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Visual attention in mother-infant dyads in three species of great apes *(Pan troglodytes, Pan paniscus and Gorilla gorilla*)

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1. Introduction

This is a report of the procedures and results from a study on mother-infant visual attention to each other in three species of great apes: *Pan troglodytes, Pan paniscus* and *Gorilla gorilla*. The goal was to investigate the primary intersubjectivity in mother-infant dyads. Primarily, the study focuses on mutual gazing and visual attention to body or face.

2. Participants

Three chimpanzee dyads and one bonobo dyad included in this study live at the Wolfgang Köhler Primate Research Centre (WKPRC) in Leipzig, Germany: Kofi, a chimpanzee male born July 7 in 2005, and his mother Ulla born June 8 in 1977 at Rijswick (in Leipzig since February 28, 2001). Kara, a chimpanzee female born on June 23 in 2005 and her mother Fraukje born April 6 in1976 at Rijswick (in Leipzig since February 28, 2001). Lobo, a chimpanzee male born April 21 in 2004, and his mother Corrie born December 12 in 1976 in Rijswick (in Leipzig since February 28, 2001). Luiza, a bonobo female born January 27 in 2005, and her mother Ullindi, born October 10 in 1993 in Frankfurt Zoo (in Leipzig since May 17, 2001).

The gorilla dyad in this study lives at Givskud Zoo in Denmark. Sammi, a male born July 24 in 2005, and his mother Minnie born in Les Mathes (in Givskud since June 23 1999).

3. Procedures

Each mother and infant dyad was videotaped in their everyday surroundings. In order to get representative samples of their behaviour, films were collected in different times of the day and on different days. There were no restrictions on the everyday procedures or activities for the animals. In all, about 40 hours of material was collected. The shooting took place outside the animals' enclosures, which means that there were little opportunities to choose the camera angle.

Then, a selection of the video material was made. Two main criteria were used for this selection. The quality of the material had to be sufficiently good to undergo microanalysis where the gazing behaviour could be observed. The age of the infants should be as close as possible to the specifications of task 6.2 (4-6 months). After this selection, the following amount of video material was analyzed: female chimpanzee Kara (5 months at the time) 3 hours, 31 minutes and 17 seconds; male chimpanzee Kofi (4.5 months at the time) 4 hours, 32 minutes and 30 seconds; male chimpanzee Lobo (19 months at the time) 3 hours, 51 minutes and 30 seconds; female bonobo Luiza (7 months at the time) 2 hours, 2 minutes and 24 seconds; male gorilla Sammi (9 months at the

time) 2 hours and 4 minutes. This adds up to a total of 16 hours, 1 minute and 41 seconds of micro-analyzed material, in 5 dyads. The only two dyads within the age interval according to specifications in task 6.2 are emphasized by more analyzed time than the rest (8 hours 3 minutes and 51 seconds). The material on the chimpanzees was collected at WKPRC by Mathias Osvath (MO), who also collected the material on the gorillas at Givskud Zoo. The analyzed material on the bonobo was collected by personnel at WKPRC at location.

3.1 Behavioural coding system

A coding system was created in order to analyse interactive visual behaviour and physical contact between mother and infant. The considerable age differences between the infants in the different dyads made it hard to maintain both mother and infant as focal animals in the analyses of different dyads (as will be seen, the codes require that both mother and infant is the focal animal depending on what is coded). Since the oldest animal, Lobo, is much more mobile, he tended to leave his mother at distances that cannot be covered by the camera with maintained quality ensuring observable gazing between mother and infant. Hence, in the younger dyads, Kara, Kofi, Luiza and Sammi, both the mother and the infant are the focal animals depending on what is coded. Whereas in the older dyad, Lobo, the infant, is in focus more frequently than the mother. The coding system will be described below; for a better overview of the hierarchical structure of the codes connected to visual behaviour (all except *Physical contact*), see Figure 1.

Mutual gaze occurs when mother and infant are looking at each other's faces at the same time. This code is divided into three sub-categories. *Mutual gaze initiated by mother* is defined as the mother looking at the infants face before the infant looks back. Consequently, *Mutual gaze initiated by infant* is defined as the infant looking at the mother's face before the mother looks back. *Simultaneous mutual gaze* is defined as both mother and infant starting to look at each other's faces at the same time. This division of mutual gaze was motivated by an attempt to reveal any biological predispositions in the infants.

