5 General discussion

This thesis examined the relations between love withdrawal, oxytocin administration, and asymmetric frontal brain activity on the one hand, and neural processing of and responses to socio-emotional stimuli on the other. A schematic illustration of the findings is presented in Figure 1. Chapters 2 and 3 focused on the neural processing of emotionally relevant stimuli. The findings presented in these chapters include effects of both maternal love withdrawal and intranasally administered oxytocin on different aspects of the processing of emotional faces presented with performance feedback. Chapter 4 focused on a specific type of prosocial behavior, donating money to charity, after viewing a charity's (emotion eliciting) promotional video showing a child in need. Asymmetric frontal brain activity predicted donations and, moreover, moderated the effect of oxytocin and parental love withdrawal on donating behavior. These findings will be discussed in greater detail below.

Parental use of love withdrawal

Evidence was obtained that maternal love withdrawal relates to both relatively early, automatic and later, more controlled aspects of processing stimuli that combine performance feedback with emotional facial expressions.

First, in Chapter 2, associations between maternal love withdrawal and two ERP components were studied within the placebo condition of our experiment, the vertex positive potential (VPP, a component sensitive to the extent of configural processing of faces [e.g., Luo, Feng, He, Wang, & Luo, 2010]) and N400 (a component sensitive to the salience of a mismatch between information and its context [e.g., Caldera, Jermann, Lopez Arango, & Van der Linden, 2004]). Maternal use of love withdrawal significantly and positively predicted the VPP, indicating that participants reporting relatively high maternal use of love withdrawal showed heightened processing of emotional faces.

In addition, maternal use of love withdrawal was related to the difference between VPP amplitudes in response to happy and disgusted facial expressions. For participants reporting higher maternal use of love withdrawal the amplitude of the VPP was clearly larger in response to disgusted compared to happy facial expressions, whereas for participants reporting lower maternal use of love withdrawal the effect of disgust was smaller or absent. Results thus suggest a more pronounced preferential processing of disgusted faces compared to happy ones in participants reporting high maternal use of love withdrawal. A possible explanation is that in a performance situation disgusted facial expressions are

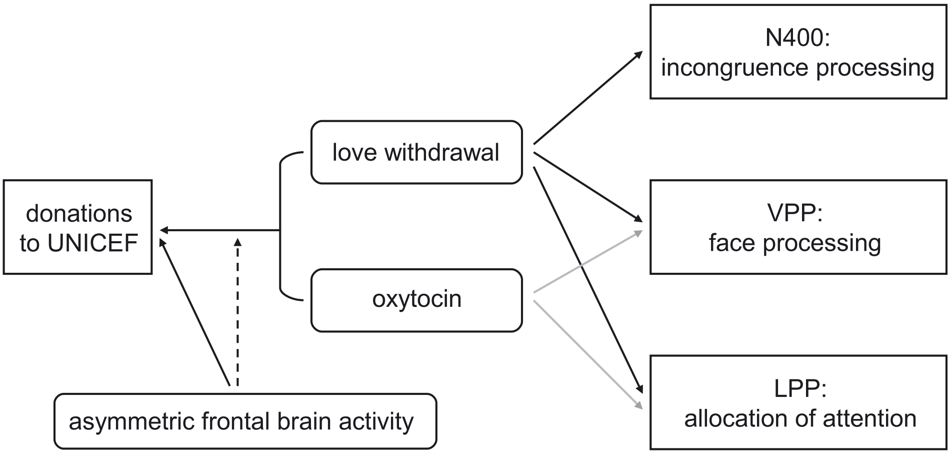

Figure 1. Graphic summary of the effects of love withdrawal, oxytocin, and asymmetric frontal brain activity. Participants reporting higher love withdrawal showed a heightened processing of emotional faces (VPP), appeared to be more sensitive to incongruence between feedback and facial expressions (N400), and preferentially directed attentional resources toward disgusted faces after making an error (LPP). Oxytocin enhanced the processing of emotional faces (VPP) and attention to the feedback stimuli (LPP). Greater left compared to right frontal brain activity, reflecting greater approach motivation, predicted larger donations after viewing a video of a child in need and, moreover, asymmetric frontal activity moderated effects of oxytocin and parental love withdrawal on donating behavior. Parental love withdrawal and oxytocin were related to donations only for those showing greater relative right frontal brain activity (reflecting withdrawal rather than approach motivation).

