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The influence of maternal sensitivity on monitoring of an abstract animation of social interaction

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Abstract

Maternal sensitivity influences the maternal working model of the way mothers act on their infant's signals. In the current study we investigated if this working model also influences mother's monitoring of an animation of social interaction. Forty mothers participated in the study with their twelve-month-old infants. Maternal sensitivity was observed during three episodes, using the Ainsworth's Scales. Mothers watched animations while their eye-movements were registered by an eye-tracking apparatus. In the animation a mother-infant interaction was shown at an incline, in which a separation took place. The infant figure made crying or laughing sounds and at the end the larger figure either returned to the smaller figure or went uphill. We analysed the duration of fixations at the baby figure and overall fixations during the response segment. No effects for sensitivity were found, but mothers tended to look longer when the larger figure was unresponsive compared to responsive. Mothers also looked significantly longer at the first four movies, compared to the second four movies. The results suggest that mothers' looking behaviour at the animation is not affected by maternal sensitivity. This could be due to the relatively small sample or the classification of the low- and high sensitive groups. Another possibility is that the working model of sensitivity is not generalized to other interactions. More research in the future is needed on this topic.

Keywords: eye tracker, maternal sensitivity, monitoring, social interaction, animation.

Content

Picking up infant's signals is crucial for an optimal relationship between mother and infant (Ainsworth, 1969). Maternal sensitivity is an aspect in this. Maternal sensitivity to an infant is captured in working models (Collins, 1996). Is this working model generalizable to other mother-infant interactions, for example, to abstract animations in which a mother-infant interaction is depicted. The aim of the current study is to investigate if there is a relation between mothers' sensitivity to their own child and their monitoring behaviour of an animation of social interaction.

Maternal sensitivity

A sensitive mother notices the signals her child sends out (Ainsworth, 1969), and responds to them in a way that is suitable and prompt for the child. According to Ainsworth, Blehar, Waters and Wall (1978) "the optimally sensitive mother is able to see things from her baby's point of view. She is alert to perceive her baby's signals, interprets them accurately, and responds appropriately and promptly, unless no response is the most appropriate under the circumstances" (p. 142). As Ainsworth (1969) indicates sensitivity has four important aspects. The first aspect is that the mother sees the signals her child sends out. The second part is that the mother 'reads' these signals in the correct way and knows what the child wants or needs. The third step is to react in the appropriate manner and give the infant what he or she wants. And the last aspect is that the response of the mother needs to happen quickly. If the mother waits an hour to respond the child will not link his signal to that response and it is not a sensitive response for the child.

A mother is expected to respond to her infant's needs (Donovan, Taylor & Leavitt, 2007). In doing so she is dependent of the facial and vocal expressions of her infant. For example, a crying face would imply distress and the mother is expected to interpret this in the correct manner, and react appropriate (Bolzani-Dinehart, 2005).

Gelfand and Teti (1990) discovered that maternal depression was associated with

unresponsiveness and intrusiveness. Several studies on depression have shown that infants with a depressed mother are at greater risk for insecure attachment (Gelfand & Teti, 1990; Huang, Lewin, Mitchell & Zhang, 2012; Lovejoy, Graczyk, O'Hare & Neuman, 2000) or behavior problems (Vondra, Shaw, Swearingen, Cohen & Owens, 2001). Gelfand and Teti (1990) claim that the unresponsiveness and less sensitivity that is shown by depressed mothers explains the insecure attachment rather than the depression itself.

Sensitivity has been found an important factor for infant attachment (Morley & Moran, 2011). When an infant received sensitive and consistent caregiving it had more chance to develop a secure attachment relationship with the caregiver. It has also been found that infants with insecure attachment representations overall experienced inconsistent caregiving, which is an aspect of low maternal sensitivity.

The sensitivity of the mother influences the attachment of the child and later child development (Arteche et al., 2011). The quality of the relationship between mother and child depends on the mother's sensitivity and her ability to react to the vocal and facial signals the infant sends out (Arteche et al., 2011). If the mother is not responsive towards the infant there is a larger chance for the infant to have difficulties in later child development (Yarrow et al. 1984). The study of Hane and Fox (2006) shows that variations in maternal caregiving behaviour influence the infants' reaction to stress and novelty. Infants who received lower quality of maternal care showed more fearfulness, less sociability and a pattern of right frontal EEG asymmetry when presented with novel or stressful stimuli. Right frontal EEG asymmetry is associated with withdrawal behaviours (Hane & Fox, 2006), thus the quality of maternal care an infant receives is important for the infant's development.