Mother looking at infants face is defined as the mother looking at the infant's face without the infant looking back. This code combined with *Mutual gaze* constitutes *Mother's visual attention to infants face*.

Mother looking at infant is defined as the mother looking at the infant's body or head. *Visual inspection during grooming* is defined as the mother looking at the infant when grooming. These codes, including *Mother's visual attention to infants face*, is ordered under *Mother's visual attention to infant*.

Infant looking at mother's face is defined as the infant looking at the mother's face without her looking back. This code, including *Mutual gaze*, is placed under *Infant's visual attention to mother's face*. Note that there is no counterpart to the code *Mother's visual attention to infant* for the infant. This is because often it is nearly impossible to decide when the infant is actually looking at the mother's body. Furthermore, it never happened that the infant grooms the mother.

All the codes are measured both in mean instances per hour as well as percent of overall time, except *Mother's visual attention to infants face*, *Mother's visual attention to infant* and *Infant's attention to mother's face* that are only expressed in percent of overall

time. For the codes under *Mutual gaze, Mother looking at infant's face* and *Infant looking at mother's face* a mean duration per instance is also calculated.

Physical contact is defined as when the mother and infant stand in any physical contact to each other. This code is used simultaneously with other codes. For example, *Physical contact* can occur during the same time as *Mother looking at infant's face. Physical contact* is measured in percent of observed time.

When the subjects were positioned in a way that made coding of their visual behaviour impossible for more than 5 seconds, the code *Non-observable* was used. The total amount of *Non-observable* was then subtracted from the total of filmed time for each subject, leaving the total observed time. All the calculations in this report are based on the observed time.

