Dyadic interactions, attachment and the presence of triadic interactions in chimpanzees and humans

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- Strong similarities between human and chimpanzee infants are found in early dyadic social and object-based interactions
- Strong similarities between human and chimpanzee infants can be found in early triadic interactions
- Early experiences in engagement with social partners and emotional engagements begin to have a major impact on the level and form of social cognition in the first year of life for both humans and chimpanzees.

Abstract

From a developmental perspective, dyadic interactions with social partners and dyadic interactions with objects underpin early social cognition in humans and chimpanzees. In humans, dyadic social relationships form in the first three months of life, dyadic relations with objects form in the first 6 months of life, and triadic relations begin around 8-12 months. In chimpanzees, a similar developmental pattern is evident with dyadic social relationships forming in the first three months of life, dyadic relations with objects forming in the first 5 months of life, and triadic relations in the latter half of the first year of life. During ontogeny humans and chimpanzees experience emotional engagements, both with social partners and with objects, and these impact outcomes in social cognition. Rather than being considered too complex, diversity of socio-emotional experiences during development can be embraced, with the goal to specify how they influence social cognition outcomes in humans and in chimpanzees. This process may provide the evolutionary and biological foundations for plasticity.

Introduction

Primates form socio-emotional bonds from infancy, primates interact with objects in their environment, and primates communicate. Early forms of social cognition are manifest when primates communicate intentionally or otherwise engage jointly with others about objects or events. Current theories of the evolution of social cognition highlight the importance of cognition, primarily, and of cooperative motivations, secondarily (e.g., Dean. Kendal, Schapiro, Thierry, & Laland, 2012; Herrmann, Call, Hernandez-Lloreda, Hare, & Tomasello, 2007), but these early forms of social cognition may rely more on emotional engagements than cognition (Bard, Bakeman, Boysen, & Leavens, 2014a). In support of this aim to discuss the emotional engagements that underpin social cognition, the term 'coordinated joint engagement' (Bakeman & Adamson, 1984) will be used rather than 'joint attention'. This definition offers three advantages to the term joint attention; 1) it allows diversity in the forms of social cognition, beyond the visual modality typical of attention; 2) it focuses on the coordination between infant and social partner; and 3) it places emphasis on the process of joint engagement, that is when infant and social partner are together jointly engaged with some object or event.

By focusing on engagement rather than just visual attention, differences are allowed in the modality with which infant and/or social partners jointly engage. Allowing diversity in the form of early social cognition is important since modalities of engagement differ across some settings and across some cultures (e.g., some cultures prefer face-to-face engagement whereas others prefer physical contact engagement with 3-month-old infants: Keller, 2007). The more conceptual term of ‘engagement’ rather than ‘attention’ also allows for variety in the form of resulting events. For example, in some cultures it is not polite to point (Wilkins, 2003), and in some cultures, it is not polite for children to look at their elders in the eye. A typical instance of joint engagement between 1-year-old infants and adults in a rural non-

Western culture can be found in the culturally specified ‘give & give back’ offering of objects in social exchange (Bakeman, Adamson, Konner, & Barr, 1990), in which infants do not meet the eyes of their elders (Mead & Macgregor, 1951). This pattern contrasts with typical examples of coordinated joint engagement in urban Western cultures, which include infants pointing to or ‘showing’ an object to an adult, i.e., moving an object into the visual field of a social partner (directing the attention of a social partner to an object, e.g., Salomo & Liszkowski, 2012).

In this review, I will discuss the foundational aspects of early social cognition in dyadic interactions (with social partners & with objects), in triadic interactions (among infants, social partners, and objects), and in attachment (the emotional bond with social partners: e.g., Bullowa, 1979). This review necessarily will take a developmental perspective: In humans, dyadic social relationships form in the first three months of life, dyadic relations with objects form in the first 6 months of life, and triadic relations form beginning at 8-12 months (e.g., Adamson, 1996). In chimpanzees, dyadic social relationships form in the first three months of life (Bard, 1994; van Lawick-Goodall, 1968), dyadic relations with objects form in the first 5 months of life (Bard et al., 2014a), and triadic relations form beginning around 4-12 months of life (Bard et al., 2014a; Bard, Dunbar, Maguire-Herring, Veira, Hayes, & McDonald, 2014b). Interactions during ontogeny are crucially important for human infants to become intentional beings, yet little comparable attention has been given to the impact of these same processes in support of ape infants becoming intentional beings. The Lived Experiences model is proposed for the study of primate social cognition since it specifies evolutionary and biological foundations by which socio-emotional experiences during development influence social cognition outcomes (Bard & Leavens, 2014; Leavens, Hopkins & Bard, 2005).

Joint attention is said to be important because of its link with language. To learn the names of things, for instance, the infant must be able to coordinate the word with the 'thing', the referent for which the word stands. More broadly, however, joint attention is required for many of the forms of coordinated joint engagement, such as intentional communication (i.e., using a pointing gesture to indicate to a social partner, the location of a desired object). Joint attention also underlies social learning, especially imitative learning, and social referencing.

