The Impact of Early Experiences on Behavioral and Neural Correlates of Psycho-Social Functioning:
A Study on Attachment, Social Interaction and Facial Familiarity Processing in Foster Children and a Control Group
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Der Einfluss früher Erfahrungen auf behaviorale und neuronale Korrelate der psychosozialen Anpassung:
Eine Studie zu Bindung, sozialer Interaktion und Gesichterverarbeitung bei Pflegekindern und einer Kontrollgruppe
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Maintaining a scientific jargon, I can definitely say that writing the acknowledgements has been my major focus throughout the past months. Now that I have reached this goal, I am looking back at an exciting journey that has led me over steep hills and valleys, and I want to thank the people who have supported me along the way.

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Abstract

The current doctoral thesis set out to investigate the impact of early adverse caregiving experiences on children’s psycho-social functioning on a behavioral and on a neurophysiological level. Therefore sixteen 3- to 6-year-old foster children, who had been living within the foster home for 1 year, were compared to an age matched control group consisting of thirty children living with their birth family. To assess children’s behavioral and neural responses to caregivers and strangers as important aspects of their socio-emotional development, we applied a behavioral system as well as an ERP approach. Attachment theory provided the theoretical background. Different behavioral correlates of attachment to (foster) mother and disinhibited social engagement towards stranger were assessed during home and laboratory visits. Neurophysiological correlates of facial familiarity processing were assessed during a passive viewing task presenting (foster) mother and stranger face stimuli.

On a behavioral level, our results showed that, after 1 year in placement, foster children were comparable to control children with regard to attachment security. However, they were more likely to show dependent behaviors within the foster mother–child relationship. Furthermore, we found a remarkable presence of attachment behaviors towards their foster mother when being approached by a stranger. Regarding (foster) children’s behavior towards strangers, we found foster mothers to be more likely to report disinhibited social engagement behaviors than mothers of control children. Also, we found foster children to verbally engage more with a stranger and show more looking behavior when being approached by her. Interestingly, our results suggest that foster children were more likely to show these behaviors when having their foster mother close to them, which emphasizes the importance of the foster mother’s availability as a secure base.

Regarding ERPs, we found that facial familiarity processing patterns were clearly different in foster as compared to control children. More precisely, the foster group showed dampened N170 amplitudes for both the foster mother’s and stranger’s face.Collapsed over groups, dampened N170 amplitudes were also found for the stranger as compared to the (foster) mother’s face, and, for insecurely attached children as compared to securely attached children. Thus, it is suggested that smaller amplitudes reflect children’s lack of experience with that particular type of stimulus. If this interpretation is true, in foster children as well as insecurely attached children, this neural pattern could be viewed as a result of poorer social interactions in earlier life. Regarding the Nc component, the overall findings suggest that foster children, but not control children, elicited larger Nc amplitudes to the stranger as compared to the (foster) mother’s face, indicating heightened attentional processing. Taking into account attachment security, we found insecurely attached
children to relocate more attentional resources for processing both face types in terms of larger Nc amplitudes responses. However, this effect was apparent in control children only. While the subgroup of securely attached foster children elicited smaller Nc amplitude responses to the foster mother’s face as compared to the stranger’s face, all foster children elicited large amplitudes to the stranger’s face regardless of attachment security. Also, certain brain-behavior correlations were evident with regard to the components’ latency responses.

In sum, our findings suggest that foster children are able to form an attachment relationship to their foster mother that—in terms of security—is comparable to control children. However, the nature of this relationship seems to be substantially different when comparing both groups. Indeed, attachment security appears to be associated with different behavioral as well as neural correlates depending on group status. Furthermore, foster children showed atypical social behavior towards strangers while, at the same time, eliciting larger Nc amplitudes to the stranger’s face. Assuming that early adverse experience account for behavioral differences, we have found evidence for their impact on a neurophysiological level as well. These findings can be important to our understanding why some behavioral patterns seem to be more resistant to change than others. Still, due to the somewhat exploratory nature of the study, replication of findings is needed.
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To my big boy Liam.
Chapter 1: The Role of Early Caregiving Experiences in Children’s Development

In his work, Rene Spitz observed that despite being provided with all essential elements of care like nutrition and medicine, young children extremely suffer from the enduring absence of a close relationship with a loving caregiver\(^1\). For example, they were likely to elicit signs of depression and were more susceptible to mortality (Spitz & Wolf, 1946; Spitz, 1945). Influenced by these ideas, John Bowlby, in his initial report on “maternal care and mental health” to the World Health Organization (WHO), reviewed numerous studies on the debilitating effects of maternal separation (as, e.g., in institutional care) that emphasize the primacy of a warm, intimate and continuous relationship for children to grow up mentally and physically healthy (Bowlby, 1951). Even though this review included many findings from methodologically critical studies (van der Horst & van der Veer, 2008), the overall conclusions led Bowlby (1958, 1969) to develop a new theoretical framework on early attachment relationships that has influenced our understanding of childcare ever since. In 2004, the World Health Organization again published a review on “The importance of child–caregiver interactions in children’s healthy development” (Richter & WHO, 2004), which emphasizes the topic’s relevance in the 21st century. Indeed, during the past few decades different lines of research have strongly enlarged our understanding of child development. Nevertheless, accumulated empirical evidence supports the key feature of Bowlby’s early proposition, which is, that early caregiving relationships are central to young children’s healthy development and later psychological adjustment (Rutter, 1995; also see Richter & WHO, 2004).

Today, emerging insights from related disciplines like developmental neuroscience can complement our understanding of the mechanisms linking early relational experiences to individual developmental outcomes. While aberrations of the endocrinological system in high-risk samples have been a major focus, neurophysiological studies investigating correlates of social-information processing related to the child–caregiver relationship are limited to the work of few research groups. However, early processing steps, like the recognition of faces and the interpretation of their socio-emotional relevance are fundamental aspects preceding behavior in social interactions, and thus, may be important to the understanding of children’s psychosocial functioning. Moreover, despite its proposed explanatory value (Nelson, 1999), there clearly is a void in the research literature regarding the combination of behavioral and neurophysiological paradigms. Finally, event related potentials

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\(^1\) Children can be attached to their mother, their father, but also to other primary caregivers (e.g., foster or adoptive parents). Therefore, I will use the term “caregiver” when generally referring to a child’s attachment figure.
(ERP) indicating the brain’s ongoing response to discrete stimuli provide the opportunity to assess the neural circuits probably underlying social behavior.

This dissertation sets out to contribute to a better understanding of the mechanisms involved in socio-emotional development of children with a background of adverse rearing experiences by using multiple methods derived from traditional behavioral research as well as neurophysiological science. More precisely, applying a behavioral system approach (Chapter 4) to attachment and stranger sociability as well as an ERP approach (Chapter 5) to facial familiarity processing allowed to integrate data on both behavioral as well neural responses to caregivers and strangers. Comparing a group of high-risk foster children with a community sample regarding these correlates of psychosocial functioning can add to our understanding of how early adverse experiences affect children’s development and may explain why some behavioral deficits turn out to be resistant to improvements in the caregiving environment. Thus, the current dissertation finally aims to provide knowledge not only valuable to researchers, but also therapists, caregivers, and people involved in the child-welfare system.
I will begin this Chapter with an introduction to the nature of the early child–caregiver relationship and present evidence suggesting human’s biological preparedness to engage in contingent social interactions from early on (also see Richter & WHO, 2004). Then, I will turn from the importance of these early experiences to the negative impact of pathogenic care on children’s psychosocial adjustment. Thereby, I will explain principles of attachment theory, which provides the theoretical framework of this investigation, and complement its assumptions with a neurodevelopmental viewpoint on the matter. Finally, I will describe the situation of foster children as a high-risk sample, which will be a major focus throughout the current dissertation.

1.1 Functions of Early Caregiver–Child Interactions

Undoubtedly, after birth children existentially depend on the care of an experienced and responsible adult to ensure their survival. Resulting from specific needs that are common to all children in infancy and beyond, caregiving serves several regulatory and evolutionary meaningful functions. More precisely, according to Bradley and Caldwell (1995) these functions are sustenance (providing food and shelter), stimulation (engaging attention and providing experience and information), support (meeting social and emotional needs), structure (differentiating inputs with regard to child’s capabilities), and surveillance (monitoring the child’s activities) (p.44).

The interaction between infants and their caregivers naturally derives on both the infant’s and the caregiver’s side and it seems to be driven by an inherent predisposition that is common to all human beings (Bowlby, 1982; Trevarthen, 1979). Thus, from early on infants show a preference for human over non-human events and appear to discriminately respond to them (e.g., Legerstee, 1992). Furthermore, encounters with the caregiver elicit several interactive behaviors like vocalizations and gestures in the child who shows a strong interest in communicating with his or her face-to-face (e.g., Brazelton & Tronick, 1980; Richter, 2004, p. 26). On the caregiver’s side the child’s communicative attempts are met by, for example, touching and adjusting his/her tone accompanied by synchronized facial expressions and movements in attunement to the child’s behavior (e.g., Papoušek & Papoušek, 1981, Brazelton & Tronick, 1980). Such remarkably early reciprocity characterizes infant–caregiver relationships as early as the second month of life with caregiver and infant frequently engaging in an affectionate dialogue by “alternating their communicative signals” (Richter, 2004, p.14).

Supporting evidence for the infant’s preparedness for socially interacting with the caregiver also comes from studies where the infant’s expectations of typical caregiver feedback are violated, for example, by instructing the mother to present a neutral look and remain affectionless when facing her child (referred to as “still face paradigm”, Tronick, Als, Adamson, Wise, & Brazelton, 1978). Such perturbation experiments have shown that infants are sensitive to being responded to as otherwise
they show clear signs of distress and sudden attempts to reinitiate contact (Cohn & Tronick, 1983; Tronick et al., 1978) accompanied by several physiological reactions like elevated heart rate (Weinberg & Tronick, 1996).

From an evolutionary point of view such inherent preparedness for contingent human interactions is highly meaningful as these early interactions are crucial to the child’s development in several domains. In fact, the prolonged periods of immaturity in infancy provide plasticity that is highly beneficial to human development (Bjorklund, 1997). However, this evolutionary function requires inherent systems that drive the interaction between caregiver and child and thus, ensure the stimulation necessary for essential developmental as well as the acquisition of cultural achievements (Trevathan, 2011). For example, the early caregiver–child symbiosis provides certain indispensable amounts of sensory input, like tactile stimulation (as in close body contact) that is necessary to maintain specific hormone levels needed for physical growth (Kuhn, Pauk, & Schanberg, 1990). Thus, stimulation is not only beneficial to the infants development, rather is it inevitable. Beside physical closeness, early interactions are also characterized by an alternating interchange of looks, vocalizations and expressions that are being viewed as proto-conversations (Bateson, 1975) in which the caregiver —probably unintentionally— sensitizes the infant to certain sounds. Indeed, early social interactions are fundamental to language acquisition which is implemented by the child’s use of imitative learning and joint attention (Tomasello, 1992).

Furthermore, by interpreting and commenting on the infant’s activities and inferring on its state of mind the caregiver adds meaning to the child’s inner and outer world and make it more and more comprehensible. In this view, the caregiver serves as a social mediator by simplifying and structuring the environmental input. Thus, he/she slowly introduces the infant to concepts with increasing complexity by assisting him/her in a scaffolding manner (Richter & WHO, 2004, p.13).

The above examples show that the intimate caregiver–child relationship serves a range of evolutionary important functions above sustenance and surveillance. In particular, through interaction with a caring adult, the child receives the stimulation and structure that is needed to develop complex concepts about the world and the self, hence, these experiences facilitate cognitive growth. Moreover, during caregiver–child interactions the child also experiences the caregiver to be more or less effective in meeting his social and emotional needs. In this sense, specific child–caregiver interactions may comprise several regulatory functions at a time (Bradley & Caldwell, 1995).
In contrast, considering the effects of early adverse experiences, several functions of caregiving might be negatively affected. For example, being raised in a neglecting family environment, children might lack the cognitive stimulation to develop properly, which is even more evident in children brought up in institutions. Indeed, for decades researchers have repeatedly reported cognitive deficits in previously institutionalized children (for a review see van IJzendoorn, Luijk, & Juffer, 2008). However, the affective component in caregiving is nevertheless important and providing for the basic needs for cognitive stimulation and physical care alone does not prevent children who lack “a relationship with at least one emotionally invested, predictably available caregiver” from displaying an “array of developmental deficits that endure over time” (Shonkoff & Phillips, 2000, p.389). For example, when, given maternal depression, reciprocal interactions are continuously disturbed, infants are likely to develop a depressed interactional style themselves (Field, 1984) and are at increased risk for later behavioral problems (Field, 1995). Moreover, due to their biological proneness, children may even develop “intense emotional ties to … caregivers who are unresponsive, rejecting, highly erratic or frankly abusive, and these relationships can also be a source of serious childhood impairment.” (Shonkoff & Phillips, 2000, p.389, also see Richter & WHO, 2004). Keeping this statement in mind, I would now like to turn to attachment theory, which provides an excellent framework to explain how early relationships with a primary caregiver affect later adjustment.
1.2 Attachment as a Theoretical Framework

1.2.1 Principles of attachment theory

Inarguably, an infant’s survival is contingent upon the presence of a caring adult. As theorized by Bowlby (1969, 1982), both the infant and the caregiver are evolutionary prepared to behave in a way that ensures the offspring’s survival. Serving this biological function, attachment promotes maintenance of proximity between infant and a primary caregiver. Thus, from birth on infants are equipped with a behavioral set that signals their need for proximity (e.g., crying for the caregiver, reaching out) while on the caregiver’s side there is an inherent behavioral bias to complimentary respond to these signals with care and protection. Additionally, the infant’s behavior is determined by another motivational system, the exploration system that is believed to be complementary to the attachment system and thus drives the dynamic of the infant–caregiver attachment relationship (Ainsworth & Bell, 1970).

While the general functions of early social interactions described above (see section 1.2) are not necessarily person-specific, it is a distinct feature of attachment theory to focus on interactions with the primary attachment figure. According to Bowlby (1988), this specific person cannot easily be replaced by other caring adults, however, the child, in addition, might form distinct attachment relationships to fathers or other persons (Howes & Hamilton, 1992; Main & Weston, 1981; van Ijzendoorn & Wolff, 1997).

1.2.2 Early experiences and the development of attachment

Infants are not automatically attached to their caregiver by birth, as it needs a series of ongoing interactions to form an attachment relationship. Infants usually get attached to their primary caregiver within the first year of life (Bowlby, 1969), which is also true for those growing up in abusive households. However, the quality of attachment is highly sensitive to the appropriateness of early experiences (Cicchetti & Barnett, 1991; Crittenden, 1988). More precisely, based on the caregiver’s ability to accurately, promptly and appropriately respond to the infant’s need (Ainsworth, Bell, & Stayton, 1974), the infant develops expectations and assumptions about how he/she can rely on his/her caregiver’s availability in the face of distress and also appraises his/her own worthiness. These mental representations are theorized to be organized within an inner working model of attachment, that in turn guides subsequent interpersonal behavior in an adaptive manner (Bowlby, 1969; Bretherton & Munholland, 1999). Finally, these early caregiving experiences may result in individual behavioral patterns that particularly come to light within attachment relevant situations such as unfamiliar encounters or separations from the caregiver (Ainsworth, Blehar, Waters, & Wall, 1978; also see Grossmann & Grossmann, 2004).
Individual differences in attachment

Patterns of attachment. In need for a standardized measure to verify these theoretical assumptions, Ainsworth and Wittig (1969) developed an experimental paradigm that has become the gold-standard for assessing attachment security in infants. The so-called Strange Situation Procedure (SSP) takes place in an unfamiliar setting and consists of eight episodes including a confrontation with a strange person, short separations from the caregiver, and reunions with him/her. Thus, inducing a mild level of stress, it was especially designed to activate both attachment and exploratory behavior. While the „principal quantitative dimension of an attachment is the degree to which it is characterized by feelings of security or insecurity“, the Strange Situation Procedure yields “qualitative distinctions” (Crittenden & Ainsworth, 1989, p.438) indicating how the infant organizes his/her behavior towards the caregiver in times of distress. Based on these behavioral patterns, infants can be assigned to three major attachment classifications: secure, insecure-avoidant or insecure-ambivalent (Ainsworth et al., 1978) and an additional orthogonal classification referred to as disorganized (Main & Solomon, 1986, 1990). Indeed, these types have been found to be closely related to specific caregiving experience in the pioneering work conducted by Mary Ainsworth (1974) and a number of subsequent studies (e.g., Grossmann, Grossmann, Spangler, Suess, & Unzner, 1985; Spangler, Schieche, Ilg, Maier, & Ackermann, 1994; see De Wolff & van Ijzendoorn, 1997 for a meta-analytic review). Interestingly, regarding attachment disorganization, Spangler, Fremmer-Bombik, and Grossmann (1996) have found newborn behavioral organization to play an important role, while attachment security was solely found to be predicted by maternal sensitivity. Thus, even though genetic contributions need to be considered especially in the development of disorganized attachment behaviors, the determining role of parental behavior in the development of individual differences in attachment security has become a central tenet to attachment theory. The section below will focus on this relationship while referring to Crittenden and Ainsworth (1989) as well as Grossmann and Grossmann (2004).

Antecedents of individual differences in attachment. A caregiver that promptly and appropriately responds to the infant’s need for proximity by comforting him/her paves the way for a secure attachment. This means, that the child develops the ability to use the caregiver as a secure base from which he/she can walk off and explore and as a safe haven to which he/she can return when distressed. Typically, the secure infant spontaneously explores new situations with joy while steadily back-checking with the caregiver. He/she is clearly concerned when separated from the caregiver. Upon reunion he is easily reassured and soon returns to playing. The overall sense is that the infant
Chapter 1: The Role of Early Caregiving Experiences in Children’s Development

relies on the caregiver’s support and comfort when needed and that attachment and exploratory system are well balanced.

On the other hand, when the caregiver is inaccessible and repeatedly rejects the infant’s needs for proximity (e.g., by withholding close body contact) the infant learns to dampen its attachment behavior as it has proofed to be ineffective. Thus, the so-called insecure–avoidant infant does not show signs of distress when he/she realizes to be left alone, but, typically, there is a decrease in the quality of his/her play behavior. He/she tends to agree with being distracted and comforted by an unfamiliar adult and to ignore the caregiver upon return. In other words, the infant seeks to deactivate the attachment system by disconnecting to negative feelings that arise upon separation in an avoidant defense. However, despite appearances, evidence suggests that, on a physiological level, the infant indeed experiences increased distress in these situations (Spangler & Grossmann, 1993).

Finally, if the caregiver tends to repeatedly respond to the infant’s signals in an inconsistent manner this promotes a sense of unpredictability leading into insecure–ambivalent attachments. Typically the insecure-ambivalent infant seems anxious and does not tolerate to be separated from the caregiver. On the caregiver’s return he/she desperately seeks proximity to him/her, but, at the same time shows resistance to the caregiver’s attempts to initiate contact. The infant clearly struggles to cope with its negative emotions and hyperactivates the attachment system at the cost of any exploratory behavior. Insecure attachment strategies, however, are not necessarily dysfunctional—at least not in the environment they have emerged. Indeed, they are conceived as necessary adaptions to a less optimal caregiving (Main, 1990). Indeed, insecure attached infants appear to have access to organized strategies for regulating their behavior after all. In contrast, Main and Solomon (1986, 1990) identified infants that failed to maintain a clear organized strategy in stressful attachment related situations, but instead, appear highly irritated. They typically display unusual behaviors like freezing, shaking, or incomplete, undirected sequencing of movements, which seems to result from a breakdown of any underlying attachment strategy (Hesse & Main, 2006; Main & Solomon, 1990). Hence, this behavioral pattern is categorized as a disorganized attachment.

Adverse parenting and children’s attachment

The term maltreatment, including multiple forms of neglect and abuse, refers to probably the most severe forms of insensitive and inadequate care and it is hardly surprising that converging evidence confirms that there is a strong linkage between maltreatment and the development of organized insecure and disorganized attachments (Baer & Martinez, 2006). Also, more distal factors like accumulated social risk and parental psychopathology have been associated with insecure

2 Note: in some cases children cannot be assigned to any pattern of the organized type (Cyr et al., 2010).
1.2 Attachment as a Theoretical Framework


In particular, disorganized attachment is hypothesized to result from constellations where the caregiver represents both a source of comfort and, simultaneously, a source of fright (Hesse & Main, 2006) evoking a severe unresolvable approach/avoidance conflict (Schuengel, Bakermans-Kranenburg, & Van IJzendoorn, 1999). While frightening and sudden anomalies in parenting (e.g., momentary dissociative behavior) have been described to trigger disorganized attachment in non-maltreated children (see Madigan et al., 2006 for a meta-analytic review), being cared for by a maltreating parent is probably the most illustrative example of the unsolvable paradox described above. As a consequence, high proportions (36%-90%) of disorganized attachments have repeatedly been found in maltreated children (Barnett, Ganiban, & Cicchetti, 1999; Cicchetti, Ganiban, & Barnett, 1991; Cicchetti, Rogosch, & Toth, 2006; Crittenden, 1988; Lyons-Ruth, Connell, Grunebaum, & Botein, 1990; also see Cyr et al., 2010). Again, it should be noted, that there are also early individual determinants of disorganized patterns of attachment (Spangler et al., 1996).

Furthermore, studies examining attachment as a function of type of maltreatment suggest neglected children to be more likely to show organized insecure attachments (Valenzuela, 1990) whereas physical abuse is associated with the development of disorganized attachments (e.g., Crittenden, 1988). In turn, insecure and disorganized attachments implicate a high risk for a number of negative developmental outcomes and vulnerability to later psychopathology (Carlson, 1998; Lyons-Ruth & Jacobvitz, 2008; van Ijzendoorn, Schuengel, & Bakermans-Kranenburg, 1999).

While secure attachment in infancy is related to positive developmental outcomes (e.g., Sroufe, Egeland, Carlson, & Collins, 2005), it is assumed that early adverse caregiving behaviors have a major impact on the shaping of less favorable developmental pathways due to their momentous effects on the child’s internal working model of attachment as well as on its self-regulatory capacities in later life (Bretherton & Munholland, 1999; van der Kolk & Fisler, 1994).
1.2.3 Attachment disorders: The clinical relevance of attachment theory

While the above section referred to attachment as a scientific construct that emerged in the field of developmental psychology, the concept has also been transferred into clinical practice to describe certain abnormal phenomena that, by definition, result from pathogenic care.

Disorders of attachment were first described in the third edition of the Diagnostic and Statistical Manual of Mental Disorders in 1980, though criteria were revised with the fourth edition a few years later (DSM-III, DSM-IV; American Psychiatric Association, 1980, 1987). For a long time there has been major consensus about the phenomenology of attachment disorders (Zeanah & Gleason, 2010; Zeanah et al., 2004) while at the same time there appeared to be a lack in systematic empirical studies (Zeanah & Gleason, 2015). In accordance with the tenth edition of the International Classification of Diseases (ICD-10; World Health Organization, 1992) throughout the DSM-IV two clinical subtypes of so-called reactive attachment disorders (RAD) have been described: a) the emotionally withdrawn type, in which the “child rarely seeks and responds to comfort” and b) the disinhibited type, which describes a child’s tendency to behave “oversociable” by approaching and interacting with unfamiliar adults while failing to display the degree of reticence that would be expected within the given social norms (Zeanah et al., 2004, p.878).

Within the diagnostic criteria it is claimed that both types are etiologically closely tied to “a pattern of extremes of insufficient care” (313.89, Criterion C in DSM-V, American Psychiatric Association, 2013), which includes maltreatment and neglect as well as other circumstances that hinder the formation of stable and selective attachments to a primary caregiver (i.e., repeated changes of caregivers and institutional rearing). A recent study by Jonkman et al. (2014) tested the association between different forms of pathogenic care and types of symptoms (inhibited vs. disinhibited). However, in contrast to their hypotheses, they could not identify clear predictors of the inhibited subtype like the absence of a preferred caregiver; neither could they identify a distinctive pathway leading to the disinhibited type. Along with other studies (e.g., Smyke, Dumitrescu, & Zeanah, 2002; Zeanah et al., 2004) they also found a co-existence of inhibited and disinhibited children.

Despite etiological similarities, both subtypes differ in important ways like, for example, behavioral correlates and response to intervention (Zeanah & Gleason, 2010, 2015a). For example, research with post institutionalized as well as never institutionalized foster children has shown that signs of the inhibited type are likely to decrease with an improve of the caregiving environment while disinhibited behavior show a strong persistence (Jonkman et al., 2014; Smyke et al., 2012), even when children managed to establish secure attachment relationships with their adoptive parents (Chisholm, 1998; O’Connor, Marvin, Rutter, Olrick, & Britner, 2003).