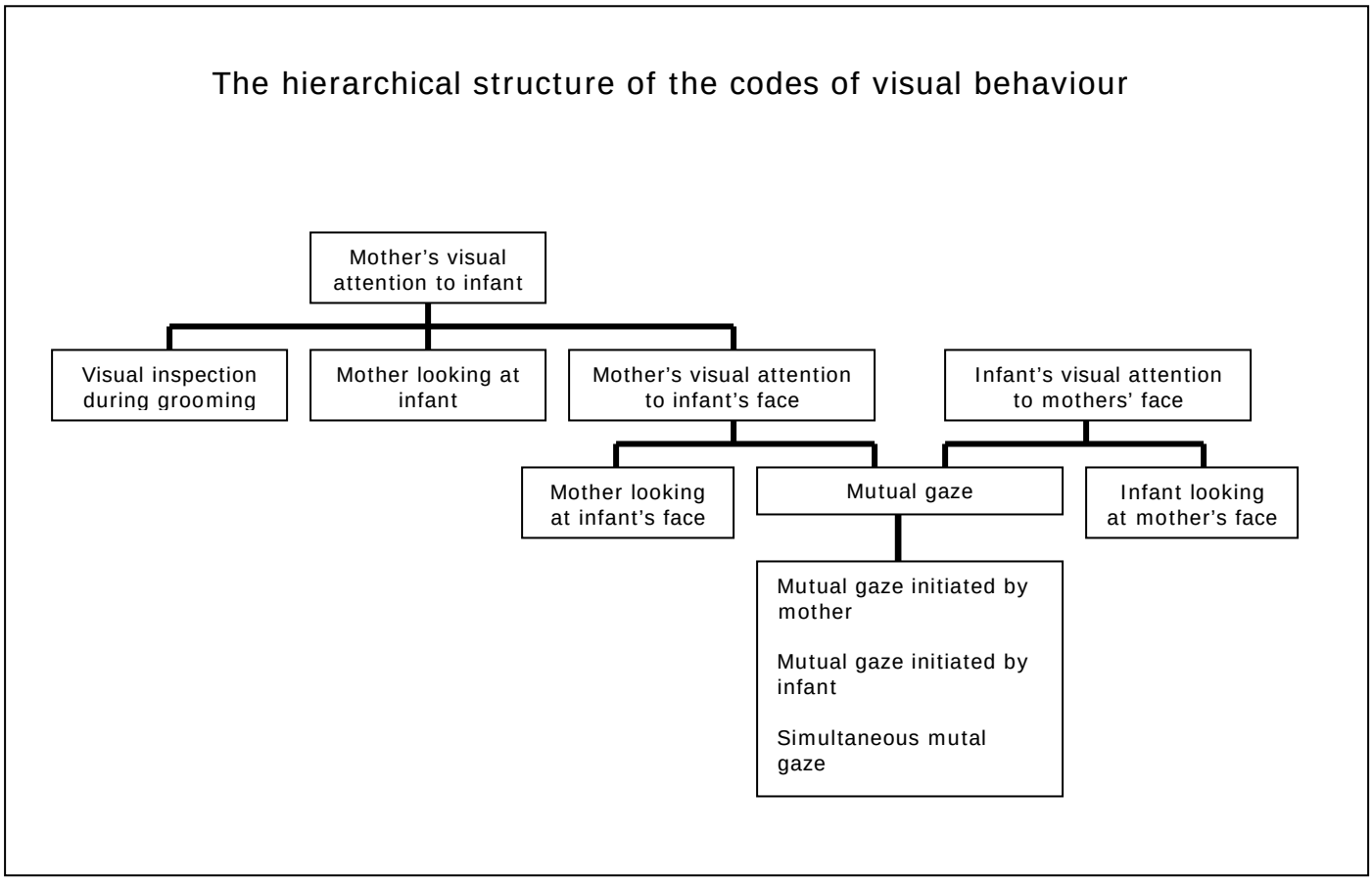

Figure 1: The structure and the relationships of the codes measuring the visual behaviour. Note the codes Infant's visual attention to infants face, Mother's attention to infant's face and Mother's visual attention to infant are measured only in percent of observed time. Note also that this figure describes all codes except Physical contact.

3.2 Observers' agreement

Coding all of the codes in all of the material was made by MO. Observing gazing in great apes is often difficult due to their lack of visible white sclera. MO was given brief observational training by Josep Call from WKPRC. MO also gained some experience in

observing great apes since he collected a majority of the material. Calculating the interrater reliability was made by letting Mats Andrén (MA) code approximately 10 % of the material. MA was totally naïve in observing great apes. The observers' agreement was 98 % with a Cohen's kappa of 0.67. These figures must be read taking into consideration the very few codes that actually occurred (as will be returned to).

4. Results

Since the material consists of a wide disparity of ages and species, as well as a small number of subjects, only descriptive statistics is used. Accordingly, simple statistics is used in presenting the performance of each dyad by itself. It is not viable to make generalizations about species or ages from the material. Therefore no statistical comparisons are made between the dyads (or ages or species). Any similarities or differences between the dyads should be read from the text and the tables as they are. The results should be viewed as pilot material.

The results of this study indicate far lower visual attentive behaviour (including mutual gazing) than previous similar studies do. Some of the details of these differences as well as possibly reasons for them will be discussed in the next section.

The results are presented per individual below; a better overview can be obtained in Table 1.

Kofi (male chimpanzee, 4.5 months):
A mean of 0.40 instances of *Mutual gaze* per hour. The mean duration was 0.65 seconds per instance. All of the observed mutual gazes were *Simultaneous mutual gaze.*
Mother looking at infants face occurred with a mean of 4.03 instances per hour (a mean duration of 2.43 seconds per instance). *Mother's visual attention to infants face* occurred in 0,273 % of the observed time.
Mother looking at infant had a mean of 35.03 instances per hour (a mean duration of 4.06 seconds per instance).
Visual inspection during grooming had a mean of 7.25 instances per hour (a mean duration of 19.6 seconds per instance).
Mother's visual attention to infant occurred in 8.173 % of the observed time.
Infant looking at mother face had a mean of 0.81 instances per hour (a mean duration of 1.39 seconds per instance).
Infant's visual attention to mother's face occurred in 0.037 % of the observed time.
Physical contact was coded for in 99.6 % of the observed time.

Kara (female chimpanzee, 5 months):
A mean of 0.96 instances of *Mutual gaze* per hour (a mean duration of 0.35 seconds per instance). All of the observed mutual gazes were *Mutual gaze initiated by infant.*

Mother looking at infants face had a mean of 1.44 instances per hour (a mean duration of 3.77 seconds per instance). *Mother's visual attention to infants face* occurred in 0.109 % of the observed time.
Mother looking at infant had a mean of 23.09 instances per hour (a mean duration of 3.77 seconds per instance).
Visual inspection during grooming had a mean of 12.51 instances per hour (a mean duration of 5.68 seconds per instance).
Mother's visual attention to infant occurred in 4.479 % of the observed time.
Infant looking at mother's face had a mean of 7.697 instances per hour (a mean duration of 1.63 seconds per instance).
Infant's visual attention to mother's face occurred in 0.359 % of observed time.
Physical contact was coded for in 100 % of the observed time.

