilla (G1) as displayed on G1's Positional Circle. Values include: 0, .5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5, or 5.5.
G2: CAM	The camera angle in relation to the second designated gorilla (G2) as displayed on G2's Positional Circle. Values include: 0, .5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5, or 5.5.
G3: CAM	The camera angle in relation to the third designated gorilla (G3), if one exists, as displayed on G3's Positional Circle. Values include: 0, .5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5, or 5.5.
G4: CAM	The camera angle in relation to the fourth designated gorilla (G4), if one exists, as displayed on G4's Positional Circle. Values include: 0, .5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5, or 5.5.
G1: HEAD	The head position of the first designated gorilla (G1). Values include: A, A+, B, B+, C, C+, D, D+, E, E+, F, F+, G, G+, H, H+, I, I+, J, J+, K, K+, L, or L+. (See Head Orientations in Appendix A)

G2: HEAD	The head position of the second designated gorilla (G2). Values include: A, A+, B, B+, C, C+, D, D+, E, E+, F, F+, G, G+, H, H+, I, I+, J, J+, K, K+, L, or L+. (See Head Orientations in Appendix A)
G3: HEAD	The head position of the third designated gorilla (G3), if one exists. Values include: A, A+, B, B+, C, C+, D, D+, E, E+, F, F+, G, G+, H, H+, I, I+, J, J+, K, K+, L, or L+. (See Head Orientations in Appendix A)
G4: HEAD	The head position of the fourth designated gorilla (G4), if one exists. Values include: A, A+, B, B+, C, C+, D, D+, E, E+, F, F+, G, G+, H, H+, I, I+, J, J+, K, K+, L, or L+. (See Head Orientations in Appendix A)
G1 ID	The age class of the first designated gorilla (G1). Values include: IF, IM, JF, JM, SF, SM, AF, BB, or SB. Note: A designation of left ("L"), right ("R"), front ("F"), or back ("B") may be added behind the age class for clarification in situations where multiple gorillas of the same age class exist within the frame. For example, IB, AFL, etc.
G2 ID	The age class of the second designated gorilla (G2). Values include: IF, IM, JF, JM, SF, SM, AF, BB, or SB. Note: A designation of left ("L"), right ("R"), front ("F"), or back ("B") may be added behind the age class for clarification in situations where multiple gorillas of the same age class exist within the frame. For example, IB, AFL, etc.
G3 ID	The age class of the third designated gorilla (G3), if one exists. Values include: IF, IM, JF, JM, SF, SM, AF, BB, or SB. Note: A designation of left ("L"), right ("R"), front ("F"), or back ("B") may be added behind the age class for clarification in situations where multiple gorillas of the same age class exist within the frame. For example, IB, AFL, etc.
G4 ID	The age class of the fourth designated gorilla (G4), if one exists. Values include: IF, IM, JF, JM, SF, SM, AF, BB, or SB. (Note: A designation of left ("L"), right ("R"), front ("F"), or back ("B") may be added behind the age class for clarification in situations where multiple gorillas of the same age class exist within the frame. For example, IB, AFL, etc.
G1 (G5)	G1 represents the first designated gorilla within the frame. G5 represents the fifth designated gorilla, if one exists, within the frame. G1(G5) represents the orientational relationship between G1 and G5, as displayed on G1's Positional Circle. Values include: 0, .5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5, or 5.5.
G2 (G5)	G2 represents the second designated gorilla within the frame. G5 represents the fifth designated gorilla, if one exists, within the frame. G2(G5) represents the orientational relationship between G2 and G5, as displayed on G2's Positional Circle. Values include: 0, .5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5, or 5.5.

G3 (G5)	G3 represents the third designated gorilla, if one exists, within the frame. G5 represents the fifth designated gorilla, if one exists, within the frame. G3(G5) represents the orientational relationship between G3 and G5, as displayed on G3's Positional Circle. Values include: 0, .5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5, or 5.5.
G4 (G5)	G4 represents the fourth designated gorilla, if one exists, within the frame. G5 represents the fifth designated gorilla, if one exists, within the frame. G4(G5) represents the orientational relationship between G4 and G5, as displayed on G4's Positional Circle. Values include: 0, .5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5, or 5.5.
G5 (G1)	G5 represents the fifth designated gorilla, if one exists, within the frame. G1 represents the first designated gorilla within the frame. G5(G1) represents the orientational relationship between G5 and G1, as displayed on G5's Positional Circle. Values include: 0, .5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5, or 5.5.
G5 (G2)	G5 represents the fifth designated gorilla, if one exists, within the frame. G2 represents the second designated gorilla within the frame. G5(G2) represents the orientational relationship between G5 and G2, as displayed on G5's Positional Circle. Values include: 0, .5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5, or 5.5.
G5 (G3)	G5 represents the fifth designated gorilla, if one exists, within the frame. G3 represents the third designated gorilla, if one exists, within the frame. G5(G3) represents the orientational relationship between G5 and G3, as displayed on G5's Positional Circle. Values include: 0, .5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5, or 5.5.
G5 (G4)	G5 represents the fifth designated gorilla, if one exists, within the frame. G4 represents the fourth designated gorilla, if one exists, within the frame. G5(G4) represents the orientational relationship between G5 and G4, as displayed on G5's Positional Circle. Values include: 0, .5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5, or 5.5.
G5: CAM	The camera angle in relation to the fifth designated gorilla (G5), if one exists, as displayed on G5's Positional Circle. Values include: 0, .5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5, or 5.5.
G5: HEAD	The head position of the fifth designated gorilla (G5), if one exists. Values include: A, A+, B, B+, C, C+, D, D+, E, E+, F, F+, G, G+, H, H+, I, I+, J, J+, K, K+, L, or L+. (See Head Orientations in Appendix A)
G5 ID	The age class of the fifth designated gorilla (G5), if one exists. Values include: IF, IM, JF, JM, SF, SM, AF, BB, or SB. Note: A designation of left ("L"), right ("R"), front ("F"), or back ("B") may be added behind the age class for clarification in situations where multiple gorillas of the same age class exist within the frame. For example, IB, AFL, etc.

Cross Out Unused Boxes On Data Sheet

We will be working across from left to right on each row. The column titled "P1#" indicates how many gorillas are in the frame. If there are only 2 gorillas, any reference to G3 or G4 on the data sheet on that page can be crossed off, as shown in the data sheet example above.

Assign Numbers to Each Gorilla

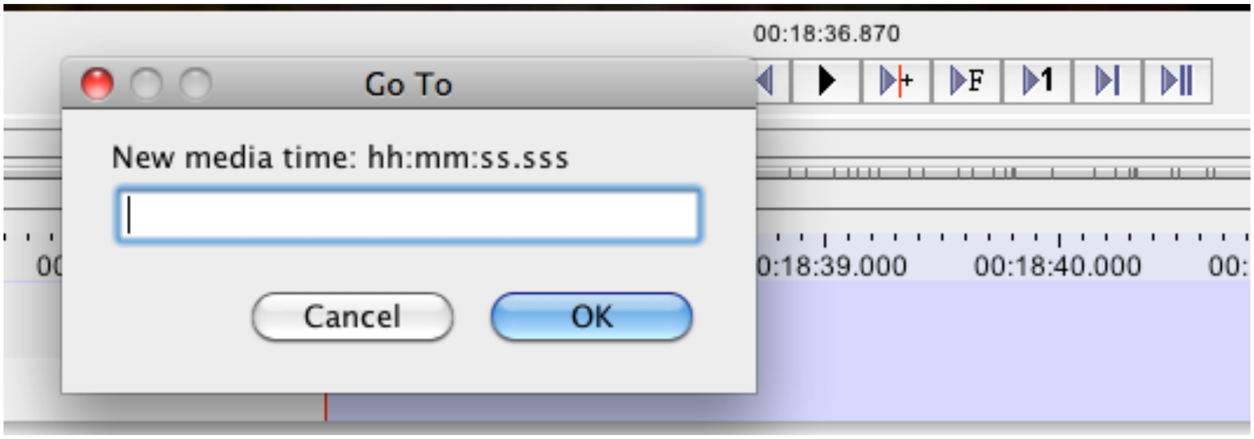
ID each gorilla (you can use their given names or age-classes) and assign each gorilla to numbers 1-4 (if two gorillas 1-2 and if three gorillas 1-3). Enter in their respective ID under **G1 ID, G2 ID, G3 ID**, and **G4 ID** at the top.

Age classes are as follows:

IF = infant female (0-4 years)
IM = infant male (0-4 years)
JF = juvenile female (4-6 years)
JM = juvenile male (4-6 years)
SF = subadult female (6-8 years)
SM = subadult male (6-8 years)
AF = adult female (> 8 years)
BB = blackback (8-12 years)
SB = silverback (> 12 years)

Move Video to Exact Time

Only look at the Phase 2 snapshot in time given under "PHASE 2 TIMES." To get to an exact time, click on the time above the media control buttons in ELAN and enter the time in hh:mm:ss.sss, as shown here:



Place Gorillas on Positional Circles

Place the POSITIONAL CIRCLE below each gorilla in the frame such that his/her shoulders are perpendicular to 0 (zero) on the circle

Gorilla 1

When logging numbers in this section, the selection is normally 0, 1, or 5; however, use the following rules if the orientation falls between two numbers on the circle:

- In the case of 1.5, 2.5, 3.5 and 4.5, write "*OUT*"
- In the case of .5 and 5.5, log 0

- Using the POSITIONAL CIRCLE under Gorilla 1, determine the orientation to Gorilla 2. If the number is 2, 3, or 4, write "*OUT*" under **G1 (G2)**; otherwise, log the number.

➢ *If only 2 gorillas, skip to Step 6.*

- Using the POSITIONAL CIRCLE under Gorilla 1, determine the orientation to Gorilla 3. If the number is 2, 3, or 4, write "*OUT*" under **G1 (G3)**; otherwise, log the number.

➢ *If only 3 gorillas, skip to Step 6.*

- Using the POSITIONAL CIRCLE under Gorilla 1, determine the orientation to Gorilla 4. If the number is 2, 3, or 4, write "*OUT*" under **G1 (G4)**; otherwise, log the number.

Gorilla 2

When logging numbers in this section, the selection is normally 0, 1, or 5; however, use the following rules if the orientation falls between two numbers on the circle:

- o In the case of 1.5, 2.5, 3.5 and 4.5, write "*OUT*"
- o In the case of .5 and 5.5, log 0

- Using the POSITIONAL CIRCLE under Gorilla 2, determine the orientation to Gorilla 1. If the number is 2, 3, or 4, write "*OUT*" under **G2 (G1)**; otherwise, log the number.

➢ *If only 2 gorillas, skip to Step 9.*

- Using the POSITIONAL CIRCLE under Gorilla 2, determine the orientation to Gorilla 3. If the number is 2, 3, or 4, write "*OUT*" under **G2 (G3)**; otherwise, log the number.

➢ *If only 3 gorillas, skip to Step 7.*

- Using the POSITIONAL CIRCLE under Gorilla 2, determine the orientation to Gorilla 4. If the number is 2, 3, or 4, write "*OUT*" under **G2 (G4)**; otherwise, log the number.

Gorilla 3

When logging numbers in this section, the selection is normally 0, 1, or 5; however, use the following rules if the orientation falls between two numbers on the circle:

- o In the case of 1.5, 2.5, 3.5 and 4.5, write "*OUT*"
- o In the case of .5 and 5.5, log 0

- Using the POSITIONAL CIRCLE under Gorilla 3, determine the orientation to Gorilla 1. If the number is 2, 3, or 4, write "*OUT*" under **G3 (G1)**; otherwise, log the number.

- Using the POSITIONAL CIRCLE under Gorilla 3, determine the orientation to Gorilla 2. If the number is 2, 3, or 4, write "*OUT*" under **G3 (G2)**; otherwise, log the number.