more relevant or more threatening for them, because of the association between these expressions and the negative relational consequences linked to failure. Higher levels of maternal love withdrawal were also related to larger amplitudes of the N400, suggesting that participants reporting higher maternal use of love withdrawal are more sensitive to a mismatch (incongruence) between the feedback and facial expression accompanying that feedback.

Second, in Chapter 3 the relations between maternal love withdrawal and the VPP and late positive potential (LPP, an ERP component thought to reflect the allocation of attentional resources to motivationally relevant stimuli [Hajcak, Dunning, & Foti, 2009; Pastor et al., 2008]) were studied across both the placebo and oxytocin conditions of our experiment, and in a larger sample of participants. Higher maternal love withdrawal was related to smaller increases in VPP amplitude after oxytocin compared to placebo administration. As no evidence for anxiolytic effects of oxytocin was found (i.e., there was no evidence that oxytocin reduced love withdrawal related anxiety about any relational consequences associated with performance or task performance itself), an explanation for this interaction between oxytocin administration and love withdrawal may be that participants reporting higher love withdrawal likely show near maximum processing of facial expressions even under placebo conditions, thus limiting potential increases after oxytocin administration.

Maternal love withdrawal was also related to LPP amplitudes, consistent with an attentional bias resulting from an association between performance and relational consequences established through the experience of love withdrawal. Higher love withdrawal was related to more positive LPP amplitudes in response to disgusted compared to happy faces, specifically when faces were presented in red (i.e., after an error). Thus, participants reporting higher love withdrawal increasingly direct attention toward disgusted (compared to happy) faces, implying that their attention is biased toward disgusted faces, specifically after they have made an error. In terms of the emotional or motivational significance of stimuli, the congruent combination of a disgusted face presented in red may well be the most relevant stimulus for participants who experienced more love withdrawal, because of its association with negative relational outcomes linked to failure.

Thus, our findings suggest that the association between performance and relational consequences that is established through the experience of love withdrawal does affect the processing of information relevant to this association. Within a performance context, those reporting higher love withdrawal show a heightened processing of facial expressions under placebo conditions (maybe particularly disgusted expressions), which may limit potential increases in processing after oxytocin administration. In addition, they appear to be more sensitive to incongruence between feedback and facial expressions (at least under placebo conditions), which violates the performance-relational consequence link. In a relatively late, controlled stage of processing attentional biases are evident. Higher love withdrawal is associated with the allocation of attentional resources toward the motivationally most relevant combination of a disgusted face presented with negative feedback.

Although the main focus of Chapter 4 was on asymmetric frontal brain activity, it is important to note that love withdrawal not only relates to the neural processing of emotional stimuli, but may also, under certain conditions, affect prosocial behavior. Parental love withdrawal was found to interact with oxytocin and asymmetric frontal brain activity to predict donations to UNICEF. Parental love withdrawal, through its emotional consequences (fear of failure, low self-esteem, low emotional well-being, and feelings of resentment toward the parents), may both hinder empathic concern (Kanat-Maymon & Assor, 2010) and bias decision making in social situations away from other-oriented (e.g., empathy for someone in need of help) to self-oriented concerns (doing what relevant others expect, out of fear for negative reactions), which might ultimately alter effects of oxytocin (cf. Van IJzendoorn, Huffmeijer, Alink, Bakermans-Kranenburg, & Tops, 2011). The consequences of parental love withdrawal for prosocial behavior may be investigated in future studies.