Lobo (male chimpanzee, 19 months):
A mean of 1.09 instances of *Mutual gaze* per hour. *Mutual gaze initiated by mother* had a mean of 0.73 instances per hour (a mean duration of 0.93 seconds per instance), and *Mutual gaze initiated by infant* had a mean of 0.36 instances per hour (a mean duration of 0.19 seconds per instance).
Mother looking at infant's face had a mean of 2.18 instances per hour (a mean duration of 2.00 seconds per instance). *Mother's visual attention to infant's face* occurred in 0.142 % of observed time.
Mother looking at infant had a mean of 20.01 instances per hour (a mean duration of 2.88 seconds per instance).
Visual inspection during grooming had a mean of 2.91 instances per hour (a mean duration of 42.56 seconds per instance).
Mother's visual attention to infant occurred in 5.182 % of observed time.
Infant looking at mothers face had a mean of 0.73 instances per hour (a mean duration of 1.82 seconds per instance).
Infant's visual attention to mothers face occurred in 0.253 % of observed time.
Physical contact was coded for in 15.13 % of observed time.

Luiza (female bonobo, 7 months):
A mean of 7.33 instances of *Mutual gaze* per hour. *Simultaneous mutual gaze* occurred in a mean of 2.75 instances per hour (mean duration 0.74 seconds per instance). *Mutual gaze initiated by mother* had a mean of 2.75 instances per hour (mean duration 1.67 seconds per instance). *Mutual gaze initiated by infant* had a mean of 1.83 instances per hour (mean duration 1.12 seconds per instance).
Mother looking at infants face had a mean of 2.75 instances per hour (a mean duration of 0.33 seconds per instance). *Mother's visual attention to infants face* occurred in 0.26 % of observed time.
Mother looking at infant had a mean of 43.95 instances per hour (a mean duration of 1.27 seconds per instance).
Visual inspection during grooming had a mean of 15.56 instances per hour (a mean duration of 5.36 seconds per instance).
Mother's visual attention to infant occurred in 4.13 % of observed time.

Infant looking at mother's face had a mean of 24.72 instances per hour (a mean duration of 1.12 seconds per instance).
Infant's visual attention to mother's face occurred in 1.00 % of observed time.
Physical contact was coded for in 89.27 % of the observed time.

Sammi (male gorilla, 9 months):
A mean of 1 instance of *Mutual gaze* per hour (a mean duration of 0.65 per instance). All observed mutual gazes were *Mutual gaze initiated by mother.*
Mother looking at infants face had a mean of 1.11 instances per hour (a mean duration of 0.38 seconds per instance). *Mother's visual attention to infant's face* occurred in 0.029 % of the observed time.
Mother looking at infant had a mean 40.04 instances per hour (a mean duration of 0.96 seconds per instance).
Visual inspection during grooming did not occur in the observed time.
Mother's visual attention to infant occurred in 1.129 % of the observed time.
Infant looking at mother's face did not occur in the observed time.
Infant's visual attention to mother's face occurred in 0.019 % of the observed time.
Physical contact was coded for in 94.15 % of the observed time.

	Kofi *P. troglodytes* *4.5 months*	**Kara** *P. troglodytes* *5 months*	**Lobo** *P. troglodytes* *19 months*	**Luiza** *P. paniscus* *7 months*	**Sammi** *G. gorilla* *9 months*
	mean inst./h	mean inst./h	mean inst./h	mean inst./h	mean inst./h
Mutual gaze (total)	0.40	0.96	1.09	7.33	1.00
simultaneous	0.40	0.00	0.00	2.75	0.00
initiated by mother	0.00	0.00	0.73	2.75	1.00
initiated by infant	0.00	0.96	0.36	1.83	0.00
Mother looking at infants' face	4.03	1.44	2.18	2.75	1.11
Mother looking at infant	35.03	23.09	20.01	43.95	40.04
Visual inspection during grooming	7.25	12.51	2.91	15.56	0.00
Infant looking at mothers' face	0.81	7.697	0.73	24.72	0.00
	% of obs. time	% of obs. time	% of obs. time	% of obs. time	% of obs. time
Mother's visual attent. to inf. face	0.273	0.109	0.142	0.260	0.029
Mother's visual attent. to infant	8.173	4.479	5.182	4.130	1.129
Infant's visual attent. to m. face	0.037	0.359	0.253	1.00	0.019
Physical contact	99.600	100	15.13	89.27	94.15

Table 1. The results are presented in mean instances per hour, except the codes describing visual attention and physical contact that are measured in percentage of observed time.