➢ *If only 3 gorillas, skip to Step 9.*

- Using the POSITIONAL CIRCLE under Gorilla 3, determine the orientation to

Gorilla 4. If the number is 2, 3, or 4, write "*OUT*" under **G3 (G4)**; otherwise, log the number.

Gorilla 4

When logging numbers in this section, the selection is normally 0, 1, or 5; however, use the following rules if the orientation falls between two numbers on the circle:

- In the case of 1.5, 2.5, 3.5 and 4.5, write "*OUT*"
- In the case of .5 and 5.5, log 0

- Using the POSITIONAL CIRCLE under Gorilla 4, determine the orientation to Gorilla 1. If the number is 2, 3, or 4, write "*OUT*" under **G4 (G1)**; otherwise, log the number.

- Using the POSITIONAL CIRCLE under Gorilla 4, determine the orientation to Gorilla 2. If the number is 2, 3, or 4, write "*OUT*" under **G4 (G2)**; otherwise, log the number.

- Using the POSITIONAL CIRCLE under Gorilla 4, determine the orientation to Gorilla 3. If the number is 2, 3, or 4, write "*OUT*" under **G4 (G3)**; otherwise, log the number.

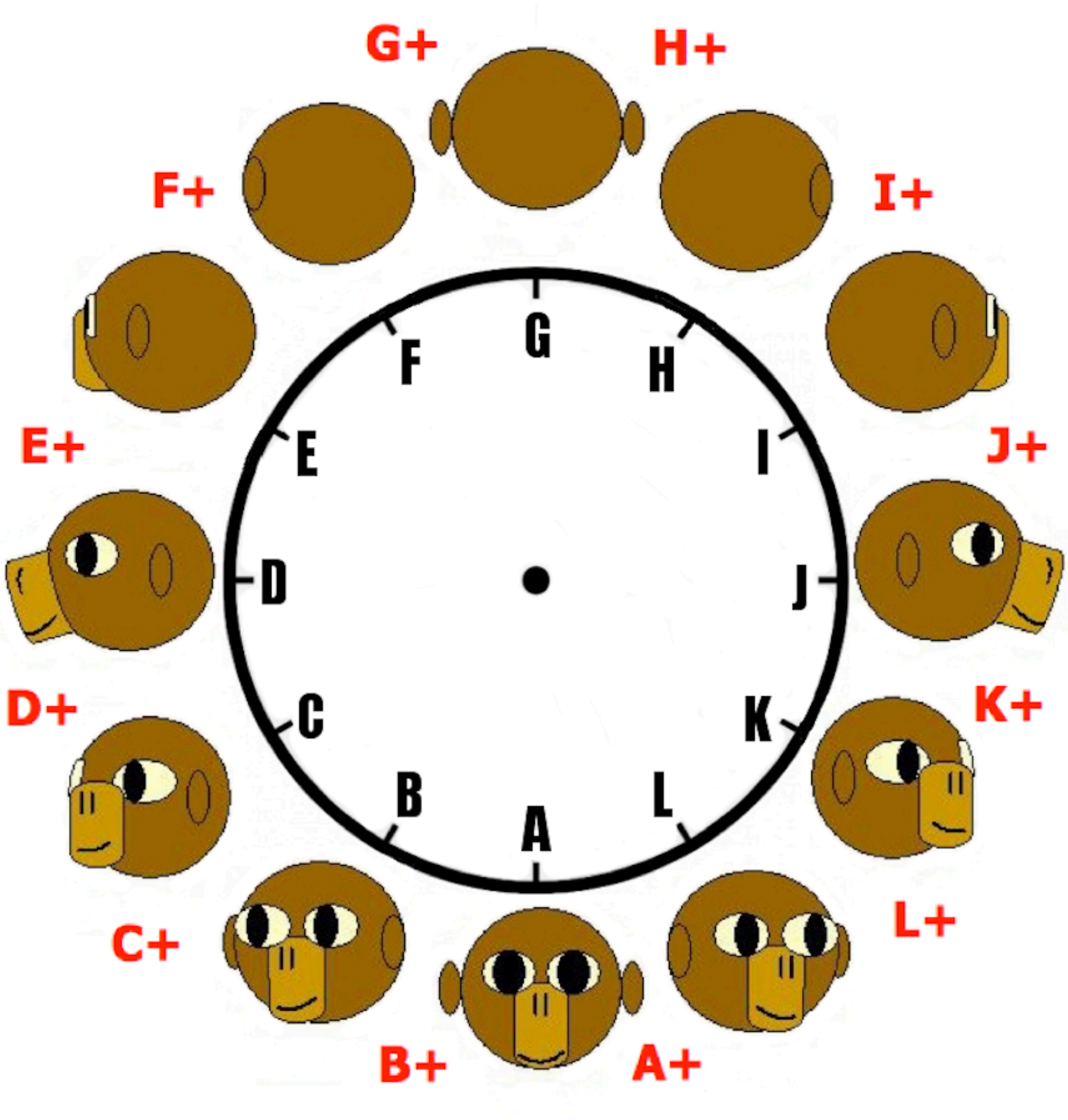
Camera Angles

When logging numbers in this section, the selection is normally 0-5; however, .5, 1.5, 2.5, 3.5, 4.5, and 5.5 may be used.

- Determine the orientation (using the POSITIONAL CIRCLE under Gorilla 1) of the camera to Gorilla 1. Log this number under **G1:CAM**.
- Determine the orientation (using the POSITIONAL CIRCLE under Gorilla 2) of the camera to Gorilla 2. Log this number under **G2:CAM**.
- *If only 2 gorillas, skip to Step 10.*
- Determine the orientation (using the POSITIONAL CIRCLE under Gorilla 3) of the camera to Gorilla 3. Log this number under **G3:CAM**.
- *If only 3 gorillas, skip to Step 10.*
- Determine the orientation (using the POSITIONAL CIRCLE under Gorilla 4) of the camera to Gorilla 4. Log this number under **G4:CAM**.

Head Orientations

Use the following figure to determine exactly what the camera sees as far as head orientation of each gorilla.



In the case of Head Orientation C and K, make sure that the second eye is slightly visible.

- Log this letter under **G1:HEAD.**
- Log this letter under **G2:HEAD.**

➢ *If only 2 gorillas, skip to Step 11.*

- Log this letter under **G3:HEAD.**

➢ *If only 3 gorillas, skip to Step 11.*

- Log this letter under **G4:HEAD.**

Advance Video

In ELAN, use the  button to advance exactly 1 second. If the time advanced is the same as the time printed on the next row of the data sheet, start over at Step 4; otherwise, start at Step 3.

An example data sheet for Phase 3 filled out:

PHASE 3 SAN DIEGO-DAY1-1 masters.eaf

P1 #	PHASE 2 TIMES	G1 (G2)	G1 (G3)	G1 (G4)	G2 (G1)	G2 (G3)	G2 (G4)	G3 (G1)	G3 (G2)	G3 (G4)	G4 (G1)	G4 (G2)	G4 (G3)	G1: CAM	G2: CAM	G3: CAM	G4: CAM	G1: HEAD	G2: HEAD	G3: HEAD	G4: HEAD	G1 ID	G2 ID	G3 ID	G4 ID	G1 (G5)	G2 (G5)	G3 (G5)	G4 (G5)	G5 (G1)	G5 (G2)	G5 (G3)	G5 (G4)	G5: CAM	G5: HEAD	G5 ID
5	00:03:25.780	5.5	0	0	5.5	4.5	5	5.5	1	0	2	4.5	0	1.5	5	5	1	J	D	D	K	SM	SB	AF	IML	0	4.5	1	5	.5	2.5	5.5	.5	0	B	IMR
5	00:03:26.780	5.5	0	0	5.5	4.5	5	5.5	1	0	2	4.5	0	1.5	5	5	1	J	D	D	K+	SM	SB	AF	IML	0	4.5	1	5	.5	2.5	5.5	.5	0	B	IMR
5	00:03:29.780	5.5	0	X	5.5	4.5	X	5.5	1	X	X	X	X	1.5	5	5	X	J	D	D	X	SM	SB	AF	IML	0	4.5	1	5	.5	2.5	5.5	.5	0	B	IMR
4	00:03:38.420	5.5	X	X	5.5	X	X	X	X	X	X	X	X	1.5	5	X	X	K	D+	X	X	SM	SB	AF	IML											
4	00:03:39.420	5.5	X	X	5.5	X	X	X	X	X	X	X	X	1.5	5	X	X	K	D	X	X	SM	SB	AF	IML											
4	00:03:40.420	5.5	X	X	5.5	X	X	X	X	X	X	X	X	1.5	5	X	X	K	C	X	X	SM	SB	AF	IML											
3	00:03:44.090	5.5	X		5.5	X		X	X					1.5	5	X		I	C	X		SM	SB	AF												
3	00:03:45.090	5.5	X		5.5	X		X	X					1.5	5	X		I	C	X		SM	SB	AF												
3	00:05:36.250																																			
2	00:05:37.980	4.5			1.5									5	5			D+	E			SB	SM													
2	00:05:38.980	4.5			1.5									5	5			D+	E			SB	SM													
2	00:05:39.980	4.5			1.5									5	5			D+	E			SB	SM													
3	00:07:27.160	X	.5		X	X		5	X					5	X	0		D+	X	L		SB	IM	SM												
4	00:07:27.340	X	.5	X	X	X	X	5	X	X	X	X	X	5	X	0	X	C	X	A	X	SB	IMF	SM	IMB											
3	00:07:28.470	X	5.5		X	X		2	X					5	X	4.5		C	X	E		SB	IMB	SM												
2	00:07:30.050																																			

Note: A blank or "X" may be used in any cell where the coder is unable to make a clear assessment.

Appendix B

Excel Spreadsheet Variables and Formulas

Chart for Coding Head Position

(Phase 4)

EXCEL SPREADSHEET VARIABLES and FORMULAS

G1 CAM+HEAD	**DEFINITION**	G1 CAM is the camera angle in relation to the first designated gorilla (G1) as displayed on G1's Positional Circle. Values include: 0, .5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5, or 5.5. HEAD is the head position of the first designated gorilla (G1). Values include: A, A+, B, B+, C, C+, D, D+, E, E+, F, F+, G, G+, H, H+, I, I+, J, J+, K, K+, L, or L+. (See Head Orientations in Appendix A). G1 CAM+HEAD concatenates the camera angle and the head position into one string (for example, 1.5J).
	EXCEL FORMULA	$S2&$X2
G2 CAM+HEAD	**DEFINITION**	G2 CAM is the camera angle in relation to the second designated gorilla (G2) as displayed on G2's Positional Circle. Values include: 0, .5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5, or 5.5. HEAD is the head position of the second designated gorilla (G2). Values include: A, A+, B, B+, C, C+, D, D+, E, E+, F, F+, G, G+, H, H+, I, I+, J, J+, K, K+, L, or L+. (See Head Orientations in Appendix A). G2 CAM+HEAD concatenates the camera angle and the head position into one string (for example, 1.5J).
	EXCEL FORMULA	$T2&$Y2
G3 CAM+HEAD	**DEFINITION**	G3 CAM is the camera angle in relation to the third designated gorilla (G3), if one exists, as displayed on G3's Positional Circle. Values include: 0, .5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5, or 5.5. HEAD is the head position of the third designated gorilla (G3), if one exists. Values include: A, A+, B, B+, C, C+, D, D+, E, E+, F, F+, G, G+, H, H+, I, I+, J, J+, K, K+, L, or L+. (See Head Orientations in Appendix A). G3 CAM+HEAD concatenates the camera angle and the head position into one string (for example, 1.5J).
	EXCEL FORMULA	$U2&$Z2
G4 CAM+HEAD	**DEFINITION**	G4 CAM is the camera angle in relation to the fourth designated gorilla (G4), if one exists, as displayed on G4's Positional Circle. Values include: 0, .5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5, or 5.5. HEAD is the head position of the fourth designated gorilla (G4), if one exists. Values include: A, A+, B, B+, C, C+, D, D+, E, E+, F, F+, G, G+, H, H+, I, I+, J, J+, K, K+, L, or L+. (See Head Orientations in Appendix A). G4 CAM+HEAD concatenates the camera angle and the head position into one string (for example, 1.5J).
	EXCEL FORMULA	$V2&$AA2