Oxytocin

Effects of intranasally administered oxytocin on electrocortical responses to facial feedback stimuli, both in relatively early (VPP) and later (LPP) stages of processing, were described in Chapter 3. It is well known that elevations of oxytocin levels in blood (in which it has a half-life of only a few minutes) after exogenous administration of the neuropeptide do not adequately reflect the time-range of its neurobehavioral effects, but little is known about oxytocin in other fluids (McEwen, 2004). We demonstrated the effect of oxytocin administration on salivary oxytocin levels up to 2¼ hours after use of the nasal spray. Thus, clear elevations of oxytocin levels were observed within a time-range comparable to its neurobehavioral effects, suggesting that salivary concentrations may be a valuable biomarker for oxytocin (see also Grewen, Davenport, & Light, 2010) .

This study was the first to investigate influences of oxytocin on electrocortical responses in women, although one study using fMRI methodology found enhanced activity in various brain areas involved in face processing after oxytocin administration in healthy women (Domes et al., 2010). Consistent with those findings, VPP amplitudes were more positive after oxytocin compared to placebo administration, indicating that oxytocin enhanced the (configural) processing of emotional faces, regardless of the expression or feedback. LPP amplitudes were also more positive after oxytocin compared to placebo administration, indicating that oxytocin enhanced attention to the feedback stimuli. It is tempting to speculate that the increased LPP amplitude observed here reflects the allocation of attention toward the facial expressions specifically, as the LPP is known to be strongly modulated by emotional facial expressions (Domes, Heinrichs, Michel, Berger, & Herpertz, 2007; Haxby, Hoffman, & Grobbini, 2002) and oxytocin also enhanced the processing of emotional faces (as indexed by VPP amplitude). However, the possibility that oxytocin enhanced attention to faces in general or even to the feedback itself can not be ruled out, because no neutral facial expressions were included and faces and feedback were presented simultaneously.

Oxytocin is well known to enhance prosocial behavior (e.g., MacDonald & MacDonald, 2010) and effects of oxytocin on donating behavior have been described previously (Barraza, McCullough, Ahmadi, & Zak, 2011; Van IJzendoorn et al., 2011). It is therefore interesting to observe that in the current study, as described in Chapter 4, oxytocin administration resulted in larger donations to UNICEF than placebo only for some individuals, i.e. those both showing greater relative right frontal brain activity and reporting relatively low parental love withdrawal. No more than a few studies have focused on the boundaries of oxytocin's prosocial effects (e.g., Bartz et al, 2010; De Dreu et al. 2010; De Dreu, Greer, Van Kleef, Shalvi, & Handgraaf, 2011; Shamay-Tsoory et al., 2009; see for meta-analytic results Van IJzendoorn and Bakermans-Kranenburg, in press) and this topic clearly deserves more attention in the future.

Asymmetric frontal brain activity

The main topic of Chapter 4 was asymmetric frontal brain activity as a predictor of donating behavior. In line with the idea that higher approach motivation and a greater tendency to experience approach-related emotions, associated with greater relative left frontal activity, would cause an individual to donate more money to actively help-out those in need, greater relative left / less relative right frontal activity predicted larger donations.

Moreover, asymmetric frontal activity moderated the interactive effect of oxytocin and parental love withdrawal on donating behavior, in such a way that lower love withdrawal was associated with larger donations after oxytocin compared to placebo administration only for those showing relative right frontal activity (whose response to emotional material is characterized by withdrawal rather than approach). Those showing greater relative left frontal activity seem likely to donate money in response to promotional material showing an individual in need, irrespective of whether and how their empathic feelings are affected by oxytocin administration or experiences of love withdrawal, because approach-related tendencies motivate them to take action, and thus to donate money. For those less inclined to donate out of approach motivation (i.e., those showing less relative left / greater relative right frontal activity), empathic and other concerns affected by oxytocin and experiences of love withdrawal may play a more important part in deciding on the amount of money they donate.

It is important to note that although individuals showing less relative left / greater relative right frontal activity appear to be more sensitive to influences of oxytocin and parental love withdrawal on (processes involved in) decision making in the donating task, these influences are not necessarily unidirectional. Compared to those showing greater relative left frontal activity, individuals showing greater relative right frontal activity may show both larger increases and smaller increases or even decreases in donations after oxytocin compared to placebo administration, depending on their experiences of parental love withdrawal. It is a recurrent observation in studies of the interplay between neurobiological characteristics and external factors or experiences that certain characteristics are associated with a greater sensitivity to (influences of) external factors and experiences, and that effects of this heightened sensitivity can go both ways (e.g., see Bakermans-Kranenburg & Van IJzendoorn, 2011; Ellis, Boyce, Belski, Bakermans-Kranenburg, & Van IJzendoorn, 2011). Future studies should pay attention to this type of interaction.