Maternal brain research

Previous research on the neural basis of maternal responsiveness by Ranote and colleagues (2004) shows right sided brain effects on visual object recognition and face

processing. It indicates that recognition of facial and vocal expressions of emotions are important factors for interaction and for an appropriate, sensitive response towards the infant. Infants show their needs through facial and vocal expressions, so the caregiver should be able to interpret these in the correct manner. In the study of Rodrigo et al. (2011) mothers were placed in two groups on the basis of being neglectful or not. Neglectful mothers showed fewer skills in emotional communication and less understanding of their infant's emotions compared to non-neglectful mothers. It has been suggested that maternal brain activity may show differences for mothers with different maternal sensitivity. The mothers in the control group (the non-neglectful mothers) showed clear differences in their ERP patterns between crying infant faces and laughing or neutral faces. Neglectful mothers did not show these differences in ERP pattern between crying and laughing faces. Leibenhuft, Gobbine, Harrison and Haxby (2004) showed mothers images of their own children, familiar children that were not their own, unfamiliar children and unfamiliar adults. Different brain areas were activated when mothers looked at their own children versus other children, familiar or unfamiliar. These activations could reflect the attention and attachment a mother has for her own child. The relationship between a mother and her own child versus another child are very different, so this is reflected in brain activity.

Working models

The expectations an individual has about a situation or event are represented in models, also called working models (Collins, 1996). Everything that happens in life is constructed in models. The accessibility and responses of a mother towards her child and also the child's responses are captured in the child's model, and also in the working model of the mother (Thompson, 2008; Ziv, Aviezer, Gini, Sagi & Koren-Karie, 2000). Past experiences influence the behaviours and feelings (Bowlby, 1988). Both mother and child influence and shape these models as contributors and receivers by past experiences and expectations about

the future.

Through these models mothers have expectations about infant-caregiver interactions and these working models influence how mothers will monitor and respond to their own infant. When the relationship between mother and child is secure more appropriate responses will happen compared to a more insecure relationship between mother and child. According to Bowlby (1988) a mother of a securely attached infant will be continuously checking how the infant is doing, pick up the signals the child sends out and will act appropriately upon the signals. Besides a working model of the interaction with the child the mother also has a working model for other social interactions, in which her infant is not present. The working model with her child influences the interaction with the child. We propose that the working models could also be reflected in mothers monitoring of interactions of others. Therefore we asked whether mothers with different levels of sensitivity would monitor a social interaction in different ways. In the current study we used an animation of a social interaction, in which a child-caregiver interaction was depicted. There has not been much research on the relationship between mothers' sensitivity towards their own infants and their monitoring pattern for observed interactions. Does a mother's sensitivity influence her attention for an animated infant-caregiver interaction? Do sensitive mothers watch animations on social interactions differently compared to insensitive mothers? The aim of this study is to explore if mothers' monitoring of animated social interactions is influenced by the sensitivity towards their own child.

Children's monitoring behaviour

There has been more research on children's processing and representation of social interactions (Biro, Alink, Van IJzendoorn & Bakermans-Kranenburg, 2014; Johnson, Dweck & Chen, 2007; Johnson et al., 2010; Morita et al., 2012). Johnson et al. (2007) and Johnson et al. (2010) studied the relation between infants' expectations based on their looking behaviour

and the quality of the infants' attachment. In these studies the infants were habituated to an animation. During the animation infants watched the separation of a large and a small oval shape and heard a crying sound. In one of the test events the large oval shape returned to the small figure, while in the other test event it went uphill. Johnson et al. (2010) found that infant's behaviour in the Strange Situation Procedure was related to the way the infants looked at the test events. In other words, Johnson et al. (2010) found that the infants had different expectations about how an infant-caregiver interaction would be depending on their attachment security. The securely attached infants expected the mom to react when an infant was crying (Johnson et al., 2010). Securely attached infants looked longer when the response of the caregiver was unresponsive and thus relatively unexpected compared to a responsive caregiver. Biro et al. (2014) tested how the monitoring of social interactions of infants was influenced by emotional cues in an eye tracking study. A similar animation as in the Johnson et al. (2007) and Johnson et al. (2010) study was used. Biro et al. (2014) found that infants fixated longer in the separation at the large figure when the smaller figure cried compared to when the smaller figure laughed. The crying drew the focus of the infants to the larger figure.