There is an extensive indirect literature indicating that chimpanzees have joint attention. The numerous ape language projects provide compelling evidence that chimpanzees can learn symbols (reviewed in Bard & Leavens, 2014). Chimpanzee adults communicate intentionally with gestures (e.g., Call & Tomasello, 1996; Leavens et al., 2005), as do orangutans (Bard, 1992; Cartmill & Byrne, 2010), and gorillas (Genty, Breuer, Hobaiter, & Byrne, 2009; Tanner & Byrne, 2006). Joint attention is required for an individual to learn something about an object from watching how a social partner manipulates it (broad definition of social learning, including imitation). Chimpanzees have learned to imitate actions on objects (Whiten, Custance, Gomez, Teixidor, & Bard, 1996) and learned to imitate tool use by watching others (Bard, Fragaszy & Visalberghi, 1995): Imitative learning requires joint attention. Chimpanzees have engaged with a social partner to learn about how an object functions as a tool (Tomasello, Davis-DaSilva, Camak, & Bard, 1987). Some theorists suggests that although chimpanzees may engage in joint attention, that it is not 'truly joint' because there is not evidence of the requisite "knowing together" (Carpenter & Call, 2015). There is a growing body of research that supports the conclusion that joint attention is not unique to humans: Joint attention is found in chimpanzees, and the other great apes.

In this review, I focus on the role that emotion and engagement play in the development of coordinated joint engagement, and explore how this might help us to understand why different studies arrive at different conclusions about the capacity for joint

attention in chimpanzees. In particular, there may be differences in emotional responsiveness, or emotional engagements with social partners and with objects, or in the motivation to coordinate engagements with social partners. In other words, emotion might play a role at each stage in the development of joint attention.

Enculturation and socialization effects

Chimpanzees are responsive to various environmental factors, including social partners and their cultural practices. 'Enculturated' was a term used to describe chimpanzees that had been raised by humans in language-enriched environments (e.g., Carpenter, Tomasello, & Savage-Rumbaugh, 1995; Tomasello, Savage-Rumbaugh, & Kruger, 1993). These enculturated apes showed enhanced outcomes in imitation, joint attention, and tool use compared to chimpanzees not raised in these environments. Bard & Gardner (1996) extended this concept by arguing that since chimpanzees were always responsive to the socialization process, they could be said to be enculturated by any set of socialization experiences, whether in response to a particular human social environment (human enculturated) or a particular chimpanzee social environment (chimpanzee enculturate). However, the majority of researchers reserved the term 'enculturated' to refer only to being raised in a human culture, in particular, with a symbol system.

Chimpanzee infants can be influenced by a diversity of human cultures (see below), as well as a diversity of chimpanzee cultures (e.g., Whiten et al., 1999). Therefore, there is a need to specify the details of the socio-ecologies experienced by infants across settings, to understand the influence of environmental experiences in infancy on outcomes later in life (e.g., Bard & Leavens, 2014). For example, many of the comparisons reviewed here are between two groups of chimpanzees raised in the Great Ape Nursery of the Yerkes National Primate Research Center. Although both groups were raised by humans in this biomedical institution, while living 24/7 in groups of 4-6 same-aged chimpanzees, one group (Standard

Care) experienced less than 1 hour per day of human caregiving (common to institutional care), whereas the other group (Responsive Care) experienced an additional 4 hours per weekday of caregiving focused on enhancing their chimpanzee species-typical skills (see Bard et al., 2014a for additional details). In this review, there are many details about how just 20 hours per week of the Responsive Care intervention changed social cognitive outcomes for chimpanzee infants. It would be misleading, however, to gloss both nursery care systems with the common term of 'human rearing'. There is no single 'human' environment, human and chimpanzee environments are diverse. Chimpanzee infants, in many ways like human infants, are adjusting to the social, emotional, ecological, and cultural demands of the particular environment.

Dyadic Interactions

Infant engagement with social partners

In human infants, joint attention develops gradually over the first year of life. The earliest developing necessary component consists of emotional engagements with social partners, sometimes called primary intersubjectivity (Trevarthen & Aitken, 2003). Infants exhibit their ability to engage with social partners, in part by distinguishing animate from inanimate objects, and in part by directing emotional expressions, such as a smile, to social partners (i.e. the social smile). In the first 30 days of life, human and chimpanzee infants orient to social stimuli at more mature and more consistent levels than they orient to nonsocial stimuli (Bard, Brent, Lester, Worobey, & Suomi, 2011). Moreover, during an interactive assessment with a human examiner, the number of smiles increased from day 2 to day 30 for Yerkes nursery-reared chimpanzee infants and human infants (Bard, et al., 2011). In comparing chimpanzee newborns to human newborns, there were few species differences. There are significant cross-cultural differences in newborn humans (e.g., Nugent, Lester, & Brazelton, 1989), and significant cross-setting differences in newborn chimpanzees,

highlighting their flexibility in adjusting to the socio-ecology of their environment (Bard et al., 2011). Evidence of imitation of facial movements in newborn chimpanzees points to one mechanism by which these socio-emotional differences may become instantiated (Bard, 2007; Myowa-Yamakoshi, Tomonaga, Tanaka, & Matsuzawa, 2004). Therefore, the degree to which the neonatal system matures in interaction with specific features of the post-natal environment illustrates the plasticity inherent in the genome of chimpanzees and of humans allowing for differential responding to particular types of stimuli, including emotional engagements.