Mirror neuron systems

The question remains what brain regions mediate effects of love withdrawal, oxytocin, and asymmetric frontal activity on the processing of and responding to (socio-)emotional stimuli. A likely candidate is the mirror neuron system. Mirror systems are both active when an individual performs an action and when another individual performs an action from the same class of actions or an action with a similar goal or meaning (Di Pellegrino, Fadiga, Fogassi, Gallese, & Rizzolatti, 1992; Rizzolatti & Craighero, 2004). Areas containing mirror neurons, in particular the inferior frontal gyrus (and adjacent anterior insula) and superior temporal sulcus, are involved in generating the N400 (Frühholz, Fehr, & Hermann, 2009; Gazzola, Aziz-Zadeh, & Keysers, 2006; Silva-Pereyra et al., 2003; Wildgruber, Ackermann, Kreifelts, & Ethofer, 2006) and may be linked to the LPP as well. It has been suggested that activity in the areas generating the LPP (inferotemporal, posterior parietal, and occipital visual areas) may result from reentrant connections from the amygdala to visual areas (Sabatinelli, Lang, Keil, & Bradly, 2007). The amygdala is connected to and interacts with areas such as the inferior frontal gyrus, fusiform gyrus, and superior temporal areas in the processing of facial expressions (Amaral & Price, 1984; Haxby et al., 2002; Iidaka et al., 2001). Mirror neurons in the inferior frontal gyrus (and adjacent anterior insula) and superior temporal sulcus have been found to respond to emotional expressions and emotional prosody (Gazzola et al., 2006; Wildgruber et al., 2006).

Furthermore, mirror neurons play an important role in social cognition (Iacoboni & Dapretto, 2006). Mirror systems have been found to be involved in affect mirroring, understanding others' actions, and empathy, and areas containing mirror neurons are involved in judging the appropriateness of facial affect (Carr, Iacoboni, Dubeau, Mazziotta, & Lenzi, 2003; Gazzola et al., 2006; Kim et al., 2005). Some of these processes, in particular empathy, are recruited during the donating task (cf. Burt & Strongman, 2004; Verhaert & Van den Poel, 2011). In accordance with these social processes involving mirror neurons, oxytocin has been suggested to influence the mirror neuron system (Perry et al., 2010; Tops, 2010). In addition, it is likely that mirror neurons are involved in affect mirroring and contingency detection in mother-child interactions that are central to the development of emotional self-awareness, self-control, and empathy from infancy through adolescence (Feldman, 2007; Fonagy, Gergely, & Target, 2007; Gergely & Watson, 1996). This system is thus also a likely candidate for parenting strategies like love withdrawal to take effect.

Limitations and future directions

In addition to investigating the consequences of parental love withdrawal for prosocial behavior and the boundaries of oxytocin's prosocial effects, future studies could also address some limitations of the current ERP and donating experiments. Future studies on the neural processing of facial expressions within our paradigm might include neutral facial expressions to distinguish between effects of oxytocin and love withdrawal (and other relevant variables) on the processing of faces in general and emotional facial expressions in particular. Furthermore, in our study participants committed about 16% errors, and they were therefore presented with more green than red stimuli. Future studies may (additionally) use more difficult tasks resulting in higher error percentages and thus more equal numbers of green and red feedback stimuli. To test the interpretation of the effects of asymmetric frontal activity on donating behavior in terms of approach-withdrawal motivation, future studies could include behavioral or questionnaire measures of approach-withdrawal motivation (such as the BIS/BAS Scales; Carver & White, 1994). Importantly though, our results were specific to frontal alpha asymmetry, which is related to approach-withdrawal motivation, and not affected by the inclusion of central and posterior alpha asymmetry, which are not associated with approach-withdrawal motivation, increasing confidence in our findings.