G5 CAM+HEAD	**DEFINITION**	G5 CAM is the camera angle in relation to the fifth designated gorilla (G5), if one exists, as displayed on G5's Positional Circle. Values include: 0, .5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5, or 5.5. HEAD is the head position of the fifth designated gorilla (G5), if one exists. Values include: A, A+, B, B+, C, C+, D, D+, E, E+, F, F+, G, G+, H, H+, I, I+, J, J+, K, K+, L, or L+. (See Head Orientations in Appendix A). G5 CAM+HEAD concatenates the camera angle and the head position into one string (for example, 1.5J).
	EXCEL FORMULA	$AU2&$AW2
G1 CHART CODE	**DEFINITION**	The chart code uses the camera angle and head position of the first designated gorilla (G1), as displayed on G1's Positional Circle and assigns a code that is used in the variables below. Values include: 0, 0.25, 0.5, 0.75, 1, 1.25, 1.5, 1.75, 2, 2.25, 2.5, 2.75, 3, 3.25, 3.5, 3.75, 4, 4.25, 4.5, 4.75, 5, 5.25, 5.5, or 5.75. (See Chart for Coding Head Position in Appendix B).
	EXCEL FORMULA	IF(OR($BA2 = "",ISNUMBER(SEARCH("X",$BA2))),"",VLOOKUP($BA2,'[CHART for CODING HEAD POSITION.xlsx]Sheet1'!$A$2:$E$300,5,FALSE))
G2 CHART CODE	**DEFINITION**	The chart code uses the camera angle and head position of the second designated gorilla (G2), as displayed on G2's Positional Circle and assigns a code that is used in the variables below. Values include: 0, 0.25, 0.5, 0.75, 1, 1.25, 1.5, 1.75, 2, 2.25, 2.5, 2.75, 3, 3.25, 3.5, 3.75, 4, 4.25, 4.5, 4.75, 5, 5.25, 5.5, or 5.75. (See Chart for Coding Head Position in Appendix B).
	EXCEL FORMULA	IF(OR($BB2 = "",ISNUMBER(SEARCH("X",$BB2))),"",VLOOKUP($BB2,'[CHART for CODING HEAD POSITION.xlsx]Sheet1'!$A$2:$E$300,5,FALSE))
G3 CHART CODE	**DEFINITION**	The chart code uses the camera angle and head position of the third designated gorilla (G3), if one exists, as displayed on G3's Positional Circle and assigns a code that is used in the variables below. Values include: 0, 0.25, 0.5, 0.75, 1, 1.25, 1.5, 1.75, 2, 2.25, 2.5, 2.75, 3, 3.25, 3.5, 3.75, 4, 4.25, 4.5, 4.75, 5, 5.25, 5.5, or 5.75. (See Chart for Coding Head Position in Appendix B).
	EXCEL FORMULA	IF(OR($BC2 = "",ISNUMBER(SEARCH("X",$BC2))),"",VLOOKUP($BC2,'[CHART for CODING HEAD POSITION.xlsx]Sheet1'!$A$2:$E$300,5,FALSE))

G4 CHART CODE	**DEFINITION**	The chart code uses the camera angle and head position of the fourth designated gorilla (G4), if one exists, as displayed on G4's Positional Circle and assigns a code that is used in the variables below. Values include: 0, 0.25, 0.5, 0.75, 1, 1.25, 1.5, 1.75, 2, 2.25, 2.5, 2.75, 3, 3.25, 3.5, 3.75, 4, 4.25, 4.5, 4.75, 5, 5.25, 5.5, or 5.75. (See Chart for Coding Head Position in Appendix B).
	EXCEL FORMULA	IF(OR($BD2 = ””,ISNUMBER(SEARCH(“X”,$BD2))),””,VLOOKUP($BD2,’[CHART for CODING HEAD POSITION.xlsx]Sheet1’!$A$2:$E$300,5,FALSE))
G5 CHART CODE	**DEFINITION**	The chart code uses the camera angle and head position of the fifth designated gorilla (G5), if one exists, as displayed on G5's Positional Circle and assigns a code that is used in the variables below. Values include: 0, 0.25, 0.5, 0.75, 1, 1.25, 1.5, 1.75, 2, 2.25, 2.5, 2.75, 3, 3.25, 3.5, 3.75, 4, 4.25, 4.5, 4.75, 5, 5.25, 5.5, or 5.75. (See Chart for Coding Head Position in Appendix B).
	EXCEL FORMULA	IF(OR($BE2 = ””,ISNUMBER(SEARCH(“X”,$BE2))),””,VLOOKUP($BE2,’[CHART for CODING HEAD POSITION.xlsx]Sheet1’!$A$2:$E$300,5,FALSE))
G1- > G2 HEAD ORIENTED?	**DEFINITION**	G1 represents the first designated gorilla within the frame. G2 represents the second designated gorilla within the frame. The Excel formula will determine if G1's head is oriented toward G2. The result is either G1's age class- > G2's age class = Y or G1's age class- > G2's age class = N. “Y” means yes and “N” means no.
	EXCEL FORMULA	IF(OR($BA2 = ””,$BB2 = ””,ISNUMBER(SEARCH(“X”,$BA2)),ISNUMBER(SEARCH(“X”,$BB2))),””, CONCATENATE($AC2,”- > ”,$AD2,” = ”,IF(AND($C2 = ”0”,OR($BG2 = 5.75,$BG2 = 0,$BG2 = 0.25)),”Y”,IF(AND($C2 = ”.5”,OR($BG2 = 0.25,$BG2 = 0.5,$BG2 = 0.75)),”Y”,IF(AND($C2 = ”1”,OR($BG2 = 0.75,$BG2 = 1,$BG2 = 1.25)),”Y”,IF(AND($C2 = ”1.5”,OR($BG2 = 1.25,$BG2 = 1.5,$BG2 = 1.75)),”Y”,IF(AND($C2 = ”2”,OR($BG2 = 1.75,$BG2 = 2,$BG2 = 2.25)),”Y”,IF(AND($C2 = ”2.5”,OR($BG2 = 2.25,$BG2 = 2.5,$BG2 = 2.75)),”Y”,IF(AND($C2 = ”3”,OR($BG2 = 2.75,$BG2 = 3,$BG2 = 3.25)),”Y”,IF(AND($C2 = ”3.5”,OR($BG2 = 3.25,$BG2 = 3.5,$BG2 = 3.75)),”Y”,IF(AND($C2 = ”4”,OR($BG2 = 3.75,$BG2 = 4,$BG2 = 4.25)),”Y”,IF(AND($C2 = ”4.5”,OR($BG2 = 4.25,$BG2 = 4.5,$BG2 = 4.75)),”Y”,IF(AND($C2 = ”5”,OR($BG2 = 4.75,$BG2 = 5,$BG2 = 5.25)),”Y”,IF(AND($C2 = ”5.5”,OR($BG2 = 5.25,$BG2 = 5.5,$BG2 = 5.75)),”Y”,”N”)))))))))))))

G1- > G3 HEAD ORIENTED?	**DEFINITION**	G1 represents the first designated gorilla within the frame. G3 represents the third designated gorilla, if one exists, within the frame. The Excel formula will determine if G1's head is oriented toward G3. The result is either G1's age class- > G3's age class = Y or G1's age class- > G3's age class = N. "Y" means yes and "N" means no.
	EXCEL FORMULA	IF(OR($BA2 = "",$BC2 = "",ISNUMBER(SEARCH("X",$BA2)),ISNUMBER(SEARCH("X",$BC2))),"", CONCATENATE($AC2,"- > ",$AE2," = ",IF(AND($D2 = "0",OR($BG2 = 5.75,$BG2 = 0,$BG2 = 0.25)),"Y",IF(AND($D2 = ".5",OR($BG2 = 0.25,$BG2 = 0.5,$BG2 = 0.75)),"Y",IF(AND($D2 = "1",OR($BG2 = 0.75,$BG2 = 1,$BG2 = 1.25)),"Y",IF(AND($D2 = "1.5",OR($BG2 = 1.25,$BG2 = 1.5,$BG2 = 1.75)),"Y",IF(AND($D2 = "2",OR($BG2 = 1.75,$BG2 = 2,$BG2 = 2.25)),"Y",IF(AND($D2 = "2.5",OR($BG2 = 2.25,$BG2 = 2.5,$BG2 = 2.75)),"Y",IF(AND($D2 = "3",OR($BG2 = 2.75,$BG2 = 3,$BG2 = 3.25)),"Y",IF(AND($D2 = "3.5",OR($BG2 = 3.25,$BG2 = 3.5,$BG2 = 3.75)),"Y",IF(AND($D2 = "4",OR($BG2 = 3.75,$BG2 = 4,$BG2 = 4.25)),"Y",IF(AND($D2 = "4.5",OR($BG2 = 4.25,$BG2 = 4.5,$BG2 = 4.75)),"Y",IF(AND($D2 = "5",OR($BG2 = 4.75,$BG2 = 5,$BG2 = 5.25)),"Y",IF(AND($D2 = "5.5",OR($BG2 = 5.25,$BG2 = 5.5,$BG2 = 5.75)),"Y","N"))))))))))))))
G1- > G4 HEAD ORIENTED?	**DEFINITION**	G1 represents the first designated gorilla within the frame. G4 represents the fourth designated gorilla, if one exists, within the frame. The Excel formula will determine if G1's head is oriented toward G4. The result is either G1's age class- > G4's age class = Y or G1's age class- > G4's age class = N. "Y" means yes and "N" means no.
	EXCEL FORMULA	IF(OR($BA2 = "",$BD2 = "",ISNUMBER(SEARCH("X",$BA2)),ISNUMBER(SEARCH("X",$BD2))),"", CONCATENATE($AC2,"- > ",$AF2," = ",IF(AND($E2 = "0",OR($BG2 = 5.75,$BG2 = 0,$BG2 = 0.25)),"Y",IF(AND($E2 = ".5",OR($BG2 = 0.25,$BG2 = 0.5,$BG2 = 0.75)),"Y",IF(AND($E2 = "1",OR($BG2 = 0.75,$BG2 = 1,$BG2 = 1.25)),"Y",IF(AND($E2 = "1.5",OR($BG2 = 1.25,$BG2 = 1.5,$BG2 = 1.7)),"Y",IF(AND($E2 = "2",OR($BG2 = 1.75,$BG2 = 2,$BG2 = 2.25)),"Y",IF(AND($E2 = "2.5",OR($BG2 = 2.25,$BG2 = 2.5,$BG2 = 2.75)),"Y",IF(AND($E2 = "3",OR($BG2 = 2.75,$BG2 = 3,$BG2 = 3.25)),"Y",IF(AND($E2 = "3.5",OR($BG2 = 3.25,$BG2 = 3.5,$BG2 = 3.75)),"Y",IF(AND($E2 = "4",OR($BG2 = 3.75,$BG2 = 4,$BG2 = 4.25)),"Y",IF(AND($E2 = "4.5",OR($BG2 = 4.25,$BG2 = 4.5,$BG2 = 4.7)),"Y",IF(AND($E2 = "5",OR($BG2 = 4.75,$BG2 = 5,$BG2 = 5.25)),"Y",IF(AND($E2 = "5.5",OR($BG2 = 5.25,$BG2 = 5.5,$BG2 = 5.75)),"Y","N"))))))))))))))