Current study

In the current study mothers watched an animated interaction while their eye-movements were registered by an eye-tracker apparatus. These animations were identical to the ones used in Biro et al.'s (2014) study. The animation consisted of four parts. Start, large figure going uphill, separation and response. After the large shape went uphill the small shape would either make a crying or a laughing sound. The response outcomes were going down the incline, back to the small figure or going further uphill. In the current study we focussed on the response segment, where either a responsive or unresponsive outcome is shown.

We expected that more sensitive mothers will monitor the animations differently compared to less sensitive mothers. First we expected that the sensitive mothers will look

longer overall in the crying condition than in the laughing condition, regardless of the type of response. This is expected because the infant crying sound implies distress which may increase sensitive mothers' attention toward the situation. Second we expected that more sensitive mothers look longer overall in the unresponsive condition, because sensitive mothers would want to respond to their infants (crying or laughing) (Bowlby, 1988) and thus they may need more processing to see an unexpected response in which the large figure walks away. At last we expected that, in terms of monitoring the figures, there would be a difference between mothers with different levels of sensitivity in how long they look at the small oval figure during the response segment, especially when the crying sound was heard and when the mother figure did not return. A high sensitive mother wants to comfort her infant when he or she is crying (Bowlby, 1988). So when in the animation the smaller figure (the child) is crying and the larger figure (the mother) does not respond, but walks further on a steep incline, a highly sensitive mother is expected to look longer at the small figure.

Method

Participants

Participants took part in a larger study investigating processing of social signals in infants and their mothers. 60 mothers and their twelve months old infants visited the lab. The sample we report on consisted of 40 mothers between the age of 24 and 53 (mean age = 34.22 years, *SD* = 4.78 years).

A questionnaire on background information was filled out by the mothers. Three mothers did not fill out the questionnaire. Of the remaining 37 mothers, 20 had only one child (17 had more children). Eleven of the infants of the mothers who participated in the study went to day care for less than 10 hours per week care (27.5%), 22 infants were in care for 10

to 20 hours (55%) and 4 infants received more than 20 hours of (non-maternal) care per week (10%). The questionnaire was filled out only for the infant the mother participated with in the study. Six mothers had primary school or high school education (15%), 19 mothers had a college degree (47.5%) and 12 mothers had at least a master degree (30%).

The mothers were recruited by mailing. All parents with infants between 3 to 6 months of age in Leiden or surroundings received a letter from the 'Babylab' at the Faculty of Social Sciences of Leiden University. The letter contained information on participation in our research with a young child, a brochure about the 'Babylab' and an answer sheet that could be filled out if they were interested. The families that were interested filled out the form or e-mailed the Babylab. When the infant became 12 months old the family was contacted to make an appointment to participate in the current study. All mothers signed informed consent forms at the start of the visit.

Procedure

During the visit at the lab, the mother and infant participated in several test sessions. The sessions were performed by trained students of Leiden University. First the infant watched animations while their eyes were tracked. Then the Strange Situation Procedure was performed. After that mother and child had a little break and at the end of the break mother filled out a questionnaire, which we called as "competing demand" episode (see detailed description below). Next Lab-Tab episodes for joy, anger and fear (Goldsmith & Rothbart, 1999) were performed, and then mother and infant could play with toys. At the end of the visit the mother watched the same animations as the infant did at the start of the visit and also her eyes were tracked. After the session mothers received a questionnaire by e-mail, for background information, that they were asked to fill out. In the current study we used ratings for sensitivity based on the break, the "competing demand" and free play with toys episodes

and mothers' monitoring of the animation was analysed. The other tasks will not be further discussed.

