Neural and behavioral correlates of ostensive cues in naturalistic mother-infant interactions

Christine Michel[1,2], Daniel Matthes[1], Stefanie Hoehl[1,3]

[1]Former Max Planck Research Group Early Social Cognition, Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig;
[2]Leipzig University, Germany; [3]University of Vienna, Austria

michel@cbs.mpg.de

MAX PLANCK INSTITUTE
FOR HUMAN COGNITIVE AND BRAIN SCIENCES

Introduction

To engage in Joint Attention (JA), that is attending to the same object together with another person while being mutually aware of it, is a crucial ability helping infants to focus on socially relevant information in the environment. JA develops around 6 to 9 months of age. Previous studies showed that JA interactions including mutual gaze enhanced object encoding and object-directed attention in infants towards the end of their first postnatal year of life (Cleveland & Striano, 2007; Wass et al., 2018).

The Natural Pedagogy account states that besides mutual gaze, other ostensive cues like infant-directed speech promote social learning (Csibra & Gergely, 2006). One promising neural correlate of this state of facilitated information encoding is theta power, which is measured via the electroencephalogram and was related to infants' encoding of novel objects (Begus, Southgate, & Gliga, 2015).

To date, it remains unclear if the promoting effect of social cues also occurs during natural parent-child interactions, which specific aspects of an interaction account for it and what is its neural foundation.

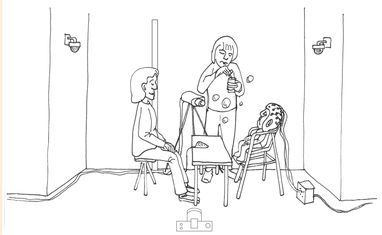
We therefore asked mothers to familiarize their infants with a novel object in either an ostensive (OS) or a non-ostensive (NOOS) interaction and recorded infants' electroencephalogram during this familiarization phase and during a nonsocial baseline. Infants' object encoding performance was tested in a subsequent object recognition test. We expected enhanced theta power during the familiarization phases as compared to the nonsocial baseline. We hypothesized that theta power would be most pronounced during the OS familiarization phase. Additionally, we expected higher attentiveness to the object and to the mothers during the OS familiarization (Begus et al., 2015; Wass et al., 2018) and enhanced object encoding for objects which infants were familiarized with in an OS context (Cleveland & Striano, 2007).

Methods

Sample information: *N* = 40, 22 female, mean age: 9 months 13 days

Nonsocial Baseline

1

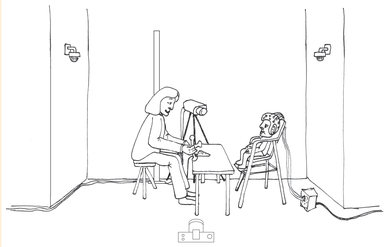


EEG in the infant was measured during up to four non-social baselines, each lasting for 20 s, in which the experimenter blew soap bubbles.

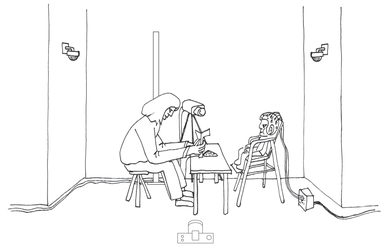
Familiarization phase

2

OS condition



NOOS condition



During the familiarization phase, mothers presented novel objects to their infants in two different ways: during the ostensive (OS) familiarization, mothers were asked to act as naturally as possible including infant-directed speech, mutual gaze and calling the infant by his/her name. During the non-ostensive (NOOS) familiarization, mothers were asked to use adult-directed speech, not to mention their infant's name or look at their infant. Each familiarization lasted until the infant looked at the object for 20 s cumulatively.

Object recognition test

3

During the subsequent recognition test, infants were presented with the object from the familiarization phase and a novel object for 20 s in total (switch of position after 10 s). Infants' looking times to both objects were analyzed.