Infant's socio-emotional engagement with social partners develop, such that strong dyadic engagements are evident between 3 and 5 months of age. In Western cultures, infants and social partners (often mothers) engage frequently in face-to-face interactions, with mutual gaze and overt expressions of positive emotion (e.g., Adamson, 1996). An important question is the extent to which this pattern of *en face* social positive emotional engagement is universal; are extensive amounts of face-to-face contact with overt positive emotion typical of the experiences of 3-month-old human infants in all cultures? Are the behaviors of infants' engagement with social partners fixed or flexible? Studies of 3-month-olds and their caregivers from non-Western rural cultures highlight that engagement occurs through the modality of physical contact, primarily, rather than through vision (Keller, 2007). In many rural non-Western cultures, infants experience high levels of body contact and body stimulation (~85% versus ~45% in urban Western), and significantly more interaction with individuals other than the mother, including older siblings (up to 30% of their waking time: Keller, 2007, p.94). In some foraging groups, infants may have more than 17 caregivers in a day (e.g., Meehan & Hawks, 2013), and many infants nurse from individuals other than the mother (Hewlett & Lamb, 2002). Thus face-to-face interaction between an infant and one

other social partner is not the most common pattern of emotional engagement for human infants.

Bard (1994) studied chimpanzee infants raised in different eco-cultural environments at the Yerkes Center; many were raised in the institutionalized nurseries of a biomedical center, where they lived in small bare enclosures and were raised in peer cohorts, and were found to have disorganized attachments (van IJzendoorn, Bard, Bakermans-Kranenburg, & Ivan, 2009); other chimpanzee infants were raised by their biological mothers, in mixed age/sex groups, with large enriched enclosures, and organized attachments (Bard, 1994). Smiling was studied in the first month of life, and mutual gaze was assessed developmentally through 3 to 4 months (Bard et al., 2005). Some of the nursery-raised groups (interacting with Western human adults) displayed higher levels of smiling and mutual gaze than did the mother-raised chimpanzees (Bard et al., 2011; Bard, unpublished observations), which provides suggestive evidence that there is an environmentally-based rearing difference in positive emotional engagement in chimpanzees.

Mother chimpanzees in laboratory settings were found to spend 66% of their time in positive emotional engagements with their infants in the first 3 months of life (Bard, et al., 2005). At Yerkes, chimpanzee mothers spent between 17 and 23% of observation time looking at their infants, and approximately half of that time was looking at their infant's face. Instances of mutual gaze, however, were relatively infrequent (~10 times in an hour) and brief, as mothers were observed to shift their gaze when infants looked back at them (Bard et al., 2005). This led to the initial conclusion that chimpanzee mothers did not encourage mutual gaze with their infants (Bard, 1994).

A few years later, mutual gaze in another group of chimpanzee mothers and their infants was documented at the Primate Research Institute of Kyoto University (PRI: Bard, et al., 2005). Significantly higher amounts of mutual gaze with infants (~27 times per hour at 3

months) were found at PRI, and some chimpanzee mothers actually did encourage mutual gaze (Bard et al., 2005): Ai, a mother chimpanzee, was observed tilting her infant's head by lifting his chin up, to establish and hold mutual gaze (illustrated by Fig 2 in Tomonaga et al., 2004).

What could explain these significant group differences in mutual gaze? The answer was suggested by a significant inverse correlation of mutual gaze with cradling contact. In the wild, chimpanzee infants typically experience almost 100% physical contact with their mothers during the first 6 months of life (van Lawick-Goodall, 1968). Although both infants and mothers exhibit positive vocal and facial emotional expressions during engagements, especially play, relatively little mutual gaze has been reported (Plooij, 1984). Infant chimpanzees living at the Yerkes Research Center and PRI, experienced more variable amounts of physical contact with their mother (Bard, 1994; Bard et al., 2005). Thus, this study of mutual gaze in infant chimpanzees raised with different *chimpanzee-based* rearing experiences, suggests a natural mechanism by which mutual gaze develops. Those captive chimpanzee mothers that maintained high levels of cradling contact had low levels of mutual gaze, and those mothers with low levels of cradling of their infants had relatively high levels of mutual gaze. Note that this mechanism also explains cross-cultural differences in mutual gaze of human infants: infant that experience a great deal of physical cradling early in life, tend to have minimal amounts of mutual gaze by 3 months (Bard et al., 2005: Keller, 2007).