As a response to accumulating empirical support (see Zeanah & Gleason, 2010) the most recent edition of the DSM now describes two distinct disorders rather than two subtypes of reactive...
attachment disorder (DSM-5; American Psychiatric Association, 2013). Here it is emphasized that the disinhibited type can occur in children regardless of being attached to a selective person as it comprises affiliative rather than solely attachment behaviors (Zeanah & Gleason, 2010). As a consequence, the subtype was renamed “disinhibited social engagement disorder” (DSED) and listed separately from the inhibited subtype, still referred to as “reactive attachment disorder” (RAD). In a recent review Zeanah and Gleason (2015) report considerable evidence that supports the distinction in two phenotypical different disorders. Still, the authors emphasize the need for further research to obtain a “clear story” on both disorders and, finally, to inform intervention (Zeanah & Gleason, 2015a, p.218).

At this point it should be noted, that the topic of the current dissertation is not restricted to the clinical picture of a manifest disinhibited social engagement disorder as described in the DSM-5. In fact, it aims to examine and explain also minor variations of sociability towards strangers displayed by children with a history of adverse caregiving experiences as compared to control children. Therefore, in concordance with other studies I will use the term disinhibited social engagement (DSE) to describe children’s approach behavior towards unfamiliar adults including typical and atypical patterns of this behavior (Lawler, Hostinar, Mliner, & Gunnar, 2014).

Disinhibited social engagement, in general, is a common phenomenon in children with a background of pathogenic care like, for example, institutionalization (Bruce, Tarullo, & Gunnar, 2009; Chisholm, Carter, Ames, & Morison, 1995; Chisholm, 1998; Dobrova-Krol, Bakermans-Kranenburg, Van IJzendoorn, & Juffer, 2010; O'Connor & Rutter, 2000; Rutter, Colvert, et al., 2007) as well as maltreatment (Albus & Dozier, 1999; Pears, Bruce, Fisher, & Kim, 2010). At first glance, such lack of reticence towards strangers seems highly dysfunctional for survival as it clearly puts children at a safety risk (O’Connor & Rutter, 2000). However, it has been suggested that when there is no reliant continuous relationship with a primary caregiver, such behaviors might indeed represent an adaptive response as it attracts the attention of other potential caregivers and thus increases the likelihood to be cared of (Chisholm, 1998). Finally there appears to be a co-existence of various approaches in attempt to shed light on the etiology of DSE (for a discussion see Lawler et al., 2014).

Summing up, regardless of being adaptive or not, DSE can be viewed as extremely dysfunctional when carried into new relationships with caregivers or other interaction partners (Albus & Dozier, 1999). Unfortunately, these behaviors have been shown to be quite resistant to intervention (e.g., Chisholm, 1998; also see Zeanah & Gleason, 2010, 2015), which led Rutter to assume some kind of biological programming to underlie these behaviors (Rutter, Beckett, et al., 2007; also see Bakermans-Kranenburg et al., 2011, p.71). Indeed, a number of studies have found neurobiological aberrancies in children displaying DSE (Zeanah & Gleason, 2015a, p.215).
1.3 A Neurodevelopmental View on Early Adverse Caregiving Experiences

The adaptive nature of the child’s inner organization of his/her social world and the long-lasting negative socio-emotional outcomes of maltreatment and neglect, suggest that early experiences affect development on multiple levels. Regarding “the interplay between […] different organismic systems”, inner working models of attachment are assumed to serve a regulatory function (Spangler & Zimmermann, 1999, p.270). In this sense, manifest behavioral outcomes represent the product of a series of mechanisms that operate on a more subtle level that is hardly accessible using traditional observational methods. Indeed, without exceptions, all mental processes and behavioral actions are based on operations carried out by the brain (Kandel, 1998). Thus, applying a neurodevelopmental approach to complement what is known about behavioral outcomes of early experiences seems inevitable to understand, why some behaviors seem more resistant to improvements in the caregiving environment.

In the last decades, a growing body of research has focused on the effects of early adverse experiences on neurobiological functioning to explain psycho-social adjustment and later health outcomes (e.g., Pechtel & Pizzagalli, 2011). Such research is grounded in the assumption that early experiences create indelible changes in biological systems that develop in an adaptive response to the social environment. In this view, socio-emotional deficits in maltreated children do not only reflect psychological processes inferred by parents’ aberrant caregiving behaviors, but also stems from alterations in brain structure that result from such adverse experiences (Cicchetti, 2002). For example, threatening parenting behavior might provide the child with a cognitive construct that the world is unpredictable leading to a persisting feeling of psychological insecurity. Moreover, to avoid further harm, the child’s brain structure might also form in a way that predisposes him/her to be vigilant, meaning that his/her sensory system may become over-sensitive to threatening cues (see section 1.3.3.2).

When we ask how early experiences shape the developing brain, it is fundamental to state that "experience in general shapes neural function and brain architecture” (Siegel, 2001, p.71). The brain’s particular vulnerability to early adverse experiences and the persistence of effects is due to the fact that the early years reflect a stage of rapid changes in brain structure (e.g., Dawson, Ashman, & Carver, 2000). During early childhood, the brain expects and requires meaningful environmental input to form and retain neural connections while at the same time being especially sensitive to its quality (see section 1.3.1). Since the caregiving environment can be assumed to provide the major source of immediate external input, it suggests itself that early experiences with a primary caregiver play a significant role in the shaping of the developing brain. In fact, such early relationships have regulatory effects on infants’ behavior and psychophysiology (e.g., Hofer, 1994; Spangler et al.,
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1994) and thus, drawing from empirical evidence, in their comprehensive review, Kolb & Gibb (2011) discuss the caregiver–child relationship as one of the major factors that influence the development and function of the brain.

1.3.1 Stages of brain development in infancy

Brain development (as outlined by e.g., Kolb & Gibb, 2011, and Nelson, Bos, Gunnar, & Sonuga-Barke, 2011) starts prenatailly with the formation of the neural tube following a genetic program. The generation of neurons and glia during the first months after fertilization is enormous with hundred thousands of neurons formed per minute. Following neurogenesis, neurons migrate to a certain target position, where they begin to differentiate by developing axons, and to some slower extent, dendrites, a process referred to as cell maturation. With one millimeter per day axons grow rapidly as they extend to their targets leading into the formation of synapses, which are fundamental to brain functioning as they form the bases of communication between neurons. Within the development of the human cortex synaptogenesis refers to the formation of more than 100,000 trillion synapses, reaching a peak in the second year of life (Kolb & Gibb, 2011, p.266). The arrangement of synapses and thus the neural circuits are highly predetermined by genetic codes. However, environmental factors have a major influence on the individual structuring of the brain which is especially true for postnatal exposure to experience (Nelson et al., 2011). Indeed, substantially driven by postnatal experiences cell death and pruning of synapses take place and counteract the preventive massive overproduction of neurons and their connections in early life. To explain this process Kolb and Gibb (2011) use the metaphor of a “sculptor who creates a statue with a block of stone and a chisel to remove the unwanted pieces” (p.266). Even more illustrative, they outline evidence that the cortex actually does get thinner with specialization in behavioral domains. Another general principle of brain development is myelogenesis, which describes the development of a “coating that speeds information along the length of the axon” (Nelson et al., 2011, p.128), and which—in many cortical regions—is not complete before the age of 18 (Kolb & Gibb, 2011). At this point, it should be clear that the maturing brain is open to a wide range of experiences, a key concept often referred to as neural plasticity. Importantly, in many cases the timing of experience is crucial to the actual developmental outcome. For example, there are certain sensitive periods, throughout which the brain depends on a certain amount of external stimulation to form in an appropriate manner (as shown in studies on visual deprivation, see Nelson et al., 2011, p.128). This leads to another related concept that is central to our understanding of how early experiences affect development, namely that of experience-expectant and experience-dependent processes.
1.3.2 Brain plasticity: Experience-expectant and experience-dependent processes

Referring to Greenough, Black, and Wallace (1987), sensitive periods are associated with experience-expectant development, which refers to the brain’s genetically-driven pre-preparedness for a certain class of experiences, specifically those that are common to all members of one species. As a part of this process, there initially is a large number of more or less unspecified synapses expecting typical environmental input (e.g., “linguistic input, access to a caregiver, sensory and cognitive stimulation” Nelson, 2011, p.140). This specific input then in turn leads to an ongoing pruning of unneeded synapses, however, there is a great variety among systems regarding the amount and timing of experiences needed to evolve properly (Nelson, 2011). In contrast, associated with synaptic pruning as well as the formation of new synapses (Kolb & Gibb, 2011), experience-dependent development like learning and memory is based on the unique experiences one makes throughout the lifespan. For example, under normal circumstances children are continuously spoken to in interaction with the caregiver. Consequently, hearing a language would be the experience-expectating process in human language acquisition while the specific language a child is exposed to determines his/her mother tongue via an experience-dependent process.

Interestingly, Nelson and colleagues (2011) suggest this concept to also hold for the development of attachment relationships in a very similar way. They argue that the presence of a selective attachment figure (which, apart from perhaps institutional rearing is mostly the case) resembles an expected experience that is fundamental to the formation of an attachment relationship. The way children organize their behavior in attachment related situations, however, depends on individual experiences of caregiver’s sensitivity during early development (Nelson et al., 2011, also see section 1.2.2 of the current dissertation).

So what does this concept mean when it comes to the study of early adverse caregiving experiences? As has been outlined above, within repeated cycles of dyadic interactions and intimate contact the caregiver provides an essential source of sensory stimulation, the infant brain requires to develop properly (Cirulli, Berry, & Alleva, 2003). So first, deficits may occur due to a lack of sufficient experiential input which is likely to be the case in in neglecting environments. In this case experience-dependent processes would be affected, which may lead to underspecification and “miswiring of the neural circuits” (Nelson et al., 2011, p.140). A second concern refers to experience-dependent processes, and thus, the nature of experiences. More precisely, it can be assumed that in maltreating environments abnormal environmental cues (e.g., threatening facial expressions) are frequent and this may lead into predisposing the developing brain to respond in an adaptive manner, which in turn is likely to influence behavior later in development (Nelson et al., 2011; Richter, 2004). Finally, both such alterations in caregiving can put children at a considerable risk of abnormal development (Nelson et al., 2011).
1.3 A Neurodevelopmental View on Early Adverse Caregiving Experiences

In the following section, I will report accumulating evidence that shows the tremendous impact pathogenic care can have on different neurobiological systems. To do so, I will outline some major findings from neurochemical as well as neurophysiological studies, which is meant to be rather illustrative than exhaustive.

1.3.3 Adverse caregiving and neurobiological functioning

*Neuroendocrinological findings*

There is a great body of research that suggests a major negative impact of adverse caregiving experiences on later physical and mental health outcomes in general (e.g., Danese et al., 2009; Dube et al., 2003; Edwards et al., 2003; Felitti et al., 1998). To explore the links between these variables numerous studies have focused on the mediating role of the dysregulation of neurobiological stress responses that are associated with adverse relational experiences (e.g., Lueckn & Lemery, 2004, for an attachment-related perspective on the issue see Fox & Hane, 2008). The stress response system, especially the hypothalamic-pituitary-adrenocortical (HPA) axes, has been a major focus as it regulates the production and release of stress hormones like cortisol, which is necessary to prepare our body for challenging situations. However, when being exposed to high levels of cortisol for a prolonged time, body and brain may suffer from its negative effects (Glaser, 2000; Gunnar & Quevedo, 2007; McEwen & Wingfield, 2003), a phenomenon often associated with the term toxic stress (e.g., Shonkoff & Garner, 2012). While the plasticity of the response system provides the opportunity to adapt to the immediate environment (e.g., the family), such early alterations tend to be permanent and increase the risk for later maladaptation.

The primary caregiver’s interactional behavior plays a central role in the development of the stress-response system with him/her, being the major source to modulate the child’s state of physiological arousal (Hofer, 1994; Lueckn & Lemery, 2004; Spangler et al., 1994). Sensitive caregivers actively respond to their child’s needs and thus, facilitate affect regulation in emotionally challenging situations (see also section 1.2.2). Measuring cortisol levels, evidence suggests that securely attached infants are better able to cope with stress in the Strange Situation Procedure than those who are insecurely attached (Nachmias, Gunnar, Mangelsdorf, Parritz, & Buss, 1996; Spangler & Grossmann, 1993; but see Gunnar, Larson, Hertsgaard, Harris, & Brodersen, 1992; Gunnar, Mangelsdorf, Larson, & Hertsgaard, 1989).
Further support stems from animal models. In their remarkable work, Meaney and his colleagues found that normal variations in rats’ maternal behavior (e.g., licking and grooming) lead to systematic modifications in their offspring’s psychobiological stress response with lower levels of such caregiving behaviors being associated with greater hormonal responses to stress (e.g., Meaney et al., 2000; Weaver et al., 2004, for a review see Cameron et al., 2005). Furthermore, these studies provided evidence that the epigenetic regulation of certain genes, that are involved in adrenocortical responses, is sensitive to modification by early caregiving experiences (Weaver et al., 2004).

On the one hand, sensitive and responsive caregiving is assumed to buffer reactivity of the HPA system to potentially stressful events (see Gunnar, 1998), which again emphasizes the importance of safe and secure early caregiving environments. On the other hand, however, adverse experiences increase stress vulnerability and thus heighten the risk for psychopathology (Luecken & Lemery, 2004). In the case of abusive families, children are directly exposed to threatening, unpredictable parenting behaviors and, most likely, a high-conflict family environment providing numerous environmental stressors. Such unfortunate circumstances are a typical example of early life stress (ELS), which refers to one’s “exposure to a single or multiple events during childhood that exceeds the child’s coping resources and leads to prolonged stress” (Pechtel & Pizzagalli, 2011, p.55).

As a consequence, different abnormal neurohormonal profiles can be found in severely maltreated children (Cicchetti & Rogosch, 2001; DeBellis, 1999; Hart, Gunnar, & Cicchetti, 1995; Teicher, Andersen, Polcari, Anderson, & Navalta, 2002) as well as in children experiencing lower forms of maltreatment like frequent physical punishment or mother’s emotional withdrawal (Bugental, Martorell, & Barraza, 2003, also see Luecken & Lemery, 2004). Regarding attachment, frightening and unpredictable parenting behavior is associated with infant’s disorganization (Madigan et al., 2006), and, indeed, affected infants have been found to display elevated cortisol levels (Hertsgaard, Gunnar, Erickson, & Nachmias, 1995; Spangler & Grossmann, 1993).

**Neurophysiological findings**

Neurophysiological measures include the measurement of event-related potentials (ERPs, see Chapter 2), which reflect brain responses to discrete stimuli as well as oscillations in the ongoing EEG. The latter, for example, might be used as a global measure of cortical activity or an index of a motivational tendency that is associated with hemispherial asymmetry (e.g., Fox et al., 1995; Marshall & Fox, 2007). In particular, the use of ERPs provides the opportunity to precisely measure the time course of cortical responses during social information processing that occurs within one minute following the presentation of social cues. Thus it holds to possibility to reveal the mental precursors of social behavior.
Referring to attachment theory, Pollack, Cicchetti, Klorman, and Brumaghim (1997) assumed that activation of internal working models of self and others (Bowlby, 1988) may not only manifest in overt behavior, but also be reflected in neurophysiological processes related to emotion regulation. In the first ERP studies of this kind they repeatedly found that maltreated children as compared to non-maltreated children, elicited different response patterns when attending to angry faces as compared to happy faces (Pollak et al., 1997; Pollak, Klorman, Thatcher, & Cicchetti, 2001), but not fearful faces (Pollak et al., 2001). In a subsequent study, Shackman, Shackman, and Pollak (2007) similarly found physical abused children to over-attend to visual and auditory anger task relevant and —in the case of the auditory anger cue— also task irrelevant stimuli in terms of eliciting certain ERP waveform patterns. Moreover, this effect mediated the relationship between physical abuse and childhood anxiety suggesting these neural alterations to play a significant role in the development of psychopathology (Shackman et al., 2007). Together with behavioral findings showing a facilitated ability to detect anger cues, Cicchetti (2002) concluded that “the experiences that maltreated children encountered during their development cause particular stimuli to become personally meaningful, based, in part, upon the stored mental representations that have been associated with that stimulus over time.” (Cicchetti, 2002, p.1418). Referring to Dodge, Bates, and Pettit (1990), it is suggested that this response bias predisposes maltreated children to an early detection of an angry face, which “utilizes behavioral responses that are adaptive to address the challenges presented by their environment” (Cicchetti, 2002, p.1419). Importantly, it was acknowledged that such behavioral responses may be highly dysfunctional when active outside the threatening home environment. (Cicchetti, 2002).

Further evidence of alterations in the neural circuits of social information processing associated with early caregiving experiences comes from studies with institutionalized children. Investigating ERPs in response to facial familiarity processing and facial emotion processing, Parker, Nelson and the BEIP Core group (2005a, 2005b) found that institutionalized children as compared to family-reared children elicited smaller amplitudes to faces in general in a number of widespread ERP components. In two follow-up studies with the same sample, Moulson and her colleagues found the effect to be persistent\(^3\) over the early years of childhood (Moulson, Fox, Zeanah, & Nelson, 2009; Moulson, Westerlund, Fox, Zeanah, & Nelson, 2009). The authors concluded that institutionalization may lead to cortical hypoarousal, which is supported by other (non-ERP) studies with the same sample (Marshall & Fox, 2004; Marshall, Reeb, Fox, Nelson, & Zeanah, 2008; Vanderwert, Marshall, Nelson, Zeanah, & Fox, 2010), and toddlers adopted from Asian institutions (Tarullo, Garvin, & Gunnar, 2011). Furthermore this phenomenon seems to be related to atypical social

\(^{3}\) Results vary depending on the component of interest
behaviors in institutionalized children in a Portuguese sample of institutionalized children (Mesquita et al., 2015). To date, little is known about how facial familiarity processing is affected by early adverse caregiving experiences beyond institutional rearing. Apart from abuse and/or neglect, further evidence from ERP studies suggests that also normal variations in observed parenting behavior (Taylor-Colls & Pasco Fearon, 2015) and mother’s personality (de Haan, Belsky, Reid, Volein, & Johnson, 2004) impact infants neural coding of facial emotion. To the best of our knowledge, however, there is no study linking children’s attachment to their caregiver with socio-emotional processing using ERPs.

Understanding how ERP patterns may be linked to different rearing backgrounds in general, and attachment in particular, can enlarge our understanding of the impact of early caregiving experiences on the shaping of the neural circuits underlying social behaviors, and it may then provide in-depth knowledge of deficits in socio-emotional functioning as a result of adverse caregiving experiences.

Finally, few studies reported associations between caregiving and certain patterns of children’s brain oscillations (i.e., hemispheric asymmetries). Measuring EEG asymmetry Dawson (2001) has found reduced left frontal brain activation in insecurely attached children’s alpha frequency range, which has been associated with negative affect and withdrawal tendencies (e.g., Fox et al., 1995; Marshall & Fox, 2007). Similarly, this pattern has also been found in children of depressed mothers as compared to non-depressed mothers in a resting state condition (Dawson, Klinger, Panagiotides, Hill, & Spieker, 1992; Jones, Field, & Almeida, 2009, also see Taylor - Colls & Pasco Fearon, 2015). Furthermore, ordinary variations in observed maternal caregiving behaviors appear to influence the expression of this neural system: Examining 185 mother-infant dyads Hane and Fox (2006) found children receiving lower quality of care to display relatively reduced left frontal activity (Hane & Fox, 2006; Hane, Henderson, Reeb-Sutherland, & Fox, 2010). As for the study of maltreatment this pattern has also been found in (resilient) maltreated females as compared to their counterparts (Curtis & Cicchetti, 2007) and in adolescent maltreated females (Miskovic, Schmidt, Georgiades, Boyle, & MacMillan, 2009). Further evidence suggests a severe impact of maltreatment of hemispheric integration in school-aged children, which is indicated to be a vulnerability factor (Ito, Teicher, Glod, & Ackerman, 1998; Teicher et al., 1997).

The above findings represent accumulating evidence that suggests children’s neural systems to be highly sensitive to the caregiving environment in general, and, the effects of adverse relational experiences in particular. In a recent review, Gander and Buchheim (2015) list a number of studies linking attachment and neurophysiology in different age groups, however, regarding children’s attachment security in particular, research in the field is sparse. The current research aims to fill this gap in the literature.
1.4 Foster Children as a High-Risk Sample

The preceding sections have illustrated how pathogenic care, puts children at high risk for maladjustment in several developmental domains and increases vulnerability to psychopathological outcomes in later life (e.g., Cicchetti, 2002). In this section, I will focus on foster children as a group that is highly affected by a number of unfortunate circumstances, mostly from early on.

When living with their biological family provides an insufficient environment to thrive properly or poses a threat to children’s mental and physical integrity, legal authorities need to take action in attempt to protect them from any further harm. Moreover, when outpatient services are considered incapable of improving the child’s living conditions, removing him/her from home becomes an inevitable consequence. In Germany, a total of 21,631 children under the age of 6 years are affected by such out-of-home placements, 17,253 of which are living in long-term foster care (Statistisches Bundesamt, 2015). Referring to the German Federal Statistical Office (Statistisches Bundesamt, 2015), between 2000 and 2013 the number of children placed in foster care has increased almost by half so that by now there are quite as many children permanently living with a foster family as there are in other out-of-home placements\(^4\) (67,812 and 69,203 respectively). Indeed, favoring foster care intervention for its benefits of providing a family-like environment represents a common trend in Germany’s child welfare system.

Furthermore, in contrast to other countries, reunifying children with their birth family often remains an unrealizable objective (Deutsches Jugendinstitut e.V. & Deutsches Institut für Jugendhilfe und Familienrecht e.V., 2006), rather do most foster care interventions permanently provide children with a safe place to grow. Fortunately, this way many children are able to benefit from continuous, warm and supportive relationships, which may potentially buffer previous negative experiences (Bowlby, 1988; Sroufe et al., 2005). However, the transition into foster care can be a very challenging process for both the child and its new caregivers (see Gabler, 2013). In fact, at the time of placement foster parents bear a heavy psychological burden and it is likely that having been exposed to pathogenic care, children have already developed several adaptive strategies that may be highly dysfunctional when living with the new caregivers. In fact, many of the children entrusted to their care have experienced physical and emotional maltreatment or neglect in their biological families (Chernoff, Combs-Orme, Risley-Curtiss, & Heisler, 1994; Minnis, Everett, Pelosi, Dunn, & Knapp, 2006; Takayama, Wolfe, & Coulter, 1998), which is associated with a series of negative outcomes in general (e.g., Éthier, Lemelin, & Lacharité, 2004; Glaser, 2000; Hildyard & Wolfe, 2002; Tyler, 2002; Youngblade & Belsky, 1990) and insecure attachments in particular (e.g. Cicchetti & Barnett, 1991; Egeland & Sroufe, 1981; also see Baer & Martinez, 2006 for a review).

\(^4\) Including institutions and other supported forms of housing, more analogue to a family environment
As an unfortunate consequence, carrying an internal working model of attachment that contains negative beliefs about themselves and the caregiver (Bretherton & Munholland, 1999) into the new relationship may impede the establishment of new secure attachments (Dozier, Stovall, Albus, & Bates, 2001; Dozier, 2003; Stovall & Dozier, 2000). Additionally, placement in foster care also brings about further risk factors as it implies the loss of continuity in a well-known environment and, the loss of a primary caregiver, which itself is likely to have debilitating effects on development as it has been shown in human and non-human primates (Bowlby, 1973; Cirulli et al., 2003; Suomi, Collins, Harlow, & Ruppenthal, 1976; Yarrow & Goodwin, 1973). Moreover, many foster children experience more than one placement, and thus, often multiple disruptions of social relationships. So, in addition, the uncertainty of whether the current foster home provides a stable and safe environment on a permanent basis makes it even harder for the child to settle and develop a feeling of safety.

In conclusion, foster children clearly form a high-risk sample that are affected by a number of attachment related themes, containing considerable risks as well as the chance of protective factors coming into effect (see Gabler, 2013). Referring to the importance of the early years in the development of attachment as well as the shaping of the neural circuits underlying social-information processing (see the above sections), there is reasonable cause for concern that dysfunctional behavioral tendencies may be rather resistant and may endure despite intervention.
The human infant is born immature and not ready to survive without a caring other for an extended period of time. Indeed, this incompleteness is evolutionary highly beneficial as it allows the organism to mature in transaction with the environment and, by doing so, optimally adapt to it (Bjorklund, 1997). Therefore, the human infant is predisposed for receiving particular environmental input that in turn drives the maturation of systems in several developmental domains. In this sense, the brain’s plasticity allows for individual attunement to the infant’s unique physical and social world. Indeed, this is what Bowlby (1982) has proposed with regard to the attachment system as well. In his view, the development of attachment is phylogenetically anchored, but also includes a component that is learned ontogenetically and thus makes the attainment of set-goals within the individual environment more likely (Bowlby, 1982; also see Mikulincer & Shaver, 2010, p.21). More precisely, on a cognitive-affective level early experiences form children’s internal working models, which in turn guide behavior in relevant social or emotional situations (Main, Kaplan, & Cassidy, 1985). Moreover, neurological development occurs during social interactions as well (Nelson & Bloom, 1997), and, on a physiological level, such experiences are thought to finally shape the child’s nervous system in a way that it responds to external cues in adaption to the early social environment (Richter & WHO, 2004, p.39). However, referring to the development of attachment, but also applicable to developmental plasticity in general, Bretherton (1992) has argued that such “flexible organisms pay a price […], because adaptable behavioral systems can more easily be subverted from their optimal path of development” (p.766). Thus, alterations in children’s behavioral organization as well as their neurophysiological regulation that are designed to adapt to a challenging environment (i.e., pathogenic care), however, may not be “optimal for survival and reproductive success in a more benign environment.” (Teicher et al., 2003, p.39).

