1 General introduction

Humans are inherently social beings, and rely on a range of both verbal and non-verbal skills for effective social interaction and behavior. Emotional expressions play an important role in the social environment, being primary sources of information about others' mental states and intentions (e.g. Bowlby, 1969; Ekman, 1993). It is therefore not surprising that the human brain contains extensive circuitry for processing and responding to socio-emotional information, including both sub-cortical and cortical structures such as the amygdala, anterior insula, cingulate cortex, and various areas within the frontal and temporal cortices (Esslen, Pascual-Marqui, Hell, Kochi, & Lehmann, 2004; Lindquist, Wager, Kober, Bliss-Moreau, & Feldman-Barett, in press). Various factors may influence the development, functioning, and responsiveness of this circuitry, as well as, ultimately, social behavior. Potential contributions of some of these factors are the subject of the current dissertation.

Parenting: use of love withdrawal

Parents provide the earliest social environment an individual comes into contact with and interacts in, and relationships with parents usually remain important throughout life (Bowlby, 1969; Hrdy, 1999). Evidently, the way in which parents raise their children has a significant impact on their later social functioning and well-being. Some of the strategies used to socialize children, though very effective in the short run, may come at a considerable cost in terms of the later well-being and functioning of the child. The use of love withdrawal is such a strategy. Love withdrawal is a disciplinary strategy that involves withholding love and affection when a child misbehaves or fails at a task. When used excessively, it is considered psychological maltreatment (Euser, Van IJzendoorn, Prinzie, & Bakermans-Kranenburg, 2010). By using love withdrawal the parent communicates to the child that his or her love and affection for the child are conditional upon the child's compliance and success. The formation of this link between compliance or performance on the one hand and relational consequences on the other is thought to underlie both the effectiveness and emotional costs of love withdrawal (Assor, Roth, & Deci, 2004; Elliot & Thrash, 2004). Parental, and in particular maternal, use of love withdrawal has been associated with fear of failure, low self-esteem, low emotional well-being, and feelings of resentment toward the parents in adolescence and young adulthood, which may all negatively affect social behavior (Assor et al., 2004; Bowlby, 1973, p. 243; Elliot & Thrash, 2004; Goldstein & Heaven, 2000; Renk, McKinney, Klein, & Oliveros, 2006; Soenens, Vansteenkiste, Luyten, Duriez, & Goossens, 2005).

It remains unclear, however, whether the use of love withdrawal also affects the deeper level of information processing in the brain. It remains to be studied whether the association of compliance and performance with relational consequences, formed through the experience of parental love withdrawal, affects the perception and processing of information relevant to this association. This is investigated in Chapters 2 and 3, focusing on event-related potentials (ERPs) to one type of information that is especially relevant to this association: emotional facial expressions accompanying performance feedback.

'Social' hormones: oxytocin

Various hormones have been found to be somehow involved in human social behavior and emotion, including testosterone (e.g., Archer, 2006; Sánchez-Martín et al., 2000), estrogen (e.g., Österlund & Hurd, 2001), cortisol (e.g., Schmidt, Fox, Goldberg, Smith, & Schulkin, 1999; Tops et al., 2005), and the neuropeptides vasopressin and oxytocin (e.g., Heinrichs, von Dawans, & Domes, 2009). Over the past decade, attention for the role of oxytocin, in particular, in social behavior, thinking, and perception has increased in scientific investigations (e.g., see Heinrichs et al., 2009; MacDonald & MacDonald, 2010; Van IJzendoorn & Bakermans-Kranenburg, in press). Oxytocin is a neuropeptide that is synthesized in magnocellular neurons of the supraoptic (SON) and paraventricular (PVN) nuclei of the hypothalamus that project to the posterior pituitary from which oxytocin is released into the bloodstream. In addition, neurons in the PVN project to various limbic, mid- , and hindbrain structures (e.g., hippocampus, amygdala, and nucleus accumbens) containing oxytocin receptors. Within the brain, oxytocin can act both as a neurotransmitter and as a neuromodulator (Landgraf & Neumann, 2004; Suske & Gallagher, 2009). In mammals, oxytocin is well known for its role in parturition and lactation, is involved in regulation of the hypothalamic-pituitary-adrenal axis, and facilitates reproductive and maternal behavior, infant attachment, and social behavior (Carter, 2003; Galbally, Lewis, Van IJzendoorn, & Permezel, 2011; Insel, 1992; Parker, Buckmaster, Schatzberg, & Lyons, 2005).