Maternal sensitivity

Mothers' sensitivity towards her child was observed during three episodes. First during a six-minute break, while mother and infant had something to eat or drink. Then during a "competing demand" episode where mother filled out a questionnaire while the infant was in the room. And last during free play with toys. During free play mothers were told they could play with their child like they would do at home without further instructions. All the episodes were recorded on camera. The three episodes were separately coded afterwards (6 minutes of the break, 5 minutes of "competing demand", 5 minutes of free play), and an overall sensitivity score was given by the coder. The Ainsworth's Sensitivity Scales were used with 9 representing a highly sensitive mother and 1 a very low sensitive mother. A trained researcher coded all the sessions. A second, expert coder coded 15 cases from the entire sample of 60 cases. Intercoder reliability was adequate, the intra-class correlation coefficient (single measures, absolute agreement), was .73 for the Break, .74 for Competing demands, .71 for play with toys and .80 for the average score.

The overall sensitivity score of the mothers is reported in Figure 1. The majority of the 40 mothers scored around 6 on the 9-point sensitivity scale as can be seen in Figure 1. The mean sensitivity score was 5.99 (*SD* = .96).

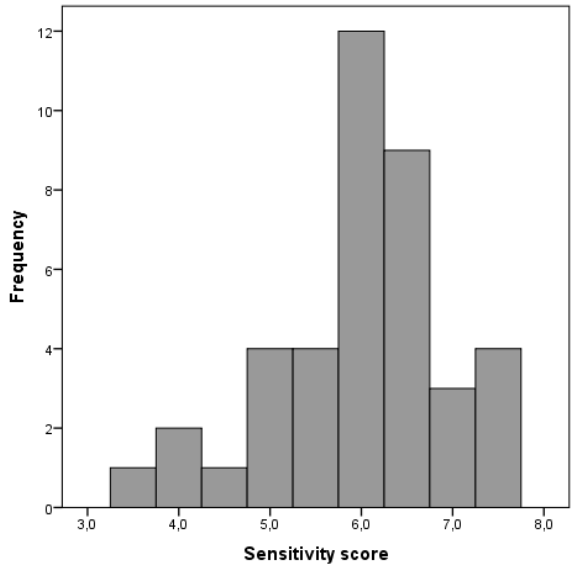

Figure 1. Overall maternal sensitivity scores.

The mothers were divided in two groups. One group representing high sensitivity toward the infant and one group representing lower sensitivity toward the infant. A score of 6 was chosen as the cut-off point, which was the median score of the total score of the sample. Because a 6 is a relatively high score on the sensitivity scale, mothers with a total score of 6 or higher were in the higher sensitive group. Mothers who scored lower than 6 on the sensitivity scale were in the lower sensitive group. 28 mothers were in the high sensitive group, 12 mothers were in the low sensitive group.

Eye tracker

At the end of the visit the mother watched animations while her eye-movements were registered with the Tobii T120x eye tracker. The mother was sitting in a booth that could be closed with a curtain, at about 60 centimetres distance from the monitor at eye-level. Before the animations were shown a 5-point calibration was carried out. In between all movies a short attention getter was displayed.

Stimuli

The animation showed two oval figures, a small (2 x 1.5 cm) and a large (3.5 x 2.5 cm) one. They stood at the bottom of a steep incline, which had a little platform halfway up (see Figure 2). The animation started with both figures at the bottom of the incline. Then a separation occurred, the large figure walked up the hill and stopped halfway. At that moment the little figure, at the bottom of the incline, started to cry or started to laugh. When the infant figure was crying or laughing it expanded and contracted slightly and changed of colour two times. Next, two outcomes could happen, called the response. First the responsive outcome in which the larger figure returned to the little figure down the incline. The other outcome was the unresponsive outcome and showed the larger figure moving up the steep incline. Four different movies (cry and responsive; cry and unresponsive; laugh and responsive; laugh and unresponsive) were shown twice. In total mothers watched eight movies, divided in two blocks. Each block started with either two crying or two laughing animations. In the second block the movies were repeated. The colour of the responsive versus unresponsive mother (red or blue) was counterbalanced. The animation used is similar to the one used by Johnson et al. (2007) and Johnson et al (2010). The mothers were randomly assigned to the four order conditions and two colour conditions.