Thus, on the one hand, early intervention including the formation of new affectional bonds to available and loving caregivers can buffer the effects of negative experiences. One the other hand, since the early years represent a phase of rapid neural development, early experiences can have enduring negative effects on children’s development and thus, challenge the new relationship that was meant to improve the child’s wellbeing. To better understand the needs of families taking care of such vulnerable children it seems crucial that current research takes into account that early adverse experiences affect the growing organism on multiple levels.
1.6 Aims and Scopes of the Doctoral Thesis

This doctoral thesis investigates behavioral and neural responses towards familiar and unfamiliar adults by comparing preschool-aged foster children to a control sample. With this research I aim to make two novel contributions to the existing literature: First, I attempt to specify how early adverse caregiving experiences affect socio-emotional development by applying a behavioral system approach. In particular, I will reveal characteristics of the newly formed relationship between foster mother and foster child with regard to attachment security, dependency, and overt behavioral correlates on the one hand, and foster children’s behavioral reactions to unfamiliar adults, on the other hand. Second, I will investigate neurophysiological processes assumedly underlying behavior in social interactions. I will do so by comparing foster children’s and control children’s ERP responses to the (foster) mother and a stranger faces. Furthermore, I will examine how attachment security affects the neural correlates of facial familiarity processing in both groups. Thereby, the research will add to the existing literature on relations between potential aberrations in neural development and behavioral outcomes in high-risk samples, and, moreover, holds the potential to contribute to current knowledge on brain-behavior correlations in general.
Chapter 2: Methodological Aspects of Children’s EEG and ERP in Psychological Research

“The recording and analysis of ERPs is complex. Since the human brain works in complicated ways, one should not expect otherwise” (Picton & Taylor, 2007, p. 252).

As this was the first study collecting neurophysiological data in children at the local department for developmental psychology and the lab has been set up in its course, methodological considerations were a major part of my work. Thus, here, I will provide an overview of the use of the EEG in psychological research. In particular, I will explain the event-related potential (ERP) technique and principles of ERP assessment including practical issues that need to be considered in studies with young children. Finally, I will explain the approach in the context of the current study.

2.1 An Introduction to the Method

The history of the EEG method goes back to the 1930s when neurologist Hans Berger marked a milestone with the first publication on electric activity recorded along the human scalp (Berger, 1929). He proposed that complex mental processes have distinct physiological correlates, which, at the time was sensational. For the first time, it was possible to “read” the operating human brain and the EEG has been the only measure to provide this insight until the late 60s (Seifert, 2005). Even though today neurophysiological imaging methods like positron emission tomography (PET) or functional magnetic resonance imaging (fMRI) enjoy great popularity, the EEG holds some major advantages that are especially interesting when investigating psychological variables. Above all, it has excellent temporal solutions. This means that it is able to reveal changes in ongoing mental processing on the basis of milliseconds, which may outweigh its lack in spatial resolution. More practical nevertheless important issues are that comparatively the EEG is more affordable and the resulting data is somewhat easier to handle than such derived from neuroimaging procedures. Still, the EEG can —at least roughly— inform about the localization of activated brain areas, furthermore, under certain conditions, it is also possible to subsequently conduct more precise source analyses (see Grech et al., 2008). However, which measure to choose is always a tradeoff and mainly depends on the question one would like to answer. When neuroanatomical specificity is of minor importance and

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the main focus lies on performance of the neural tissue rather than its physical structure, using EEG most likely is the better choice (Luck, 2005; Picton & Taylor, 2007).

In the following, I will briefly explain some basic principles of what is measured with an EEG and then give an introduction to ERPs including their measurement and a standard convention of how waveforms are described (also see Luck, 2005, and Seifert, 2005 for a detailed description of ERPs).

The EEG reflects changes in voltage at the cerebral cortex. When a neuron fires, it means that an action potential is released and travels to the axon terminals. Here, neurotransmitters are released and bind to receptors, which in turn generates voltage referred to as postsynaptic potentials. Still, this electric activity is not necessarily measurable along the scalp rather do postsynaptic potentials need to be summated to gain measurable output. Therefore, it requires a substantial number of neurons that are favorably aligned (like neo-cortex pyramidal cells) and fire synchronously. Moreover, as electric fields tend to become smaller with distance, those that are located closer to the scalp are more likely to be reflected in the EEG. Consequently, sub-cortical activity is much harder to detect with an EEG and structures like the thalamus even are barely visible (Coles & Rugg, 1995).

Regarding EEG we need to distinguish spontaneous EEG activity and ERPs (also see Luck, 2005). While the spontaneous EEG reflects ongoing neural oscillations (e.g., the well-known alpha activity) in the absence of a specific task, ERPs only represent a subset of the brain’s electric activity that is locked to the occurrence of a certain event (e.g., the sensory input of a facial image) and reveals itself in a certain ERP waveform. To identify the brain’s unique response to such events, the subject needs to be continuously presented with a certain stimulus coupled with a brief post-stimulus recording interval each representing a so-called trial (Figure 1a). ERPs are assumed to be identical on each trial, but obscured by random noise, that again is assumed to be unrelated to the presentation of the stimulus. In order to isolate the small ERP waveform from the much larger EEG, trial segments need to be extracted. Finally, averaging a substantial number of trials is thought to eliminate non-time locked neural background activity, and thus, is the standard procedure in ERP data reduction (Figure 1b).
The resulting ERP waveform consists of a series of “hills and valleys” (Nelson, Fox, & Zeanah, 2014, p.194) that is assumed to be the graphic representation of neural signals stemming from underlying neurocognitive processes (Luck, 2005). Based on their polarity, peak latency, scalp location, and experimental manipulation, these positive and negative deflections have been separated into more or less distinguishable components (Swick, Kutas, & Neville, 1994). It should be noted, however, that mental processes naturally unfold while brain activity from previous processing steps still persists. This may result in a simultaneous generation of multiple possibly overlapping ERPs which can be methodologically challenging (for a discussion of the issue see Kappenman & Luck, 2012).

Typically, components are defined by their peak (local voltage maximum) and even terms are sometimes used interchangeably, it is actually rather the component underlying a visual salient peak (Kappenman & Luck, 2012). Following a standard convention peaks are labeled N or P, indicating a negative or positive deflection, respectively. Furthermore, a number is used to indicate the peak’s ordinal position within the waveform or it makes reference to its precise latency. For example, an early visually evoked potential that reaches its maximum positive peak at about 100 ms is usually labeled P1, but it is also common to refer to it as P100 (Luck & Kappenman, 2012; Luck, 2005). Apart from timing and polarity information, scalp distribution may be used to label components. For
example, the Nc represents a negative component occurring at electrode sites distributed around the center of the scalp. Furthermore, subcomponents differentially affected by experimental factors (e.g., N2pc) may be defined (for an overview see Kappenman & Luck, 2012). Figure 1b) shows an idealized waveform of a visually evoked potential. Here, the earliest peak appears at around 100 ms. Referring to a traditional simple classification (Donchin, Ritter, & McCallum, 1978), these peaks belong to endogenous potentials while potentials as early as <50 ms are called exogenous with the further reflecting more advanced psychological processes than simple perceptual responses affected by the physical characteristics of the stimulus.

2.2 EEG/ERP Data Collection and Reduction

In the following section, I will give an overview of how ERP data can be collected with regard to studying young children and, as this is of major interest for the current study, referring to studies of facial familiarity processing. Next, I will explain major offline processing steps that are necessary to reduce the EEG data, extract ERP waveforms and prepare it for export in statistical analyses programs (for further discussions on recording and analyzing ERP data in developmental populations see DeBoer, Scott, & Nelson, 2007; Hoehl & Wahl, 2012; Taylor & Baldeweg, 2002; and Luck, 2005, for a general introduction to the ERP technique).

2.2.1 Principles of recording an EEG

For the conduction of an EEG, electrodes, mostly out of Ag/AgCh, are placed at the scalp in a certain order. The contact quality between scalp and electrode is often enhanced by inserting gel and can be measured as the impedance. Now, the electrodes pick up the tiny EEG signal at the scalp and via cables lead it to an amplifier with a set amplification factor or “gain” (20,000 mV is recommended in children from 3 months to 6 years of age, DeBoer et al., 2007), where it is resolved and converted from analog to digital. When digitalized, the recorded signal can only approximate the original and its accuracy is determined by the sampling rate (Seifert, 2005). As the minimum sampling rate is twice the maximum frequency it can depict: larger sampling rates produce more precise digitalized signals and improve reconstructions of the waveform. Therefore, even though high sampling rates produce large files, most experiments intend a minimum sampling rate of 200Hz (see Seifert, 2005, p.35). While one computer is needed for recording the EEG signal, another computer generates the stimuli that are presented on a screen in front of the participant. For the offline analyses of ERPs, that are time-locked to the presentation of a stimulus, the occurrence of any event needs to be marked within the ongoing EEG and thus, systems need to be synchronized (for a detailed description of an ERP lab set up see Luck, 2005).
2.2.2 ERP data acquisition

Data collection systems

A major decision one has to make refers to the data collection system. There are a number of features that differ among available systems. For example, there are low-density systems for placement of up to 32 electrodes and such that allow high-density arrays with up to 256 electrodes. Both hold advantages and disadvantages. Of course, high-density arrays are more precise and allow for further analysis like source localization procedures as well as detection of subcortical potentials (DeBoer et al., 2007). However, they are more expensive and often require prolonged time for the application (an exception is the geodesic sensor net, GSN, see Johnson et al., 2001). Thus, in studies with young children or clinical samples their necessity should carefully be considered. In fact, researchers have not found significant differences in quality when comparing low- to high-density systems (Carver et al., 1999, cited in DeBoer et al., 2007; Johnson et al., 2001; Luck, 2005). Thus, when spatial information is less important and components of interest are well-defined a priori, low-density arrays might be more appropriate.

For reasons of comparisons between studies as well as age groups the location of electrodes needs to be standardized and usually follows the 10-20 system by Jasper (1958), where adjacent electrodes are placed at a certain distance that is relative to the participant’s head size. When using electrode caps, electrode positions are sewn-in, which facilitates the application procedure. They are available in different sizes and should sit tight to hold electrodes in place during the experiment, when e.g., a child is moving or scratching his/her head. Still, a conductive gel is required to maximize contact between the electrodes and the scalp (exceptions are “dry” electrodes, e.g., acticap Xpress, Brain Products, Gilching, Germany), which has to be applied carefully to avoid “low impedance bridges” connecting electrodes underneath the cap (Hoehl & Wahl, 2012, p.189).

When recording EEGs in infants and young children it is very likely to find participants moving their heads and being restless at least at some point and this is something to already be considered when choosing the equipment. As mentioned, electrode caps are less likely to be affected by movements than for example, the GSN, where electrodes are not as rigidly adhered to the scalp (Hoehl & Wahl, 2012). Furthermore, some electrode caps come with active rather than passive electrodes (e.g., acticap; Brain Products, Gilching, Germany). These are electrodes with integrated circuits that convert impedances directly making the signal less sensitive to interferences like ambient noise or cable movements.

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6 It may be convenient to know the child’s head size in advance and plug electrodes into the cap before the child arrives to the testing room.
Paradigms and stimuli

Regarding the experimental design of ERP studies with children it should be considered to keep it as simple and as short as possible. Importantly, in children the amount of usable data may substantially decrease during offline processing as several trials may need to be rejected due to, for example, movement artifacts. Thus, not to compromise the signal to noise ratio it is necessary to include a sufficient number of trials for each condition in the first place. Consequently, as the number of independent variables increases so does the need for more trials and the length of the experiment, as tolerated by the child, is easily exceeded. Another aspect in the design of experimental tasks refers to the simultaneous recording of ERP and behavioral data. There are studies that have combined ERP methodology with behavioral measures by simultaneously recording behavioral data such as visual fixation (e.g., Karrer & Monti, 1995). However, behavioral measures like button-press tasks are not easily feasible below the age of 4 to 5 years (DeBoer et al., 2007). Thus, passive-viewing paradigms are recommended for children at this age as they do not need complex instructions and also hold the advantage of not adding any neural activity due to task engagement. Still, it is possible and important to record behavioral performance before or after wearing the electrode cap and thus, “ground EEG/ERP measures in behavior … [which] … will yield converging evidence and lead to more reliable results” (DeBoer et al., 2007, p.12).

Furthermore, the choice of age-appropriate stimuli is important (Hoehl & Wahl, 2012; Picton & Taylor, 2007). As faces are highly salient to young children and different aspects of face processing (e.g., face recognition and processing with regard to facial familiarity and facial emotion expression) can be investigated from early on (see de Haan, Johnson, & Halit, 2003; Taylor, Batty, & Itier, 2004) they are popular stimuli. Photographed images of faces seem to be most valid as they naturally occur in the external environment and in the case of more advanced mental processes like categorization (e.g., facial familiarity processing) such natural stimuli are considered to be appropriate (Picton & Taylor, 2007). However, they are also very complex stimuli and it can be challenging to control for all their properties (e.g., luminance, size, shape), which the brain might differentially respond to. Thus, even when low-level perceptual processes are not the focus of interest, to avoid confounds and misleading interpretations of response differences, it is still essential to match for these factors between conditions (Hoehl & Wahl, 2012).
Testing environment and procedures

In his well-known guide, Luck (2005) spends two pages on the importance of “keeping the subjects happy” to ensure high quality data (pp.311-312). Therefore, he recommends a reasonable length for blocks of trials interrupted by short breaks, to offer drinks and even to play background music for the sake of the subject’s well-being. Now, when it comes to young children one can assume how important it is to provide a non-fear inducing environment, to keep preparation time short and to make sure they remain motivated and attentive to a task, that naturally tends to be repetitive and rather boring.

So, when testing infants or young children, the environment should be child-friendly and colorful (Hoehl & Wahl, 2012). Responding to children’s needs, researchers have also designed welcoming testing rooms or built up stories like telling them to be “astronauts going into space” (Solomon et al., 2012, p.5). In any case, the main goal is to create a comfortable atmosphere for children and their caregivers, who often need to stay in the room during testing or rest their hand on the child’s shoulder for comfort.

Also, even though absolutely painless, the application of electrodes can be found to be unpleasant to some children, so it is useful to meanwhile distract them by letting them watch cartoons (e.g., Solomon, DeCicco, & Dennis, 2012). Younger children often need to be entertained by an additional experimenter (Hoehl & Wahl, 2012). In general, some experience and the right equipment are needed to keep the preparation time as short as possible.

Then, during testing, it should be ensured to avoid distractors, so many researchers use some kind of shield to surround the monitor that presents visual stimuli and dim surrounding lights (see DeBoer et al., 2007; Hoehl & Wahl, 2012). How to keep up the child’s attention during the testing procedure mainly depends on the age group. Infants might be attracted by sound animations (Taylor - Colls & Fearon, 2015) older children might be motivated to keep looking at the screen when promised little tokens like stickers after having attended to a predefined number of trials. It should be noted, that introducing such exogenous factors might somehow influence the data, but this is not of major concern as long as they are unrelated to the presentation of stimuli. The disadvantage of adding noise, however, might be outweighed by a moderate increase in data quantity and quality (DeBoer et al., 2007; Luck, 2005).

Furthermore, during the recording of the EEG it is essential for studies with infants (Hoehl & Wahl, 2012), but also advisable for studies with children, to monitor their behavior during the recording of the EEG. Thereby, the experimenter can promptly react to inattentiveness by pausing the experiment (if the paradigm allows for it), remind the child of the task, or simply set markers to identify and eliminate segments where the child was not looking at the screen when processing the
data afterwards. This can be done by directly observing children (de Haan & Nelson, 1997, 1999; Swingler, Sweet, & Carver, 2007; Webb, Long, & Nelson, 2005) or by watching them via a video camera that is placed in front of the child (Todd, Lewis, Meusel, & Zelazo, 2008). Also, some researchers synchronously record the video and code behavior offline (e.g., Hoehl, Wiese, & Striano, 2008; see Hoehl & Wahl, 2012). Notably, some video recording devices produce substantial noise that can contaminate the data. At least in our experience simple webcams are less likely to do so.

2.2.3 ERP data reduction

To detect the components of interest that are embedded in a large individual EEG signal that was recorded, it has to be made more comprehensible and thus processed offline. There is a series of fundamental steps that need to be conducted before one is able to export individual values of a components response amplitude and latency for further statistical analyses. EEG Analyzing software programs (e.g., BrainVision Analyzer; Brain Products, Gilching, Germany) allow navigating through individual raw files and offer assistance in the signal processing procedure.

Raw-Data Inspection. First, it is advisable to visually inspect the raw data to e.g., check for electrode drifts, messy intervals or other abnormalities in the ongoing EEG. Optimally, critical intervals were already marked during recording (when the recording software allows for it) and/or notes were put down in a log-book, particularly when the child was not attending. This can highly facilitate the inspection and interpretation of any conspicuities in the ongoing EEG reducing the risk for errors.

Re-Referencing. The EEG signal that was recorded at an active electrode site reflects the fluctuations in voltage differences between this specific site and a reference site, which optimally does not record much neural activity itself. Today, many researchers use the Cz as an online reference. However, as it is located in the center of the scalp where it usually records lots of information on neural activity itself, it is necessary to re-reference the signal offline (Seifert, 2005). There are different approaches to an optimal reference, for example, the new reference could be the mean activity of two electrodes that were placed at the subject’s earlobes (mastoid reference) or of all electrodes taken together (average reference). For the latter approach it is a pre-requisite to obtain something approximating the “true average” (Luck, 2005, p.111) of the entire head, but mostly not much of, for example, the facial surface is covered during recording. It is recommended that the average reference is only used when applying high-density arrays (Dien, 1998), however, it has also been used in studies with 32 electrodes (Swingler, Sweet, & Carver, 2010) or less (Batty & Taylor, 2007). This overview intends to illustrate major processing steps. However, neither is it meant to be exhaustive nor is the order of transformation steps depicted here obligatory.
2.2 EEG/ERP Data Collection and Reduction

2006; Marshall & Fox, 2004; Tarullo et al., 2011). Taken together, there is no consensus about the set of electrodes needed for the adequate use of an average reference (Luck, 2005). Still, it remains crucial to keep in mind that using different references can clearly affect the results (Dien, 1998). Thus, comparability with other studies might also be considered when choosing a reference.

**Filtering.** Another important point concerns the issue of filtering (also see Luck, 2005, Chapter 5). In the recording of an EEG lots of noise ads to the signal, some of which can be identified by its frequencies. For example, muscle contraction consist of very high frequencies (< 100Hz), relaxation produces noise by eliciting alpha waves (10Hz). Furthermore, non-neural origin frequencies are added by 50Hz frequencies, which are common in the laboratory environment as it is generated by the operation of electrical advices and lightning. Now, as most ERPs are composed of frequencies less than 30Hz, basically, anything above this point can be ignored and might as well be filtered out (Luck, 2005). This also applies to very slow, but often very large, voltage shifts (<.01Hz), that are created by e.g., sweating and best be filtered out already whilst recording to avoid amplifier saturation. In the end, filtering produces a much smoother signal and one might get the impression it should be used where possible. Yet, the opposite is true. Indeed, filters affect the ERP waveform in different ways like causing artifactual oscillations or changing its timing and this is particularly true when filtering frequencies that make up a considerable proportion of the ERP waveform (which is why one would not filter out alpha waves at 10Hz). Luck (2005) recommends to do as little filtering as possible, especially during recording and suggests using a high-pass filter (attenuating low frequencies) with a cutoff⁸ at .01Hz and a low-pass filter (attenuating high frequencies) with a cutoff at 30Hz. While this bandwidth seems reasonable when studying cooperative subjects, infants and children are more likely to move around (causing slow wave artifacts) and high-pass filter cutoffs are usually set higher (e.g., Batty & Taylor, 2006; Carver et al., 2003; Dawson et al., 2002; Moulson, Fox, Zeanah, & Nelson, 2009; Otero, 2003; Todd, Lewis, Meusel, & Zelazo, 2008).

There are some more minor transformations that can be done at this point. For example, missing or messy electrode sites can be interpolated and thus substituted. The next obligatory step towards the emerging ERP waveform, however, is segmenting of the data.

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⁸ Note: In ERP studies usually "cutoff" means the frequency where the amplitude is cut by 50% (sometimes referred to as half-amplitude cutoff)
**Segmenting.** By segmenting the data, any dispensable parts of the EEG will be excluded. Here, the researcher needs to specify a time interval that comprises recording periods around the time of the presentation of stimuli that are necessary for further analyses. The single segments should probably at least start at 100 ms prior to stimulus onset and terminate after about 1000 ms post-stimulus recording time (as most ERP research focuses on processes within one second after stimulus onset, see Luck, 2005).

**Baseline correction.** The reason for leaving a pre-stimulus recording interval to the segment is to correct the measurement for any pre-stimulus activity. Therefore, the mean voltage found prior to the onset of each stimulus, needs to be subtracted from the post-stimulus recording. Luck (2005) suggests using a pre-stimulus interval of 200 ms as the so-called baseline. Still, he recommends to be aware, that even this period is not absolutely neutral as it might be affected by “preparatory processes” prior to stimulus onset as well as “late potentials [resulting] from the previous stimuli” (p.236), which is especially true when inter-stimulus intervals are short.

**Artifact rejection.** As has been mentioned the ERP waveform is contaminated by a series of possible artifacts and affected segments need to be rejected before the calculation of an average ERP waveform. For example, there can be high frequencies due to muscle activity (electromyogram, EMG) or heart beating (electrocardiogram, EKG) and slow voltage shifts (skin potentials caused by e.g., sweating), potentially leading to amplifier saturation and producing a flat line (“blocking”, Luck, 2005, p.167). As mentioned above, by constraining the signals bandwidth, filtering might eliminate many of these types of artifacts, however, this does not apply to artifacts like eye movements and eye blinks which result from changes in the eyes’ “intrinsic voltage gradient” (p.162) and produce potentials that affect conductions across the entire scalp. To detect potentials induced by blinks or saccades, it is common to place electrodes around the subject’s eyes. This so-called electrooculogram (EOG) is very sensitive to eye movements or blinking and facilitates the detection of ocular artifacts. Optimally, EOG electrodes are placed vertically and horizontally, but when the child refuses to have multiple electrodes attached to this sensitive area, vertical placements are preferred (DeBoer et al., 2007). Artifacts can be identified by typical patterns in the waveform that result from irregular voltage changes. Most ERP analyzing software offer the possibility to automatically detect artifacts by choosing a maximum voltage threshold or other criteria like a pre-defined maximum voltage difference within an ERP epoch (for an overview and discussion of artifact rejection measures and possibilities to correct artifacts see Luck, 2005, Chapter 4). Picking a rejection threshold that allows for a sufficient number of hits and correct rejections while minimizing the risk of misses and false alarms (see Luck, 2005, p.153) is not easy, but previous studies with comparable samples can inform the criteria. For example, due to physiological factors like less skull
thickness children generally produce larger amplitudes than adults (DeBoer et al., 2007), so criteria are very different here. For example, while trials exceeding a threshold of +/-75 mV would be rejected in an adult study (e.g., Rossion & Caharel, 2011) an amplitude up to +/- 250 mV has been accepted in infant studies (Swingler, 2010). Also, when choosing a semi-automatic artifact detection one still has the option to visually inspect the signal and decide whether to reject segments or not. However, the disadvantage of this procedure is a subjective bias, which is why experimenters should be blind to conditions. Moreover, even though more time and cost consuming, some studies have even used two experimenters and calculated reliability for the artifact rejection procedure.

Averaging. The final step to obtain the original ERP waveform is averaging condition-wise. For example, in an ERP experiments comparing familiar versus unfamiliar stimuli, there are now two average ERP waveforms for each individual subject. The basic principle here is that while the waveform is assumed to be the same in all trials (of each condition) the noise, which is unrelated to the stimuli, will be eliminated by averaging a substantial number of trials. Consequently, the more trials are used for averaging the smaller the remaining noise (as it “decreases as a function of the square root of the number of trials” (Luck, 2005, p.133). However, collecting a high number of trials per condition means an expanded period of recording time and a small number of trials that need to be rejected due to artifacts. Unfortunately, in ERP experiments with children both requirements are challenged by subjects “who are more concerned with growing up than being measured” and “do not wish to stay still” (Picton & Taylor, 2007, p.254 and p.271) and thus, the number of artifact-free trials may be less. For studies with infants DeBoer, Scott, and Nelson (2007) recommend a minimum of 10 to 20 artifact-free trials to be contributed by each infant (p.26). In studies of facial familiarity processing in older children the minimum number of required trials per condition is similar (e.g. Dawson et al., 2002; Moulson, Westerlund, Fox, Zeanah, & Nelson, 2009; Todd et al., 2008).