There is now substantial of evidence that chimpanzee are very responsive to early experiences, and that primary socio-emotional outcomes differ in systematic ways as a result. There are effects of socialization on many behavioural markers of Primary Intersubjectivity, including mutual gaze, positive emotional expressions, and negative emotional expressions (Bard, 2005). In chimpanzees, as in humans, the outcomes of infants' emotional engagement with social partners vary flexibly as a result of their socialization experiences.

Infant engagement with objects and/or events

The second necessary component in the development of coordinated joint engagement is engagement with objects, evident in human infants from about 5 to 7 months. At this age, infants manipulate objects, and in Western urban cultures, these manipulations are surrounded by positive affect from caregivers (Adamson, 1996). Infants from non-Western rural cultures also manipulate objects, at about the same age, but caregivers often ignored them when doing so, with a notable lack of positive affect from infants and caregivers (Bakeman, et al., 1990). In a standardized test, the manipulative ability of two groups of nursery-raised chimpanzees was compared to a heterogenous sample of US humans, from 3 to 12 months of age (Bard et al., 2014a). Until 6 months, the chimpanzees were significantly better than the human infants, but from 7 to 12 months, the human infants were more skillful than the chimpanzees (Bard et al., 2014a). Even as skills increase across development, there are strong effects from rearing environments.

There is strong evidence that there are environmental influences on object manipulation in humans and chimpanzees, especially on the emotion accompanying contact with objects. Some of the early research on object manipulation in chimpanzees involved individuals raised in isolation. Without exposure to objects in the first 2 years of life, these chimpanzees showed extreme fear when given new objects (Menzel, 1964). Significant differences in skill at object manipulation were found between the Standard Care and Responsive Care chimpanzees, with the Responsive Care group expressing more happiness and less fear during the test, and exhibiting significantly better object manipulation skills: Bard et al., 2014a). In other captive settings, different early rearing experiences impacted how well objects were used as tools by adult chimpanzees (Furlong, Boose & Boysen, 2008).

Play may be a context in which skills develop, as it is both positive in emotional quality and not linked to necessary functional outcomes. Wild chimpanzee infants engage in

solitary play, sometimes with objects, about 2.5% of observation time in the first 6 months of life (Lonsdorf et al., 2014). In captive settings (zoo and PRI) with a large social group and a complex physical setting, 1-year-old chimpanzee infants engaged in solitary object play for approximately19% of their play time (Ross, Bard, & Matsuzawa, 2014). The amount of time that infant chimpanzees play with objects differs dramatically as a function of their ecology. Thus, we can conclude that engagements with objects is flexible in chimpanzee infants as a result of early experiences, and can be influenced by socialization processes and emotions.

Triadic Interactions

Around 9 to 12 months, human infants become able to coordinate the two types of dyadic engagements, with social partners and with objects, and show coordinated joint engagement, a form of triadic engagement, sometimes called Secondary Intersubjectivity (Trevarthan & Aitken, 2013). Although the importance of joint attention was initially thought to be its link with language, more broadly, joint attention is required for many non-linguistic processes, such as intentional communication (i.e., using a pointing gesture to indicate to a social partner, the location of a desired object). Joint attention also underlies social learning, that is learning about something as a result of watching others doing it. Joint attention is especially critical in imitative learning. Additionally, joint attention is the basis for social referencing, where infants learn about the emotional valence of an object as a result of emotional displays by a social partner. In all these forms of triadic interaction, infants coordinate the two types of dyadic engagements, with objects (or events), and with social partners.

In a standardized test with infants from 5 to 12 months of age, US humans' and nursery-reared chimpanzees' skill at joint attention was assessed with a variety of tasks, such as imitating actions on objects, following verbal requests with objects, and following demonstrated actions (Bard et al., 2014a). The human infants began to pass these tasks only

at 6 & 7 months, when they passed only 1 of 30 tasks requiring joint attention. Nursery-raised chimpanzees, in contrast, passed 2 joint attention tasks already at 5 months of age. The Responsive Care chimpanzee group, with enriched species-typical emotional engagement experiences, passed significantly more joint attention tasks than the human group through 8 months, and more than the Standard Care chimpanzees through 12 months. By 10 months, however, the human group began to excel, passing 7 of 30 tasks, significantly surpassing both groups of institutionally-reared chimpanzees, who did not pass more than 6 tasks through 12 months (Bard et al., 2014a).

A hierarchical multiple regression revealed that early rearing experiences, dyadic social skills, and emotion during testing were the significant unique predictors, accounting for over 40% of the variance in joint attention success in nursery-reared chimpanzees across the first year of life (Bard et al., 2014a). Interestingly, when the same analysis was conducted to predict cooperation, early rearing experiences and affect were found to be significant variables, predicting over 50% of the variance in cooperativeness scores across the first year of life (Bard et al., 2014a). This confirms the importance of previous engagement histories with social partners for early social cognition in chimpanzees (Bard & Leavens, 2014). Coordinated joint engagement, defined either as joint attention with objects and social partners, or as cooperation in the 'give & take' of objects, was commonly seen in chimpanzees from 5 months of age, but the levels of both differed significantly based on the chimpanzees' early social engagement experiences. Joint Attention outcomes in chimpanzees by 12 months of age are flexible and highly influenced by concurrent emotion, and past emotional engagements.