G1- > G5 HEAD ORIENTED?	**DEFINITION**	G1 represents the first designated gorilla within the frame. G5 represents the fifth designated gorilla, if one exists, within the frame. The Excel formula will determine if G1's head is oriented toward G5. The result is either G1's age class- > G5's age class = Y or G1's age class- > G5's age class = N. "Y" means yes and "N" means no.
	EXCEL FORMULA	IF(OR($BA2 = "",$BE2 = "",ISNUMBER(SEARCH("X",$BA2)),ISNUMBER(SEARCH("X",$BE2))),"", CONCATENATE($AC2,"- > ",$AY2," = ",IF(AND($AH2 = "0",OR($BG2 = 5.75,$BG2 = 0,$BG2 = 0.25)),"Y",IF(AND($AH2 = ".5",OR($BG2 = 0.25,$BG2 = 0.5,$BG2 = 0.75)),"Y",IF(AND($AH2 = "1",OR($BG2 = 0.75,$BG2 = 1,$BG2 = 1.25)),"Y",IF(AND($AH2 = "1.5",OR($BG2 = 1.25,$BG2 = 1.5,$BG2 = 1.75)),"Y",IF(AND($AH2 = "2",OR($BG2 = 1.75,$BG2 = 2,$BG2 = 2.25)),"Y",IF(AND($AH2 = "2.5",OR($BG2 = 2.25,$BG2 = 2.5,$BG2 = 2.75)),"Y",IF(AND($AH2 = "3",OR($BG2 = 2.75,$BG2 = 3,$BG2 = 3.25)),"Y",IF(AND($AH2 = "3.5",OR($BG2 = 3.25,$BG2 = 3.5,$BG2 = 3.75)),"Y",IF(AND($AH2 = "4",OR($BG2 = 3.75,$BG2 = 4,$BG2 = 4.25)),"Y",IF(AND($AH2 = "4.5",OR($BG2 = 4.25,$BG2 = 4.5,$BG2 = 4.75)),"Y",IF(AND($AH2 = "5",OR($BG2 = 4.75,$BG2 = 5,$BG2 = 5.25)),"Y",IF(AND($AH2 = "5.5",OR($BG2 = 5.25,$BG2 = 5.5,$BG2 = 5.75)),"Y","N")))))))))))))
G2- > G1 HEAD ORIENTED?	**DEFINITION**	G2 represents the second designated gorilla within the frame. G1 represents the first designated gorilla within the frame. The Excel formula will determine if G2's head is oriented toward G1. The result is either G2's age class- > G1's age class = Y or G2's age class- > G1's age class = N. "Y" means yes and "N" means no.
	EXCEL FORMULA	IF(OR($BB2 = "",$BA2 = "",ISNUMBER(SEARCH("X",$BB2)),ISNUMBER(SEARCH("X",$BA2))),"", CONCATENATE($AD2,"- > ",$AC2," = ",IF(AND($G2 = "0",OR($BH2 = 5.75,$BH2 = 0,$BH2 = 0.25)),"Y",IF(AND($G2 = ".5",OR($BH2 = 0.25,$BH2 = 0.5,$BH2 = 0.75)),"Y",IF(AND($G2 = "1",OR($BH2 = 0.75,$BH2 = 1,$BH2 = 1.25)),"Y",IF(AND($G2 = "1.5",OR($BH2 = 1.25,$BH2 = 1.5,$BH2 = 1.75)),"Y",IF(AND($G2 = "2",OR($BH2 = 1.75,$BH2 = 2,$BH2 = 2.25)),"Y",IF(AND($G2 = "2.5",OR($BH2 = 2.25,$BH2 = 2.5,$BH2 = 2.75)),"Y",IF(AND($G2 = "3",OR($BH2 = 2.75,$BH2 = 3,$BH2 = 3.25)),"Y",IF(AND($G2 = "3.5",OR($BH2 = 3.25,$BH2 = 3.5,$BH2 = 3.75)),"Y",IF(AND($G2 = "4",OR($BH2 = 3.75,$BH2 = 4,$BH2 = 4.25)),"Y",IF(AND($G2 = "4.5",OR($BH2 = 4.25,$BH2 = 4.5,$BH2 = 4.75)),"Y",IF(AND($G2 = "5",OR($BH2 = 4.75,$BH2 = 5,$BH2 = 5.25)),"Y",IF(AND($G2 = "5.5",OR($BH2 = 5.25,$BH2 = 5.5,$BH2 = 5.75)),"Y","N")))))))))))))

G2- > G3 HEAD ORIENTED?	**DEFINITION**	G2 represents the second designated gorilla within the frame. G3 represents the third designated gorilla, if one exists, within the frame. The Excel formula will determine if G2's head is oriented toward G3. The result is either G2's age class- > G3's age class = Y or G2's age class- > G3's age class = N. "Y" means yes and "N" means no.
	EXCEL FORMULA	IF(OR($BB2 = "",$BC2 = "",ISNUMBER(SEARCH("X",$BB2)),ISNUMBER(SEARCH("X",$BC2))),"", CONCATENATE($AD2,"- > ",$AE2," = ",IF(AND($H2 = "0",OR($BH2 = 5.75,$BH2 = 0,$BH2 = 0.25)),"Y",IF(AND($H2 = ".5",OR($BH2 = 0.25,$BH2 = 0.5,$BH2 = 0.75)),"Y",IF(AND($H2 = "1",OR($BH2 = 0.75,$BH2 = 1,$BH2 = 1.25)),"Y",IF(AND($H2 = "1.5",OR($BH2 = 1.25,$BH2 = 1.5,$BH2 = 1.75)),"Y",IF(AND($H2 = "2",OR($BH2 = 1.75,$BH2 = 2,$BH2 = 2.25)),"Y",IF(AND($H2 = "2.5",OR($BH2 = 2.25,$BH2 = 2.5,$BH2 = 2.75)),"Y",IF(AND($H2 = "3",OR($BH2 = 2.75,$BH2 = 3,$BH2 = 3.25)),"Y",IF(AND($H2 = "3.5",OR($BH2 = 3.25,$BH2 = 3.5,$BH2 = 3.75)),"Y",IF(AND($H2 = "4",OR($BH2 = 3.75,$BH2 = 4,$BH2 = 4.25)),"Y",IF(AND($H2 = "4.5",OR($BH2 = 4.25,$BH2 = 4.5,$BH2 = 4.75)),"Y",IF(AND($H2 = "5",OR($BH2 = 4.75,$BH2 = 5,$BH2 = 5.25)),"Y",IF(AND($H2 = "5.5",OR($BH2 = 5.25,$BH2 = 5.5,$BH2 = 5.75)),"Y","N"))))))))))))))
G2- > G4 HEAD ORIENTED?	**DEFINITION**	G2 represents the second designated gorilla within the frame. G4 represents the fourth designated gorilla, if one exists, within the frame. The Excel formula will determine if G2's head is oriented toward G4. The result is either G2's age class- > G4's age class = Y or G2's age class- > G4's age class = N. "Y" means yes and "N" means no.
	EXCEL FORMULA	IF(OR($BB2 = "",$BD2 = "",ISNUMBER(SEARCH("X",$BB2)),ISNUMBER(SEARCH("X",$BD2))),"", CONCATENATE($AD2,"- > ",$AF2," = ",IF(AND($I2 = "0",OR($BH2 = 5.75,$BH2 = 0,$BH2 = 0.25)),"Y",IF(AND($I2 = ".5",OR($BH2 = 0.25,$BH2 = 0.5,$BH2 = 0.75)),"Y",IF(AND($I2 = "1",OR($BH2 = 0.75,$BH2 = 1,$BH2 = 1.25)),"Y",IF(AND($I2 = "1.5",OR($BH2 = 1.25,$BH2 = 1.5,$BH2 = 1.75)),"Y",IF(AND($I2 = "2",OR($BH2 = 1.75,$BH2 = 2,$BH2 = 2.25)),"Y",IF(AND($I2 = "2.5",OR($BH2 = 2.25,$BH2 = 2.5,$BH2 = 2.75)),"Y",IF(AND($I2 = "3",OR($BH2 = 2.75,$BH2 = 3,$BH2 = 3.25)),"Y",IF(AND($I2 = "3.5",OR($BH2 = 3.25,$BH2 = 3.5,$BH2 = 3.75)),"Y",IF(AND($I2 = "4",OR($BH2 = 3.75,$BH2 = 4,$BH2 = 4.25)),"Y",IF(AND($I2 = "4.5",OR($BH2 = 4.25,$BH2 = 4.5,$BH2 = 4.75)),"Y",IF(AND($I2 = "5",OR($BH2 = 4.75,$BH2 = 5,$BH2 = 5.25)),"Y",IF(AND($I2 = "5.5",OR($BH2 = 5.25,$BH2 = 5.5,$BH2 = 5.75)),"Y","N"))))))))))))))

G2- > G5 HEAD ORIENTED?	**DEFINITION**	G2 represents the second designated gorilla within the frame. G5 represents the fifth designated gorilla, if one exists, within the frame. The Excel formula will determine if G2's head is oriented toward G5. The result is either G2's age class- > G5's age class = Y or G2's age class- > G5's age class = N. "Y" means yes and "N" means no.
	EXCEL FORMULA	IF(OR($BB2 = "",$BE2 = "",ISNUMBER(SEARCH("X",$BB2)),ISNUMBER(SEARCH("X",$BE2))),"", CONCATENATE($AD2,"- > ",$AY2," = ",IF(AND($AJ2 = "0",OR($BH2 = 5.75,$BH2 = 0,$BH2 = 0.25)),"Y",IF(AND($AJ2 = ".5",OR($BH2 = 0.25,$BH2 = 0.5,$BH2 = 0.75)),"Y",IF(AND($AJ2 = "1",OR($BH2 = 0.75,$BH2 = 1,$BH2 = 1.25)),"Y",IF(AND($AJ2 = "1.5",OR($BH2 = 1.25,$BH2 = 1.5,$BH2 = 1.75)),"Y",IF(AND($AJ2 = "2",OR($BH2 = 1.75,$BH2 = 2,$BH2 = 2.25)),"Y",IF(AND($AJ2 = "2.5",OR($BH2 = 2.25,$BH2 = 2.5,$BH2 = 2.75)),"Y",IF(AND($AJ2 = "3",OR($BH2 = 2.75,$BH2 = 3,$BH2 = 3.25)),"Y",IF(AND($AJ2 = "3.5",OR($BH2 = 3.25,$BH2 = 3.5,$BH2 = 3.75)),"Y",IF(AND($AJ2 = "4",OR($BH2 = 3.75,$BH2 = 4,$BH2 = 4.25)),"Y",IF(AND($AJ2 = "4.5",OR($BH2 = 4.25,$BH2 = 4.5,$BH2 = 4.75)),"Y",IF(AND($AJ2 = "5",OR($BH2 = 4.75,$BH2 = 5,$BH2 = 5.25)),"Y",IF(AND($AJ2 = "5.5",OR($BH2 = 5.25,$BH2 = 5.5,$BH2 = 5.75)),"Y","N"))))))))))))))
G3- > G1 HEAD ORIENTED?	**DEFINITION**	G3 represents the third designated gorilla, if one exists, within the frame. G1 represents the first designated gorilla within the frame. The Excel formula will determine if G3's head is oriented toward G1. The result is either G3's age class- > G1's age class = Y or G3's age class- > G1's age class = N. "Y" means yes and "N" means no.
	EXCEL FORMULA	IF(OR($BC2 = "",$BA2 = "",ISNUMBER(SEARCH("X",$BC2)),ISNUMBER(SEARCH("X",$BA2))),"", CONCATENATE($AE2,"- > ",$AC2," = ",IF(AND($K2 = "0",OR($BI2 = 5.75,$BI2 = 0,$BI2 = 0.25)),"Y",IF(AND($K2 = ".5",OR($BI2 = 0.25,$BI2 = 0.5,$BI2 = 0.75)),"Y",IF(AND($K2 = "1",OR($BI2 = 0.75,$BI2 = 1,$BI2 = 1.25)),"Y",IF(AND($K2 = "1.5",OR($BI2 = 1.25,$BI2 = 1.5,$BI2 = 1.75)),"Y",IF(AND($K2 = "2",OR($BI2 = 1.75,$BI2 = 2,$BI2 = 2.25)),"Y",IF(AND($K2 = "2.5",OR($BI2 = 2.25,$BI2 = 2.5,$BI2 = 2.75)),"Y",IF(AND($K2 = "3",OR($BI2 = 2.75,$BI2 = 3,$BI2 = 3.25)),"Y",IF(AND($K2 = "3.5",OR($BI2 = 3.25,$BI2 = 3.5,$BI2 = 3.75)),"Y",IF(AND($K2 = "4",OR($BI2 = 3.75,$BI2 = 4,$BI2 = 4.25)),"Y",IF(AND($K2 = "4.5",OR($BI2 = 4.25,$BI2 = 4.5,$BI2 = 4.75)),"Y",IF(AND($K2 = "5",OR($BI2 = 4.75,$BI2 = 5,$BI2 = 5.25)),"Y",IF(AND($K2 = "5.5",OR($BI2 = 5.25,$BI2 = 5.5,$BI2 = 5.75)),"Y","N"))))))))))))))