Finally, individual averages are again averaged for each group leading to the so-called grand-average waveform. Notably, the number of trials included in the calculation of averages need to be balanced across conditions and groups when intending to compare peak amplitudes (Luck, 2005, p.231).
Chapter 2: Methodological Aspects of Children’s EEG and ERP in Psychological Research

2.3 ERP Measures

There are two measures that are commonly attributed to a single component. First, there is the size of the maximum peak amplitude (mV), which is determined by the “number of synapses activated in the region generating the response” as well as their “synchronization” (Picton & Taylor, 2007, p.253). Generally speaking, the larger the amplitude’s absolute value the more brain activity is involved in a given mental process. The scoring of the components’ peak amplitude is not simply inferred. Previous studies with comparable age groups can inform about the intervals where the component is expected to show its deflection. Still, a visual inspection of the grand average waveform is necessary to account for the individuality of each study. Second, there is peak latency, that can be used as an indicator of how rapidly the brain responds to a stimulus as it reflects “conduction velocity in the pathway from the sensory receptor to the generator of the ERP and the length of this pathway” (Picton & Taylor, 2007, p.253). Here, shorter latencies are thought to reflect more efficient or rapid processing (Nelson, Fox, & Zeanah, 2014). Notably, the calculation of the peak latency requires the use of a peak amplitude rather than a mean amplitude, which refers to the mean activity within a predefined interval (advantages of the mean amplitude are discussed in Luck, 2005, pp.234-237).

It is important to keep in mind that in studies with infants and children latency and amplitude reflect changes in both white and grey matter (Picton & Taylor, 2007, p.253). Thus, their size is highly dependent on developmental age (e.g., see Taylor et al., 2004 for age-related changes in ERPs related to facial processing).

2.4 The ERP Approach in the Context of the Current Study

Measuring ERPs in young children is challenging, however, the method is very promising to the investigation of children’s mental functioning in a number of different domains. We applied this approach as it can yield knowledge about successive mental processing steps on a millisecond basis, yet being non-invasive. Regarding socio-emotional development, children’s neural responses to caregiver and stranger faces have shown to be related to important aspects of the caregiver–child relationship and are assumed to underlie behavior (see Chapter 5). Facial familiarity processing can be assessed by recording EEG while the child passively views face stimuli. In the current study, it was an advantage that there were no task demands that may can challenged by children’s mental capacities, especially in vulnerable samples.
Chapter 3: Overview of the Current Study

For the purpose of the current study foster children were re-recruited from a preceding longitudinal study that I will briefly outline in the following section. Then, I will describe the overall design of the current study, its participants and give an overview of methods that were applied.

3.1 Outline of the Preceding Longitudinal Study

Before targeting the current research, I will give an overview of the procedure of the preceding longitudinal study and clarify, at which point I refer to data from that study.

The longitudinal study “Attachment and Psychosocial Adjustment of Foster Children: Individual and Social Factors of Influence” (Spangler, Bovenschen, & Nowacki, 2009) aimed to investigate preschool-aged foster children during the transition into the foster home. Major research questions focused on the development of the attachment relationship between foster children and their new primary caregivers as well as changes in behavior problems, symptoms of attachment disorders and developmental status. Also, a variety of factors potentially contributing to positive development in these different domains were of particular interest. Therefore, children placed in non-related foster families residing in the German cities Erlangen/Nuremberg and Dortmund as well as surrounding areas, were assessed at three waves: First, within 3 months after arrival to the foster home, second, 6 months, and third, 12 months after placement. At each wave, identical assessments took place during a home visit as well as a laboratory visit.

The findings that are of interest for the current study refer to foster children’s attachment security and disinhibited social engagement with strangers and will be summarized in section 4.1.1. A detailed description of the study as well as its findings can be found in other publications focusing on the development of attachment (Gabler et al., 2014; Lang, 2014) and attachment disorders (Zimmermann, 2015).
3.2 Overview of Study Parameters

3.2.1 Participants

The current study’s total sample consisted of 46 preschool-aged children (23 male/23 female) of whom 16 children were living in foster care while 30 children were living in their biological family. Sample attrition occurring in the neurophysiological part of the study is indicated in Chapter 5’s method section.

Foster care sample

The group forms a subsample of foster children who took part in the preceding longitudinal study. We re-invited all of the 24 foster children and their foster mothers from the Erlangen sub-sample that have completed the 1-year longitudinal assessment and met our criteria, which included children aged 3 to 6 years before entering elementary school. However, eight foster children and their foster mothers did not attend, as foster mothers described them to be too impulsive (n = 1), too emotionally unstable (n = 1) for any further assessment, or indicated other unspecified personal reasons (n = 6).

Drop-out analysis. Table 1 shows that foster children who could be re-recruited did not significantly differ from the rest of the sample regarding age at placement, and the main study variables attachment security, dependency, and signs of disinhibited engagement disorder as reported by the foster mother. Furthermore, there were no differences in problem behavior between both groups.

Table 1
Drop out Analysis for Foster Children’s Age at Placement, Attachment Security, Dependency, Signs of Disinhibited Attachment, and Problem Behavior. Means, Standard Deviations, and T-Test Results

<table>
<thead>
<tr>
<th>Variables</th>
<th>Final sample</th>
<th>Drop-out</th>
<th>t(df)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n = 16</td>
<td>n = 8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age at placement in months</td>
<td>33.54 (14.10)</td>
<td>28.35 (18.18)</td>
<td>-.77 (22)</td>
<td>ns</td>
</tr>
<tr>
<td>Attachment security⁻</td>
<td>.30 (.21)</td>
<td>.36 (.14)</td>
<td>.68 (22)</td>
<td></td>
</tr>
<tr>
<td>Dependency⁻</td>
<td>.14 (.23)</td>
<td>-.01 (.19)</td>
<td>-1.56 (22)</td>
<td>ns</td>
</tr>
<tr>
<td>Signs of disinhibited attachmentᵇ</td>
<td>1.31 (1.49)</td>
<td>1.63 (1.86)</td>
<td>.45 (22)</td>
<td></td>
</tr>
<tr>
<td>Problem behaviorᶜ</td>
<td>54.25 (10.16)</td>
<td>57.25 (13.54)</td>
<td>.61 (22)</td>
<td></td>
</tr>
</tbody>
</table>

Note. Attachment Q-Sort (AQS) security and dependency scores represent z-values transformed according to Fisher, values represent scores on the Disturbances of Attachment Interview (DAI) disinhibited scale, T-values for total score on the Child Behavior Checklist (CBCL)

⁻ A detailed analyses of problem behavior in the total sample of foster children was part of the analysis in the longitudinal study (Gabler et al., 2014; Lang, 2014)
The final sample of foster children consisted of 16 children (9 male/7 female) who attended the study with their foster mother. Foster children’s age ranged from 39 to 77 months ($M = 54.36, SD=11.66$). Fourteen of the foster parents were married. Foster mothers were aged 39 to 51 years ($M = 44.38, SD = 3.67$) and indicated to be the child’s primary caretaker ($n = 12$) or to share caretaking responsibilities with their partners ($n = 4$). In less than half of the foster families (43.7%), mothers were working in a full or part time position. Table 2 shows data on further family characteristics. As can be seen here, most families belonged to the middle class, and 21.3% of foster mothers and 43.8% of foster fathers held a high school certificate.

Foster children’s characteristics. Foster children’s age at placement ranged from 15 to 61 months ($M = 33.54, SD = 14.10$). At the time of the laboratory assessment the average time children have spent in the current foster home was 21 month (range: 15-30 months, $M = 21.09, SD = 4.61$).

Reasons for placement in foster care were manifold and several children had been faced with multiple forms of endangerment of their welfare. These adverse experiences included maltreatment ($n = 15$), violation of duty of supervision ($n = 13$), neglect ($n = 11$), parents’ mental illness ($n = 11$), physical maltreatment ($n = 5$), sexual abuse ($n = 2$). In two cases the reason for placement was parent’s imprisonment and one child was given into care voluntarily. Only four out of 16 children have been placed with their current foster family straight away while others have experienced one ($n = 7$), two ($n = 3$), three ($n = 1$) or five ($n = 1$) previous placements.

Control sample

The sample of children living with their biological family was recruited in Erlangen and the surrounding area and consisted of 30 children (14 male/16 female) that participated in the study together with their biological mother. Two more children were tested, but not included in the final sample, because they only provided insufficient data due to an early drop out ($n = 1$) and missing data ($n = 1$).

Children’s age ranged from 41-70 months ($M = 56.22, SD = 8.57$) and they were living with their mother ($n = 3$) or both their biological parents ($n = 27$) of whom 26 were married. Mothers were aged 25 to 44 years ($M =37.03, SD = 4.25$) and indicated to be the child’s primary caretaker ($n = 20$) or to share caretaking responsibilities with their partners ($n = 10$). In 40% of the families mothers were working in a full or part time position. Most of the families belonged to the middle class with 71.5% having at least 2500 Euros per month at their disposal, and, At least 73.3% of mothers and 83.3% of fathers held a high school certificate.

10 For initial recruitment criteria and a comprehensive description of the original sample see, e.g. Gabler, 2013 or Lang, 2014
The demographic data indicates that there were specific characteristics to each sample. For instance, foster mothers on average were significantly older than mothers in the control group, \( t(44) = -5.84, p < .001 \). Table 2 also shows, that control families were more likely to have an academic background. We assume that these differences are characteristic for the two types of families assessed here. Data from foster children’s birth family were not available due to data protection.

**Table 2**  
*Parent’s Educational Level and Family Income in Foster and Control Group*

<table>
<thead>
<tr>
<th></th>
<th>Foster group</th>
<th>Control group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( n = 16 )</td>
<td>( n = 30 )</td>
</tr>
<tr>
<td><strong>(Foster) mother’s educational level</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>lower secondary education(^a)</td>
<td>3 (18.8%)</td>
<td>4 (13.3%)</td>
</tr>
<tr>
<td>intermediate school leaving certificate(^b)</td>
<td>8 (50%)</td>
<td>4 (13.3%)</td>
</tr>
<tr>
<td>university entrance qualification(^c)</td>
<td>3 (18.8%)</td>
<td>6 (20.0%)</td>
</tr>
<tr>
<td>university degree</td>
<td>2 (12.5%)</td>
<td>16 (53.3%)</td>
</tr>
<tr>
<td><strong>(Foster) father’s educational level</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>lower secondary education</td>
<td>1 (6.3%)</td>
<td>3 (10%)</td>
</tr>
<tr>
<td>intermediate school leaving certificate</td>
<td>7 (43.8%)</td>
<td>2 (6.7%)</td>
</tr>
<tr>
<td>general university entrance qualification</td>
<td>1 (6.3%)</td>
<td>4 (13.3%)</td>
</tr>
<tr>
<td>university degree</td>
<td>6 (37.5%)</td>
<td>21 (70.0%)</td>
</tr>
<tr>
<td>other</td>
<td>1 (6.3%)</td>
<td>--</td>
</tr>
<tr>
<td><strong>Monthly family income (Euro)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>up to 1500</td>
<td>--</td>
<td>3 (10%)</td>
</tr>
<tr>
<td>1500-2000</td>
<td>1 (6.3%)</td>
<td>2 (6.7%)</td>
</tr>
<tr>
<td>2000-2500</td>
<td>--</td>
<td>3 (10.0%)</td>
</tr>
<tr>
<td>2500-3000</td>
<td>3 (18.8%)</td>
<td>1 (3.3%)</td>
</tr>
<tr>
<td>3000-4000</td>
<td>5 (31.3%)</td>
<td>7 (23.3%)</td>
</tr>
<tr>
<td>4000-5000</td>
<td>5 (31.3%)</td>
<td>7 (23.3%)</td>
</tr>
<tr>
<td>n/s</td>
<td>2 (12.5%)</td>
<td>2 (6.7%)</td>
</tr>
</tbody>
</table>

Note. German equivalents: \(^a\) = Hauptschulabschluss; \(^b\) = Mittlere Reife; \(^c\) = Abitur
3.2.2 Design and overall procedure

Data collection took place at three assessment points, one at the laboratory, one at home, and one via telephone. Table 3 gives a short overview of the central measures of the study including instruments and modality of assessment.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Instruments</th>
<th>Modality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attachment security and dependency</td>
<td>Attachment Q-Sort (AQS)attachment</td>
<td>Home observation</td>
</tr>
<tr>
<td>Disinhibited social engagement with strangers (DSE)</td>
<td>Disturbances of Attachment Interview (DAI)</td>
<td>(Foster) mother’s report</td>
</tr>
<tr>
<td></td>
<td>Waiting room procedure</td>
<td>Laboratory observation</td>
</tr>
<tr>
<td>Attachment exploratory balance</td>
<td>Waiting room procedure</td>
<td>Laboratory observation</td>
</tr>
<tr>
<td>Dyadic interactional behavior</td>
<td>Free-play with mother vs. stranger</td>
<td>Laboratory observation</td>
</tr>
<tr>
<td>Neural correlates of facial familiarity processing</td>
<td>ERPs to (foster) mother and stranger faces</td>
<td>Neurophysiological assessment</td>
</tr>
</tbody>
</table>

Overview of assessment points

In all behavioral assessments, experimenters were female and unfamiliar to the child. For the laboratory assessment mother and child were invited to come to the university for a 2.5 hour visit that was conducted by myself and one research assistant. They were greeted upon arrival and led to a room, where they could settle before the assessment started. Meanwhile, one of the experimenters introduced (foster) mothers to the procedure and handed out instructions on what they are expected to do during observational sessions. Also, all (foster) mothers gave written informed consent. In the first behavioral session a waiting room situation was set up, whereupon the child was gradually approached by an unfamiliar adult, the other experimenter. This procedure has been used to identify children’s disinhibited social behavior (Lawler et al., 2014). Here, we were also interested in children’s attachment behaviors towards the (foster) mother and, additionally, specific behavior variables. In the second part of the behavioral sessions, children’s dyadic interactional behaviors were observed, first, when being left alone with the unfamiliar adult, and subsequently, with the (foster) mother, both of whom were instructed to engage the child in free play. While the child played with the stranger, we took pictures of the (foster) mother’s face. Then, (foster) mother and child were brought to another testing room. To collect neurophysiological data on children’s facial familiarity processing, they were semi-randomly presented with images of their (foster) mother’s and a stranger’s face using a passive viewing paradigm while recording EEG.
Two trained research assistants conducted the home assessment by visiting (foster) families and staying at their home for an approximate time of three hours. To observe the interplay of (foster) mother and child in different contexts, two interactions were induced. First, (foster) mother and child were asked to play with toys provided by the experimenters. Embedded in this interaction was a short separation-reunion procedure. In another sequence (foster) mother and child’s interaction was observed during problem solving tasks. Furthermore, the home assessment also included a developmental test, which, was not included in the current study. The whole session was semi-structured and videotaped for further behavioral analyses. Attachment security and dependency was immediately coded after the home visit using the German version 3.2 of the Attachment Q-Sort (Schölmerich & Leyendecker, 1999; Waters & Deane, 1985).

In addition a telephone appointment was arranged to interview (foster) mothers about the child’s behavior in attachment-relevant situations and towards strangers using the Disturbances of Attachment Interview (DAI, Smyke & Zeanah, 1999) within the next four weeks following the lab visit.

The home assessment was only administered to control children as for foster children recent data could be retrieved from the longitudinal study’s final home assessment. Thus, when talking about foster children’s attachment security and dependency it refers to AQS data from the longitudinal study. It has to be noted, that the time interval between the home assessment and the laboratory visit differed between both the foster and the control groups. While in control children the home assessment was conducted one month after the laboratory visit ($M = 1.59, SD = .84$), in foster children according data was derived, when foster children’s average duration in the foster home was 13 months ($M = 12.62, SD = .91$) leading to a time interval of 8 months ($M = 8.15, SD = 4.24$) between both assessment points. This time was not regarded as a methodological issue as, in general, attachment security has shown to be stable during childhood in normative samples (Main et al., 1985; Wartner, Grossmann, Fremmer-Bombik, & Suess, 1994). In the current sample, the longitudinal data indicated that foster children’s attachment security increased during the first six months in the foster home and changed only marginally during the following 6 months (Lang, 2014). Thus, data retrieved from the earlier home assessment in foster children was not considered to be affected by significant changes over the intermediating time interval. To compare foster children’s initial attachment security and dependency scores to those of the control group we additionally derived data from the first wave of the longitudinal study. At this point duration in the foster home was 2 months on average ($M = 2.31, SD = 2.18$).
Children’s age was matched with regard to the time of the laboratory assessment to control for age effects in the neurophysiological data. As a consequence, at the home assessment, foster children were younger than control children. However, all behavioral variables were tested for the influence of age in preliminary analyses, and, when indicated, this influence was controlled for in the main analysis. Table 4 shows children’s age at different assessment points.

Table 4
Foster and Control Children’s Age at all Assessment Points in Months. Means, Standard Deviations, and T-Test Results

<table>
<thead>
<tr>
<th>Age variables</th>
<th>Foster children</th>
<th>Control children</th>
<th>t(df)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n = 16</td>
<td>n = 30</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>M(SD)</td>
<td>M(SD)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age at home assessment I</td>
<td>35.85 (13.68)</td>
<td>N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age at home assessment II</td>
<td>46.21 (13.97)</td>
<td>57.30 (10.10)</td>
<td>3.10 (44)</td>
<td>.003</td>
</tr>
<tr>
<td>Age at laboratory assessment</td>
<td>54.36 (11.66)</td>
<td>55.31 (10.07)</td>
<td>.29 (44)</td>
<td>ns</td>
</tr>
</tbody>
</table>

Note. In foster children home assessment I and II refer to assessments conducted at the first and final wave of the longitudinal study respectively, control children were only assessed during one home assessment.

3.3 Analysis of Behavioral and Neurophysiological Data

The behavioral and the neurophysiological part of the current research will be targeted in two consecutive chapters. Chapter 4 will focus on behavior. Here, we compared both groups of children regarding attachment security, dependency and reported signs of DSE. Moreover, we investigated (foster) children’s actual behavior in social interactions in presence of (foster) mother and a stranger with regard to attachment behavior, exploratory behavior, and DSE behaviors towards the unfamiliar adult. Chapter 5 will focus on neural responses to familiar and unfamiliar adults in foster children as compared to control children. Furthermore, we investigated relations between attachment security and facial familiarity processing in general and with regard to group status. Finally, we examined associations between children’s behavioral and neurophysiological responses to (foster) mother and stranger. In both of the following chapters, research questions will be specified following a comprehensive theoretical introduction, and any method that was applied to answer these question will be described in detail. Finally, Chapter 6 will conclude by integrating major findings from the overall study.
Chapter 4: Attachment and Social Interaction in Foster Children and a Control Group

Children placed in foster care are likely to have experienced maltreatment and neglect early in life (e.g., Minnis, Everett, Pelosi, Dunn, & Knapp, 2006) and thus are especially vulnerable to later social and emotional maladjustment (Éthier et al., 2004; Hildyard & Wolfe, 2002; Tyler, 2002; Youngblade & Belsky, 1990). Indeed, mental health problems are already highly evident in children when placed in foster care (Clausen et al., 1998). The intervention, however, can serve a protective function as the development of new secure attachment relationships may have the capacity to buffer effects from previous experiences (e.g., Sroufe, Egeland, Carlson, & Collins, 2005), even though, there is a risk that negative relational experiences may hinder the development of new secure attachment relationships (Dozier et al., 2001; Dozier, 2003).

In the current Chapter, I will focus on the effect of early adverse caregiving experiences on socio-emotional outcomes in foster children by applying a behavioral system approach (Greenberg & Marvin, 1982; Marvin & Britner, 2008). According to attachment theory, the first year of life provides a critical period in the development, not only of the balance of attachment and exploratory behaviors, but also closely related constructs —like wariness and sociability towards unfamiliar adults— leading to a more or less predictable interrelatedness of these behaviors. Whereas a continuous relationship with a caregiver facilitates a balanced organization of related behavioral system, a lack of such experiences may lead to persistent disturbances (O’Connor et al., 2003). In the following I will show how different behavioral systems may be affected by maltreatment and neglect by, first, explaining their normative development and, second, by listing evidence of its alterations in children with a background of pathogenic care.
4.1 Theory

4.1.1 The behavioral system approach to attachment

Implying an ethological viewpoint, Bowlby (1969, 1982) theorized that humans (like other species) are provided with different inherent behavioral systems that are evolutionary anchored. More precisely, he argued that associated behaviors that are elicited by the activation of any of these systems lead to a specific predictable outcome which serves the biological function of the offspring’s survival.

The human infant is born quite immature, and, relative to other species, lags behind in a number of developmental domains for a prolonged period of development, which, indeed, is evolutionary functional (Bjorklund, 1997; Thompson-Schill, Ramscar, & Chrysikou, 2009). Despite its benefits, from an evolutionary perspective, this incompleteness had not prevailed itself if there was no compensating caregiving behavior on the mother’s side (Trevathan, 2011). Inarguably, for an extended period the child highly depends on the close presence of an “individual who is conceived as better able to cope with the world.” (Bowlby, 1988, p.27). Therefore, according to Bowlby, infants are equipped with a repertoire of so called attachment behaviors that are rudimentary present from birth and, finally, become more organized over childhood (Bretherton, 1992). These interchangeable behaviors that are governed by an inherent attachment behavior system can be categorized into two distinctive sets: On the one hand, approach behaviors (e.g., crawling to the caregiver or reaching out for her) bring the child closer to the caregiver, while, on the other hand, signaling behaviors (e.g., crying) have the function to bring the caregiver to the child by in turn activating the complimentary caregiver behavior system on his/her side. Furthermore, the child may cling to the caregiver in order to remain contact with the mother. Similarly, behaviors governed by the wary behavior system, which gets activated by novel situations and persons, also have the effect of maintaining proximity to the caregiver and, thus, all together these three systems primarily serve the biological function of protection (Marvin & Britner, 2008, p.272).

However, successful development of an organism also implies the acquisition of skills that are necessary to act self-reliantly and secure one’s own survival by adapting to the individual physical and social world (Grossmann & Grossmann, 2004; Marvin & Britner, 2008). Humans prolonged infancy facilitates this adaption process, but would fail its purpose if the child’s need for proximity wouldn’t be complemented by a need to actively venture forth and learn about his/her environment (Ainsworth & Bell, 1970; Hamburg, 1968). The behavior systems that promote such behavior are the exploratory behavior system and, as Ainsworth (1990) and Marvin (1977) suggested, the sociable behavior system, that is directed to interact with peers or adults to facilitate the infants’ “integration into the social group” (Marvin & Britner, 2008, p.272). In this view, attachment to a stronger person
provides a protective framework that optimally allows as much independence as possible to ensure the infant’s autonomous skill-development, but, simultaneously limits his/her actions and excursion into the world with regard to his/her own competencies.

Regarding the interplay of behavioral systems Ainsworth and Bell (1970) stated that, humans “genetic biases provide for a balance in infant behaviors (and in reciprocal maternal behaviors) between those which lead the infant away from the mother and promote exploration and acquisition of knowledge of the properties of the physical and social environment, and those which draw mother and infant together and promote the protection and nurturance that the mother can provide.” (p.51). The basic principle of this “equilibration process”, as Marvin and Bittner (2008, p.272) call it, is, that activation of one system concurrently leads to the termination of an antithetical system. To explain this linkage I will now discuss the concept of the attachment-exploration balance by introducing two key principles of attachment theory, namely secure base and safe haven (Ainsworth & Bell, 1970; Ainsworth, 1967; Bowlby, 1988).

Without controversy it is biological functional that infants show attachment behaviors like back-checking with the caregiver before walking off in an unfamiliar environment or engage with unfamiliar strangers. The caregiver’s function here is to serve as a secure base that makes the infant feel safe, knowing that he/she is cared for and that there is a stronger individual that optimally will promptly respond to his/her needs when necessary. Consequently, the infant’s attachment behavior system gets deactivated, which allows for exploratory behaviors to arise. As soon as the infant becomes irritated the caregiver optimally serves as a safe haven to which he/she can return to be comforted and reestablish a feeling of safety.

The dynamic balance among these distinct behavioral systems that humans seek to maintain is complex (Bretherton, 1992), especially when taking into account not only the attachment and the exploratory behavior system, but also the wary and sociable system, all of which are relevant in social interactions with strangers (Bretherton & Ainsworth, 1974, cited in Greenberg & Marvin, 1982). For example, meeting an unfamiliar person might instantly terminate the exploratory behavior system and activate the wary and the attachment behavior system leading the infant back to his/her safe haven. On the other hand, especially in older children, the sociable system might simultaneously be activated by the unfamiliar person, which may elicit social approach behavior (Greenberg & Marvin, 1982).