Around a year of age, human infants begin to show many other types of coordinated joint engagement skills; e.g., pointing as an act of intentional communication; showing objects; offering objects; engaging in social referencing; and using single words

appropriately. Interestingly, there is cultural variation in the amount of pointing, showing, and offering objects, with infants living in Western urban settings exhibiting more pointing and showing, but infants living in some non-Western rural settings exhibiting more offering of objects (e.g., Bakeman et al., 1990; Salomo & Liszkowski, 2012).

Most agree that adult chimpanzees point as a referential and intentional communication, and that a larger proportion of language-trained chimpanzees than institutionally-reared chimpanzees point, although it is still not known when infant chimpanzees begin to produce points (see review by Leavens & Bard, 2011). Some two-year-old chimpanzees, living in an orphanage sanctuary in Africa, pointed communicatively in a standardized test situation (Wobber, Herrmann, Hare, Wrangham, & Tomasello, 2014), but note that the rearing experiences of orphaned sanctuary chimpanzees are not optimal to nurture the earliest expressions of communicative development with humans (see Bard & Leavens, 2014 for an elaboration of this argument). Although the frequency of pointing is highly influenced by interaction with Western humans, a recent report of rarely observed pointing in wild chimpanzees demonstrate that pointing can occur between conspecifics as well (Hobaiter, Leavens & Byrne, 2013).

Russell, Bard, & Adamson (1997) conducted a study on social referencing in young chimpanzees, which is particularly interesting as it illustrates a mechanism, common to humans and chimpanzees, by which emotion can directly impact joint attention outcomes. In social referencing experiments, when the infant looks to the caregiver, seeking information about a novel object, the caregiver is instructed to give an emotional message about the object (usually a message that conveys 'I like that object' or alternatively, 'I am frightened by that object'). When the chimpanzees' favourite caregiver expressed positive affect about the object, young chimpanzees acted more positively, by looking longer at the object and when young chimpanzees were given the fearful message, they reacted more negatively, by

withdrawing from the novel object (Russell et al., 1997). The rate at which the chimpanzees sought information from their caregiver was indistinguishable from the rate reported for human children (Russell et al., 1997). This process of social referencing may be a commonplace mechanism underpinning social learning, especially of emotionally-relevant stimuli, in wild chimpanzees (Boesch & Boesch-Achermann, 2000).

Early development of intentionally communicative gestures was found in young chimpanzees raised in an enriched Responsive Care institutional nursery that focused on meeting the chimpanzees emotional needs: gestures developed as early as 4 months of age for invitations to social partners for tickle play, and within the first year for chase play, and grooming requests, but also non-requestive gestures, such as submissive rump presentations, and wrist bends that communicate recognition of dominance and apology (Bard et al., 2014b). In fact, one of these responsively raised chimpanzee infants engaged in a proto-declarative 'showing' of an object during the social referencing experiment, confirming that chimpanzees can share attention on an object just for the sake of sharing with his favourite caregiver, without any imperative goal (Russell et al., 1997).

The divergence in social cognition outcomes reported in the literature may both a consequence and an index of the important roles of emotion engagement in the development of joint attention (see Bard & Leavens, 2014). Chimpanzees have flexible outcomes in emotional engagement with social partners, and flexible outcomes in emotional engagement with objects. Therefore, it should not be surprising that chimpanzees have flexible outcomes in coordinated joint engagement, as well. It is quite possible that reports stating that chimpanzees do not have joint attention with humans are based on chimpanzee groups that do not have a developmental history of positive emotional engagement with humans about human artifacts, such as orphans living in sanctuaries or mother-raised chimpanzees (e.g., Dean et al., 2012; Tomonaga et al., 2004). Some chimpanzee adults have little motivation to

engage with humans about objects, based on these pre-experimental histories. Emotion is an underlying biologically-relevant cause of behaviour (e.g., Panksepp, 1996); Emotion varies as a function of experiences, and emotion is also a significant influence on social cognitive outcomes.