5. Discussion

5.1 Explaining the differences in comparison to similar studies

The results are remarkably different from a study made by Bard et al. (2005) on mutual gazing in chimpanzees. For example, they report that mutual gaze occurs with a mean of 16.9 times per hour, when two populations of captive chimpanzees are averaged. Even if significant differences were seen between the populations, explained as cultural, each population still had a notably higher mean than any individual in this study. In the population at Yerkes National Primate Center, a mean of 12 instances per hour was measured. In the population at the Primate Research Institute in Kyoto, a mean of 22 instances per hour was measured. Even vaster discrepancies can be noted when looking at the percentage of Mother's visual attention to infant, and its face, in the observed time. A serious attempt must be made to explain these differences by comparing the two studies.

First of all, there is a difference in the number of dyads, 5 in this study and 11 in Bard et al. (2005). If one just considers the different numbers of dyads, one reasonable explanation is that the low occurrences in the present study might be a result of individual differences. Bard et al. note that their number is small and that the individual differences are moderately large. Since the present study has even fewer numbers of dyads, individual factors might influence the data to a considerable extent. However, this is probably not the complete explanation.

All the 11 subjects in the study by Bard et al. were equally old, and the infants were younger than the youngest in the present study. However, this does not seem to cause the differences in results between the studies. In fact, in both studies the younger the infant is, the less mutual gaze one finds.

The study by Bard et al focused on only one species, *Pan troglodytes*. The present study includes three species. The bonobo dyad and the gorilla dyad would not in itself explain the result. The results from the bonobo dyad are the only ones that are somewhat comparable to the ones in the Bard et al (2005). The gorilla dyad, on the other hand, even lacks occurrences of some codes that are present in the rest of the dyads. Beside the age differences, this could be explained as differences in behaviour of the species, as well as individual differences. The only two actually comparable dyads of chimpanzees (those with Kofi and Kara) still show far less mutual gazing and visual attention than the apes in the study by Bard et al. The third chimpanzee dyad (with Lobo) is hard to use in comparison for at least two reasons: the infant was mainly the focal animal, and the age difference is extensive.

Bard et al. (2005) show that there exist significant differences in mutual gazing in different chimpanzee cultures. So, of course, some of the differences could be explained in terms of culture. However, the vast differences make it improbable that this is the sole cause.

Another reasonable explanation is that the coding was more conservatively executed in this study, as an effect of the quality of the video material. In many cases both animals are seen in the picture but they are positioned in a way that makes it very difficult to get a clear view of their gazing. Since the camera was located outside the animals' enclosure, the camera angle could in many cases not be adjusted enough to capture the gazes. If the code *non-observable* had been used in all these occasions, then the material would suffer from other methodological problems since it would have been

chopped up into chunks that can hardly be seen as representative, and the total of the observed time would decrease significantly. This problem combined with the ground rule of observational studies, not to code what you do not actually see, might have contributed to the outcome of the results. The codes as such are very clear when a good view is given, but they become increasingly subjective when the video material has a low quality (an acceptable observers' agreement shows however that subjectivity in the coding was kept low). However, it should be noted that the quality of the video material in the study by Bard et al. is not known to us.

5.2 Phylogenetical sequencing of intersubjectivity based on the results

The objective of this study is to collect data on non-human primate primary intersubjectivity. The general thesis behind the study is that there is a difference between humans and great apes in primary intersubjectivity that results in a more advanced intersubjectivity in the adult human. The present study is meant to provide some evidence concerning the evolution of intersubjectivity, the so-called phylogenetic sequencing.