A growing body of research suggests that in humans oxytocin also plays a role in mother-infant bonding as well as in parenting behavior (e.g., Bakermans-Kranenburg & Van IJzendoorn, 2008; Campbell, 2008; Feldman, Weller, Zagoory-Sharon, & Levinde, 2007; Naber, Van IJzendoorn, Deschamps, Van Engeland, & Bakermans-Kranenburg, 2010), and that early interpersonal experiences may be important for shaping the oxytocin system (Feldman, Gordon, & Zagoory-Sharon, 2010; Heim et al., 2008). Many studies have addressed the influence of oxytocin on social stress, perception, cognition, and decision making in adults. Oxytocin has been found to attenuate stress responses in social situations, to influence the processing of and memory for salient social stimuli, to promote trust and generosity toward an opponent (for reviews see Heinrichs et al., 2009, and MacDonald & MacDonald, 2010; for a meta-analysis see Van IJzendoorn & Bakermans-Kranenburg, in press), and to increase the amount of money

donated to charity (Barraza, McCullough, Ahmadi, & Zak, 2011; Van IJzendoorn, Huffmeijer, Alink, Bakermans-Kranenburg, & Tops, 2011). Although quite a few studies have focused on the effects of oxytocin on the processing of social and emotional stimuli, the vast majority of these studies have been conducted with male participants, in some cases using fMRI methodology. The lack of studies in this area focusing on women is understandable, because of effects of the female menstrual cycle on circulating levels of oxytocin (Mitchell, Haynes, Anderson, & Turnbull, 1981; Salonia et al., 2005), but nevertheless striking (but see Domes et al., 2010; Riem et al., 2011). Chapter 3 of this thesis focuses on effects of oxytocin (as well as experiences of love withdrawal) on women's event-related potential (ERP) responses to emotional facial expressions accompanying feedback.

Individual differences: asymmetric frontal brain activity

Individual differences in asymmetric frontal cortical activity have been widely implicated in (socio-)emotional processes in individuals of all ages (e.g., Coan & Allen, 2004; Davidson & Fox, 1989; Fox, Henderson, Rubin, Calkins, & Schmidt, 2001). Early studies of asymmetric frontal activity focused on emotional valence, showing a relation between greater relative left activity and a tendency to experience certain positive emotions (e.g., happiness) and between greater relative right activity and a tendency to experience certain negative emotions (e.g., fear).

More recent research, however, suggests that asymmetric frontal activity relates to motivational direction (of emotions) rather than emotional valence (for a review see Harmon-Jones, Gable, & Peterson, 2010). Frontal asymmetries seem to be best characterized as reflecting a general tendency for approach versus withdrawal, with greater left activity reflecting greater approach motivation, and greater right activity reflecting greater withdrawal motivation, although there is more evidence for the link between left frontal activity and approach than for the link between right frontal activity and withdrawal (Demaree, Everhart, Youngstrom, & Harrison, 2005; Harmon-Jones & Allen, 1997; Harmon-Jones et al., 2010). Measures of asymmetric frontal activity have been shown to reflect both a general trait of and state-related fluctuations in approach-withdrawal motivation, with the contributions of trait- and state-related variation estimated to be about 50% each (Coan & Allen, 2004; Hagemann, Hewig, Seifert, Naumann, & Bartussek, 2005).

As a measure of approach-withdrawal motivation, asymmetric frontal activity may be expected to relate to certain aspects of social behavior, particularly when emotional expressions or displays are involved. This is investigated in Chapter 4, which focuses on effects of asymmetric frontal brain activity on a well-known prosocial behavior, donating money to charity, after viewing a charity's (emotion eliciting) promotional video showing a child in need.

Goal of the study

The general aim of the current thesis is to gain more insight into the associations between experiences of parental love withdrawal, oxytocin, and asymmetric frontal brain activity (reflecting basic motivational tendencies) on the one hand, and (neural) processing of and responses to socio-emotional stimuli on the other. The first chapters of this thesis focus on the processing of emotional stimuli in the brain, investigating whether experiences of love withdrawal (Chapters 2 and 3) and oxytocin administration (Chapter 3) are related to event-related potential (ERP) responses to emotional facial expressions accompanying feedback, within a double-blind, placebo-controlled, within-subjects design. Chapter 4 focuses on behavioral responses to emotionally relevant information: donating money (earned during the ERP experiment) to charity after viewing a video of a child in need. The central question in this chapter is whether asymmetric frontal brain activity, as a measure of approach-withdrawal motivation, predicts donations to charity, and, in addition, the possibility that asymmetric frontal brain activity mediates or moderates the combined effect of oxytocin and parental love withdrawal on donating behavior is explored (see Van IJzendoorn et al., 2011).

Because there are 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 it is particularly the use of love withdrawal by mothers with their daughters that has been linked to unfavorable outcomes in adolescence and young adulthood (e.g., Elliot & Thrash, 2004; Renk et al., 2006), the current thesis focuses on effects of love withdrawal, oxytocin administration, and asymmetric frontal brain activity in women.

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