Attachment

An important milestone in emotional development is the formation of attachment relationships by 1 year of age. Attachment reflects, in part, the quality of care received by an infant from his or her primary caregiver, and, as currently conceptualized, is a marker of the infants' emotional well-being (see also Keller, 2013). The impact of attachment relationships in social cognition has been mostly ignored in comparative psychology. In the first study to use the Strange Situation Procedure in chimpanzees, van IJzendoorn et al (2009) found that the attachment classification of nursery-reared chimpanzees was primarily secure (54%) with some individual expressing insecure-ambivalent (33% resistant) and insecure-avoidant (7%) classifications (when a choice of one of these classification was forced). However, many nursery-raised infants exhibited the distinctive signs of a disorganized attachment system, which include stereotypic rocking and lack of contact with attachment figures, indicating that these nursery-reared chimpanzees were experiencing stress but not seeking comfort from their attachment figure (as opposed to use any of the above organized strategies). The classification of 61% of the nursery chimpanzees as disorganized, was strikingly similar to that of human infants raised in poor quality Greek or Romanian orphanages (van IJzendoorn, et al., 2009). However, the nursery chimpanzees that had been given enriched engagement experiences (Responsive Care) displayed less abnormal attachment to objects, and, most importantly, exhibited less disorganized attachment, compared to those chimpanzees raised with more institutional experiences (Standard Care). We concluded that enriched engagement

experiences positively stimulates chimpanzees' cognitive and emotional development (van IJzendoorn et al., 2009).

A recent follow-up study found long-term detrimental effects of early disorganized attachment into adulthood for these nursery-raised chimpanzees, including increased stereotypical rocking, increased veterinary interventions for upper respiratory infections, and below average assessments of psychological well-being compared to chimpanzees found to have an organized attachment system at 1 year of age (Clay, Bloomsmith, Bard, Maple, & Marr, 2015). The implication from this study is that the emotional responsivity of caregivers, as assessed in attachment relationships with infants, is a very important factor in ameliorating some of the adverse effects of institutional care for chimpanzees (Bard & Leavens, 2014; van IJzendoorn et al., 2009).

Conclusion

Comparative psychologists, developmental psychologists, and primatologists who study social cognition should be reminded that social cognition has a developmental history. This developmental history is crucially important to take into consideration in understanding variation in developmental outcomes, especially for chimpanzees since their engagement histories with human partners, chimpanzee partners, and triadic engagements about objects can vary dramatically (Bard & Leavens, 2014). Engagement experiences in the first months of life can change emotional expressions and mutual gaze, imitation of facial movements and sounds, and the favoured modality for engagement; in other words, all types of primary intersubjectivity found in infant chimpanzees are influenced by early socio-emotional experiences. Moreover, engagements with objects are also influenced by experience, and by social partners nurturing (or not) object interaction by infants. Finally, the form and frequency of each of these dyadic engagements strongly influence the form and frequency of

triadic interactions (of coordinated joint engagement of infants with social partners and objects or events).

Infant chimpanzees develop many different types of triadic interactions, specifically joint attention, cooperation, gestural communication, and pointing, for example, through processes of social referencing, co-construction of communicative meaning, and solving the referential problem space (Bard et al., 2014a Leavens, Hopkins, & Bard, 2005). Significant enhancements of joint attention and cooperation, as well as increased skill in object manipulation and higher cognition scores, were found when institutionally-reared chimpanzees were given a Responsive Care intervention.

Joint attention, the essential element of the 9-month social cognitive revolution, is commonly displayed by 8-month, 9-month, and 10-month-old chimpanzees, even when reared in an institutional setting, in the absence of any overt training or caregiver nurturing of joint engagement. A history of positive emotional engagements is a significant explanatory factor in forms of coordinated joint engagement. Early social cognition has a developmental history, and best performance is unlikely to result when infants do not have a history of positive emotional engagements with social partners about objects.

References

Adamson LR. 1996. *Communication Development During Infancy*. Boulder, CO: Westview Press.

Bakeman, R., Adamson, L.B., Konner, M., & Barr, R. (1990). !Kung infancy: the social context of object exploration. *Child Development, 61*, 794-809.

Bard, K.A. (1992). Intentional behavior and intentional communication in young free-ranging orangutans. *Child Development, 63*, 1186-1197.

Bard, K. A. (1994). Evolutionary roots of intuitive parenting: Maternal competence in chimpanzees. *Early Development and Parenting, 3*, 19-28.

Bard, K.A. (2005). Emotions in chimpanzee infants: the value of a comparative developmental approach to understand the evolutionary bases of emotion. In J. Nadel & D. Muir (Eds), *Emotional Development: Recent Research Advances*, pp. 31-60. New York, NY: Oxford University Press.

Bard, K.A. (2007). Neonatal imitation in chimpanzees (*Pan troglodytes)* tested with two paradigms. *Animal Cognition, 10*, 233-242.

Bard, K.A., & Gardner, K.H. (1996). Influences on development in infant chimpanzees: Enculturation, temperament, and cognition. In A. Russon, K. Bard, & S. T. Parker (Eds.) *Reaching into thought: The minds of the great apes*, pp. 235-256. Cambridge, UK: Cambridge University Press.

Bard, K.A. & Leavens, D.A. (2014). The importance of development for comparative primatology. *Annual Review of Anthropology, 43*, 183-200.

Bard, K.A., Fragaszy, D.M. & Visalberghi, E. (1995). Acquisition and comprehension of a tool-using behavior by young chimpanzees: Effects of age and modeling. *International Journal of Comparative Psychology, 8*, 47-68.