Parental use of love withdrawal and fear of failure were measured with self-report questionnaires. There are obvious limitations to the accuracy and reliability of participants' self-reports, although without longitudinal data it is difficult to conceive of observational or experimental measures of love-withdrawal. Lastly, our participants were all female. We chose to include only women in this study, because of the considerable differences between males and females in the oxytocin system (Suske & Gallagher, 2009), because the effects of oxytocin on the neural processing of emotional stimuli are less frequently studied in women than in men, and because most of the studies on the behavioral or psychological outcomes of love withdrawal focus on maternal use of love withdrawal with daughters (e.g., Elliot & Thrash, 2004; Renk, McKinney, Klein, & Oliveros, 2006). It would be interesting to study the same processes in men.

Conclusion

The current thesis provides insight into the associations between experiences of parental, particularly maternal, love withdrawal, oxytocin, and asymmetric frontal brain activity on the one hand, and neural processing of and responses to socio-emotional material on the other. The current findings demonstrate that higher maternal love withdrawal is not only related to increased processing of emotional faces in a performance context (VPP) and heightened sensitivity to incongruence between feedback and facial expressions (N400), but also to the allocation of attentional resources toward the motivationally most relevant combination of negative feedback presented with a disgusted face (LPP).

Furthermore, this study was the first to describe effects of oxytocin on electrocortical responses to facial stimuli in females, using pictures combining emotional faces with performance feedback. The findings of more positive VPP and LPP amplitudes suggest that oxytocin increases attention to the facial feedback stimuli (LPP) and enhances the processing of emotional faces (VPP). Finally, greater left compared to right frontal brain activity predicted larger donations after viewing a video of a child in need and, moreover, asymmetric frontal activity moderated effects of oxytocin and parental love withdrawal on donating behavior. When approach motivation is high (reflected in greater relative left frontal activity), individuals are likely inclined to take action upon seeing someone in need, and thus to donate more money to actively help-out. When approach motivation is low (reflected in less relative left/ more relative right activity), empathic and other concerns affected by oxytocin and experiences of love withdrawal do seem to play an important part in deciding about donations.

In conclusion, measures of electrocortical activity constitute subtle indicators of the processing of emotional stimuli that are not under conscious control. As such, they are ideally suited and should be used more often to uncover the operation of internal working models or mental representations as they are being shaped by childhood experiences and neurobiological factors, as well as shaping the individuals' perception of their social world.

References

Amaral, D.G., & Price, J.L. (1984). Amygdalo-cortical projections in the monkey (Macaca fascicularis). *Journal of Comparative Neurology, 230 (4),* 465-496.

Bakermans-Kranenburg, M.J., & Van IJzendoorn, M.H. (2011). Differential susceptibility to rearing environment depending on dopamine-related genes: New evidence and a meta-analysis. *Development and Psychopathology, 23,* 39-52.

Barraza, J.A., McCullough, M.E., Ahmadi, S., & Zak, P.J. (2011). Oxytocin infusion increases charitable donations regardless of monetary resources. *Hormones and Behavior, 60 (2),* 148-151.

Bartz, J., Simeon, D., Hamilton, H., Kim, S., Crystal, S., Braun, A., Vicens, V., & Hollander, E. (2010). Oxytocin can hinder trust and cooperation in borderline personality disorder. *SCAN, 6 (5),* 556-563.

Burt, C.D.B., & Strongman, K. (2004). Use of images in charity advertising: Improving donations and compliance rates. *International Journal of Organisational Behaviour, 8 (8),* 571-580.

Caldera, R., Jermann, F., Lopez Arango, G., & Van der Linden, M. (2004). Is the N400 category specific? A face and language processing study. *NeuroReport, 15 (17),* 2589-2593.

Carr, L., Iacoboni, M., Dubeau, M., Mazziotta, J.C., & Lenzi, G.L. (2003). Neural mechanisms of empathy in humans: A relay from neural systems for imitation to limbic areas. *PNAS, 100 (9),* 5497-5502.