G3- > G2 HEAD ORIENTED?	**DEFINITION**	G3 represents the third designated gorilla, if one exists, within the frame. G2 represents the second designated gorilla within the frame. The Excel formula will determine if G3's head is oriented toward G2. The result is either G3's age class- > G2's age class = Y or G3's age class- > G2's age class = N. "Y" means yes and "N" means no.
	EXCEL FORMULA	IF(OR($BC2 = "",$BB2 = "",ISNUMBER(SEARCH("X",$BC2)),ISNUMBER(SEARCH("X",$BB2))),"", CONCATENATE($AE2,"- > ",$AD2," = ",IF(AND($L2 = "0",OR($BI2 = 5.75,$BI2 = 0,$BI2 = 0.25)),"Y",IF(AND($L2 = ".5",OR($BI2 = 0.25,$BI2 = 0.5,$BI2 = 0.75)),"Y",IF(AND($L2 = "1",OR($BI2 = 0.75,$BI2 = 1,$BI2 = 1.25)),"Y",IF(AND($L2 = "1.5",OR($BI2 = 1.25,$BI2 = 1.5,$BI2 = 1.75)),"Y",IF(AND($L2 = "2",OR($BI2 = 1.75,$BI2 = 2,$BI2 = 2.25)),"Y",IF(AND($L2 = "2.5",OR($BI2 = 2.25,$BI2 = 2.5,$BI2 = 2.75)),"Y",IF(AND($L2 = "3",OR($BI2 = 2.75,$BI2 = 3,$BI2 = 3.25)),"Y",IF(AND($L2 = "3.5",OR($BI2 = 3.25,$BI2 = 3.5,$BI2 = 3.75)),"Y",IF(AND($L2 = "4",OR($BI2 = 3.75,$BI2 = 4,$BI2 = 4.25)),"Y",IF(AND($L2 = "4.5",OR($BI2 = 4.25,$BI2 = 4.5,$BI2 = 4.75)),"Y",IF(AND($L2 = "5",OR($BI2 = 4.75,$BI2 = 5,$BI2 = 5.25)),"Y",IF(AND($L2 = "5.5",OR($BI2 = 5.25,$BI2 = 5.5,$BI2 = 5.75)),"Y","N"))))))))))))))
G3- > G4 HEAD ORIENTED?	**DEFINITION**	G3 represents the third designated gorilla, if one exists, within the frame. G4 represents the fourth designated gorilla, if one exists, within the frame. The Excel formula will determine if G3's head is oriented toward G4. The result is either G3's age class- > G4's age class = Y or G3's age class- > G4's age class = N. "Y" means yes and "N" means no.
	EXCEL FORMULA	IF(OR($BC2 = "",$BD2 = "",ISNUMBER(SEARCH("X",$BC2)),ISNUMBER(SEARCH("X",$BD2))),"", CONCATENATE($AE2,"- > ",$AF2," = ",IF(AND($M2 = "0",OR($BI2 = 5.75,$BI2 = 0,$BI2 = 0.25)),"Y",IF(AND($M2 = ".5",OR($BI2 = 0.25,$BI2 = 0.5,$BI2 = 0.75)),"Y",IF(AND($M2 = "1",OR($BI2 = 0.75,$BI2 = 1,$BI2 = 1.25)),"Y",IF(AND($M2 = "1.5",OR($BI2 = 1.25,$BI2 = 1.5,$BI2 = 1.75)),"Y",IF(AND($M2 = "2",OR($BI2 = 1.75,$BI2 = 2,$BI2 = 2.25)),"Y",IF(AND($M2 = "2.5",OR($BI2 = 2.25,$BI2 = 2.5,$BI2 = 2.75)),"Y",IF(AND($M2 = "3",OR($BI2 = 2.75,$BI2 = 3,$BI2 = 3.25)),"Y",IF(AND($M2 = "3.5",OR($BI2 = 3.25,$BI2 = 3.5,$BI2 = 3.75)),"Y",IF(AND($M2 = "4",OR($BI2 = 3.75,$BI2 = 4,$BI2 = 4.25)),"Y",IF(AND($M2 = "4.5",OR($BI2 = 4.25,$BI2 = 4.5,$BI2 = 4.75)),"Y",IF(AND($M2 = "5",OR($BI2 = 4.75,$BI2 = 5,$BI2 = 5.25)),"Y",IF(AND($M2 = "5.5",OR($BI2 = 5.25,$BI2 = 5.5,$BI2 = 5.75)),"Y","N"))))))))))))))

G3- > G5 HEAD ORIENTED?	**DEFINITION**	G3 represents the third designated gorilla, if one exists, within the frame. G5 represents the fifth designated gorilla, if one exists, within the frame. The Excel formula will determine if G3’s head is oriented toward G5. The result is either G3’s age class- > G5’s age class = Y or G3’s age class- > G5’s age class = N. “Y” means yes and “N” means no.
	EXCEL FORMULA	IF(OR($BC2 = ””,$BE2 = ””,ISNUMBER(SEARCH(“X”,$BC2)),ISNUMBER(SEARCH(“X”,$BE2))),””, CONCATENATE($AE2,”- > ”,$AY2,” = ”,IF(AND($AL2 = ”0”,OR($BI2 = 5.75,$BI2 = 0,$BI2 = 0.25)),”Y”,IF(AND($AL2 = ”.5”,OR($BI2 = 0.25,$BI2 = 0.5,$BI2 = 0.75)),”Y”,IF(AND($AL2 = ”1”,OR($BI2 = 0.75,$BI2 = 1,$BI2 = 1.25)),”Y”,IF(AND($AL2 = ”1.5”,OR($BI2 = 1.25,$BI2 = 1.5,$BI2 = 1.75)),”Y”,IF(AND($AL2 = ”2”,OR($BI2 = 1.75,$BI2 = 2,$BI2 = 2.25)),”Y”,IF(AND($AL2 = ”2.5”,OR($BI2 = 2.25,$BI2 = 2.5,$BI2 = 2.75)),”Y”,IF(AND($AL2 = ”3”,OR($BI2 = 2.75,$BI2 = 3,$BI2 = 3.25)),”Y”,IF(AND($AL2 = ”3.5”,OR($BI2 = 3.25,$BI2 = 3.5,$BI2 = 3.75)),”Y”,IF(AND($AL2 = ”4”,OR($BI2 = 3.75,$BI2 = 4,$BI2 = 4.25)),”Y”,IF(AND($AL2 = ”4.5”,OR($BI2 = 4.25,$BI2 = 4.5,$BI2 = 4.75)),”Y”,IF(AND($AL2 = ”5”,OR($BI2 = 4.75,$BI2 = 5,$BI2 = 5.25)),”Y”,IF(AND($AL2 = ”5.5”,OR($BI2 = 5.25,$BI2 = 5.5,$BI2 = 5.75)),”Y”,”N”)))))))))))))
G4- > G1 HEAD ORIENTED?	**DEFINITION**	G4 represents the fourth designated gorilla, if one exists, within the frame. G1 represents the first designated gorilla within the frame. The Excel formula will determine if G4’s head is oriented toward G1. The result is either G4’s age class- > G1’s age class = Y or G4’s age class- > G1’s age class = N. “Y” means yes and “N” means no.
	EXCEL FORMULA	IF(OR($BD2 = ””,$BA2 = ””,ISNUMBER(SEARCH(“X”,$BD2)),ISNUMBER(SEARCH(“X”,$BA2))),””, CONCATENATE($AF2,”- > ”,$AC2,” = ”,IF(AND($O2 = ”0”,OR($BJ2 = 5.75,$BJ2 = 0,$BJ2 = 0.25)),”Y”,IF(AND($O2 = ”.5”,OR($BJ2 = 0.25,$BJ2 = 0.5,$BJ2 = 0.75)),”Y”,IF(AND($O2 = ”1”,OR($BJ2 = 0.75,$BJ2 = 1,$BJ2 = 1.25)),”Y”,IF(AND($O2 = ”1.5”,OR($BJ2 = 1.25,$BJ2 = 1.5,$BJ2 = 1.75)),”Y”,IF(AND($O2 = ”2”,OR($BJ2 = 1.75,$BJ2 = 2,$BJ2 = 2.25)),”Y”,IF(AND($O2 = ”2.5”,OR($BJ2 = 2.25,$BJ2 = 2.5,$BJ2 = 2.75)),”Y”,IF(AND($O2 = ”3”,OR($BJ2 = 2.75,$BJ2 = 3,$BJ2 = 3.25)),”Y”,IF(AND($O2 = ”3.5”,OR($BJ2 = 3.25,$BJ2 = 3.5,$BJ2 = 3.75)),”Y”,IF(AND($O2 = ”4”,OR($BJ2 = 3.75,$BJ2 = 4,$BJ2 = 4.25)),”Y”,IF(AND($O2 = ”4.5”,OR($BJ2 = 4.25,$BJ2 = 4.5,$BJ2 = 4.75)),”Y”,IF(AND($O2 = ”5”,OR($BJ2 = 4.75,$BJ2 = 5,$BJ2 = 5.25)),”Y”,IF(AND($O2 = ”5.5”,OR($BJ2 = 5.25,$BJ2 = 5.5,$BJ2 = 5.75)),”Y”,”N”)))))))))))))