Bard, K.A., Bakeman, R., Boysen, S.T., & Leavens, D.A. (2014a). Emotional engagements predict and enhance social cognition in young chimpanzees. *Developmental Science*, *17*, 682-696 DOI: 10.1111/desc.12145

Bard, KA, Brent, L., Lester, B., Worobey, J. & Suomi, SJ. (2011). Neurobehavioral integrity of chimpanzee newborns: Cross-group and cross species comparisons. *Infant and Child Development, 20*, 47-93

Bard, KA, Dunbar, S., Maguire-Herring, V., Veira, Y., Hayes, K., & McDonald, K. (2014b). Gestures and socio-emotional communicative development in chimpanzee infants. *American Journal of Primatology, 76*, 14-29.

Bard, K.A., Myowa-Yamakoshi, M., Tomonaga, M., Tanaka, M., Costall, A., & Matsuzawa, T. (2005). Group differences in the mutual gaze of chimpanzees (*Pan troglodytes*). *Developmental Psychology, 41*, 616-624.

Boesch, C. & Boesch-Achermann, H. (2000). *The chimpanzees of the Tai forest: Behavioral ecology and evolution*. Oxford, UK: Oxford University Press.

Bullowa, M. (1979). (Ed.), *Before Speech: The beginnings of interpersonal communication*. New York: Cambridge University Press.

Call, J. & Tomasello, M. (1996). The effect of humans on cognitive development of apes. In A. E. Russon, K. A. Bard & S. T. Parker (Eds.), *Reaching into thought: The minds of the great apes* (pp. 371-403). New York, NY: Cambridge University Press.

Cartmill, E., & Byrne, R.W. (2010). Semantics of primate gestures: Intentional meanings of orangutan gestures. *Animal Cognition, 13*, 793-804.

Carpenter, M. & Call, J. (2013). How joint is the joint attention of apes and human infants? In J. Metcalfe & H.S. Terrace (Eds). *Agency and joint attention*. Oxford University Press.

Carpenter, M., Tomasello, M. & Savage-Rumbaugh, E.S. (1995). Joint attention and imitative learning in children, chimpanzees, and enculturated chimpanzees. *Social Development, 4*, 217-237.

Clay, A.W., Bloomsmith, M.A., Bard, K.A., Maple, T.L., & Marr, M.J. (2015). Long-term effects of infant attachment organization on adult behavior and health in nursery-reared captive chimpanzees (*Pan troglodytes*). *Journal of Comparative Psychology, 129,* 145-159.

Dean, L., Kendal, R.L., Schapiro, S.J., Thierry, B., & Laland, K.N. Identification of the social and cognitive processes underlying human cumulative culture. Science, 335, 1114-1118.

Furlong, E.E., Boose K.J., & Boysen, S.T. 2008. Raking it in: the impact of enculturation on chimpanzee tool use. *Animal Cognition, 11,*:83–97.

Genty, E., Breuer, T., Hobaiter, C., & Byrne, R.W. (2009). Gestural communication of

the gorilla (*Gorilla gorilla*): Repertoire, intentionality and possible origins. *Animal Cognition, 12*, 527-546.

Herrmann, E., Call, J., Hernandez-Lloreda, M.V., Hare, B., & Tomasello, B. (2007). Humans have evolved specialized skills of social cognition: The Cultural Intelligence hypothesis. *Science, 317*, 1360-1366.

Hewlett, B., & Lamb, M. (2002). Integrating evolution, culture, and developmental psychology: Explaining caregiver-infant proximity and responsiveness in Central Africa and the USA. In H. Keller, Y. Poortinga, & A. Scholmerich (Eds). *Between culture and biology: Perspectives on ontogenetic development*, p 241-269. Cambridge: Cambridge University Press.

Hobaiter, C., Leavens, D.A., & Byrne, R.W. (2014). Deictic gesturing in wild chimpanzees *Pan troglodytes*? Some possible cases. *Journal of Comparative Psychology,*

Keller, H. (2007). *Cultures of infancy*. Mahwah, NJ: L. Erlbaum.

Keller, H. (2013). Attachment and culture. *Journal of Cross-cultural Psychology, 44*, 175-194.

Leavens DA, & Bard KA. (2011). Environmental influences on joint attention in great apes: Implications for human cognition. *Journal of Cognitive and Educational Psychology, 10*, 9-31.

Leavens, D. A., Hopkins, W. D., & Bard, K. A. (2005). Understanding the point of chimpanzee pointing: Epigenesis and ecological validity. *Current Directions in Psychological Science, 14*, 185-189.

Leavens, D.A., Russell, J. & Hopkins, W.D. (2005). Intentionality as measured in the persistence and elaboration of communication by chimpanzees (*Pan troglodytes*). *Child Development, 76*, 291-306.