Carver, C.S., & White, T.L. (1994). Behavioral inhibition, behavioral activation, and affective responses to impending reward and punishment: The BIS/BAS Scales. *Journal of Personality and Social Psychology, 67,* 319-333.

De Dreu, C.K.W., Greer, L.L., Handgraaf, M.J.J., Shalvi, S., Van Kleef, G.A., Baas, M., Ten Velden, F.S., Van Dijk, E.H., & Feith, S.W.W. (2010). The neuropeptide oxytocin regulates parochial altruism in intergroup conflict among humans. *Science, 328,* 1408-1411.

De Dreu, C.K.W., Greer, L.L., Van Kleef, G.A., Shalvi, S., & Handgraaf, M.J.J. (2011). Oxytocin promotes human ethnocentrism. *PNAS, 108 (4),* 1262-1266.

Di Pellegrino, G., Fadiga, L., Fogassi, L., Gallese, V., & Rizzolatti, G. (1992). Understanding motor events: A neurophysiological study. *Experimental Brain Research, 91,* 176-180.

Domes, G., Heinrichs, M., Michel, A., Berger, C., & Herpertz, S.C. (2007). Oxytocin improves "mind-reading" in humans. *Biological Psychiatry, 61,* 731-733.

Domes, G., Lischke, A., Berger, C., Grossmann, A., Hauenstein, K., Heinrichs, M., & Herpertz, S.C. (2010). Effects of intranasal oxytocin on emotional face processing in women. *Psychoneuroendocrinology, 35 (1),* 83-93.

Elliot, A.J., & Thrash, T.M. (2004). The intergenerational transmission of fear of failure. *Personality and Social Psychology Bulletin, 30,* 957-971.

Ellis, B.J., Boyce, W.T., Belsky, J., Bakermans-Kranenburg, M.J., & Van IJzendoorn, M.H. (2011). Differential susceptibility to the environment: An evolutionary-neurodevelopmental theory. *Development and Psychopathology, 23,* 7-28.

Feldman, R. (2007). Mother-infant synchrony and the development of moral orientation in childhood and adolescence: Direct and indirect mechanisms of developmental continuity. *American Journal of Orthopsychiatry, 77 (4)*, 582-597.

Fonagy, P., Gergely, G., & Target, M. (2007). The parent-infant dyad and the construction of the subjective self. *Journal of Child Psychology and Psychiatry, 48*, 288-328.

Frühholz, S., Fehr, T., & Herrmann, M. (2009). Early and late temporo-spatial effects of contextual interference during perception of facial affect. *International Journal of Psychophysiology, 74,* 1-13.

Gazzola, V., Aziz-Zadeh, L., & Keysers, C. (2006). Empathy and the somatotopic auditory mirror system in humans. *Current Biology, 16,* 1824-1829.

Gergely, G., & Watson, J.S. (1996). The social biofeedback theory of parent affect-mirroring: The development of emotional self-awareness and self-control in infancy. *International Journal of Psycho-Analysis, 77,* 1181-1211.

Grewen K.M., Davenport R.D., & Light K.C. (2010). An investigation of plasma and salivary oxytocin response in breast- and bottle-feeding mothers of infants. *Psychophysiology, 47*, 625-632.

Hajcak, G., Dunning, J.P., & Foti, D. (2009). Motivated and controlled attention to emotion: Time-course of the late positive potential. *Clinical Neurphysiology, 120,* 505-510.

Haxby, J.V., Hoffman, E.A., & Gobbini, M.I. (2002). Human neural systems for face recognition and social communication. *Biological Psychiatry, 51,* 59-67.

Iacoboni, M., & Dapretto, M. (2006). The mirror neuron system and the consequences of its dysfunction. *Nature Reviews of Neuroscience, 7,* 942-951.

Iidaka, T., Omori, M., Murata, T., Kosaka, H., Yonekura, Y., Okada, T., & Sadato, N. (2001). Neural interaction of the amygdala with the prefrontal and temporal cortices in the processing of facial expressions as revealed by fMRI. *Journal of Cognitive Neuroscience, 13 (8),* 1035-1047.