G4- > G2 HEAD ORIENTED?	**DEFINITION**	G4 represents the fourth designated gorilla, if one exists, within the frame. G2 represents the second designated gorilla within the frame. The Excel formula will determine if G4’s head is oriented toward G2. The result is either G4’s age class- > G2’s age class = Y or G4’s age class- > G2’s age class = N. “Y” means yes and “N” means no.
	EXCEL FORMULA	IF(OR($BD2 = ””,$BB2 = ””,ISNUMBER(SEARCH(“X”,$BD2)),ISNUMBER(SEARCH(“X”,$BB2))),””, CONCATENATE($AF2,”- > ”,$AD2,” = ”,IF(AND($P2 = ”0”,OR($BJ2 = 5.75,$BJ2 = 0,$BJ2 = 0.25)),”Y”,IF(AND($P2 = ”.5”,OR($BJ2 = 0.25,$BJ2 = 0.5,$BJ2 = 0.75)),”Y”,IF(AND($P2 = ”1”,OR($BJ2 = 0.75,$BJ2 = 1,$BJ2 = 1.25)),”Y”,IF(AND($P2 = ”1.5”,OR($BJ2 = 1.25,$BJ2 = 1.5,$BJ2 = 1.75)),”Y”,IF(AND($P2 = ”2”,OR($BJ2 = 1.75,$BJ2 = 2,$BJ2 = 2.25)),”Y”,IF(AND($P2 = ”2.5”,OR($BJ2 = 2.25,$BJ2 = 2.5,$BJ2 = 2.75)),”Y”,IF(AND($P2 = ”3”,OR($BJ2 = 2.75,$BJ2 = 3,$BJ2 = 3.25)),”Y”,IF(AND($P2 = ”3.5”,OR($BJ2 = 3.25,$BJ2 = 3.5,$BJ2 = 3.75)),”Y”,IF(AND($P2 = ”4”,OR($BJ2 = 3.75,$BJ2 = 4,$BJ2 = 4.25)),”Y”,IF(AND($P2 = ”4.5”,OR($BJ2 = 4.25,$BJ2 = 4.5,$BJ2 = 4.75)),”Y”,IF(AND($P2 = ”5”,OR($BJ2 = 4.75,$BJ2 = 5,$BJ2 = 5.25)),”Y”,IF(AND($P2 = ”5.5”,OR($BJ2 = 5.25,$BJ2 = 5.5,$BJ2 = 5.75)),”Y”,”N”)))))))))))))
G4- > G3 HEAD ORIENTED?	**DEFINITION**	G4 represents the fourth designated gorilla, if one exists, within the frame. G3 represents the third designated gorilla, if one exists, within the frame. The Excel formula will determine if G4’s head is oriented toward G3. The result is either G4’s age class- > G3’s age class = Y or G4’s age class- > G3’s age class = N. “Y” means yes and “N” means no.
	EXCEL FORMULA	IF(OR($BD2 = ””,$BC2 = ””,ISNUMBER(SEARCH(“X”,$BD2)),ISNUMBER(SEARCH(“X”,$BC2))),””, CONCATENATE($AF2,”- > ”,$AE2,” = ”,IF(AND($Q2 = ”0”,OR($BJ2 = 5.75,$BJ2 = 0,$BJ2 = 0.25)),”Y”,IF(AND($Q2 = ”.5”,OR($BJ2 = 0.25,$BJ2 = 0.5,$BJ2 = 0.75)),”Y”,IF(AND($Q2 = ”1”,OR($BJ2 = 0.75,$BJ2 = 1,$BJ2 = 1.25)),”Y”,IF(AND($Q2 = ”1.5”,OR($BJ2 = 1.25,$BJ2 = 1.5,$BJ2 = 1.75)),”Y”,IF(AND($Q2 = ”2”,OR($BJ2 = 1.75,$BJ2 = 2,$BJ2 = 2.25)),”Y”,IF(AND($Q2 = ”2.5”,OR($BJ2 = 2.25,$BJ2 = 2.5,$BJ2 = 2.75)),”Y”,IF(AND($Q2 = ”3”,OR($BJ2 = 2.75,$BJ2 = 3,$BJ2 = 3.25)),”Y”,IF(AND($Q2 = ”3.5”,OR($BJ2 = 3.25,$BJ2 = 3.5,$BJ2 = 3.75)),”Y”,IF(AND($Q2 = ”4”,OR($BJ2 = 3.75,$BJ2 = 4,$BJ2 = 4.25)),”Y”,IF(AND($Q2 = ”4.5”,OR($BJ2 = 4.25,$BJ2 = 4.5,$BJ2 = 4.75)),”Y”,IF(AND($Q2 = ”5”,OR($BJ2 = 4.75,$BJ2 = 5,$BJ2 = 5.25)),”Y”,IF(AND($Q2 = ”5.5”,OR($BJ2 = 5.25,$BJ2 = 5.5,$BJ2 = 5.75)),”Y”,”N”)))))))))))))

G4- > G5 HEAD ORIENTED?	**DEFINITION**	G4 represents the fourth designated gorilla, if one exists, within the frame. G5 represents the fifth designated gorilla, if one exists, within the frame. The Excel formula will determine if G4's head is oriented toward G5. The result is either G4's age class- > G5's age class = Y or G4's age class- > G5's age class = N. "Y" means yes and "N" means no.
	EXCEL FORMULA	IF(OR($BD2 = "",$BE2 = "",ISNUMBER(SEARCH("X",$BD2)),ISNUMBER(SEARCH("X",$BE2))),"", CONCATENATE($AF2,"- > ",$AY2," = ",IF(AND($AN2 = "0",OR($BJ2 = 5.75,$BJ2 = 0,$BJ2 = 0.25)),"Y",IF(AND($AN2 = ".5",OR($BJ2 = 0.25,$BJ2 = 0.5,$BJ2 = 0.75)),"Y",IF(AND($AN2 = "1",OR($BJ2 = 0.75,$BJ2 = 1,$BJ2 = 1.25)),"Y",IF(AND($AN2 = "1.5",OR($BJ2 = 1.25,$BJ2 = 1.5,$BJ2 = 1.75)),"Y",IF(AND($AN2 = "2",OR($BJ2 = 1.75,$BJ2 = 2,$BJ2 = 2.25)),"Y",IF(AND($AN2 = "2.5",OR($BJ2 = 2.25,$BJ2 = 2.5,$BJ2 = 2.75)),"Y",IF(AND($AN2 = "3",OR($BJ2 = 2.75,$BJ2 = 3,$BJ2 = 3.25)),"Y",IF(AND($AN2 = "3.5",OR($BJ2 = 3.25,$BJ2 = 3.5,$BJ2 = 3.75)),"Y",IF(AND($AN2 = "4",OR($BJ2 = 3.75,$BJ2 = 4,$BJ2 = 4.25)),"Y",IF(AND($AN2 = "4.5",OR($BJ2 = 4.25,$BJ2 = 4.5,$BJ2 = 4.75)),"Y",IF(AND($AN2 = "5",OR($BJ2 = 4.75,$BJ2 = 5,$BJ2 = 5.25)),"Y",IF(AND($AN2 = "5.5",OR($BJ2 = 5.25,$BJ2 = 5.5,$BJ2 = 5.75)),"Y","N"))))))))))))))
G5- > G1 HEAD ORIENTED?	**DEFINITION**	G5 represents the fifth designated gorilla, if one exists, within the frame. G1 represents the first designated gorilla within the frame. The Excel formula will determine if G5's head is oriented toward G1. The result is either G5's age class- > G1's age class = Y or G5's age class- > G1's age class = N. "Y" means yes and "N" means no.
	EXCEL FORMULA	IF(OR($BE2 = "",$BA2 = "",ISNUMBER(SEARCH("X",$BE2)),ISNUMBER(SEARCH("X",$BA2))),"", CONCATENATE($AY2,"- > ",$AC2," = ",IF(AND($AP2 = "0",OR($BK2 = 5.75,$BK2 = 0,$BK2 = 0.25)),"Y",IF(AND($AP2 = ".5",OR($BK2 = 0.25,$BK2 = 0.5,$BK2 = 0.75)),"Y",IF(AND($AP2 = "1",OR($BK2 = 0.75,$BK2 = 1,$BK2 = 1.25)),"Y",IF(AND($AP2 = "1.5",OR($BK2 = 1.25,$BK2 = 1.5,$BK2 = 1.75)),"Y",IF(AND($AP2 = "2",OR($BK2 = 1.75,$BK2 = 2,$BK2 = 2.25)),"Y",IF(AND($AP2 = "2.5",OR($BK2 = 2.25,$BK2 = 2.5,$BK2 = 2.75)),"Y",IF(AND($AP2 = "3",OR($BK2 = 2.75,$BK2 = 3,$BK2 = 3.25)),"Y",IF(AND($AP2 = "3.5",OR($BK2 = 3.25,$BK2 = 3.5,$BK2 = 3.75)),"Y",IF(AND($AP2 = "4",OR($BK2 = 3.75,$BK2 = 4,$BK2 = 4.25)),"Y",IF(AND($AP2 = "4.5",OR($BK2 = 4.25,$BK2 = 4.5,$BK2 = 4.75)),"Y",IF(AND($AP2 = "5",OR($BK2 = 4.75,$BK2 = 5,$BK2 = 5.25)),"Y",IF(AND($AP2 = "5.5",OR($BK2 = 5.25,$BK2 = 5.5,$BK2 = 5.75)),"Y","N"))))))))))))))

G5- > G2 HEAD ORIENTED?	**DEFINITION**	G5 represents the fifth designated gorilla, if one exists, within the frame. G2 represents the second designated gorilla within the frame. The Excel formula will determine if G5's head is oriented toward G2. The result is either G5's age class- > G2's age class = Y or G5's age class- > G2's age class = N. "Y" means yes and "N" means no.
	EXCEL FORMULA	IF(OR($BE2 = "",$BB2 = "",ISNUMBER(SEARCH("X",$BE2)),ISNUMBER(SEARCH("X",$BB2))),"", CONCATENATE($AY2,"- > ",$AD2," = ",IF(AND($AQ2 = "0",OR($BK2 = 5.75,$BK2 = 0,$BK2 = 0.25)),"Y",IF(AND($AQ2 = ".5",OR($BK2 = 0.25,$BK2 = 0.5,$BK2 = 0.75)),"Y",IF(AND($AQ2 = "1",OR($BK2 = 0.75,$BK2 = 1,$BK2 = 1.25)),"Y",IF(AND($AQ2 = "1.5",OR($BK2 = 1.25,$BK2 = 1.5,$BK2 = 1.75)),"Y",IF(AND($AQ2 = "2",OR($BK2 = 1.75,$BK2 = 2,$BK2 = 2.25)),"Y",IF(AND($AQ2 = "2.5",OR($BK2 = 2.25,$BK2 = 2.5,$BK2 = 2.75)),"Y",IF(AND($AQ2 = "3",OR($BK2 = 2.75,$BK2 = 3,$BK2 = 3.25)),"Y",IF(AND($AQ2 = "3.5",OR($BK2 = 3.25,$BK2 = 3.5,$BK2 = 3.75)),"Y",IF(AND($AQ2 = "4",OR($BK2 = 3.75,$BK2 = 4,$BK2 = 4.25)),"Y",IF(AND($AQ2 = "4.5",OR($BK2 = 4.25,$BK2 = 4.5,$BK2 = 4.75)),"Y",IF(AND($AQ2 = "5",OR($BK2 = 4.75,$BK2 = 5,$BK2 = 5.25)),"Y",IF(AND($AQ2 = "5.5",OR($BK2 = 5.25,$BK2 = 5.5,$BK2 = 5.75)),"Y","N")))))))))))))
G5- > G3 HEAD ORIENTED?	**DEFINITION**	G5 represents the fifth designated gorilla, if one exists, within the frame. G3 represents the third designated gorilla, if one exists, within the frame. The Excel formula will determine if G5's head is oriented toward G3. The result is either G5's age class- > G3's age class = Y or G5's age class- > G3's age class = N. "Y" means yes and "N" means no.
	EXCEL FORMULA	IF(OR($BE2 = "",$BC2 = "",ISNUMBER(SEARCH("X",$BE2)),ISNUMBER(SEARCH("X",$BC2))),"", CONCATENATE($AY2,"- > ",$AE2," = ",IF(AND($AR2 = "0",OR($BK2 = 5.75,$BK2 = 0,$BK2 = 0.25)),"Y",IF(AND($AR2 = ".5",OR($BK2 = 0.25,$BK2 = 0.5,$BK2 = 0.75)),"Y",IF(AND($AR2 = "1",OR($BK2 = 0.75,$BK2 = 1,$BK2 = 1.25)),"Y",IF(AND($AR2 = "1.5",OR($BK2 = 1.25,$BK2 = 1.5,$BK2 = 1.75)),"Y",IF(AND($AR2 = "2",OR($BK2 = 1.75,$BK2 = 2,$BK2 = 2.25)),"Y",IF(AND($AR2 = "2.5",OR($BK2 = 2.25,$BK2 = 2.5,$BK2 = 2.75)),"Y",IF(AND($AR2 = "3",OR($BK2 = 2.75,$BK2 = 3,$BK2 = 3.25)),"Y",IF(AND($AR2 = "3.5",OR($BK2 = 3.25,$BK2 = 3.5,$BK2 = 3.75)),"Y",IF(AND($AR2 = "4",OR($BK2 = 3.75,$BK2 = 4,$BK2 = 4.25)),"Y",IF(AND($AR2 = "4.5",OR($BK2 = 4.25,$BK2 = 4.5,$BK2 = 4.75)),"Y",IF(AND($AR2 = "5",OR($BK2 = 4.75,$BK2 = 5,$BK2 = 5.25)),"Y",IF(AND($AR2 = "5.5",OR($BK2 = 5.25,$BK2 = 5.5,$BK2 = 5.75)),"Y","N")))))))))))))