Figure 2. Separation segment, unresponsive and responsive outcome.

Data analysis

Tobii Studio software calculated the fixation times, these were analysed with SPSS. We were interested in fixations during the response segment (4.3 sec). We defined an area of

interest around the smaller figure (2.26% of the entire area) during both response types. The overall fixation duration and the fixation duration at the smaller figure relative to overall fixation was calculated for each animation and analysed.

An important note is that the recording does not distinguish between the larger and smaller figure when they are next to each other. Thus in the responsive response outcome in the end, it is impossible to distinguish between watching at the smaller or larger figure. As a consequence the direct comparison of the fixation duration ratio for the area of interest between the two outcomes gives a distorted outcome and thus it will not be interpreted.

Results

Preliminary analysis

Preliminary analysis showed that mother's age, having one or more than one child, and hours of external care for the infant was not associated with any of the fixation measures ($p_s > .27$). Therefore these factors were omitted from the analysis.

Furthermore, there was a relation between mother's education category and sensitivity score, $F(2, 34) = 5.29$, $p = .01$, $\eta^2 = .24$. Maternal sensitivity was significantly lower in the lowest education category (primary or high school, $M_{sens} = 5.08$) compared to the higher two categories (college $M_{sens} = 5.06$, master or above $M_{sens} = 6.15$). An important note to make is that the low education category is very small ($n = 6$) compared to the other two categories ($n = 19$, $n = 12$).

Fixation duration at the area of interest: the baby

Repeated measures ANOVA was performed on the fixation duration ratio at the Baby AOI, during the response segment with response outcome (2, responsive and unresponsive), emotion (2, cry and laugh) and block (2, first four movies and last four movies) as within-

subject factors and sensitivity category as between-subject factor. We found a response outcome main effect, $F(1, 38) = 322.09$, $p < 0.001$, $\eta^2 = .89$. There were significantly higher fixation duration ratios on the baby (area of interest) in the responsive outcome than in the unresponsive outcome. Due to perceptual differences this result is not interpretable. No effect of sensitivity was found.

Overall looking in the response segment

Repeated measures ANOVA was performed on overall fixation duration during the response segment with response outcome, emotion and block as within-subject factors and sensitivity category as between-subject factor. There was a tendency of response outcome, $F(1, 38) = 3.33$, $p = .076$, $\eta^2 = .081$. Mothers had longer overall fixation duration in the unresponsive response segment, compared to the responsive outcome ($M_{unr} = 3.96$, $M_{resp} = 3.86$). This result suggests that mothers tended to look longer overall at the animation during the response segment where the unresponsive figure is shown than in the segment the responsive figure is shown. The mean looking durations are depicted in Figure 3.

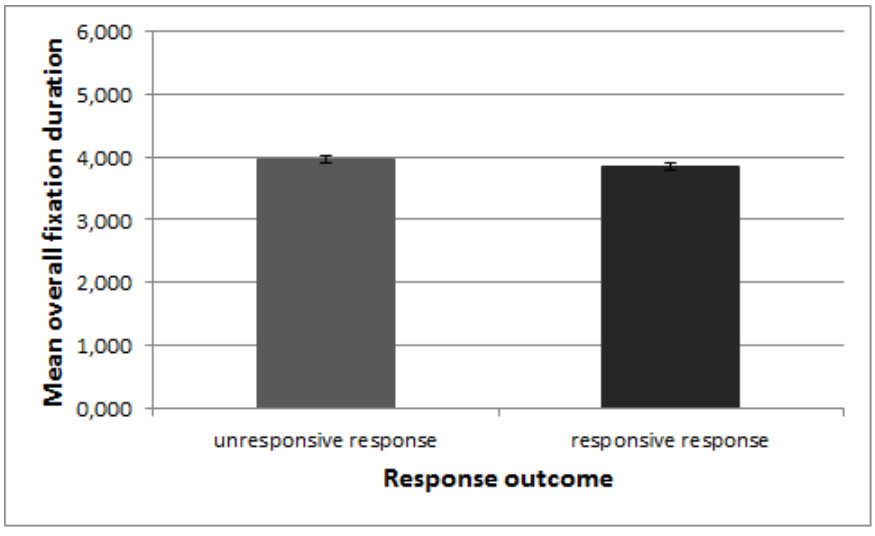

Figure 3. Mean overall fixation duration for both response outcomes.