As will be outlined in section 4.1.2 the dynamic interplay of these behavioral systems changes with development in a typical manner, however, in dissimilar caregiving environments different patterns of “equilibrated organization” (Marvin & Britner, 2008, p.273) may arise, which is perfectly logical when considering the adaptive function of behavioral systems (also see Chapter 1).
4.1.2 The normative ontogeny of behavioral systems in the first years of life

The formation of the attachment-relationship

In the following, Bowlby’s concept of major milestones in the normative development of infant–caregiver attachment is outlined (Bowlby, 1982, also see Marvin & Britner, 2008, p.275ff). It can be divided into four phases with the first three phases occurring in the first year of life. Indeed, during this time window, rapid developmental changes including the achievement of major cognitive and motor skills, that drive the formation of the infant–caregiver attachment relationship, take place. This emphasizes the importance of very early caregiving experiences.

Phase I: Orientation and signals with limited discrimination of figure. This phase stretches over the first quarter of life and can also be described as a phase of indiscriminate responsiveness. It means that the infant’s behaviors are directed to attract any adult’s attention and, by doing so, increase the likelihood of prompt responding to its basic needs like warmth, nutrition and proximity. Soon after birth, infants pick up social stimuli and show heightened responsivity especially to human faces (e.g., Mondloch et al., 1999; Wolff, 1969). Also, they appear to selectively attend to human speech over many other naturally occurring stimuli (see Shultz & Vouloumanos, 2010). Thus, human contact in general seems to soothe the infant that ceases to cry in response to seeing a face or hearing a voice (Bowlby, 1982). However, even though a preference for their own mother’s voice can already be seen in fetuses (Kisilevsky et al., 2003), the young infant’s ability to discriminate one person from the other is very limited. Regarding attachment behaviors (e.g., crying), the first indicators are rudimentary, unidirectional, and, not yet goal-directed with continuous alternations between activation and termination of these behaviors. In the course of the first weeks, the infant becomes capable of linking stimulus and response, and outcomes of his/her behaviors become more predictable. Furthermore, what develops during Phase I is a more pronounced way to engage with the caregiver and influence his/her behavior by, for example, reaching out for him/her (Bowlby, 1969). Additionally, smiling and babbling occurs and enriches the interaction between caregiver and child, bringing joy and a feeling of interpersonal relatedness to both sides.

Phase II: Orientation and Signals directed towards one (or more) discriminated figure. While the first phase marks the onset of the infant’s capability to discriminate between persons regarding familiarity, it is only after 12 weeks that this comprises both the auditory and the visual system (Bowlby, 1969). Furthermore, as interactions with primary caregivers repeat, cues for activation and termination within behavioral sequences become more and more specific and increasingly restricted to a particular interaction partner. This, in turn, optimally drives the infant to direct his/her attachment behaviors towards the caregiver and behaviorally discriminate between him/her and
others. So, in Phase II the infant becomes a sense of knowing who his/her primary caregiver is. Interestingly, in 6-month olds, behavioral changes within the mother–child relationship appear to relate to infants’ neural processing of mother and stranger faces (Swingler, Sweet, & Carver, 2007b; Swingler et al., 2010a), suggesting that both domains of infants’ discrimination between persons interact. Furthermore, with increasing behavioral control, the infant develops a more active role in the caregiver–child dyad as he/she begins to deliberately initiate and maintain interaction with the caregiver. The onset of such reciprocal interactions also means an integration of simple into more complex chain-linked behavior systems within the infant (Marvin & Britner, 2008). Thus, it is not surprising that the first 6 months of life are crucial to the shaping of the infant’s internal working model of attachment, and that differential attachment strategies may already be identified at this early age (Ainsworth, Blehar, Waters, & Wall, 1978).

Phase III: Maintenance of proximity to a discriminated figure by locomotion and signals. This phase begins around the third quarter of the first year of life and continuous throughout the second year. It marks the time window in which the consolidation of attachment between infant and caregiver is thought to take place. Not only does the infant’s behavior become even more person-specific, but, due to some major advances in motor, cognitive, and communicative development, a whole set of new attachment behaviors (e.g., following the caregiver, greeting and running towards him/her) arises (Bowlby, 1969). Moreover, with the ability to walk off the infant’s world gets extended dramatically and numerous objects attract his/her attention. However, this newly achieved wider scope of action can be frightening to the infant as well and thus, due to this ambivalence, in Phase III the use of the caregiver as a secure base and safe haven emerges. Another major change concerns the infant’s increasing wariness towards unfamiliar strangers (e.g., Gaensbauer, Emde, & Campos, 1976; Waters, Deane, Matas, & Sroufe, 1975), which ensures that he/she stays close to the caregiver. This mechanism protects him/her from harm and, in turn, strengthens the tie between infant and caregiver. Driven by major cognitive achievements (e.g., object permanence, Piaget, 1964) the infant now optimally develops an internal image of the caregiver as a source of comfort and protection even if he/she is currently not present (Marvin & Britner, 2008).

Even though Bowlby (1969) viewed Phase III as a sensitive period for the consolidation of infant–caregiver attachment, evidence from studies of adopted or foster children suggests that infants can form attachments to new caregivers even beyond 1 year of age (e.g., Gabler et al., 2014). The formation of such relationships, however, may be hindered by the child’s prior experiences (see Dozier & Rutter, 2008).
Phase IV: Formation of a goal-corrected partnership While during former phases the infant begins to conceive the caregiver as an independent object, he/she still has no understanding of what drives the caregiver’s actions. Even though during phase I to III he/she is able to try and manipulate the caregiver’s behavior (e.g., making him/her stop current activities to pick him/her up), the infant is not yet capable of knowing why the caregiver will not meet all of his/her wishes right away (Grossmann & Grossmann, 2004). Phase IV commences with the infant’s increasing understanding of the caregiver’s own feelings and motives (Bowlby, 1969). Around the middle of the third year the infant (or the child) starts to coordinate psychological perspectives of the self and the other person (Selman, 1980), and gains the ability to impute beliefs to others, manifested in a theory of mind (Baron-Cohen, Leslie, & Frith, 1985; cited in Grossmann & Grossmann, 2004). So what emerges in phase IV is the beginning of a much more “complex relationship” between caregiver and child, one that Bowlby terms a “partnership” (Bowlby, 1982, p. 267).

Distinguishing attachment and dependency

Attachment behaviors and dependency behaviors (e.g., clinging to the caregiver) essentially overlap, however, while dependency “entirely is a behavioral concept” (Ainsworth, 1969, p.40), attachment itself functions in substantially different ways (Ainsworth, 1969, 1972).

In general, with the infant’s ability to move away from the caregiver, attachment behaviors tie the infant to the caregiver ensuring the infant’s safety. However, applying an organizational perspective (Sroufe & Waters, 1977), it can be assumed —and evidence confirms— that children’s need for physical proximity decreases with age and overt attachment behaviors become less frequent (e.g., Marvin & Greenberg, 1982). In particular, internal representations of —optimally— a secure attachment relationship provide the basis for developmental tasks like the endurance of prolonged separations from the caregiver, and thus facilitate autonomous functioning (also see Wong et al., 2011, p.490).

As a consequence, attachment and dependency clearly need to be distinguished from one another. Historically, the concept of dependency was first and described the child’s need to be cared for in terms of a basic drive. Later, both terms were understood as interchangeable as they include the same classes of behavior, like, for example, crying or proximity seeking (Maccoby & Masters, 1970). In the following years, however, it became widely understood, that Bowlby’s concept of attachment was substantially distinctive from dependency (Bowlby, 1969, p.228f). Listing a series of major differences, Sroufe, Fox, and Pancake (1983) first state that the infant is dependent on the caregiver before becoming attached to him/her and that later, he/she can be attached to a caregiver even though not depending on his/her presence in a given situation. Second, attachment not solely refers to the use
of attachment behaviors, but their flexible organization in service of an affective bond between caregiver and child, hence being a more abstract construct (Sroufe et al., 1983; Sroufe & Waters, 1977). As for the concept of dependency, it is possible that children lag to develop autonomy and thus show an excessive and age-inappropriate need for contact and attention. However, maladaptation in terms of attachment quality cannot be viewed as failing to become less attached with increasing age, especially as attachment relationships are understood as an essential part of social functioning during the whole life span (Sroufe et al., 1983, p.1616). After having detangled both these concepts it is important to note that they are still related. For example, it is suggested that those children who were able to effectively depend on their caregiver and develop a secure attachment relationship with him/her early in life, act more self-confident and autonomously in later stages of development (e.g., Sroufe et al., 1983). However, research examining this relation is highly limited.

Social behavior towards strangers in early childhood

As Greenberg and Marvin (1982) concluded, infants’ reactions to strangers are complex and cannot easily be described as either fearful, wary or sociable. This complexity becomes more evident when regarding different forms of behavioral systems towards strangers (i.e., the sociability system and the wary system) as further “organizational construct[s]” (Sroufe, 1977, p. 732) that interact with each other as well as with the attachment system and the exploratory system (Bretherton & Ainsworth, 1974, cited in Greenberg & Marvin, 1982). As described above, infants start to show wariness towards strangers at around 6 months of life (Waters et al., 1975), which increases during the second half year (Gaensbauer et al., 1976), while some have also found earlier peaks (Brooker et al., 2013). Either way, stranger wariness appears to rise at the time when infants become more mobile, thus, it is believed to counterbalance the infant’s need for exploration (Bronson, 1972).

Greenberg and Marvin (1982) were the first to describe preschool-aged children’s reactions to a friendly stranger in terms of qualitative patterns that result from the interplay between the different behavioral systems. To shed light on individual and age-related differences in these behavioral patterns they observed children aged 2 to 4 years meeting a stranger during a standardized sequence of 8 episodes mainly following the Ainsworth Strange Situation protocol (Ainsworth & Wittig, 1969). They found that in most children the initial confrontation with the stranger deactivated the exploratory system for only a short time where children sought proximity. However, some simultaneously showed wariness or sociable behavior towards the stranger. Also, as the stranger approached, most children showed sociable or wary behavior, whereas the latter soon were able to engage in exploratory or sociable behavior. Furthermore, compared to 1-year olds (Ainsworth et al., 1978), most pre-school children’s behavioral organization was unaffected by mother’s departure.
Regarding age differences, Greenberg and Marvin (1982) found a developmental shift occurring at 3 years of age. Thus, when being confronted with a stranger, the inhibition of the exploratory system in older children is present only for a short amount of time in which the child appraises the stranger. In younger children, however, both the attachment and the wary system tend to be activated simultaneously and inhibit the exploratory and sociable system for a substantial amount of time (also see Bretherton & Ainsworth, 1974, cited in Greenberg & Marvin, 1982). Interestingly, older children were less likely to, for example, seek proximity to the mother (activation of attachment system), but still displayed signs of wariness towards the stranger (activation of wariness system). In a number of children, the latter co-occurs with an activation of the sociable system, showing that these two systems are not mutually exclusive at this age. These findings relate to what Greenberg and Marvin (1982) call a “developmental coupling of … systems” (p.489), that decreases between the wary and the attachment system and increases between the wary and sociable system. The authors suggest this to be as an indicator of children’s increasing self-regulatory abilities. In this view, children progressively tend to be less dependent on physical contact, but may still be cautious when confronted with a stranger. With age, however, children may become capable of simultaneously activating the sociable system, serving the biological function of both primary protection and the adaptive integration into the social group.

Assessment of attachment and dependency as quantitative constructs

Referring to Waters and Deane (1985) since the early 70s it has been widely recognized that —at least in infancy and early childhood— the secure base phenomenon reveals itself in overt behavior towards the caregiver, thus, observational methods are central to attachment research. The most popular technique to assess individual differences in attachment security is the Strange Situation Procedure (Ainsworth & Wittig, 1969). Even though it is not a natural setting there is strong empirical evidence for its external validity (Van IJzendoorn & Kroonenberg, 1988). Also, as compared to classic observational methods (e.g., time sampling, frequency counts) it is well informed by theory and the data collected is much more manageable. However, the resulting taxonomic classifications limit the options for statistical analyses. They are also compromised as the distribution of classification across secure, insecure-avoidant and insecure-ambivalent is highly unbalanced (see Ainsworth et al., 1978; Van IJzendoorn & Kroonenberg, 1988). Moreover, it has been discussed whether attachment patterns may actually be distributed dimensionally rather than categorically (Fraley & Spieker, 2003). Furthermore, the Strange Situation Procedure is sensitive to repeated assessments and is only applicable within the narrow age range between 12-18 months which are both unqualified aspects when it comes to investigating, for example, the development of new
attachment relationships beyond infancy (for an evaluation of methods also see Waters & Deane, 1985, p.48-51).

Waters and Deane (1985) presented an alternative approach to assess the quality of the attachment relationship between child and caregiver by covering the entire domain of behaviors (secure base and exploratory behavior, affective response, social referencing, etc.) that are relevant to it. Informed by previous literature on attachment they initially listed relevant constructs and specified particular behaviors that were thought to best represent them. Notably, using the AQS behavior is not assessed by counting its frequency, but by considering its potential significance within a given attachment relationship. The AQS observational procedure takes place in a naturalistic setting, the child’s home, and assesses behavior as it occurs over the course of 2 to 3 hours, which both contributes to a more reality-informed assessment that is able to capture a broader range of attachment-relevant behaviors. Most commonly, the resulting Q sorts are scored in terms of broadly defined constructs. Among others, criterion sorts for security and dependency are available to correlate a child’s profile with and obtain a continuous variable. Thus, the AQS provides data for investigating the attachment relationship beyond attachment security. Further advantages of the method are that response-biases are limited and observers do not need to have in-depth knowledge of underlying constructs, which makes data economical to obtain (Waters & Deane, 1985). The AQS has successfully been used in studying children up to almost 6 years of age (Clark & Symons, 2000) and is considered a valid measure of attachment (Van Ijzendoorn, Vereijken, Bakermans-Kranenburg, & Riksen-Walraven, 2004).
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4.1.3 Attachment security and stranger sociability in foster children

As suggested by O’Connor et al. (2003) a lack of a warm and predictable relationship “may have impaired the child’s ability to develop (interaction-based) strategies for regulating his/her arousal level and for the activation and termination of attachment, exploratory, wary and sociable behavior” (p.34). The following section provides findings on how attachment related systems are affected by early adverse caregiving experiences.

Attachment in foster children.

Meta-analytic data suggests that in normative samples the distribution of attachment classifications is 62% secure, 15% avoidant, 9% ambivalent and 15% insecure-disorganized (van Ijzendoorn, Schuengel, & Bakermans-Kranenburg, 1999, N=2104). Research examining attachment in children in out of home placements mostly stems from studies with institutionalized children (e.g., Dobrova-Krol, Bakermans-Kranenburg, Van IJzendoorn, & Juffer, 2010; Vorria et al., 2003; Zeanah, Smyke, Koga, & Carlson, 2005) or previously institutionalized adopted children (e.g., Juffer, Bakermans-Kranenburg, & IJzendoorn, 2005; O’Connor et al., 2003; Veríssimo & Salvaterra, 2006; Vorria et al., 2006, also see van den Dries, Juffer, Van IJzendoorn, & Bakermans-Kranenburg, 2009). The latter group shares the most similarities with children placed in foster care. However, research particularly focusing on attachment in foster children is scarce and findings appear to be mixed.

Including meta-analytic data from 39 adoption and 11 foster studies, van den Dries et al. (2009) found that compared to normative samples adopted children were less likely to form secure attachments (47%), but were more likely to be classified as disorganized (31%). Age at placement was a significant moderator for attachment security (i.e., early placed children equal non-adopted children), but not for attachment disorganization, suggesting that despite an early intervention, highly severe negative experiences within the infant–caregiver relationships have long-term effects on socio-emotional development. Still, compared with children in institutional care, where only 11% showed secure attachments and 73% were classified as disorganized, this suggests an enormous catch-up facilitated by adoption (Vorria 2003, Zeanah, 2005).

Closely following ten children during the transition to the foster home, Stovall and Dozier (2000) identified foster children to display attachment behaviors to their new caregivers within a few weeks after placement. Regarding the quality of attachment some studies only found 30 to 40% of foster children to display secure attachment behaviors.

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11 Adoption and foster care placement both imply experiences of major disruptions in child–caregiver relationships as well as the development of a new attachments enabled by intervention (van den Dries et al., 2009). Also, both groups are likely to share a history of psychosocial neglect and maltreatment, which affects foster children (e.g. Chernoff, Combs-Orme, Risley-Curtiss, & Heisler, 1994) and children in institutions (e.g., McGuinness & Pallansch, 2000; Tirella et al., 2008). However, adoption studies mostly refer to international adoption implying different reasons for placement (van den Dries et al., 2009) as well as several cultural concerns.
children to be securely attached (Lamb, Gaensbauer, Malkin, & Schultz, 1985; Swanson, Beckwith, & Howard, 2000). However, longitudinal data suggests a significant catch-up during the first year in the foster home (e.g., Gabler et al., 2014; Lang, 2014). Also, several other studies found foster children to be capable of forming secure attachments to their foster parents (Cole, 2005; Dozier et al., 2001; Jacobsen, Ivarsson, Wentzel-Larsen, Smith, & Moe, 2014; Oosterman & Schuengel, 2008; Ponciano, 2010; Stovall-McClough & Dozier, 2004). Here, meta-analytic results revealed that they are as likely to be securely attached as children raised in their birth families, but, like adoptees, show more disorganized attachment patterns (van den Dries et al., 2009). Yet, the majority of studies did not examine children before 8 months after placement (but see Bernier, Ackerman, & Stovall-McClough, 2004; Gabler et al., 2014; Lang, 2014; Stovall & Dozier, 2000; Stovall-McClough & Dozier, 2004).

In sum, a series of studies suggests that foster children are able to form secure attachment relationships towards their new caregivers, but less is known about the nature of this relationship. As claimed by Lyons-Ruth (2005) we do not know if this late established bond serves developmental functions comparable to attachment relationship that originated from early interactions with one primary caregiver. The current research responds to this claim by applying a behavioral system approach that is likely to reveal a multi-faceted picture of the newly formed attachment relationship.

**Sociability towards strangers in foster children.**

As outlined above children usually become wary of unfamiliar adults during the second half of the first year of life. Even though they show increased interest in strangers by three years of age (Greenberg & Marvin, 1982), children stand out when they are overly friendly with an unfamiliar adult or even disregard social norms like personal by, for example, verbally or physically initiating close contact with that person. Moreover, a typically developing child is expected to check back with the mother before approaching a stranger and to be reluctant to walk off with him/her.

A phenomenon commonly associated with early adverse rearing environments is a lack in such an age-appropriate reticence around strangers referred to as disinhibited social engagement (DSE, see Lawler et al., 2014). Interestingly, these behaviors can be identified in children regardless of their ability to form an attachment relationship with a preferred caregiver, still co-occurrence with insecure attachments seems to be more likely (O’Connor, Marvin, Rutter, Olrick, & Britner, 2003, but see Chisholm, Carter, Ames, & Morison, 1995; Bakermans-Kranenburg et al., 2011, p.76). Moreover, it is suggested that even though attachment relationships improve within a more adequate environment like foster care intervention, these peculiar behaviors towards strangers tend to be
persistent (Chisholm, 1998; O’Connor et al., 2003; Rutter, Colvert, et al., 2007; Smyke et al., 2002; Zimmermann, 2015).

Originally, substantial proportions of DSE have been reported in institutionalized children (e.g., Dobrova-Krol, Bakermans-Kranenburg, Van IJzendoorn, & Juffer, 2010; Smyke, Dumitrescu, & Zeanah, 2002; Tizard & Rees, 1975; Zeanah, Smyke, & Dumitrescu, 2002) and in children adopted from institutions (e.g., Bruce, Tarullo, & Gunnar, 2009; Chisholm, Carter, Ames, & Morison, 1995; O’Connor & Rutter, 2000, for an overview see Bakermans-Kranenburg et al., 2011). Only during the last decade research has begun to investigate DSE in foster children without a history of institutionalization as well. Using parent reports, several studies found foster children to exhibit substantial levels of such problematic behaviors as well (Jonkman et al., 2014; Oosterman & Schuengel, 2008; Van Den Dries, Juffer, Van IJzendoorn, Bakermans-Kranenburg, & Alink, 2012; Zeanah et al., 2004) and, furthermore, to significantly differ from comparison children in this domain (Pears, Bruce, et al., 2010). These findings suggest that DSE is not necessarily restricted to children exposed to severe social deprivation in institutional settings; and that disruptions of attachment, that apply to both institutionalized as well as foster children, may play an important role (Pears et al., 2010).

This generalizability of DSE to the experience of social deprivation and/or multiple placements supports the assumption that it is an adaptive response to lacking a reliant continuous relationship with a primary caregiver, as it attracts the attention of other potential caregiver (Chisholm, 1998). In this view, disruption in the early formation of attachment relationships may alter the dynamics in the attachment and sociability system for the sake of serving the biological function of protection. Others also suggested general deficits in executive functioning (i.e., inhibiting responses to environmental cues) to be responsible for DSE in previous institutionalized (Bruce et al., 2009; Colvert et al., 2008) and foster children (Pears, Fisher, Bruce, Kim, & Yoerger, 2010). To date, there is no final conclusion that can explain the etiology of disinhibited social behavior (for a comprehensive overview of different approaches see Lawler et al., 2014), yet, neurophysiological studies suggest atypical brain activity to be associated with this behavioral pattern (Mesquita et al., 2015; Tarullo et al., 2011). To the best of our knowledge, however, there has been no study to investigate both the occurrence of disinhibited social behaviors and its possible neural correlates in a high-risk sample as compared to a control sample.

Note that these specific relational experiences may apply to both foster children as well as institutionalized children and that their relation to DSE is not yet detangled.
Assessment of disinhibited social engagement towards strangers

A major concern in investigating DSE in general are measurement issues (also see Bakermans-Kranenburg et al., 2011; Lawler et al., 2014 for an overview of methods). In order to assess DSE the majority of studies relied upon caregiver reports of children’s social behavior towards unfamiliar adults (e.g., the Disturbances of Attachment Interview, DAI, Smyke & Zeanah, 1999). Such interviews have been administered to caregivers in institutions (Dobrova-Krol et al., 2010; Smyke et al., 2002; Zeanah et al., 2002, 2005) as well as adoptive or foster parents (Bruce et al., 2009; Chisholm et al., 1995; Chisholm, 1998; Jonkman et al., 2014; O’Connor et al., 2003; Oosterman & Schuengel, 2008; Pears et al., 2010; Rutter et al., 2007; Van Den Dries et al., 2012; Zeanah et al., 2004). Even though interviews vary upon the number of items included, they are thought to assess very similar behavioral patterns (Zeanah et al., 2002). However, the major concern about these measures refers to their validity, as they are likely to be sensitive to reporter bias. Furthermore, they require the caregiver to hold substantial knowledge about the child’s behavior in different situations (Lawler et al., 2014).

As an alternative, there are observational measures that certainly provide the more objective assessment of DSE. Some depend on single item ratings of the child’s willingness to walk off with a stranger that rings at the door (Stranger at the Door Procedure, Gleason et al., 2011), however, referring to data stemming from the current sample the method has not shown to distinguish foster children from a comparison group. More detailed, yet standardized, behavioral assessments in the laboratory may be necessary to assess more complex behavioral patterns associated with DSE, however, at the cost of being time consuming and finally more expensive (Lawler et al., 2014). For example, there are standardized measurements (e.g., Rating of Infants’ Stranger Engagement, RISE, Riley, Atlas-Corbett, & Lyons-Ruth, 2005) that provide a coding system of children’s approach behavior towards the unfamiliar adult within the Ainsworth Strange Situation Procedure (Ainsworth & Wittig, 1969). While the RISE has successfully been used in young children from high-risk families (Lyons-Ruth, Bureau, Riley, & Atlas-Corbett, 2009) and toddlers residing in institutions (Oliveira et al., 2012), there are only few studies that have coded DSE in contexts other than the Strange Situation.

13 This finding relates to unpublished data collected in the course of the current study
One of the few exceptions has been made by Bruce et al. (2009), who have assessed DSE in 120 children aged 6 to 7 years, including children adopted from institutions and foster care as well as a control sample. Here, in a standardized interaction, an unfamiliar adult gradually approached the child with the adoptive mother remaining passive. Subsequently verbal initiations were coded as an indicator for DSE, which was moderately associated with parent report of children’s social engagement with strangers.

As pointed out above, the etiology of DSE is unclear and it is important to compare children from various backgrounds like high risk-families, foster care and institutions to advance our knowledge of which factors determine this peculiar pattern of behavior. However, Lawler et al. (2014) emphasized that it is also crucial to keep in mind what exactly we are measuring in these different groups. While Bruce et al. (2009), using a composite measure of parent report and verbal initiations during stranger approach, found both children adopted from institutions as well as those adopted out of foster care to elevate higher levels of DSE than control children, Lawler et al. (2014) identified behaviors discriminating between all three groups during a similar stranger interaction. In particular, they compared children, adopted from institutions, children adopted from foster care and a control sample on several social behaviors including verbal initiations, but additionally, measures of proximity and physical contact to the unfamiliar adult. Applying principal component analyses they identified two factors likely to represent a general sociability and a physical engagement dimension. Interestingly, within the behavioral spectrum of typical nonphysical sociability there was a wide variety and no group differences were found. In contrast, previously institutionalized children exhibited more atypical physical engagement than never adopted children with children adopted from foster care falling in between the two groups.