G5- > G4 HEAD ORIENTED?	DEFINITION	G5 represents the fifth designated gorilla, if one exists, within the frame. G4 represents the fourth designated gorilla, if one exists, within the frame. The Excel formula will determine if G5's head is oriented toward G4. The result is either G5's age class- > G4's age class = Y or G5's age class- > G4's age class = N. "Y" means yes and "N" means no.
	EXCEL FORMULA	IF(OR($BE2 = "",$BD2 = "",ISNUMBER(SEARCH("X",$BE2)),ISNUMBER(SEARCH("X",$BD2))),"", CONCATENATE($AY2,"- > ",$AF2," = ",IF(AND($AS2 = "0",OR($BK2 = 5.75,$BK2 = 0,$BK2 = 0.25)),"Y",IF(AND($AS2 = ".5",OR($BK2 = 0.25,$BK2 = 0.5,$BK2 = 0.75)),"Y",IF(AND($AS2 = "1",OR($BK2 = 0.75,$BK2 = 1,$BK2 = 1.25)),"Y",IF(AND($AS2 = "1.5",OR($BK2 = 1.25,$BK2 = 1.5,$BK2 = 1.75)),"Y",IF(AND($AS2 = "2",OR($BK2 = 1.75,$BK2 = 2,$BK2 = 2.25)),"Y",IF(AND($AS2 = "2.5",OR($BK2 = 2.25,$BK2 = 2.5,$BK2 = 2.75)),"Y",IF(AND($AS2 = "3",OR($BK2 = 2.75,$BK2 = 3,$BK2 = 3.25)),"Y",IF(AND($AS2 = "3.5",OR($BK2 = 3.25,$BK2 = 3.5,$BK2 = 3.75)),"Y",IF(AND($AS2 = "4",OR($BK2 = 3.75,$BK2 = 4,$BK2 = 4.25)),"Y",IF(AND($AS2 = "4.5",OR($BK2 = 4.25,$BK2 = 4.5,$BK2 = 4.75)),"Y",IF(AND($AS2 = "5",OR($BK2 = 4.75,$BK2 = 5,$BK2 = 5.25)),"Y",IF(AND($AS2 = "5.5",OR($BK2 = 5.25,$BK2 = 5.5,$BK2 = 5.75)),"Y","N"))))))))))))))
G1 <- > G2 MUTUAL HEAD ORIENTION ?	DEFINITION	G1 represents the first designated gorilla within the frame. G2 represents the second designated gorilla within the frame. The Excel formula will determine if G1 and G2 are mutually oriented toward each other. The result is either G1's age class<- > G2's age class or blank.
	EXCEL FORMULA	IF(AND(ISNUMBER(SEARCH("Y",$CL2)),ISNUMBER(SEARCH("Y",$CQ2))), CONCATENATE($AC2," <- > ",$AD2),"")
G1 <- > G3 MUTUAL HEAD ORIENTION ?	DEFINITION	G1 represents the first designated gorilla within the frame. G3 represents the third designated gorilla, if one exists, within the frame. The Excel formula will determine if G1 and G3 are mutually oriented toward each other. The result is either G1's age class<- > G3's age class or blank.
	EXCEL FORMULA	IF(AND(ISNUMBER(SEARCH("Y",$CM2)),ISNUMBER(SEARCH("Y",$CV2))), CONCATENATE($AC2," <- > ",$AE2),"")
G1 <- > G4 MUTUAL HEAD ORIENTION ?	DEFINITION	G1 represents the first designated gorilla within the frame. G4 represents the fourth designated gorilla, if one exists, within the frame. The Excel formula will determine if G1 and G4 are mutually oriented toward each other. The result is either G1's age class<- > G4's age class or blank.
	EXCEL FORMULA	IF(AND(ISNUMBER(SEARCH("Y",$CN2)),ISNUMBER(SEARCH("Y",$DA2))), CONCATENATE($AC2," <- > ",$AF2),"")

G1 <- > G5 MUTUAL HEAD ORIENTION ?	**DEFINITION**	G1 represents the first designated gorilla within the frame. G5 represents the fifth designated gorilla, if one exists, within the frame. The Excel formula will determine if G1 and G5 are mutually oriented toward each other. The result is either G1's age class<- > G5's age class or blank.
	EXCEL FORMULA	IF(AND(ISNUMBER(SEARCH("Y",$CO2)),ISNUMBER(SEARCH("Y",$DF2))), CONCATENATE($AC2," <- > ",$AY2),"")
G2 <- > G3 MUTUAL HEAD ORIENTION ?	**DEFINITION**	G2 represents the second designated gorilla within the frame. G3 represents the third designated gorilla, if one exists, within the frame. The Excel formula will determine if G2 and G3 are mutually oriented toward each other. The result is either G2's age class<- > G3's age class or blank.
	EXCEL FORMULA	IF(AND(ISNUMBER(SEARCH("Y",$CR2)),ISNUMBER(SEARCH("Y",$CW2))), CONCATENATE($AD2," <- > ",$AE2),"")
G2 <- > G4 MUTUAL HEAD ORIENTION ?	**DEFINITION**	G2 represents the second designated gorilla within the frame. G4 represents the fourth designated gorilla, if one exists, within the frame. The Excel formula will determine if G2 and G4 are mutually oriented toward each other. The result is either G2's age class<- > G4's age class or blank.
	EXCEL FORMULA	IF(AND(ISNUMBER(SEARCH("Y",$CS2)),ISNUMBER(SEARCH("Y",$DB2))), CONCATENATE($AD2," <- > ",$AF2),"")
G2 <- > G5 MUTUAL HEAD ORIENTION ?	**DEFINITION**	G2 represents the second designated gorilla within the frame. G5 represents the fifth designated gorilla, if one exists, within the frame. The Excel formula will determine if G2 and G5 are mutually oriented toward each other. The result is either G2's age class<- > G5's age class or blank.
	EXCEL FORMULA	IF(AND(ISNUMBER(SEARCH("Y",$CT2)),ISNUMBER(SEARCH("Y",$DG2))), CONCATENATE($AD2," <- > ",$AY2),"")
G3 <- > G4 MUTUAL HEAD ORIENTION ?	**DEFINITION**	G3 represents the third designated gorilla, if one exists, within the frame. G4 represents the fourth designated gorilla, if one exists, within the frame. The Excel formula will determine if G3 and G4 are mutually oriented toward each other. The result is either G3's age class<- > G4's age class or blank.
	EXCEL FORMULA	IF(AND(ISNUMBER(SEARCH("Y",$CX2)),ISNUMBER(SEARCH("Y",$DC2))), CONCATENATE($AE2," <- > ",$AF2),"")
G3 <- > G5 MUTUAL HEAD ORIENTION ?	**DEFINITION**	G3 represents the third designated gorilla, if one exists, within the frame. G5 represents the fifth designated gorilla, if one exists, within the frame. The Excel formula will determine if G3 and G5 are mutually oriented toward each other. The result is either G3's age class<- > G5's age class or blank.
	EXCEL FORMULA	IF(AND(ISNUMBER(SEARCH("Y",$CY2)),ISNUMBER(SEARCH("Y",$DH2))), CONCATENATE($AE2," <- > ",$AY2),"")

G4 <- > G5 MUTUAL HEAD ORIENTION ?	**DEFINITION**	G4 represents the fourth designated gorilla, if one exists, within the frame. G5 represents the fifth designated gorilla, if one exists, within the frame. The Excel formula will determine if G4 and G5 are mutually oriented toward each other. The result is either G4's age class<- > G5's age class or blank.
	EXCEL FORMULA	IF(AND(ISNUMBER(SEARCH("Y",$DD2)),ISNUMBER(SEARCH("Y",$DI2))), CONCATENATE($AF2," <- > ",$AY2),"")

NOTE: Any cells containing "Y" were used for statistical input for *Head Toward Other* and *Continuous Head Toward Other* variations of head orientation. *Continuous Head Toward Other* required consecutive "Y" cells for > = 2 secs and > = 3 secs. Nonblank cells under the mutual head orientation columns were used for statistical input for *Mutual Head Toward* Other. Any cells containing "N" were used for statistical input for *Head Not Toward Other*.

CHART FOR CODING HEAD POSITION

CAM + HEAD		CAMERA ANGLE	HEAD POSITION	CODE	
.5A		.5	A	0.5	
.5A+		.5	A+	0.75	
.5B		.5	B	1	
.5B+		.5	B+	1.25	
.5C		.5	C	1.5	
.5C+		.5	C+		
.5D		.5	D		
.5D+		.5	D+		
.5E		.5	E		
.5E+		.5	E+		
.5F		.5	F		
.5F+		.5	F+		
.5G		.5	G		
.5G+		.5	G+		
.5H		.5	H		

.5H+	.5	H+	
.5I	.5	I	4.5
.5I+	.5	I+	4.75
.5J	.5	J	5
.5J+	.5	J+	5.25
.5K	.5	K	5.5
.5K+	.5	K+	5.75
.5L	.5	L	0
.5L+	.5	L+	0.25
1A	1	A	1
1A+	1	A+	1.25
1B	1	B	1.5
1B+	1	B+	
1C	1	C	
1C+	1	C+	
1D	1	D	
1D+	1	D+	
1E	1	E	

1E+	1	E+	
1F	1	F	
1F+	1	F+	
1G	1	G	
1G+	1	G+	
1H	1	H	4.5
1H+	1	H+	4.75
1I	1	I	5
1I+	1	I+	5.25
1J	1	J	5.5
1J+	1	J+	5.75
1K	1	K	0
1K+	1	K+	0.25
1L	1	L	0.5
1L+	1	L+	0.75
1.5A	1.5	A	1.5
1.5A+	1.5	A+	
1.5B	1.5	B	

1.5B+		1.5	B+	
1.5C		1.5	C	
1.5C+		1.5	C+	
1.5D		1.5	D	
1.5D+		1.5	D+	
1.5E		1.5	E	
1.5E+		1.5	E+	
1.5F		1.5	F	
1.5F+		1.5	F+	
1.5G		1.5	G	4.5
1.5G+		1.5	G+	4.75
1.5H		1.5	H	5
1.5H+		1.5	H+	5.25
1.5I		1.5	I	5.5
1.5I+		1.5	I+	5.75
1.5J		1.5	J	0
1.5J+		1.5	J+	0.25
1.5K		1.5	K	0.5

1.5K+		1.5	K+	0.75	
1.5L		1.5	L	1	
1.5L+		1.5	L+	1.25	
2A		2	A		
2A+		2	A+		
2B		2	B		
2B+		2	B+		
2C		2	C		
2C+		2	C+		
2D		2	D		
2D+		2	D+		
2E		2	E		
2E+		2	E+		
2F		2	F	4.5	
2F+		2	F+	4.75	
2G		2	G	5	
2G+		2	G+	5.25	
2H		2	H	5.5	

2H+		2	H+	5.75
2I		2	I	0
2I+		2	I+	0.25
2J		2	J	0.5
2J+		2	J+	0.75
2K		2	K	1
2K+		2	K+	1.25
2L		2	L	1.5
2L+		2	L+	
2.5A		2.5	A	
2.5A+		2.5	A+	
2.5B		2.5	B	
2.5B+		2.5	B+	
2.5C		2.5	C	
2.5C+		2.5	C+	
2.5D		2.5	D	
2.5D+		2.5	D+	
2.5E		2.5	E	4.5