Unfortunately, some methodological problems weaken the value of the results presented here. First of all the quality of the data is not what would be needed in comparing with other studies of human and ape infants. The subjects are too few and have too large age differences and they belong to different species. This is due to mere practical circumstances. Because of economical limitations and the limited time available, it has not been possible to get access to and collect enough material of a sufficient number of great ape dyads. However, the diversity of great ape species in the material does not necessarily constitute a problem, since the thesis puts humans at an extreme in the intersubjectivity domain and one could simply compare humans to great apes. The small number of dyads is a more severe problem since it does not meet the statistical requirements when trying to generalize comparisons between whole taxa. The difference in ages of the infants is also a difficult problem when comparing this material to an equivalent material on human dyads. It is far from clear how such material would look like.

In addition to this, one must take into consideration what is already known within this research area. Bard et al (2005) have convincingly shown that there exist large cultural differences between different populations within the same species (*Pan troglodytes*). Others have concluded that this is the case in humans as well (Keller et al., 2004). Bard et al. state that the differences between humans and chimpanzees may actually not be so extensive in some areas as one might believe. The largest differences are the length of the gaze and the amount of time mother spent looking at infant, where humans excel (Bard et al, 2005).

The following questions should be kept in mind in future studies comparing human and great ape primary intersubjectivity, if one want to understand the evolution of intersubjectivity. Firstly, how should one deal with cultural differences in the comparison? Is it possible to draw any firm evolutionary conclusion when comparing a few subjects from a few populations that are highly influenced by culture (both humans and non-humans)? Secondly, if the largest differences between chimpanzees and humans are the length of the gaze as well as mother's visual attention to infant, in what way does this contribute to our of understanding the phylogenetic sequencing of intersubjectivity?

5.3 Possible research directions implicated by the pilot results

This study should, as mentioned earlier, be viewed as a pilot study. The methods and the results can generate ideas about possible directions to be further explored.

One of the most obvious positive results in the study is that mutual gaze occurs in all three of the observed species. However low the frequency may be, it still shows that this behaviour is spread not only in *Pan* but also in *Gorilla*.

In this study, codes were tested that could reveal infant's visual attention to mother, independently of the mother's visual behaviour. The initiation of mutual gazing was a part of the codes used. This was added in order to reveal any biological predispositions in the infant. If the infant is actively seeking eye contact and directs much visual attention to its mother's face, then this might be a result of biological predispositions. Especially interesting is to compare this to the amount that the mother seeks eye contact or has visual attention to the infant's face. If the infant is initiating more mutual gazes and spends more time with visual attention to the other's face than the mother does, this could indicate predispositions in the infant. If the mother, on the other hand, is the one with significantly more initiations and attention, this might be a result of a learned behaviour, which could be seen as a form of culture. Of course, many other reasons than culture could be attributed to the activity of the mother in this domain. It would still be fruitful to use these codes when comparing infants and mothers from different cultures. If indeed the mother is the more active part in cultures with more mutual gazing than in those with a lower amount, and if infants seem to be at the same level in initiations in many cultures, then this method could be used in establishing the role of nature versus nurture within this domain. This could then be compared to humans in the same manner (many different cultures) and a clearer picture of what is biologically inherited in each species would become more apparent. This has not been tested yet, but this study shows that the method would be possible to employ. However, a number of questions must be answered before using the current method. For example: Are infants more biologically predisposed for gazing in certain ages? At what age does the cultural factors start influencing the gazing of the infant? In the present study it is not possible to use the method to obtain a better understanding of the relationship between predispositions and culture since, as mentioned, the quality of the material is too poor.

The present study may indicate an interesting direction in research when it comes to bonobos. The bonobo dyad in this study stands out in the results. If this is not a result of individual differences, it is truly noteworthy. The most probable cause of the overall low results in this study might be a more conservative coding due to low quality video material. Out of all the material, the bonobo dyad had the lowest quality, because a more low-tech video camera was used in this data collection. Despite this, the bonobo results are somewhat comparable to those in the study of Bard et al. Without jumping to any conclusions, it is not unlikely that bonobos have a considerably more developed behaviour connected to primary intersubjectivity than other species of great apes. This is supported by earlier observations that conclude that bonobos have a more human-like eye contact pattern than chimpanzees (e.g. Savage-Rumbaugh, Rumbaugh and McDonald, 1985). A thorough investigation of bonobo mother-infant dyads would be of great importance. If the results were to show that bonobos are nearly indistinguishable from humans, then either the evolution of human intersubjectivity, or the intersubjectivity in

the bonobo species, or the view that says that early gazing patterns reveal something crucial about the evolution of intersubjectivity must be reconsidered.

6. Acknowledgements

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