On the whole, these studies suggest that when experiencing insufficient care and disruptions in the attachment relationship children are likely to develop some form of DSE towards strangers, which may be considered an attempt to counterbalance the irregularities in the formation of selective attachment relationships. However, no definitive conclusions can be drawn about the etiology of DSE. Despite some commonalities (e.g., disruptions of attachment-relationships, neglect), foster children and institutionalized or previously institutionalized children highly differ in terms of their particular caregiving experiences, thus, further investigations of DSE in foster children can shed light on the role of type of pathogenic care on the development of DSE. Importantly, as there is no gold-standard to assess DSE, it is particularly necessary to distinguish methods that primarily tap typical behaviors from those that tap atypical behaviors (Lawler et al., 2014). Only then it is feasible to compare DSE among different groups, hence detangle its precursors.
4.1 Theory

4.1.4 Preceding findings from the longitudinal study

Regarding attachment to foster parents meta-analytic data suggests a positive development (van den Dries et al., 2009), however, studies are rather scarce and only a few have focused on the transitioning into foster care (for exceptions see Bernier et al., 2004; Stovall & Dozier, 2000; Stovall-McClough & Dozier, 2004). Previous research of our research group suggests that at the time of placement – when compared to meta-analytic data of normative samples – foster children are significantly less securely attached than their counterparts (e.g., Gabler et al., 2014). However, foster children’s attachment security significantly increased during the first 6 months within the foster home with foster parent’s sensitivity and an authoritative parenting style decisively contributing to this positive development (Gabler et al., 2014; Lang, 2014). Regarding foster children’s DSE, results varied depending on the type of assessment. Foster parents reported a significant decrease in disinhibited symptoms that took place during the first 6 months after placement and then remained stable (Zimmermann, 2015). However, comparing interview data to normative data stemming from toddlers residing in Romania (Smyke et al., 2002) suggested that foster children showed higher levels of DSE than the normative sample throughout the first year in the foster home. No significant changes occurred with regard to other behavioral measures that are thought to mainly capture symptoms of disinhibited attachment disorders (Zimmermann, 2015).

4.1.5 Aims of the current study

Only recently, Lyons-Ruth, (2015) claimed that despite the recent development that emphasizes the distinction of DSE and attachment (Zeanah & Gleason, 2015a), attachment theory may still provide a strong framework to understand socio-emotional adjustment in affected children. Thus, even though children appear to be able to form secure attachments to their, for example, foster parents (e.g., Gabler et al., 2014; Stovall-McClough & Dozier, 2004), Lyons-Ruth questioned, if “caregiving relationships formed after the first 2 years of life serve the same developmental functions in organizing the child’s emotional, behavioral, and physiological systems in relation to a few selective and deeply invested relationships” (Lyons-Ruth, 2015, p.226). Furthermore, she mentioned that in the Strange Situation Procedure children’s behavior towards the stranger does not contribute to the classification of attachment security, and that “we have no validating evidence base regarding the meaning of secure-appearing behaviors when they appear outside the context of the primary attachment relationships formed in infancy” (Lyons-Ruth, 2015, p.226).
The current study now aimed to contribute to our knowledge about the nature of attachment security in the newly established attachment relationship between foster mother and foster child by investigating foster children’s attachment security, their dependency within the new relationship, and their DSE behaviors toward strangers 1 year after placement. Its major contribution to the existing literature is that it also includes the assessment of different attachment-related behaviors towards (foster) mother and stranger, first, when both of them are present and, second, in separate dyadic interactions. By examining “how and when the child seeks comfort” (Zeanah & Gleason, 2015b, p.227) we expected to gain a greater picture of the phenomena attachment security and DSE in foster children, and also validate the use of different measurements. In the following I will outline the study aims in more detail.

The first major aim of the current study was to compare foster children’s attachment security, dependency, and DSE 1 year after placement with an age-matched control sample stemming from the same community to validate and extend the longitudinal study’s findings from our work group.

One limitation of the longitudinal study is the lack of a control sample. While attachment security in the foster group was compared to meta-analytic data, parents’ report of DSE was only compared to one sample of Romanian children and the cultural background may have influenced the data. Referring to the longitudinal findings (e.g., Lang, 2014) it is hypothesized, that at placement, foster children may be less securely attached than control children, however, in line with the longitudinal findings, we expect that 1 year after placement foster children will not differ from a control sample regarding attachment security. To expand the view on the (foster) mother–child relationship, in the current study we were additionally interested whether foster children differ from a control sample regarding dependency towards the (foster) mother, at the time of placement and 1 year after. As there has been no study to examine this relation no assumptions have been made prior to the investigation. However, as the foster mother and foster child attachment relationship does not precede the typical normative development of attachment, it may substantially differ in nature from a relationship that has been established from birth on. Thus, we expect differences in dependency to occur between groups. Furthermore, in line with the longitudinal data (Zimmermann, 2015) after 1 year in placement we expect foster mothers to report more signs of DSE towards stranger in their foster children as compared to mothers of the control group. In brief, our first research question asked if after one year in placement foster children would differ from a control group regarding attachment security, dependency, and disinhibited social engagement, while additionally considering foster children’s attachment security and dependency at the time of placement.
The second major aim of the current study was to provide a deeper understanding of foster children’s adjustment to the new social environment by assessing behavior towards the (foster) mother and a strange person in different contexts, and thus, comprises two research questions.

Regarding DSE towards strangers, studies have shown that it can be elicited by a gradual stranger approach, and, evaluating children’s tendencies to approach the stranger and initiate interaction has the potential to discriminate children from adverse rearing environments from control samples (Bruce et al., 2009; Lawler et al., 2014). Moreover, within this setting, physical contact has been shown to particularly be related to the severity of past experiences (Lawler et al., 2014). Thus, it is hypothesized that compared to the control group foster children will display increased signs of DSE behaviors when being approached by an unfamiliar adult. By generally investigating children’s approach tendencies as well as the frequency and intensity of distinct behavioral variables that the child directs towards the stranger, we aimed to add to current knowledge about the occurrence of normal variations in DSE in contrast to abnormal behavior.

In addition, we were interested in how foster children regulate their behavior when being approached by a stranger applying an organizational systems approach. In particular, we were interested in how foster children are able to use the mother as a secure base while — given that the child is approached by a stranger in a novel situation — activation of several behavioral systems (i.e., attachment, exploratory and sociability or wariness system) is likely to occur at some point. In normative development the interplay of related behaviors, also referred to as the attachment-exploration balance (Ainsworth & Bell, 1970) reflects an inner organizational model that is theorized to result from repeated caregiver–child interactions (e.g., Ainsworth et al., 1978) and underlies major changes during early childhood (see Marvin & Britner, 2008). However, as suggested by O’Connor et al. (2003) severe disruptions during the formation of attachment relationships and thus, the attunement of emerging behavioral systems, may lead to major alterations, hence, making the “interrelatedness” of these behaviors less predictable (O’Connor et al., 2003, p.34). Thus, the second research question asks how foster children differ from control children with regard to disinhibited social engagement behaviors towards a stranger, and, the activation of the attachment, sociability, and exploratory behavior system during a stranger approach in (foster) mother’s presence.
Furthermore, for exploratory reasons, we intended to investigate (foster) children’s behavior in dyadic interaction with a stranger in the (foster) mother’s absence and compare it to their behavior in dyadic interaction with the (foster) mother. Studying behavior in different contexts we aimed to respond to evidence suggesting children’s sensitivity to settings and according differences in reactions to strangers at least in young children (Waters et al., 1975). Thus, the third research question asked how foster children and control children will differ from each other in play with their (foster) mother and in play with a stranger.

Finally, we were interested in correlations among measures of attachment security, dependency, mother’s report of DSE behaviors and observational data from the laboratory assessment. It has been claimed that applying a multi-method approach is necessary to detect coherent behavioral patterns and also to minimize the risk of an informant biased convergence of methods (Bruce et al., 2009; Zeanah et al., 2002). This way we may be able to provide further knowledge on the use of different measures in assessing the phenomenon of DSE. Furthermore, we may be able to contribute to what is known about its co-occurrence with attachment security in relationships that only developed after the first two years of life (Lyons-Ruth, 2015). Thus, the fourth research question asks how global measures of attachment security, dependency, and DSE are related to (foster) children’s behavioral responses towards (foster) mother and stranger during interaction in two standardized settings.
4.2 Methods

4.2.1 Participants

The total sample consisted of 46 children (23 male/23 female), 16 of which were living in foster care (9 male/7 female). Foster children’s age ranged from 39 to 77 months ($M = 54.36, SD = 11.66$). The remaining 30 children (14 male/16 female), aged between 41 and 70 months ($M = 56.22, SD = 8.57$), were living with their biological family (see section 3.2.3 for a detailed description of the sample).

4.2.2 Design and overall procedure

Data collection took place at three assessment points, one at home, one at the laboratory, and one via telephone. Children’s attachment security and dependency was assessed at a semi-structured home visit that was subsequently coded using the Attachment Q-Sort (AQS). During the home visit (foster) mother–child interaction was observed during free play, a short separation–reunion procedure and during problem solving tasks. Foster children’s AQS scores from the time of placement and 1 year after placement were derived from the longitudinal study. All children’s behavior towards stranger and (foster) mother was observed during two parts of structured laboratory assessments, the waiting room procedure and, two separate free-play sessions with a strange person and the (foster) mother. In addition, a telephone appointment was arranged to ask (foster) mothers about children’s behavior towards strangers with the Disturbances of Attachment Interview (DAI). In the following, all of the methods relevant to the current investigation will be described in detail.

4.2.3 Measures

Attachment Q-Sort

Children’s attachment security and dependency was assessed using the German version 3.2 of the Attachment Q-Sort (AQS; Waters and Deane, 1985, German version: Schölmerich & Leyendecker, 1999). The AQS is a widely used measure in studies with children aged 12 to 70 months (Ijzendoorn & Bakermans-Kranenburg, 2004) and has also been used successfully in the assessment of foster children’s attachment security (e.g., Oosterman & Schuengel, 2008). Conducting a series of meta-analyses van Ijzendoorn and his colleagues (2004) found evidence for the validity of the observer AQS (as opposed to the self-report version) as a measure of attachment. Including 139 studies (self-report and observer AQS) with a total of 13,835 children, their analyses revealed proper convergent validity of the AQS security score with attachment security assessed in the Strange Situation.
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Procedure and predictive validity with sensitivity measures. Also, its discriminant validity with temperament was reported.

The original version of the AQS (Waters & Deane, 1985) was modified by (Waters, 1995) and includes 90 items referring to children’s secure base and exploratory behavior as well as other aspects like social referencing covering the “entire domain of attachment relevant behavior” (Waters & Deane, 1985, p.52). These items are individually printed on cards that are then sorted into 9 piles (with 10 items per pile) categorizing the child’s behavior from “less characteristic” (low placements) to most characteristic (high placements). Subsequently the child’s Q-Sort is correlated with a hypothetical criterion sort developed by experts representing the prototypically behavior of a most secure subject (see Waters & Deane, 1985). This correlation results in a security score ranging from very insecure (-1) to very secure (+1). Furthermore, criterion sorts of dependency are also available allowing to form a score ranging from very dependent (-1) to very independent (+1) behavior (Waters, Vaughn, Posada, & Kondo-ikemura, 1995).

In the present study, children’s behavior was assessed during the home visit described above. Subsequently, the two trained observers separately sorted the Q-Set in the described manner. Inter-observer reliability was high, $r = .70$ (range: $rs = .39 - .87$). Afterwards, for each child a composite of both observers’ security as well as dependency score was calculated and correlated with the expert criterion sorts.

**Disturbances of Attachment Interview (DAI)**

To assess children’s DSE towards strangers, (foster) mothers were interviewed during a 30 minute phone call using the Disturbances of Attachment Interview (DAI, Smyke & Zeanah, 1999). The DAI is a semi-structured interview containing 12 complexes of questions asking about different signs for reactive attachment disorders$^{14}$. It has successfully been applied to a number of samples including children with a background of institutionalization as well as children in foster care (Gleason et al., 2011; Jonkman et al., 2014; Mesquita et al., 2015; Smyke et al., 2002; Zeanah et al., 2002) and is considered a valid measure of the construct (see e.g., Gleason et al., 2011). For the current study, we extracted three items that target children’s DSE towards unfamiliar adults. Here, caregivers are asked if the child back-checks with him/her in unfamiliar settings, shows reticence towards strangers, and, if he/she would walk off with an unfamiliar adult (negatively poled). Each item was coded by a trained rater with 0 (child clearly demonstrates the behavior), 1 (child sometimes/somewhat demonstrates the behavior), or 2 (child only minimally/rarely shows the

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$^{14}$ The DAI was developed prior the distinction between reactive attachment disorder and disinhibited social engagement disorder realized by the DSM-5. For reasons of simplicity I will use the umbrella term Disinhibited social engagement (DSE) also when referring to the DAI scale originally assessing what was called symptoms of disinhibited attachment disorders.
behavior) leading into a sum score ranging from 0 to 6. Furthermore, in accordance with Zeanah et al. (2002), scores 1 or 2 were considered mild signs of DSE while scores of 3 and above were considered marked signs. We also built a dichotomous scale to compare foster children and the control group regarding the distribution of children displaying no signs vs. at least one sign. Note that the initial sum score was used when investigating correlational relationships between different variables.

In the current study, ratings were performed by four independent raters that were trained by the group of Carlo Schuengel from Vrije University Amsterdam, Netherlands. Their inter-rater reliability of the training set was \( r = .80 \) on average, and, by double-coding 30% of DAIIs from the longitudinal study they have reached an inter-rater reliability of Cohen’s kappa \( \kappa = .80 \) for the disinhibited scale (see Zimmermann, 2015).

**Waiting room procedure**

*Behavioral assessment.* For an observation of children’s responses to a gradually approaching unfamiliar adult we conducted a 10 min long waiting room procedure that resembles an early protocol by Tizard and Rees (1975) and has successfully been applied in more recent studies including children adopted from institutions as well as out of foster care (Bruce et al., 2009; Lawler et al., 2014). The paradigm was chosen as it provides the possibility to observe children’s immediate reactions to a structured gradual approach of an unfamiliar stranger in a quasi-natural setting. Furthermore, as unfamiliar situations are expected to activate the attachment system (Ainsworth & Wittig, 1969) this behavioral procedure seemed suitable to illustrate the absence or presence of children’s attachment behaviors towards the caregiver. With the (foster) mother being instructed to play a passive role, we attempted to maximize the likelihood to observe behavior that represents the child’s individual organization of behavioral systems without being influenced by (foster) mother’s interactional responses. Before the start of the waiting room procedure, the first experimenter handed the (foster) mother written instructions, so she would signal the child to be busy filling out questionnaires during the whole procedure. Then, (foster) mother and child were led to a room with five chairs that were arranged forming an “L”. The first experimenter showed them where to sit, handed the child a picture book, and then, left the room. The session started when the second experimenter, who was unfamiliar to the child, entered the room. The following procedure that was adapted from a manual provided and recently published by Lawler and her colleagues (2014) is
outlined in Table 5. The entire session was videotaped with two cameras positioned opposite to each other and was coded afterwards.

Table 5
Outline of the Waiting Room Procedure (see Lawler et al., 2014)

<table>
<thead>
<tr>
<th>Time interval</th>
<th>Phase</th>
<th>Instruction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1:30 min</td>
<td>Stranger’s greeting</td>
<td>The stranger knocks on door and enters the room. She greets the mother and briefly introduces herself. Then, she sits down on designated chair and pretends to do paper work on a clipboard. After 30 seconds, the stranger looks up, greets the child personally and introduces herself. Then, she turns back to her paper work, not paying attention to the child or interacting with him/her.</td>
</tr>
<tr>
<td>4 min</td>
<td>Toy offering</td>
<td>The stranger now asks the child, if he/she wants to see some toys and offers him/her to play with them. She then puts some toys in a designated spot in the middle of the room. Then, she sits back on her chair with no paperwork and thus, stays approachable. Still the stranger was instructed not to interact with the child.</td>
</tr>
<tr>
<td>4 min</td>
<td>Play invitation</td>
<td>The stranger gets up, gets more toys, sits down on the floor and invites the child to play together. Children who were still seated were repeatedly encouraged to come over and play. To end up the stranger withdraws and sits back on her chair saying she has some more paper work to do.</td>
</tr>
</tbody>
</table>

Behavioral coding. The observational coding of children’s behavior in the waiting room procedure included two major coding schemes.

First, we coded children’s disinhibited social engagement behaviors directed towards the stranger. The coding included a qualitative rating of children’s disinhibited social approach behavior for each of the three phases and verbal intimacy as well as physical intimacy throughout the entire session. Coding instructions can be found in a recent publication by Lawler et al. (2014). Scales for disinhibited social approach ranged from 0–3, 0–6, and 0–4 for children’s reaction to the stranger’s greeting, toy offering, and, play invitation respectively. In the current study, intermediate scores (1.5, 2.5, etc.) were included when further differentiation between scores was necessary. Furthermore, similar to Lawler et al. (2014) communicative behavior towards the stranger was quantitatively assessed as the frequency of children’s verbal initiations throughout the session using a digital coding software (Interact, Mangold International, Arnstdorf, Germany). Verbal initiations were defined as any vocalizations directed towards the stranger that aimed to initiate or maintain conversation. Therefore, neither ongoing self-directed speech nor responses to experimenter’s questions were included. Two pairs of raters blind to condition were trained by myself using rehearsal tapes, two of which were pre-rated by Jamie Lawler from the University of Minnesota, who also gave advice on coding in personal conversations. For the qualitative coding, including the broad rating of children’s disinhibited social approach behavior as well as verbal and physical intimacy towards the stranger there were two independent raters. They coded all video tapes except for two
that were coded by myself only. Both raters finally reached weighted kappas ($\kappa_w$) between .72 and .92. For the quantitative scoring of communication towards the stranger interrater reliability was calculated based on 9% of the tapes that were rated by the same two independent coders in advance and another 9% rated post-hoc, which produced a $\kappa_w$ of 0.82 and 0.88 respectively.

Second, the attachment–exploration balance was coded with regard to children’s attachment behavior towards the (foster) mother, exploratory behavior, and looking behavior towards the stranger using a lab based rating system (see Giedigkeit, 2012). To increase precision of coding, all phases were separated into 30 second segments. Attachment behaviors in each segment were rated on a 0-3 scale. Here, a score of 0 indicated that the child did not show any attachment related behavior like seeking proximity to the (foster) mother or back-checking by looking at her while a score of 3 was given, when the child was seeking and/or maintaining proximity to the mother for more than 50% of the time. As for exploratory behavior, a score of 0 indicates that the child explores the toys (during introduction: the book) while 3 was given when he/she did not play for at least 80% of the time (scores were reversed for statistical analyses). Finally, if the child did not even once look in the stranger’s direction a 0 score was given while 3 indicated that he/she was looking at the stranger the entire 30 seconds or was continuously taking short glances at her. A second pair of coders did the scoring of the attachment-exploration balance after intense training. For the calculation of inter-rater reliability they reviewed 30% of the tapes producing averaged $\kappa_w$ between .76 and .96. As for attachment behaviors, exploratory behaviors and looking behaviors towards the stranger scores were averaged separately each of the three phases to analyze the course of these behaviors.

Free play with (foster) mother and free play with stranger

Behavioral assessment. In the next part of the behavioral session (free play), we were interested in children’s interactional behavior directed towards the play partner. For the purpose of the current study several intervals of interest were isolated from a longer mother/stranger–child interaction session including a sequence of separations and reunions with the mother.

More precisely, after the waiting room procedure, (foster) mothers were instructed to leave the room so child and stranger were left alone. Shortly after, the stranger sat down by the child trying to engage him/her in free play. After about 6 minutes the mother was sent back to the room reuniting with her child. Next, the stranger left the room and mother and child were left alone with the mother being instructed to play with her child.

For detailed analysis, we defined a warming-up phase and an advanced play phase for each free play session. In the stranger–child free play the warming-up phase started when mother left the room and the stranger first approached the child either physically or verbally. This interval lasted 90
seconds. The advanced play phase started later at exactly 90 seconds before the mother came back to the room, but no more than 3:30 minutes after termination of the warming-up phase. At this point, we expected children to have adapted to the novel situation. Subsequently, the mother–child free play session commenced. Here, the warming-up started when the stranger left the room and as soon as the mother started interacting with the child. Otherwise, intervals were structured in concordance with the stranger–child free play session.

*Behavioral coding.* The videotaped behavioral sessions were reviewed and coders isolated intervals of interest in the described manner. For detailed analyses Interact digital coding software (Mangold International, Arnsdorf, Germany) was used. Coding was done continuously applying a time-sampling method and referring to a lab based coding system (see Heinisch, 2013). In the current study, we were interested in the duration of looking at play partner, and duration of *self-initiated talk* with play partner.

More precisely, we initially coded intervals where children were looking at what the play partner is doing (watching her actions) and were they were looking at her face. For subsequent analyses we built a composite of both referred to as looking at the play partner. In a few cases children’s looking behavior could be followed continuously (e.g., when face was covered by hair). If that was the case for a total of more than 14 seconds (more than 15%) in at least one interval, the subject was not included in further analyses \(n = 4\).

Self-initiated talk with the play partner was coded with respect to children’s verbal initiations towards the play partner. This score was distinguished from the child’s responses to questions asked by the play partner that were coded independently. As we were only interested in the child’s attempts to engage with the play partner, the latter was not included in the analysis.

One pair of coders was trained and subsequently coded three individual sessions on several categories including the above variables, looking behavior towards play partner and self-initiated talk. Inter-rater reliability was \(\kappa = .93\) for looking behaviors and \(\kappa = .85\) for children’s communicative behavior during play sessions. Finally, each video was coded by one of the trained students. For further analyses intervals during which respective behaviors occurred were summed up and percentages were coded (duration relative to time interval) for both categories.
4.2.4 Statistical Considerations

Statistical analyses were carried out using IBM SPSS 23.0. Given that AQS attachment security and dependency scores represent correlation coefficients we applied a standard procedure and converted them to Fisher’s z before further analyses (Field, 2009).

Preliminary analyses using Kolmogorov-Smirnov tests revealed that the assumption of normal distributions was given in all variables from the free-play sessions, but only in a few of the other dependent variables. Thus, relations between variables were tested using Spearman’s rank correlation coefficient as a non-parametric measure. Yet, non-parametric tests hold the disadvantage of decreased power and limitations for multivariate testing. Consequently, to avoid multiple testing that forwards the risk for alpha inflation, parametric tests were performed when testing mean differences. Here, when possible, non-parametric tests (Mann U-Whitney, Friedman’s test) were additionally applied to variables violating the assumption of normal distribution and found to confirm significant effects.

In the following section, we compare foster children and control children on a number of variables measured on continuous interval scales using t-tests for independent samples or, when indicated, multivariate analyses of variance. According to Leven’s test the assumption of equality of variances was not violated in any analysis. When including more than one measuring point, t-tests for dependent samples as well as repeated measures ANOVAs were applied, and Mauchly’s test was performed to test the assumption of sphericity. If violated, Greenhouse Geisser correction was applied to correct the degrees of freedom. For analyses of variance partial eta-squared values ($\eta_p^2$) were calculated as a measure of effect sizes. According to Cohen (1988), $\eta_p^2 = .01$ is assumed to be a small, $\eta_p^2 = .06$ a medium, and $\eta_p^2 = .14$ to be a large effect. Post-hoc tests were performed using t-tests for independent samples, while post-hoc testing of more than three inter-subject variables was conducted via pairwise comparisons. Here, the level of significance was Bonferroni corrected. Pearson’s-Chi-Square tests were performed to compare groups with respect to dichotomous variables. All assumptions were tested two-sided and statistical significance was defined as a $p$-value smaller than or equal .05, while results with alpha errors ranging from more than .05 to .1 indicate tendencies.

At the home visit, where dependency and attachment security were assessed, foster children were significantly younger than control children (see section 3.2.3). Also, two variables showed to correlate with age (i.e., dependency, disinhibited social approach during stranger’s greetings). Thus, we double-checked our results adding age as a covariate wherever necessary.
Analysis of extreme values. Parametric tests are sensitive to data points that show extreme deviation from the rest of the data. Thus, to detect extreme values interquartile ranges were calculated for all continuous variables in the data set. Outliers were detected using interquartile ranges based on Tukey’s hinges. Referring to the algorithm implemented in SPSS 23.0 any data point more than 3 interquartile ranges below the first quartile or above the third quartile was defined an extreme value. Those below the first quartile were adapted by changing their value to the minimum value within the acceptable range minus one measuring unit, while extreme values above the third quartile were adapted by replacing them with the maximum value within this range plus one measuring unit respectively. The adaption was applied to three variables, namely attachment behavior ($n = 3$), frequency of verbal initiations ($n = 3$), and, self-initiated talk during warming-up in free play with stranger ($n = 1$).
4.3 Results

Results are reported in three sections according to our research questions. The first section refers to differences between foster and control group in attachment security and dependency towards their (foster) mother as observed during the home visit, and children’s DSE behavior as reported by (foster) mothers. The second section focuses on group differences in children’s behavioral responses towards their (foster) mother and a stranger as it was observed in two consecutive sessions during the laboratory visit. Therefore, in line with our research questions, the second section is divided in two parts: The waiting room procedure and the free play sessions. In the third section we report findings referring to our fourth research question on associations between the global constructs attachment security, dependency, and reported signs of DSE (see section 1) and specific behavior variables (see section 2).