2.5E+		2.5	E+	4.75	
2.5F		2.5	F	5	
2.5F+		2.5	F+	5.25	
2.5G		2.5	G	5.5	
2.5G+		2.5	G+	5.75	
2.5H		2.5	H	0	
2.5H+		2.5	H+	0.25	
2.5I		2.5	I	0.5	
2.5I+		2.5	I+	0.75	
2.5J		2.5	J	1	
2.5J+		2.5	J+	1.25	
2.5K		2.5	K	1.5	
2.5K+		2.5	K+		
2.5L		2.5	L		
2.5L+		2.5	L+		
3A		3	A		
3A+		3	A+		
3B		3	B		

3B+		**3**	**B+**	
3C		**3**	**C**	
3C+		**3**	**C+**	
3D		**3**	**D**	**4.5**
3D+		**3**	**D+**	**4.75**
3E		**3**	**E**	**5**
3E+		**3**	**E+**	**5.25**
3F		**3**	**F**	**5.5**
3F+		**3**	**F+**	**5.75**
3G		**3**	**G**	**0**
3G+		**3**	**G+**	**0.25**
3H		**3**	**H**	**0.5**
3H+		**3**	**H+**	**0.75**
3I		**3**	**I**	**1**
3I+		**3**	**I+**	**1.25**
3J		**3**	**J**	**1.5**
3J+		**3**	**J+**	
3K		**3**	**K**	

3K+		3	K+		
3L		3	L		
3L+		3	L+		
3.5A		3.5	A		
3.5A+		3.5	A+		
3.5B		3.5	B		
3.5B+		3.5	B+		
3.5C		3.5	C	4.5	
3.5C+		3.5	C+	4.75	
3.5D		3.5	D	5	
3.5D+		3.5	D+	5.25	
3.5E		3.5	E	5.5	
3.5E+		3.5	E+	5.75	
3.5F		3.5	F	0	
3.5F+		3.5	F+	0.25	
3.5G		3.5	G	0.5	
3.5G+		3.5	G+	,75	
3.5H		3.5	H	1	

3.5H+		3.5	H+	1.25	
3.5I		3.5	I	1.5	
3.5I+		3.5	I+		
3.5J		3.5	J		
3.5J+		3.5	J+		
3.5K		3.5	K		
3.5K+		3.5	K+		
3.5L		3.5	L		
3.5L+		3.5	L+		
4A		4	A		
4A+		4	A+		
4B		4	B	4.5	
4B+		4	B+	4.75	
4C		4	C	5	
4C+		4	C+	5.25	
4D		4	D	5.5	
4D+		4	D+	5.75	
4E		4	E	0	

4E+	4	E+	0.25
4F	4	F	0.5
4F+	4	F+	0.75
4G	4	G	1
4G+	4	G+	1.25
4H	4	H	1.5
4H+	4	H+	
4I	4	I	
4I+	4	I+	
4J	4	J	
4J+	4	J+	
4K	4	K	
4K+	4	K+	
4L	4	L	
4L+	4	L+	
4.5A	4.5	A	4.5
4.5A+	4.5	A+	4.75
4.5B	4.5	B	5

4.5B+		4.5	B+	5.25	
4.5C		4.5	C	5.5	
4.5C+		4.5	C+	5.75	
4.5D		4.5	D	0	
4.5D+		4.5	D+	0.25	
4.5E		4.5	E	0.5	
4.5E+		4.5	E+	0.75	
4.5F		4.5	F	1	
4.5F+		4.5	F+	1.25	
4.5G		4.5	G	1.5	
4.5G+		4.5	G+		
4.5H		4.5	H		
4.5H+		4.5	H+		
4.5I		4.5	I		
4.5I+		4.5	I+		
4.5J		4.5	J		
4.5J+		4.5	J+		
4.5K		4.5	K		

4.5K+	4.5	K+	
4.5L	4.5	L	
4.5L+	4.5	L+	
5A	5	A	5
5A+	5	A+	5.25
5B	5	B	5.5
5B+	5	B+	5.75
5C	5	C	0
5C+	5	C+	0.25
5D	5	D	0.5
5D+	5	D+	0.75
5E	5	E	1
5E+	5	E+	1.25
5F	5	F	1.5
5F+	5	F+	
5G	5	G	
5G+	5	G+	
5H	5	H	

5H+	5	H+	
5I	5	I	
5I+	5	I+	
5J	5	J	
5J+	5	J+	
5K	5	K	
5K+	5	K+	
5L	5	L	4.5
5L+	5	L+	4.75
5.5A	5.5	A	5.5
5.5A+	5.5	A+	5.75
5.5B	5.5	B	0
5.5B+	5.5	B+	0.25
5.5C	5.5	C	0.5
5.5C+	5.5	C+	0.75
5.5D	5.5	D	1
5.5D+	5.5	D+	1.25
5.5E	5.5	E	1.5

5.5E+		5.5	E+	
5.5F		5.5	F	
5.5F+		5.5	F+	
5.5G		5.5	G	
5.5G+		5.5	G+	
5.5H		5.5	H	
5.5H+		5.5	H+	
5.5I		5.5	I	
5.5I+		5.5	I+	
5.5J		5.5	J	
5.5J+		5.5	J+	
5.5K		5.5	K	4.5
5.5K+		5.5	K+	4.75
5.5L		5.5	L	5
5.5L+		5.5	L+	5.25
0A		0	A	0
0A+		0	A+	0.25
0B		0	B	0.5

0B+		0	B+	0.75	
0C		0	C	1	
0C+		0	C+	1.25	
0D		0	D	1.5	
0D+		0	D+		
0E		0	E		
0E+		0	E+		
0F		0	F		
0F+		0	F+		
0G		0	G		
0G+		0	G+		
0H		0	H		
0H+		0	H+		
0I		0	I		
0I+		0	I+		
0J		0	J	4.5	
0J+		0	J+	4.75	
0K		0	K	5	

0K+		0	K+	5.25	
0L		0	L	5.5	
0L+		0	L+	5.75	

Example data sheets for Phase 4 with Excel formula results:

PHASE 4

SAN DIEGO-DAY1-1 masters.eaf

P1 #	PHASE 2 TIMES	G1 CAM+ HEAD	G2 CAM+ HEAD	G3 CAM+ HEAD	G4 CAM+ HEAD	G5 CAM+ HEAD	G1 CHART CODE	G2 CHART CODE	G3 CHART CODE	G4 CHART CODE	G5 CHART CODE	G1->G2 HEAD ORIENTED?	G1->G3 HEAD ORIENTED?	G1->G4 HEAD ORIENTED?	G1->G5 HEAD ORIENTED?	G2->G1 HEAD ORIENTED?	G2->G3 HEAD ORIENTED?	G2->G4 HEAD ORIENTED?	G2->G5 HEAD ORIENTED?	G3->G1 HEAD ORIENTED?	G3->G2 HEAD ORIENTED?	G3->G4 HEAD ORIENTED?	G3->G5 HEAD ORIENTED?	G4->G1 HEAD ORIENTED?	G4->G2 HEAD ORIENTED?	G4->G3 HEAD ORIENTED?	G4->G5 HEAD ORIENTED?	G5->G1 HEAD ORIENTED?	G5->G2 HEAD ORIENTED?	G5->G3 HEAD ORIENTED?	G5->G4 HEAD ORIENTED?
5	00:03:25.780	1.5J	5D	5D	1K	0B	0	0.5	0.5	0	0.5	SM->SB=N	SM->AF=Y	SM->IML=Y	SM->IMR=Y	SB->SM=N	SB->AF=N	SB->IML=N	SB->IMR=N	AF->SM=N	AF->SB=N	AF->IML=N	AF->IMR=N	IML->SM=N	IML->SB=N	IML->AF=Y	IML->IMR=N	IMR->SM=Y	IMR->SB=N	IMR->AF=N	IMR->IML=Y
5	00:03:26.780	1.5J	5D	5D	1K+	0B	0	0.5	0.5	0.25	0.5	SM->SB=N	SM->AF=Y	SM->IML=Y	SM->IMR=Y	SB->SM=N	SB->AF=N	SB->IML=N	SB->IMR=N	AF->SM=N	AF->SB=N	AF->IML=N	AF->IMR=N	IML->SM=N	IML->SB=N	IML->AF=Y	IML->IMR=N	IMR->SM=Y	IMR->SB=N	IMR->AF=N	IMR->IML=Y
5	00:03:29.780	1.5J	5D	5D	XX		0	0.5	0.5			SM->SB=N	SM->AF=Y			SB->SM=N	SB->AF=N			AF->SM=N	AF->SB=N										
4	00:03:38.420	1.5K	5D+	XX	XX		0.5	0.75				SM->SB=N				SB->SM=N															
4	00:03:39.420	1.5K	5D	XX	XX		0.5	0.5				SM->SB=N				SB->SM=N															
4	00:03:40.420	1.5K	5C	XX	XX		0.5	0				SM->SB=N				SB->SM=N															
3	00:03:44.090	1.5I	5C	XX			5.5	0				SM->SB=Y				SB->SM=N															
3	00:03:45.090	1.5I	5C	XX			5.5	0				SM->SB=Y				SB->SM=N															
3	00:05:36.250																														
2	00:05:37.980	5D+	5E				0.75	1				SB->SM=N				SM->SB=N															
2	00:05:38.980	5D+	5E				0.75	1				SB->SM=N				SM->SB=N															
2	00:05:39.980	5D+	5E				0.75	1				SB->SM=N				SM->SB=N															
3	00:07:27.160	5D+	XX	0L			0.75		5.5				SB->SM=Y							SM->SB=N											
4	00:07:27.340	5C	XX	0A	XX		0		0				SB->SM=N							SM->SB=N											
3	00:07:28.470	5C	XX	4.5E			0		0.5				SB->SM=N							SM->SB=N											
2	00:07:30.050																														

PHASE 4

SAN DIEGO-DAY1-1 masters.eaf

P1 #	PHASE 2 TIMES	G1 CAM+ HEAD	G2 CAM+ HEAD	G3 CAM+ HEAD	G4 CAM+ HEAD	G5 CAM+ HEAD	G1 CHART CODE	G2 CHART CODE	G3 CHART CODE	G4 CHART CODE	G5 CHART CODE	G1 <-> G2 MUTUAL HEAD ORIENTATION?	G1 <-> G3 MUTUAL HEAD ORIENTATION?	G1 <-> G4 MUTUAL HEAD ORIENTATION?	G1 <-> G5 MUTUAL HEAD ORIENTATION?	G2 <-> G3 MUTUAL HEAD ORIENTATION?	G2 <-> G4 MUTUAL HEAD ORIENTATION?	G2 <-> G5 MUTUAL HEAD ORIENTATION?	G3 <-> G4 MUTUAL HEAD ORIENTATION?	G3 <-> G5 MUTUAL HEAD ORIENTATION?	G4 <-> G5 MUTUAL HEAD ORIENTATION?
5	00:03:25.780	1.5J	5D	5D	1K	0B	0	0.5	0.5	0	0.5				SM <-> IMR						
5	00:03:26.780	1.5J	5D	5D	1K+	0B	0	0.5	0.5	0.25	0.5				SM <-> IMR						
5	00:03:29.780	1.5J	5D	5D	XX		0	0.5	0.5												
4	00:03:38.420	1.5K	5D+	XX	XX		0.5	0.75													
4	00:03:39.420	1.5K	5D	XX	XX		0.5	0.5													
4	00:03:40.420	1.5K	5C	XX	XX		0.5	0													
3	00:03:44.090	1.5I	5C	XX			5.5	0													
3	00:03:45.090	1.5I	5C	XX			5.5	0													
3	00:05:36.250																				
2	00:05:37.980	5D+	5E				0.75	1													
2	00:05:38.980	5D+	5E				0.75	1													
2	00:05:39.980	5D+	5E				0.75	1													
3	00:07:27.160	5D+	XX	0L			0.75		5.5												
4	00:07:27.340	5C	XX	0A	XX		0		0												
3	00:07:28.470	5C	XX	4.5E			0		0.5												
2	00:07:30.050																				