There was also a significant effect for block, $F(1, 38) = 8.30$, $p = .006$, $\eta^2 = .18$. It indicated longer fixation duration in block 1 compared to block 2 ($M_1 = 4.02$, $M_2 = 3.8$). This suggests that mothers looked longer at the first four movies than the four movies in the second block. The effect for block is depicted in Figure 4.

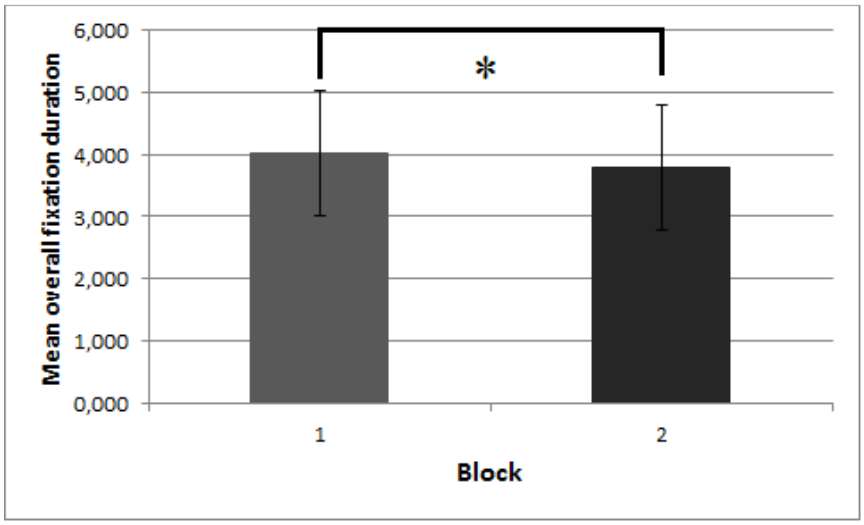

Figure 4. Mean overall fixation durations for block.

There were no effects found for sensitivity on the looking measures[1] (area of interest or overall looking). This finding suggests that the level of maternal sensitivity does not influence mothers' monitoring of the animation in our study. Table 1 shows the means and standard deviations for overall looking in the response segment for the different conditions for high sensitive and low sensitive mothers.

[1]Even when dividing the sample in three groups based on low, medium and high maternal sensitivity, no associations were found between looking behaviour and maternal sensitivity.

Table 1

Means and standard deviations for overall looking for high and low sensitive mothers

	High sensitive		Low sensitive	
Variable	*M*	*SD*	*M*	*SD*
Response outcome				
unresponsive outcome	3.91	.07	4.02	.11
responsive outcome	3.75	.09	3.96	.14
Emotion				
crying	3.81	.09	3.98	.14
laughing	3.85	.08	3.99	.13
Block				
1	3.97	.05	4.08	.08
2	3.70	.11	3.90	.17

Discussion

In this study we investigated whether mothers with higher and lower maternal sensitivity monitor animations of social interactions differently. Due to previous research of Bowlby (1988) that stated that more sensitive mothers would monitor their infant continuously and research on working models by Collins (1996), we expected that mothers with high maternal sensitivity would look differently at the animations than mothers with lower scores of maternal sensitivity. No supporting evidence for this expectation was found, however. We did not find any effects on sensitivity in our sample. This suggests that mothers who are highly sensitive watched the animations the same as mothers who show lower sensitivity. Not finding results for maternal sensitivity could be due to the sample size that maybe was not large enough and that most mothers had an overall sensitivity score around 6 on the Ainsworth's Scale. Maybe if there had been more variation and more mothers with low sensitivity score in the sample there would have been results for the influence of maternal sensitivity. Another possibility is that the maternal working model of sensitivity is not generalizable for other interactions. Like Leibenhuft et al. (2004) showed that an interaction

with one's own child versus another child is very different and that is also reflected in brain activity.

Another expectation we had was that mothers with higher sensitivity would look longer in the unresponsive condition compared to the responsive condition. However, we found that maternal sensitivity did not influence the monitoring of the animation. Although, we did find that all mothers tended to look longer overall in the unresponsive outcome compared to the responsive outcome. This could mean that the unresponsive outcome is more complicated or more unexpected for all mothers or all mothers expect that the larger figure will react on the laughing or crying signal of the baby figure.