Kanat-Maymon, M., & Assor, A. (2010). Perceived maternal control and responsiveness to distress as predictors of young adults' empathic responses. *Personality and Social Psychology Bulletin, 36,* 33-46.

Kim, J.W., Kim, J.J., Jeong, B.S., Ki, S.W., Im, D.M., Lee, S.J., & Lee, H.S. (2005). Neural mechanism for judging the appropriateness of facial affect. *Cognitive Brain Research, 25(3),* 659-667.

Luo, W., Feng, W., He, W., Wang, N., & Luo, Y. (2010). Three stages of facial expression processing: ERP study with rapid serial visual presentation. *NeuroImage, 49,* 1857-1867.

MacDonald, K., & MacDonald, T.M. (2010). The peptide that binds: A systematic review of oxytocin and its prosocial effects in humans. *Harvard Review of Psychiatry, 18,* 1-21.

McEwen, B.B. (2004). Brain-fluid barriers: Relevance for theoretical controversies regarding vasopressin and oxytocin memory research. *Advances in Pharmacology, 50,* 531-592.

Pastor, M.C., Bradley, M.M., Löw, A., Versace, F., Moltó, J., & Lang, P.J. (2008). Affective picture perception: Emotion, context, and the late positive potential. *Brain Research, 1189,* 145-151.

Perry, A., Bentin, S., Shalev, I., Israel, S., Uzefovsky, F., Bar-On, D, & Ebstein, R.P. (2010). Intranasal oxytocin modulates EEG mu/alpha and beta rhythms during perception of biological motion. *Psychoneuroendocrinology, 35 (10),* 1446-1453.

Renk, K., McKinney, C., Klein, J., & Oliveros, A. (2006). Childhood discipline, perceptions of parents, and current functioning in female college students. *Journal of Adolescence, 29,* 73-88.

Rizzolatti, G., & Craighero, L. (2004). The mirror-neuron system. *Annual Review of Neuroscience, 27,* 169-192.

Sabatinelli, D., Lang, P.J., Keil, A., & Bradley, M.M. (2007). Emotional perception: Correlation of functional MRI and event-related potentials. *Cerebral Cortex, 17,* 1085-1091.

Shamay-Tsoory, S.G., Fischer, M., Dvash, J., Harari, H., Perach-Bloom, N., & Levkovitz, Y. (2009). Intranasal administration of oxytocin increases envy and schadenfreude (gloating). *Biological Psychiatry, 66 (9),* 864-870.

Silva-Pereyra, J., Rivera-Gaxiola, M., Aubert, E., Bosch, J., Galán, L., & Salazar, A. (2003). N400 during lexical decision tasks: A current source localization study. *Clinical Neurophysiology, 114,* 2469-2486.

Suske, D.H., & Gallagher, L. (2009). Dopaminergic-neuropeptide interactions in the social brain. *Trends in Cognitive Sciences, 13 (1),* 27-35.

Tops, M. (2010). Oxytocin: Envy or engagement in others? *Biological Psychiatry, 67,* e5-e6.

Van IJzendoorn, M.H., & Bakermans-Kranenburg, M.J. (in press). A sniff of trust: Meta-analysis of the effects of intranasal oxytocin on face recognition, trust to in-group, and trust to out-group. *Psychoneuroendocrinology.* doi:10.1016/j.psyneuen.2011.07.008

Van IJzendoorn, M.H., Huffmeijer, R., Alink, L.R.A., Bakermans-Kranenburg, M.J., & Tops, M. (2011). The impact of oxytocin administration on charitable donating is moderated by experiences of parental love withdrawal. *Frontiers in Developmental Psychology, 2,* 258.

Verhaert, G.A., & Van den Poel, D. (2011). Empathy as added value in predicting donation behavior. *Journal of Business Research, 64 (12),* 1288-1295.

Wildgruber, D., Ackermann, H., Kreifelts, B., & Ethofer, T. (2006). Cerebral processing of linguistic and emotional prosody: fMRI studies. *Progress in Brain Research, 156,* 249-268.