Lonsdorf, E.V., Markham, A.C., Heintz, M.R., Anderson, K.E., Ciuk, D.J., Goodall, J. & Murray, C.M. (2014). Sex differences in wild chimpanzee behavior emerge during infancy. *PLOS ONE, 9(6)*, e99099. doi:10.1371/journal.pone.0099099

Mead, M. & Macgregor, F.C. (1951). *Growth and culture: A photographic study of Balinese childhood*. Oxford: Putnam.

Meehan, Cl. & Hawks, S. (2013). Cooperative breeding and attachment among Aka foragers. In N Quinn & J,M, Mageo (Eds). *Attachment reconsidered: Cultural perspectives on a Western theory*. Palgrave Macmillan.

Menzel, E.W. (1964). Patterns of responsiveness in chimpanzees reared through infancy under conditions of environmental restriction. *Journal of Psychological Research, 27*, 337-365.

Myowa-Yamakoshi, M., Tomonaga, M., Tanaka, M., & Matsuzawa, T. (2004). *Developmental Science, 7*, 437-442.

Nugent, J. K., Lester, B. M., & Brazelton, T. B. (1989). *The cultural context of infancy*. New Jersey: Ablex.

Panksepp, J. (1996). *Affective Neuroscience: The foundations of human and animal emotions*. Oxford: Oxford University Press.

Plooij FX. 1984. *The Behavioral Development of Free-living Chimpanzee Babies and Infants*. New York, NY: Ablex.

Ross, K.M., Bard, K.A., & Matsuzawa, T. (2014). Playful expressions in one-year-old chimpanzee infants in social and solitary contexts. *Frontiers in Psychology, 5*: 541, DOI: 10.3389/fpsyg.2014.00741.

Russell, C. L., Bard, K. A., & Adamson, L. B. (1997). Social referencing by young chimpanzees (*Pan troglodytes*). *Journal of Comparative Psychology, 111*(2), 185-191.

Salomo D & Liszkowski U. (2012). Sociocultural settings influence the emergence of prelinguistic deictic gestures. *Child Development, 84*, 1296-1307.

Tanner, J.E., & Byrne, R.W. (1996). Representation of action through iconic gesture in a captive lowland gorilla. *Current Anthropology, 37*, 162-173.

Tomasello, M., Savage-Rumbaugh, S., & Kruger, A.C. (1993). Imitative learning of actions on objects by children, chimpanzees, and enculturated chimpanzees. *Child Development, 64*, 1688-1705.

Tomasello, M., Davis-DaSilva, M., Camak, L., & Bard, K.A. (1987). Observational learning of tool-use by young chimpanzees. *Human Evolution, 2(2)*, 175-183.

Tomonaga, M., Tanaka, M., Matsuzawa, T., Myowa-Yamakoshi, M., Kosugi, D., Mizuno, Y., Okamoto, S., Yamaguchi, M., & Bard, K.A. (2004). Development of social cognition

in infant chimpanzees (*Pan troglodytes*): Face recognition, smiling, gaze, and the lack of triadic interactions. *Japanese Psychological Research, 46*, 227-235.

Trevarthen, C., & Aitken, K. J. (2001). Infant intersubjectivity: Research, theory, and clinical applications. *Journal of Child Psychology and Psychiatry, 42*, 3-48.

van IJzendoorn, M.H., Bard, K.A., Bakermans-Kranenburg, M.J. & Ivan, K. (2009). Enhancement of attachment and cognitive development of young nursery-reared chimpanzees in responsive versus standard care. *Developmental Psychobiology, 51,* 173-185.

van Lawick-Goodall J. 1968. The behaviour of free-living chimpanzees of the Gombe Stream Nature reserve. *Animal Behavior Monograph,* 1, 161-311.

Wilkins D. 2003. Why pointing with the index finger is not a universal in sociocultural and semiotic terms. In *Pointing: Where Language, Culture, and Cognition Meet*, ed. S Kita, pp. 171-215. Hillsdale, NJ: Erlbaum.

Whiten, A., Custance, D., Gomez, J.C., Teixidor, P., & Bard, K.A. (1996). Imitative learning of artificial fruit processing in children (*Homo sapiens*) and chimpanzees (*Pan troglodytes). Journal of Comparative Psychology, 110*, 3-14.

Whiten, A., Goodall, J, McGrew, W.C., Nishida, T., Reynolds, V., Sugiyama, Y., Tutin, C.E.G., Wrangham, R.W., & Boesch, C. (1999). Cultures in chimpanzees. *Nature, 399,* 682-685.

Wobber, V., Herrmann, E., Hare, B., Wrangham, R. & Tomasello, M. (2014). Differences in the early cognitive development children and great apes. *Developmental Psychobiology, 56*, 547-573.

Highlights

Strong similarities between human and chimpanzee infants are found in early dyadic social and object-based interactions

Strong similarities between human and chimpanzee infants can be found in early triadic interactions

Early experiences in engagement with social partners and emotional engagements begin to have a major impact on the level and form of social cognition in the first year of life for both humans and chimpanzees.