Theta power

- Theta power was analyzed during the nonsocial baseline and while the infant looked at the object during the familiarization phases, 3 – 5 Hz, electrodes: Fz, F3, FC3, FC1, Cz, C3, C4, FC4, FC2, F4.
- *Hypotheses:* diminished theta power during the nonsocial baseline as compared to the familiarization phases, enhanced theta power during OS than NOOS familiarization

Object-directed attentiveness

- Infants' object-directed attentiveness was calculated as infants' looking time to the object divided by the sum of infants' looking time to the object and the environment.
- *Hypothesis:*
  enhanced object-directed attention during OS than NOOS familiarization

Mother-directed attentiveness

- Infants' mother-directed attentiveness was calculated as infants' looking time to their mothers divided by the sum of infants' looking time to their mothers and the environment.
- *Hypothesis:*
  enhanced mother-directed attentiveness during OS than NOOS familiarization

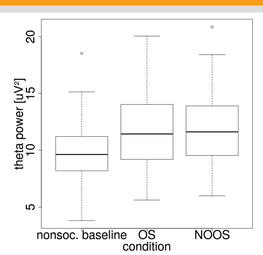
Object encoding

- Infants' object encoding performance is reflected in infants' preference for the novel object. This preference score was calculated as infants' looking times to the novel object divided by the sum of looking times to the novel and the familiarized object.
- *Hypothesis:*
  enhanced preference in the OS than the NOOS familiarization

Results

Theta power

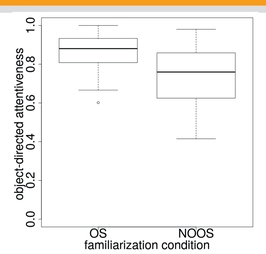
4



Theta Power: As expected, infants' theta power was decreased during the nonsocial baseline (*mean* = 9.91 µV² , *SD* = 1.48 µV²) as compared to both, the OS (*mean* = 11.87 µV² , *SD* = 2.26 µV², *t*(26) = −2.39, *p* = 0.03) and the NOOS familiarization phase (*mean* = 12.07 µV², *SD* = 1.98 µV², *t*(26) = −2.37, *p* = 0.03). Unexpectedly, no difference in theta power was found between both familiarization phases, *t*(39) = −0.69, *p* > .25.

Object-directed attentiveness

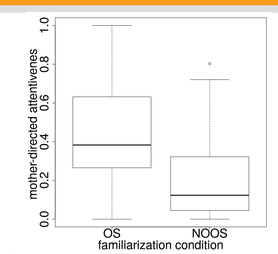
5



Object-directed attentiveness: As expected, infants showed more object-directed attentiveness in the OS (*mean* = 0.86, *SD* = 0.12) than in the NOOS condition (*mean* = 0.74, *SD* = 0.15), *t*(39) = 4.58, *p* < .001.

Mother-directed attentiveness

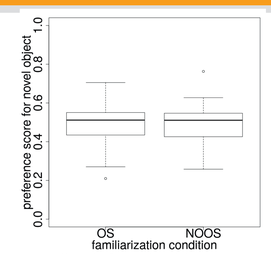
6



Mother-directed attentiveness: As expected, infants showed more mother-directed attentiveness in the OS (*mean* = 0.44, *SD* = 0.28) than in the NOOS condition (*mean* = 0.19, *SD* = 0.21), *t*(39) = 4.44, *p* < .001.

Object encoding

7



Unexpectedly, infants' object recognition performance did not differ between the OS (*mean* = 0.50, *SD* = 0.11) and the NOOS condition (*mean* = 0.51, *SD* = 0.12), *t*(39) = 0.31, *p* = 0.76.

Discussion

Behaviorally, ostensive cues focused infants' gaze to the object and their mothers. This is in line with results by Wass et al. (2018), who found that jointly playing with another person increased object-related attention as well as attention to the partner in infants. Thus, infants in our study perceived a difference between the OS and NOOS condition and adapted their behavior to the amount of social cues they received from their interaction partner: when social cues like eye gaze and infant-directed speech were present, infants' attention was focused more on the object and their mother compared to interactions without these cues.

Infants' theta power increased in both familiarization phases as compared to the rather non-social baseline. However, we did not find any neural evidence that ostensive cues increased infants' encoding (no significant difference in theta power between the OS and the NOOS familiarization). It might be that the NOOS condition still contained enough social features like speech and movement to increase infants' theta power.

Ostensive cues during the familiarization phase did not seem to influence infants' object encoding as we did not find any difference in their preference score of the recognition test at the group level. Given previous research, this effect is surprising. Further analyses will investigate whether specific aspects of the social interaction (e.g. mutual gaze) are related to infants' individual object processing.

References

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