We also expected more sensitive mothers to look longer overall in the crying condition than in the laughing condition. We did not find a significant effect for longer looking in the crying condition versus the laughing condition. The emotional signal did not influence fixation durations of the mothers. This suggests that something different happens when mothers were looking at the animations compared to when infants looked at the animations. According to the study of Biro et al. (2014) infants were affected by the emotional signal that was heard during the animation. In our study, mothers looking behaviour was not affected by the emotional signal.

We expected that more sensitive mothers would look longer at the unresponsive outcome, especially when the small figure was crying. A mother figure going uphill, while an infant is crying would imply distress for the infant. A sensitive mother would monitor her child continuously and respond appropriate to the signals (Bowlby, 1988). A less sensitive mother would not see the signals of their infant or interpret them in an incorrect manner. When looking at only the smaller figure, as Area of Interest, mothers had significantly higher

fixation ratios in the responsive outcome compared to the unresponsive outcome. Due to perceptual differences these results cannot be interpreted.

When analysing the overall monitoring of mothers during the response segment we found that mothers watched significantly longer during the first block than in the second block.

Limitations and future research

One of the limitations in our study is the relatively small variation in maternal sensitivity in our sample. To be specific most mothers scored around a 6 on sensitivity on the Ainsworth's scale. This resulted in that the high sensitive group was not that high sensitive and that the low sensitive was not that low sensitive. Even when the sample was divided in three groups, with low, medium and high sensitive mothers, no relations were found between monitoring the animation and maternal sensitivity. But these three groups were very small. A second limitation was the sample size combined with the distribution of maternal sensitivity. Although 40 participants could be sufficient for finding significant results in our study we did not find effects for sensitivity. Especially the sample size in combination with a better distribution of sensitivity could be something to work on with future research. Another option for future research could be to select mothers with high and low sensitivity. This way one can get a more clear separation between high maternal sensitivity and low maternal sensitivity.

Another limitation is that it is not known how mothers interpret the animation. The used animation is supposed to represent a mother and child interaction, but do mothers see it this way? A suggestion for future research could be a short questionnaire for the mothers to fill out, in which they are asked what they have seen and what happened in the animation. This way you can be more certain of how mothers interpret the animation and draw stronger conclusions.

A further possible limitation may lie in the interpretation of longer fixations. What does it mean when participants look longer to a certain response outcome or certain area? Does it mean that what happens is unexpected? Or is it complicated so it needs more monitoring? Or is it just more interesting to look at? Because we do not exactly know what longer fixations imply, it is important to be cautious with drawing conclusions. This could also be solved by asking mothers afterwards. For example, if they found a certain outcome or area more interesting or more complicated.

As mentioned before looking at the smaller figure during the response segment probably was not an optimal measure to analyse if mothers watched more or less at the smaller figure. In the unresponsive condition the larger figure is going uphill and has a lot of distance from the smaller figure. In the responsive outcome the larger figure moves closer to the smaller figure and will be next to the smaller figure in the end of the segment. At the end we are not able to distinguish between mother looking at the larger figure or looking at the smaller figure. Therefore the two conditions are not comparable. In future research this should not be used anymore.

Based on the limitations in our study, and the limited previous research on this topic, we recommend that more research is needed. Although we have to be cautious with making conclusions, we suggest that the working model of maternal sensitivity is possibly not generalizable to other social interactions. In summary, we investigated whether there is a relation between maternal sensitivity and mother's monitoring behaviour of a social interaction animation. No relations were found between maternal sensitivity and monitoring behaviour of social interactions in which they do not participate, even when three groups of maternal sensitivity were created on the basis of low, medium and high maternal sensitivity. It is however an interesting hypothesis that the maternal working model for sensitivity could be generalized to other social interactions as well. Therefore more research, with larger sample

sizes, and more variation in maternal sensitivity, is needed in the future in order to form stronger conclusions and to be able to find out if maternal sensitivity does not only influences the maternal behaviour toward her infant, but also monitoring an animation of a social interaction.

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