4.3.1 Group differences regarding attachment security, dependency and (foster) mother’s report of disinhibited social engagement

Before analyzing group differences we computed intercorrelations between attachment security, dependency and signs of DSE as well as the influence of age on these measures. Table 6 shows that only dependency and age significantly correlated with each other suggesting that children’s dependent behaviors toward the (foster) mother decreased with age.

<table>
<thead>
<tr>
<th>Variables</th>
<th>N</th>
<th>Age at assessment</th>
<th>Attachment security</th>
<th>Dependency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attachment security</td>
<td>46</td>
<td>.17</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dependency</td>
<td>46</td>
<td>-.52***</td>
<td>-.02</td>
<td></td>
</tr>
<tr>
<td>(Foster) mother’s report of DSEa</td>
<td>45b</td>
<td>.21</td>
<td>-.17</td>
<td>-.02</td>
</tr>
</tbody>
</table>

Note. aDSE = Disinhibited social engagement, bmissing data due to technical problems (n = 1), *** p < .001, ** p < .01, * p ≤ .05
Attachment security and dependency

Next, we addressed the question, whether foster children and control children differ with regard to attachment security and dependency using t-tests for independent samples. Including additional data from wave 1 of the longitudinal study allowed us to test if group differences were present at the time of placement as well as after 1 year in the foster home. Furthermore, we measured changes in foster children’s attachment security and dependency over both assessment points using t-tests for paired samples. Table 7 shows the descriptive data for AQS security scores as well as the AQS dependency scores for both groups.

Table 7
Attachment Security and Dependency at Time of Foster Placement and 1 Year After Placement by Group, Means, Standard Deviations, and Minimum/Maximum

<table>
<thead>
<tr>
<th>Variables</th>
<th>Foster group n=16 at placement</th>
<th>1 year after placement</th>
<th>Control group n=30</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M (SD) Min Max</td>
<td>M (SD) Min Max</td>
<td></td>
</tr>
<tr>
<td>Attachment security</td>
<td>.10 (.29) .42 .66</td>
<td>.30 (.21) .10 .56</td>
<td>.29 (.21) .13 .60</td>
</tr>
<tr>
<td>Dependency</td>
<td>.05 (.21) -.47 .46</td>
<td>.14 (.23) -.26 .47</td>
<td>-.17 (.17) -.45 -.14</td>
</tr>
</tbody>
</table>

As expected, when compared to the control group’s mean AQS score at the time of placement foster children’s attachment security was significantly lower ($M_{control group} = .29, SD = .21; M_{foster group} = .10, SD = .29; t(44) = 2.54, p = .015$). Furthermore, as previously shown for the total sample (see Lang, 2014), comparing the initial AQS security score to data assessed 1 year after placement ($M = .30, SD = .31$) the analysis confirmed that foster children’s attachment security significantly increased over the first year of living in the foster home. $t(15) = -3.73, p = .002$. Further comparisons showed that 1 year after placement foster children ($M = .30, SD = .21$) no longer differed from control children with regard to attachment security, $F(1,44) = -.24, p = .81$, ns.

Comparing foster children’s initial dependency scores assessed at the time of placement ($M = .05, SD = .21$) with those provided by the control group ($M = -.17, SD = .17$) showed that foster children elicited increased dependent behaviors in interaction with the foster mother, $t(44) = -3.13, p = .000$. In contrast to attachment security, foster children’s dependency scores showed to have remained stably high across the first year in the foster home, $t(15) = -1.33$, ns. Consequently, further group comparisons yielded that after 1 year in the foster home, foster children ($M = .14, SD = .23$) still scored significantly higher on dependency than control children, $t(44) = -5.13, p = .000$. Considering that younger children were generally more likely to show dependent behavior, we additionally conducted (repeated measures) ANCOVAs with age as a covariate where appropriate. However, adding age as a covariate did not change any of the results with respect to the level of significances.
Note that all remaining data reported in here was assessed one year after foster placement. Thus, at the time of these assessments, foster children differed from control children with regard to dependency, but not attachment security.

\textit{(Foster) mother’s report of disinhibited social engagement}

In total, 62.5\% of the foster children were described to show signs of disinhibited social engagement (score > 0) whereas this was only the case in 34.4\% of the control children and this difference has shown to be marginally significant, \(\chi^2(1) = 3.28, p = .07\). In more detail, Figure 2 shows that marked symptoms (score \(\geq 3\)) were more frequently reported for foster children (31.3\%) as compared to control children (3.4\%), while mild symptoms were equally distributed in foster and control children (31.3\% and 31.0\% respectively). Due to small cell sizes significance tests could not be performed for the reported sublevels.

Also, regarding the total score, foster children were reported to show increased signs of DSE (\(M = 1.6, SD = 1.6\)) as compared to their peers (\(M = .70, SD = 1.1\)), \(t(38) = 2.11, p = .04\).

![Figure 2](image-url)  \textit{Figure 2.} Signs of disinhibited social engagement reported by (foster) mother in the DAI in percent by group. No signs (score= 0), mild signs (score=1-2) and marked signs (score \(\geq 3\)).
4.3.2 Differences between foster and control children’s interactional behavior towards (foster) mother and stranger within two different settings

Behavioral responses to stranger approach in the waiting room procedure

Next, I will report results referring to our second research question that asks how foster children and control children differ with regard to their behavioral responses to meeting an unfamiliar adult in the waiting room. The section is divided in two parts. Part 1 refers to our hypotheses that compared to the control group foster children will display increased disinhibited social engagement behaviors (i.e., disinhibited social approach, and, concrete behavioral responses respectively). In part 2 results regarding the attachment-exploration balance are presented. Here, attachment behavior towards (foster) mother, looking behavior towards stranger, and exploratory behavior were examined with regard to changes occurring during the time-course of the procedure. For descriptive reasons, Table 8 shows intercorrelations of all variables assessed during the waiting room procedure. Also, it shows that none of the variables significantly correlated with age.

<table>
<thead>
<tr>
<th>Table 8</th>
<th>Correlations with Age and Between Behavior Variables in the Waiting Room Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Variables</strong></td>
<td><strong>1.</strong></td>
</tr>
<tr>
<td>1. Age at assessment</td>
<td></td>
</tr>
<tr>
<td>2. Disinhibited social approach</td>
<td></td>
</tr>
<tr>
<td>3. Frequency of verbal initiation</td>
<td>-.07</td>
</tr>
<tr>
<td>4. Verbal intimacy</td>
<td>.02</td>
</tr>
<tr>
<td>5. Physical intimacy</td>
<td>-.13</td>
</tr>
<tr>
<td>6. Attachment behavior towards (foster) mother</td>
<td>-.14</td>
</tr>
<tr>
<td>7. Looking behavior towards stranger</td>
<td>-.07</td>
</tr>
<tr>
<td>8. Exploratory behavior</td>
<td>-.15</td>
</tr>
</tbody>
</table>

Note. N = 46, across all phases. *** p < .001, ** p < .01, * p ≤ .05
**Disinhibited social engagement behaviors.** To test our hypotheses that states that foster children display increased DSE behaviors toward the stranger as compared to control children, analyses of variance were conducted.

**Table 9**
*Children’s Disinhibited Social Engagement During the Waiting Room Procedure by Group, Means, Standard Deviations, Minimum/Maximum, and Frequency Percentages*

<table>
<thead>
<tr>
<th>Behavior variables</th>
<th>Foster group</th>
<th>Control group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n = 16</td>
<td>n = 30</td>
</tr>
<tr>
<td><strong>Disinhibited social approach</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reaction to stranger’s greeting</td>
<td>.94 (.10)</td>
<td>.92 (.95)</td>
</tr>
<tr>
<td>Reaction to toy offering</td>
<td>2.06 (2.17)</td>
<td>2.12 (2.00)</td>
</tr>
<tr>
<td>Reaction to play invitation</td>
<td>2.58 (.83)</td>
<td>2.19 (.80)</td>
</tr>
<tr>
<td><strong>Frequency of verbal initiations</strong></td>
<td>3.49 (2.55)</td>
<td>1.63 (1.91)</td>
</tr>
<tr>
<td><strong>Verbal intimacy</strong></td>
<td>2.45 (.54)</td>
<td>1.83 (.81)</td>
</tr>
<tr>
<td>0: none</td>
<td>1.75</td>
<td>0</td>
</tr>
<tr>
<td>1: responses only</td>
<td>3.5</td>
<td>3</td>
</tr>
<tr>
<td>1-2</td>
<td>6%</td>
<td>13%</td>
</tr>
<tr>
<td>2: basic initiations</td>
<td>44%</td>
<td>33%</td>
</tr>
<tr>
<td>2-3</td>
<td>13%</td>
<td>0%</td>
</tr>
<tr>
<td>3: shared personal information</td>
<td>31%</td>
<td>23%</td>
</tr>
<tr>
<td>3-4</td>
<td>6%</td>
<td>0%</td>
</tr>
<tr>
<td><strong>Physical intimacy</strong></td>
<td>.41 (.49)</td>
<td>.10 (.28)</td>
</tr>
<tr>
<td>0: none</td>
<td>1.5</td>
<td>0</td>
</tr>
<tr>
<td>0-1</td>
<td>50%</td>
<td>87%</td>
</tr>
<tr>
<td>1: contact as a tool</td>
<td>25%</td>
<td>7%</td>
</tr>
<tr>
<td>1-2</td>
<td>19%</td>
<td>7%</td>
</tr>
<tr>
<td>1-3</td>
<td>6%</td>
<td>0%</td>
</tr>
</tbody>
</table>

Regarding disinhibited social approach ratings were qualitatively different for each phase. Thus, we chose a multivariate design with disinhibited social approach ratings in each phase (stranger’s greeting, toy offering, play invitation) as the dependent and group (foster group, control group) as the independent factor, but no repeated measure factor. Table 9 shows the descriptive data for each phase by group. Visualizing the groups’ differential responses to the stranger approach Figure 3 indicates that foster children higher on disinhibited social approach during play invitation. However, the 3 x 2 MANOVA yielded that the two groups did not significantly differ regarding social approach behavior in response to meeting the unfamiliar adult in any of the three phases, $F(1,41) = .22, p = ns$. As children’s reactions to the stranger’s greeting was positively correlated with age in our preliminary analyses, $r = .42, p = .003$, we checked the result controlling for age. Still, group differences did not reach significance.
In order to test whether foster children as compared to control children showed an increased tendency to engage with the stranger with regard to their communicative behavior, we conducted *t*-tests with *frequency of verbal initiations* and *verbal intimacy* as the dependent variables. Indeed, throughout the waiting room procedure, foster children displayed significantly more verbal initiations ($M = 3.49, SD = 2.55$) towards the unfamiliar adult than control children ($M = 1.63, SD = 1.91$), $t(44) = -2.78, p = .008$. Furthermore, foster children communicated with the unfamiliar adult on a verbally more intimate level ($M = 2.45, SD = .54$) than control children ($M = 1.83, SD = .81$), $t(44) = -2.73, p = .009$.

To examine whether *physical intimacy*, that has shown to discriminate typical from atypical social behavior in other studies, would discriminate between groups, a *t*-test for independent samples was conducted. The analysis confirmed that foster children initiated physical contact on a more intimate level ($M = .41, SD = .49$) than control children ($M = .10, SD = .28$), $t(20.17) = -2.31, p = .03$. However, Table 10 shows that regardless of group status ratings of physical intimacy only ranged 0-1.5 (out of 5) in all children, indicating that none of the children displayed high levels of physical intimacy towards the stranger. Thus, we dichotomized the scale and additionally tested if foster children were more likely to show any level of physical contact. Table 10 shows that 87% of control children ($n = 26$) did not touch the stranger during the procedure at all while this was only the case for 50% of foster children ($n = 8$). Finally, Pearson’s Chi-Square test confirmed this difference to be significant, $\chi^2(1) =7.28, p = .007$. 

![Figure 3. Disinhibited social approach throughout the waiting room procedure by group. Means and Standard Errors.](image)
**Attachment–Exploration Balance.** In the next step, groups were compared regarding the balance of behavioral systems during stranger approach in the waiting room procedure also referred to as attachment–exploration balance. To examine whether foster children as compared to control children displayed distinct patterns throughout the time-course of the observation, groups were compared on three behavioral variables (attachment behavior towards (foster) mother, looking behavior towards stranger, and exploratory behavior). We conducted repeated measures ANOVAs including the three phases (introduction, invitation to toys, invitation to play together) as the within-subjects factor and group as the between-subjects factor for each variable separately. Table 10 shows the mean values of looking behavior towards stranger, attachment behavior, and exploratory behavior in each phase for each group, and Figure 4 illustrates behavioral differences between foster and control children.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Phase</th>
<th>Foster group n = 16 Mean (SD)</th>
<th>Control group n = 30 Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attachment behavior towards (foster) mother</td>
<td>Stranger’s greeting</td>
<td>1.53 (.103)</td>
<td>1.10 (.105)</td>
</tr>
<tr>
<td></td>
<td>Toy offering</td>
<td>1.72 (.85)</td>
<td>1.02 (.90)</td>
</tr>
<tr>
<td></td>
<td>Play invitation</td>
<td>.55 (.8)</td>
<td>.22 (.54)</td>
</tr>
<tr>
<td>Looking behavior towards stranger</td>
<td>Stranger’s greeting</td>
<td>1.30 (.60)</td>
<td>.98 (.48)</td>
</tr>
<tr>
<td></td>
<td>Toy offering</td>
<td>2.11 (.94)</td>
<td>.93 (.76)</td>
</tr>
<tr>
<td></td>
<td>Play invitation</td>
<td>1.10 (.69)</td>
<td>.80 (.61)</td>
</tr>
<tr>
<td>Exploratory behavior</td>
<td>Stranger’s greeting</td>
<td>1.73 (.105)</td>
<td>1.93 (.96)</td>
</tr>
<tr>
<td></td>
<td>Toy offering</td>
<td>1.31 (.41)</td>
<td>1.50 (1.33)</td>
</tr>
<tr>
<td></td>
<td>Play invitation</td>
<td>2.38 (.81)</td>
<td>2.31 (1.04)</td>
</tr>
</tbody>
</table>

With attachment behavior towards the (foster) mother as the dependent variable the analysis revealed a significant main effect for phase, $F(1.74, 76.71) = 28.95, \ v = .87, \ p_{\text{adj}} = .000, \ \eta^2_p = .40$, as well as a main effect for group, $F(1.44) = 5.82, \ p = .02, \ \eta^2_p = .12$. There were no significant interaction effects. Mean values indicated that across all phases foster children displayed significantly enhanced attachment behaviors towards their foster mother ($M = 1.27, SD = .61$) as compared to the control group ($M = .78, SD = .68$). Regarding the main effect for phase, Figure 4 shows and post-hoc pairwise comparisons confirmed, that all children equally displayed attachment behavior towards their (foster) mother throughout stranger’s greeting and the toy offering ($M = 1.25, SD = 1.05$, and $M = 1.26, SD = .94$ respectively, $p = \text{ns}$). Comparing children’s behavior during toy offering to when the unfamiliar adult invited the child to play together the analysis yielded a significant decrease in attachment behaviors in all children ($M = 1.25, SD = 1.05$, and $M = .33, SD = .57, p = .000$).
Figure 4. Attachment behavior towards (foster) mother, looking behavior towards stranger, and exploratory behavior throughout the waiting room procedure by group. Means and Standard Errors.
Regarding children’s looking behavior towards the stranger the repeated measure analysis indicated that this behavior significantly changed over phases, \( F(2,88) = 12.81, p = .000, \eta^2_p = .23, \) and, that foster children significantly differed from control children, \( F(1,44) = 13.90, p = .001. \eta^2_p = .24. \) However, these main effects were qualified by a significant interaction of phase and group, \( F(2,88) = 9.62, p = .000, \eta^2_p = .18. \) Figure 4 shows that the control group displayed an invariable low level of looking behavior towards the stranger and post-hoc pairwise comparisons confirmed that there were no significant behavioral changes over time. In contrast, foster children showed an increase in looking behavior from the stranger’s greeting \((M = 1.30, SD = .60)\) to when the unfamiliar adult offered the child to play with her toys \((M = 2.11, SD = .94), p = .03.\) Foster children’s heightened looking behavior significantly decreased again, when the unfamiliar adult invited the child to play together, \((M = 1.10, SD = .69), p = .000.\) This means, that the difference between groups was most obvious when the child was approached by the stranger, who did not yet engage him/her in joint play.

In order to investigate whether foster children would differ from control children in terms of exploratory behavior during the stranger approach, another repeated measures ANOVA was conducted. Here, Mauchly’s test indicated that for the within subjects factor phase, the assumption of sphericity was violated and Greenhouse Geisser corrections were applied \((\epsilon = .73).\) Still, the main effect for phase was highly significant, \( F(1.46, 64.43) = 10.81, p_{adj} = .000, \eta^2_p = .20. \) However, there were no differences between foster and control children’s exploratory behavior, \( F(1,44) = .16, p = ns, \) neither was there an interaction between group and phase, \( F(1.46, 64.43) = .27, p_{adj} = ns. \) Regarding the differences between phases in all children’s exploratory behavior Figure 4 shows and post-hoc pairwise comparisons confirmed, that they equally explored when invited to play with toys \((M = 1.86, SD = .98)\) as compared to their exploratory behavior during the introduction, where they held a picture book \((M = 1.43, SD = 1.34), p = .ns\) However, all children showed significantly more exploratory behavior when the unfamiliar adult invited them to play together \((M = 2.33, SD = .96), p = .000.\)

Summing up, during the waiting room procedure, foster children and control children differed on two of the three variables used to assess the attachment-exploration balance. Foster children were found to show heightened looking behavior towards the stranger, however, simultaneously, they showed more attachment behaviors towards their mother. Groups did not differ with regard to exploratory behavior.
Behavior towards (foster) mother and stranger in free play sessions

To address our third research question, we compared foster children and control children’s interactional behavior, namely the amount of looking at the play partner and the amount of self-initiated talk, displayed during two consecutive free play sessions with, first, the (foster) mother, and second, a stranger. We also considered that each play session consisted of two phases. For each behavior variable, a 2 x 2 x 2 repeated measures ANOVA with play partner ((foster) mother, stranger) and phase (warming-up, advanced play) as the repeated measures factors, and group (foster group, control group) as the between subjects factor was conducted. To reveal how each group would behaviorally differ between both play partner, and also, to reveal how in play with a particular partner, groups would differ from one another, post-hoc testing were performed in an exploratory manner.

Regarding the amount of time children were looking at their play partner the analysis revealed a marginally significant main effect for play partner, $F(1,38) = 2.95, p = .09, \eta_p^2 = .07$, that was qualified by a significant interaction between play partner and group, $F(1,38) = 8.98, p = .005, \eta_p^2 = .19$. Figure 5 visualizes the interaction effect. There neither was a main effect for group or phase, nor were there any other interaction effects.

Table 11

<table>
<thead>
<tr>
<th>Play partner</th>
<th>Phase</th>
<th>Mean (SD)</th>
<th>Foster group</th>
<th>Control group</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Foster) mother</td>
<td>Across both phases</td>
<td>42.09 (10.94)</td>
<td>31.70 (18.36)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Warming-up</td>
<td>44.59 (12.44)</td>
<td>32.96 (22.02)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Advanced play</td>
<td>39.59 (19.24)</td>
<td>30.44 (21.12)</td>
<td></td>
</tr>
<tr>
<td>Stranger</td>
<td>Across both phases</td>
<td>37.00 (21.82)</td>
<td>50.56 (19.27)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Warming-up</td>
<td>36.63 (22.19)</td>
<td>47.22 (23.53)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Advanced play</td>
<td>37.30 (26.51)</td>
<td>53.30 (26.51)</td>
<td></td>
</tr>
</tbody>
</table>

Mean values presented in Table 11 indicated and follow-up analyses for each play partner separately confirmed that while playing with the stranger foster children ($M = 37.00, SD = 21.82$) did not look at their play partner as much as control children ($M = 50.56, SD = 19.27$), $F(1,38) = 3.87, p = .06, \eta_p^2 = .09$. In play with the (foster) mother, the opposite pattern was observed. Here, foster children were looking at the (foster) mother for a longer amount of time ($M = 42.09, SD = 10.94$) than control children ($M = 31.70, SD=18.36$), $F(1,38) = 3.31, p = .08, \eta_p^2 = .08$. Yet, these group differences appearing in each of the two free play sessions only marginally reached statistical significance.
Subsequently, we tested if the groups differed in the way they discriminated between playing with their (foster) mother and playing with a stranger regarding the amount of time they were looking at them. Therefore, we conducted two separate repeated measure ANOVAs, one for each group. These analyses clearly showed that the control group significantly differentiated between both play partners, $F(1,27) = 16.07, p < .001$. Mean values presented in Table 11 show that control children were looking at their play partner for a longer amount of time when playing with a stranger as compared to playing with their mother. For foster children, the main effect for play partner was not significant, $F(1,11) = .94, p = ns$. This means that in foster children the amount of looking at their play partner did not depend on whom they were playing with.

![Figure 5](image.png)

**Figure 5.** Amount of looking at play partner during play with (foster) mother vs. play with stranger by group, collapsed over phases. Means and Standard Errors.
Next, we investigated if (foster) children differed from the control group with regard to their communicative behavior during each play session. Therefore, the amount of time (foster) children displayed self-initiated talk in play with a stranger and play with their (foster) mother was analyzed. The 2 x 2 x 2 repeated measures ANOVA with the duration of self-initiated talk as the dependent variable revealed a significant main effect for play partner, $F(1,44) = 5.40, p = .03, \eta^2_p = .11$, that was qualified by a significant interaction between play partner and group, $F(1,44) = 14.39, p = .000, \eta^2_p = .25$. No other effects reached significance. Table 12 shows the descriptive data for children’s amount of self-initiated talk directed towards the play partner during both free-play sessions.

<table>
<thead>
<tr>
<th>Play partner</th>
<th>Phase</th>
<th>Foster group</th>
<th>Control group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$n = 16$</td>
<td>$n = 30$</td>
<td></td>
</tr>
<tr>
<td>(Foster) mother</td>
<td>across both phases</td>
<td>10.41 (5.37)</td>
<td>16.94 (8.18)</td>
</tr>
<tr>
<td></td>
<td>Warming-up</td>
<td>9.90 (5.52)</td>
<td>18.09 (10.02)</td>
</tr>
<tr>
<td></td>
<td>Advanced play</td>
<td>10.92 (7.05)</td>
<td>15.79 (9.76)</td>
</tr>
<tr>
<td>Stranger</td>
<td>across both phases</td>
<td>12.15 (5.84)</td>
<td>9.89 (7.67)</td>
</tr>
<tr>
<td></td>
<td>Warming-up</td>
<td>11.09 (8.41)</td>
<td>9.36 (7.49)</td>
</tr>
<tr>
<td></td>
<td>Advanced play</td>
<td>13.22 (7.87)</td>
<td>10.00 (9.24)</td>
</tr>
</tbody>
</table>

To reveal the interaction follow-up tests were conducted for each play partner separately. We found that groups did not differ in the duration of self-initiated talk in play with the stranger, $F(1,44) = 1.42$, ns, but in play with the (foster) mother, $F(1,44) = 8.25, p = .006, \eta^2_p = .16$. As indicated by the mean values, when playing with their (foster) mother control children displayed more self-initiated talk as compared to foster children ($M_{control\ group} = 16.94, SD = 8.18$ and $M_{foster\ group} = 10.41, SD = 5.37$). Moreover, as visualized in Figure 6 compared to control children’s self-initiated talk in the mother free play session, the amount of self-initiated talk in play with the stranger was decreased in both groups. However, in play with the mother, it was only low in the foster group. Indeed, subsequent testing confirmed that the control group differed between persons, $F(1,29) = 21.61, p = .000, \eta^2_p = .43$, while the foster group did not $F(1,15) = 1.57$, ns.
In brief, foster and control children elicited different behavioral patterns when playing with their (foster) mother and with a stranger. Surprisingly, there were no significant effects of phase neither for looking behavior towards play partner nor for (foster) children’s self-initiated talk. This means that behaviors during the warming-up phase remained stable and did not change with advanced play time.

4.3.3 Associations among measures

Finally, in our fourth research question we asked how (foster) children’s behavioral responses to familiar and unfamiliar persons within the laboratory settings were related to the more global measures of attachment security, dependency and (foster) mother’s report of disinhibited social engagement. Therefore, all behavioral variables assessed during the waiting room procedure as well as the free play sessions were correlated with these three central constructs. Here, we were interested in general relationships between measures, so we used data from the whole sample \( (n = 46) \).

Table 13 shows, that attachment security was not related to any of the behavioral variables. However, dependency, was highly correlated with overt attachment behaviors as well as with looking behaviors in the waiting room procedure. Children who scored higher on dependency were more likely to, on the one hand, keep an eye on the stranger and, on the other hand, display attachment behaviors towards the (foster) mother when being approached by the unfamiliar adult. Regarding
(foster) mother’s report of DSE, children’s disinhibited social behaviors showed to be correlated with looking behavior towards the stranger and the level of physical intimacy during the waiting room procedure. It was also highly correlated with the frequency of verbal initiations the child directed at the stranger during the session. All of these correlations were positive and indicate a strong association between retrospectively reported and directly observed DSE behaviors. However, there was no relation between (foster) mothers’ reported signs of DSE and other disinhibited behaviors, namely neither regarding the broad rating of disinhibited social approach behavior nor the level of verbal intimacy children displayed throughout the waiting room procedure.

In additional analyses, all associations including dependency were controlled for age conducting partial correlations. All effects remained significant on the same level. However, exploratory behavior, that did not show any effect before, marginally correlated negative with dependency, \( r = -.27, p = .07 \). This indicates that children scoring higher on dependency towards their (foster) mother tended to engage less in exploratory behavior.

<table>
<thead>
<tr>
<th>Setting</th>
<th>Variables</th>
<th>Attachment security N=46</th>
<th>Dependency N=46</th>
<th>Reported signs of DSE N=45</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waiting room procedure</td>
<td>Disinhibited social approach</td>
<td>-.06</td>
<td>-.20</td>
<td>.22</td>
</tr>
<tr>
<td></td>
<td>Frequency of verbal initiation</td>
<td>-.24</td>
<td>.02</td>
<td>.48**</td>
</tr>
<tr>
<td></td>
<td>Verbal intimacy</td>
<td>-.11</td>
<td>.17</td>
<td>.14</td>
</tr>
<tr>
<td></td>
<td>Physical intimacy</td>
<td>-.20</td>
<td>.10</td>
<td>.36*</td>
</tr>
<tr>
<td></td>
<td>Attachment behavior towards (foster) mother</td>
<td>-.12</td>
<td>.53***</td>
<td>.23</td>
</tr>
<tr>
<td></td>
<td>Looking behavior towards stranger</td>
<td>-.02</td>
<td>.48**</td>
<td>.33*</td>
</tr>
<tr>
<td></td>
<td>Exploratory behavior</td>
<td>.16</td>
<td>-.23</td>
<td>-.13</td>
</tr>
<tr>
<td>Free play</td>
<td>Duration of self-initiated talk towards (foster) mother</td>
<td>.10</td>
<td>-.13</td>
<td>-.04</td>
</tr>
<tr>
<td></td>
<td>Duration of self-initiated talk towards stranger</td>
<td>.03</td>
<td>.10</td>
<td>.11</td>
</tr>
<tr>
<td></td>
<td>Duration of looking towards (foster) mother</td>
<td>.03</td>
<td>.18</td>
<td>.21</td>
</tr>
<tr>
<td></td>
<td>Duration of looking towards stranger</td>
<td>.00</td>
<td>-.08</td>
<td>-.01</td>
</tr>
</tbody>
</table>

Note. DSE = Disinhibited social engagement, *** \( p < .001 \), ** \( p < .01 \), * \( p < .05 \); sample size reduced as looking behavior could not be rated in four cases; missing value due to technical problems \( n = 1 \)
4.4 Discussion

In this part of the present study we investigated the impact of different caregiving experiences on children’s socio-emotional outcomes. In particular, we asked if pre-school aged foster children would differ from a control sample with regard to attachment security, dependency, (foster) mother’s report of DSE as well as in specific behaviors directed towards caregiver and stranger. Thereby, we applied a behavioral system approach to attachment related constructs including stranger sociability, attachment behavior, and exploratory behavior. In the following section results are discussed in order of our research questions.

4.4.1 How do foster and control children differ with regard to attachment security, dependency, and reported signs of disinhibited social engagement

Our analyses on attachment security and dependency showed that they were not related to each other at any point of the study, which provides empirical evidence for the clear distinction between the two constructs theorized by Ainsworth very early (Ainsworth, 1969, 1972). Along with our expectations, we found that, shortly after placement, foster children were less securely attached to their foster mothers than control children to their mothers. However, after 1 year in foster care, foster children did not differ from control children with regard to attachment security. Thus, when placed in an environment providing continuous emotional availability of a caregiver foster children showed to be able to form a secure attachment relationship to their foster mother (also see Gabler et al., 2014; Lang, 2014). This finding also fits with several other studies using different samples (see van den Dries et al., 2009).

Interestingly, although foster children showed attachment security comparable to control children we found them to show more dependent behavior towards their foster mother than their peers, a phenomenon that was stable throughout the first year of placement. As suggested by attachment theory children depend on their caregiver from early on. With the maturation of a secure inner working model, however, they gain the confidence enabling them to explore the environment, and, by doing so, adapt to it. When the child gets unsettled he/she may turn back to his/her caregiver to get soothed and re-establish a feeling of psychological security. Consequently, in normative development it is expected that dependent behaviors may occur less frequent with age as children finally develop into more or less self-reliant human beings. This interpretation is supported by the negative correlation between dependency and age we found in our study. Interestingly, in our study there was no decrease in foster children’s dependent behaviors over 1 year in foster care, thus, at least in foster children, growing older did not seem to be associated with decreases in dependency. Hence, it can be argued that dependency in foster children is a rather resistant behavioral pattern that
seems to be a special characteristic of the newly formed attachment relationship that has been established on the bases of early adverse relational experiences.

Overall, it can be argued that foster children may have formed a more or less secure attachment relationship towards their foster mothers, however, as suggested by Lyons-Ruth (2005) the nature of this relationship may be quite different from what we find in normative developing children. I will discuss this issue further, but will first report related findings on differences regarding the other measures of foster and control children’s interactional behaviors.

Regarding DSE towards strangers, (foster) mother’s report of their children’s social behavior indicated that this phenomenon was significantly more pronounced in control children. This finding is in line with the longitudinal data (Zimmermann, 2015), but also other studies that have found children’s DSE to be rather resistant to improvements in the caregiving environment (e.g., Chisholm, 1998). Surprisingly, control children’s mothers also reported mild signs of DSE in their children. For instance, a substantial proportion of mothers could not say for certain, whether their child may walk off with a stranger, especially when the mother herself is not around. In fact, regarding the DAI scoring, this answer already represents a mild sign of DSE in terms of a (sub-) clinical symptom. Our finding suggests that –at least when directed to mothers in low-risk samples– this particular question might rather capture maternal worries than the child’s actual behavioral tendencies. Consequently, in our study, groups did not differ regarding the amount of mother’s report of mild signs of disinhibition towards strangers, rather did the summation of mild and marked signs indicate abnormal behavior in foster children, but not control children.

In sum, our findings on global measures of the child’s behavioral organization shown in interaction with familiar and unfamiliar social partners suggest that early adverse caregiving experiences and disruptions of attachment relationships lead to major alterations in the attunement of behavioral systems. As a result, the interrelatedness of behaviors in foster children appears to clearly differ from the expectable organizational structure we found in control children’s behavior towards mother and stranger.
4.4 Discussion

4.4.2 How do foster and control children differ in their behavioral responses towards (foster) mother and a stranger

Behavioral responses during a stranger approach

For a more detailed understanding of how behavioral systems are affected by rearing experiences, we compared foster children and control children regarding their behavioral responses during a standardized stranger approach. More precisely, we observed a range of DSE behaviors and assessed behaviors indicative for the attachment-exploration balance.

Disinhibited social engagement behaviors. We expected that compared to the control group foster children would display increased signs of DSE behaviors when being approached by a stranger. With regard to children’s disinhibited social approach, we found no differences between foster and control children. Both groups were equally likely to be interested in the stranger when being greeted by her, having toys offered and during play with her. Yet, neither foster nor control children did score high on the scales, and the lower scores were not able to differentiate between groups. Referring to Lawler et al. (2014), who also did not report group differences in this global rating, we assume that children’s responses to the stranger (during stranger greetings, toy offering, and play invitation) assessed with these scales may tap normal variations of sociability.

Assessing a number of additional social behaviors during the standardized stranger approach, Lawler and her colleagues identified two major factors underlying children’s behavior. The global rating on children’s social approach behavior just described as well as, for example, verbal contact items were found to load on what they called the non-physical factor. In contrast, another factor mainly defined by physical contact items showed to differentiate between children with a background of institutionalization and control group. Consequently, it was interpreted as a marker of abnormal social behavior.

Interestingly, and in line with our expectations, foster children actually displayed more physical intimacy towards the stranger than control children in the current study. However, groups additionally differed regarding non-physical items (i.e., communication towards the stranger). More precisely, compared to control children foster children initiated verbal contact with the stranger more frequently and communication was performed on a more intimate level. These differences have already been reported in children adopted from institutions and adopted out of foster care (Bruce et al., 2009). Interestingly, in Lawler et al.’s study the amount of children sharing personal information with the stranger was generally lower (0-4%) than in our study (23-31%). In contrast, physical intimacy during the stranger approach, however, was indeed more pronounced in Lawler et al.’s study. There, the amount of children eliciting contact on a low level was quite high (11-49%), while
in our study, physical contact was not even observed on a low level, rather did children use physical contact as a tool.

There are several possible explanations for these different findings. First, it is generally difficult to decide at which level physical contact is regarded as a violation of social boundaries when comparing different samples. In fact, in Lawler et al.’s study adoptees stem from different cultural backgrounds and also they were younger than our foster care sample (26-39 months). Second, it is noteworthy that they have found children to initiate contact on an intimate level and even to invade the stranger’s privacy when following the child’s behavior throughout the entire 1.5 hr. lab session. Thus, children may be more inhibited when entering the novel environment and longer observations may be needed to capture the full range of behaviors. Indeed, as indicated from single observations in our study more intimate physical contact may be observed when coding the child’s behavior throughout entire sessions (also see Zimmermann, 2015). Third, it should be noted, that Lawler et al. (2014)—like other studies— found group differences to be driven by a small sample of previously institutionalized children that scored especially high on physical contact items. Also, physical contact was reported to decrease with time in the foster home. Thus, fourth, in our foster care sample, it may be that, after 1 year in the foster home what marks the difference between groups is more subtle than the initiation of intimate physical contact, however, nevertheless noteworthy.

Summing up, we have found evidence that foster children were more likely than control children to verbally engage with a stranger in the (foster) mother’s presence. These behaviors may lead foster mothers to be more likely to report a lack of reticence towards strangers, as we have found to be true referring to (foster) mother’s report of children’s behavior assessed with the DAI. Also, foster children displayed more physical contact towards the stranger, even though mainly for instrumental purposes. Overall, within the current study it cannot be concluded that differences between foster children’s and control children’s responses towards the stranger represent abnormal behaviors in terms of severe disturbances. In contrast, the findings indicate specific behavioral tendencies that are more pronounced in foster children and, consequently, may lead to irritation on the side of the foster mother as well as unfamiliar social partners.

Attachment-exploration balance. The previous reported findings could show that foster children were able to form an attachment relationship towards their foster mother that was comparable to control children with respect to attachment security. However, compared to control children, we found the nature of this relationship to clearly differ in terms of increased dependency as well as DSE behaviors towards strangers. To clarify the interrelatedness and functions of these behavioral systems in foster children and control children, both groups were rated regarding attachment behavior towards mother, looking behavior towards the stranger, and exploratory behavior. Given the
stimulative nature of the novel situation providing different behavioral options (to engage with the stranger, explore the toys being offered, but also to check back and initiate or maintain closeness to the caregiver) we expected to be able to observe differential behavioral tendencies in both groups. Our analyses confirmed the appropriateness of this procedure as all of the three behavioral variables systematically varied as a function of phase, suggesting activations and deactivations of different behavioral systems that were triggered by the gradual stranger approach. Attachment behaviors were elicited during the stranger’s greeting and the toy offering, suggesting an activation of the attachment system. Still, children kept exploring on a low level, however, the stranger’s invitation to play together seemed to activate the exploratory system and simultaneously deactivate the attachment behavior system in all children. These findings fit well with what has been hypothesized by attachment theory. Interestingly, foster children were more likely to display attachment behaviors towards their foster mother resembling an increased need for physical proximity to her.

There were no group differences regarding children’s exploratory behavior. This means that foster children and control children equally explored the new environment, yet, for foster children, this only seemed to be possible within spatial boundaries: They kept reassuring the mother’s presence and were less likely to venture forth away from her. This means foster children’s exploration was equally activated and they could make use of their (foster) mother as a secure base from which to explore. However they appeared to need more proximity to get a sufficient extent of security that enables them to do so.

It’s highly interesting, that during the stranger approach foster children were also significantly more likely than control children to display enhanced looking behavior towards the stranger. While control children only displayed a low invariable level of looking behavior towards the stranger, foster children showed a different pattern. Especially during toy offering they showed enhanced looking behavior directed toward the stranger, who was instructed not to engage with the child during this phase. The meaning of this behavior is not easily understood, in fact, there are several interpretations.

The first one would be irritation by unexpected changes in the environment. Indeed, the toy offering phase is ambiguous in nature as the child is being approached by an unfamiliar adult, however, the stranger sitting back on the chair interrupts the initiated interaction. Thus, it is possible, that while control children may be less likely to pay attention to this irregularities in a regulative attempt, foster children may be highly unsettled by this uncommon social approach.

As another explanation, increased looking towards the stranger may, second, be interpreted as a sign of vigilance that is a result of experiencing a threatening caregiving environment and unpredictable changes of the attachment figures behavior. Watching the stranger can then be seen as an attempt to surveille her actions and detect possible threat by social partners.
Third, however, referring to the concept of DSE towards strangers, increased looking at the stranger may be interpreted as heightened interest in what the stranger is doing. Regarding our findings on frequent verbal initiations displayed by foster children, looking at the stranger may be an attempt to engage with her. Thus, they may simply await another approach by the stranger to get the chance to get in contact with her.

Notably, these explanations do not have to be mutually exclusive. With regard to our findings on increased attachment behaviors it may be possible that the stranger elicits both, wariness as well as sociability behaviors. Following this interpretation, foster children, after 1 year in the foster home may still be in a transitional phase. Being in the process to integrate in a broader social network in an appropriate way may elicit apparently contradictory behaviors simultaneously. Indeed, the sociability and the wariness system have shown to be coupled in two year old normative developing children as well (Marvin & Greenberg, 1982). Thus, foster children’s behavior may represent some kind of delay in the attunement of behavioral systems.

On the whole, we do not know how the interplay of behavioral systems will develop with advanced time in the foster home and further research would be necessary to answer this question. However, referring to our findings, what can be said for sure is that being approached by a stranger elicits heightened attention in foster children, but also, that the caregiver plays a significant role in regulating the child’s behavior in such novel situations.

Behavior during free play with the (foster) mother and free play with the stranger

Aware of the fact that the same behaviors may have different meaning depending on the context, specific aspects of (foster) children’s interactional behavior were examined in a subsequent assessment, namely free play with (foster) mother and free play with stranger respectively. In our previous analyses, (self-initiated) communicative behavior and looking behavior towards the play partner have both found to be enhanced behavioral reactions during the stranger approach in foster children, but not control children. Thus, we investigated how much (foster) children made use of these behaviors during free play with the stranger on the one hand, and, during free play with their (foster) mother, on the other. There were three major findings regarding the assessment of children’s looking behavior towards the play partner. First, in contrast to what has been expected with regard to foster children’s looking towards the stranger in the waiting room procedure, we were surprised to find control children to be more likely to look at the stranger as compared to foster children. However, when playing with the (foster) mother, control children did not look at her as much as foster children. Second, control children were more likely to look at the stranger for a longer amount of time than they were looking at their mother when playing with her. In contrast, foster children,
third, did not elicit differential looking behaviors depending on whether they were playing with their foster mother or the stranger.

The findings support the notion that foster children pay increased attention to their foster mother, who has, as indicated above, shown to be an important source of psychological security in novel situations. Also, foster children are less experienced in interacting with the (foster) mother which may lead to increased interest in what she will do next. Control children, however, are used to engage in interaction with their mother from early on, hence, her behavior may be more predictable.

In contrast, interacting with an unfamiliar adult, may elicit heightened attention and interest in control children. Also, interacting with a stranger may demand increased effort by, for instance, signaling interest in joint play. Foster children, however, seem to be more reticent in watching the stranger during this dyadic interaction. This may be interpreted as a sign of foster children’s ambivalence towards strangers that has been mentioned above. Moreover, it is possible, that (foster) children in the mother’s presence felt more confident to watch the stranger (or explore the unfamiliar situation) while when being left alone with her, stranger wariness may have increased. This may have hindered them to directly look at the stranger or even initiate eye contact with her. This interpretation is in line with the assumption that foster children need the foster mother to be close in order to freely explore the environment. In contrast, in control children, the absence of the mother may finally raise interest in the other person. Moreover, the mother leaving the child alone with the stranger may have signaled them that they are safe and encouraged them to interact with the stranger.

Regarding the amount of self-initiated talk our results indicated that in both groups children did not talk to the stranger for an extended amount of time, which is in contrast to at least what has been reported for foster children’s responses during stranger approach. Again, it has to be noted, that both situations clearly differed in nature and it is possible that, similar to looking behavior, the absence of the mother may inhibit self-initiated talk in foster children, who clearly approached the stranger verbally in the waiting room procedure. Also, in play with the mother, control children displayed self-initiated talk for a longer amount of time than foster children, which may be a sign of their increased familiarity with the situation.

Overall, our findings suggest foster children to be rather inhibited during freely structured play sessions. This is especially evident when comparing their behavior to the preceding waiting room procedure, where they clearly initiated contact with both the foster mother and the stranger. Thus, foster children, initially seemed to elicit more extreme behaviors, which may have been provoked by the novelty of the situation and an accompanying arousal that they might have trouble regulating. The control group, however, seemed to show the inverse pattern. While they were more reticent during the waiting room procedure and, thus, more socially adjusted, they seemed to come “out of their shell” with increasing familiarization. Finally, they showed an age-appropriate interest in the
unfamiliar adult, while still restricting some behaviors (i.e., ongoing self-initiated talk) to the interaction with the mother.

4.4.3 How are attachment security, dependency and reports of disinhibited social engagement related to (foster) children’s overt interactional behaviors

Finally, we examined the relationship between the more global key constructs attachment security, dependency, and (foster) mother’s report of DSE on the one hand, and, (foster) children’s behavioral responses towards (foster) mother and a stranger assessed during the waiting room procedure, on the other hand. Interestingly, attachment security was not related to any of the behavioral variables suggesting that the rating of the quality of attachment defines a more complex construct that can only be explained by the interplay of different behaviors rather than their quantity. There were no correlations between attachment security and attachment behaviors, which, however, were strongly associated with dependency towards the (foster) mother.

This finding provides further evidence for the clear distinction between attachment security and dependency (Ainsworth, 1972). Furthermore, dependency was positively related to looking behavior towards the unfamiliar adult. Taking into account the positive relationship between dependency and attachment behavior suggests that the attachment behavior system and the stranger sociability system or wariness system are somehow coupled, which has already been found in younger preschool children (Greenberg & Marvin, 1982). Also, age controlled correlations suggested that more dependent children inhibit exploratory behavior when being approached by a stranger. Thus, children who depend more on their mother seemed to be more sensitive to the presence of strangers, however, the current data does not allow drawing conclusions on the direction of this effect.

Regarding retrospectively reported signs of DSE and the broad rating of disinhibited social approach within the waiting room procedure the correlation was not significant. This is in line with our previous findings, suggesting the measure to be insensitive to the discrimination between foster group and the control group. However, there were clear associations between (foster) mother’s report of DSE and other directly observed DSE behaviors, namely the level of physical intimacy, and the frequency of verbal initiations the child made during the session. Further positive relations were also found with regard to children’s looking behavior towards the unfamiliar adult. These correlations suggest acceptable construct validity, but, again, raise the question of the role of looking behavior in social interactions. Future research may address this question, for now, we may generate the hypotheses, that within ambiguous social situations looking behavior towards the stranger may be characteristic of an enhanced sensitivity to social cues. This sensitivity may, on the one hand, provoke inadequate disinhibited behavior towards social partners, on the other hand, it may elicit an increased need for proximity to familiar persons, both reflecting deficits in self-regulatory capacities.
4.4.4 Summary

The first category of findings to be summarized here, refers to the foster mother-child relationship. Compared to a control sample, foster children were as to be securely attached, but showed enhanced dependency within the attachment relationship as well as increased attachment behaviors when being approached by a stranger. Thus, foster children’s demand for help and reassurance has been shown to be remarkably present in two different contexts. There are several explanations for this phenomenon that are not mutually exclusive.

First, enhanced attachment behaviors may result from previous negative experiences in the sense that children are intimidated by the presence of the stranger and afraid of what may happen in the novel environment. Then, proximity seeking may be an indicator of the child’s attachment to his/her foster mother while clearly discriminating between her and the stranger. Second, it could be possible, that control children were also irritated by the stranger approach, but were more confident of the mother’s presence, indicating that foster children’s attachment relationship to their foster mother is still in a transitional phase. Thus, keeping in mind that by theory, the organizational structure of the attachment system develops along a “developmental sequence from basic attachment behaviors […] to a representational organization later on.” (Spangler & Zimmermann, 1999, p.270) it is possible, that after 1 year in the foster home children have not yet internalized the foster mother as a secure base. Indeed, it is a central tenet of attachment theory that with the formation of inner working models children develop strategies that operate on a representational rather than a behavioral level. This means that, as the caregiver’s actions become more predictable, the child needs to refer to him/her less. This increasing mental autonomy allows the child to venture forth and explore his/her social world. Enhanced attachment behaviors occurring at a later developmental stage (as we have found in foster children), however, may be indicative of a less sophisticated way to maintain psychological security within novel situations, resembling strategies displayed by younger children. This view is supported by the negative correlation between age and dependency. If the assumption is true, attachment behaviors would increase with time spent in the foster home. However, at least in our study, 1 year in the foster did not appear sufficient to result in a decrease of these behaviors, and longer periods of experiencing the foster mother as a reliable attachment figure may be necessary. Interestingly, Sorce and Emde (1981) found 15-month olds to increasingly seek proximity to their mother in novel situations, when she was currently not emotionally available. Thus, third, in foster children, ongoing experiences of unresponsive caregivers within the birth family may have entrenched itself in this dependent behavioral pattern. Taken together these assumptions, it is suggested that, on the background of early adverse experiences dependency and increased attachment behaviors may serve different developmental functions than in normative development and could be understood as a sign of current behavioral reorganization (see Sroufe, 1979). Finally, positive effects
of these behaviors probably may be that they allow they strengthen the newly formed relationship by making the foster parent feel needed and related to the child, and, furthermore, it enables the child to catch up on experiences of a close intimate relationship to a reliable attachment figure.

Indeed, regarding our findings on dependency it is hard to draw theoretical implications as with the rise of attachment theory the construct has majorly been set aside and neglected by developmental research. Consequently, there is a void in the literature regarding the development of dependency in normative as well as high-risk samples. However, including a control sample supported our finding that heightened dependent behaviors observed in foster children may be a phenomenon that characterizes the newly formed attachment relationship on the background of experiences of caregiving discontinuity and the loss of a primary attachment figure.

The second category of findings refers to children’s behavior towards strangers. Regarding foster children’s DSE, we have found foster children to show more disinhibited behaviors towards strangers, which could be interpreted as an adaptive response to children’s uncertainty of who will be there to care for them (Chisholm, 1998). However, considering children’s dependency as well as their attachment relationship to foster mothers, viewing strangers as potential caregivers does not seem a necessity that serves a biological function in the current environment. Thus, it may be relic-like behavior that originally stems from early experiences of deficient care that tends to last despite having lost its adaptive function. However, the current study did not aim to explain the etiology of these behaviors. After all, without doubt, these behaviors clearly reflect children’s confusion on their own relatedness within the social network and also on the ambiguity of the function of unfamiliar adults. Furthermore, it could be argued that non-normative experiences during the attunement of behavioral systems may have led to dysfunctions regarding the interplay of behavioral systems in terms of their regulatory functions (see O’Connor et al., 2003, p.34). Consequently, some social situations may overwhelm children’s resources of behavioral organization leading the dysregulated behavioral responses described above.

Even though there were distinct group differences regarding children’s social behavior like minor violations of social boundaries, we also provided some evidence suggesting that foster children begin to adapt to the new home environment and as well as social situations. This is, foster children do not necessarily show extreme abnormalities in social interactions (e.g., in terms of physical intimacy with the stranger or a lack of back-checking with the foster mother). Also, during free play sessions foster children social behavior appeared to be more reticent. Indeed, the foster mother’s absence and presence seems to have a strong impact on children’s behavior. Repeating experiences of the caregiver’s availability may lead to more self-reliance necessary to engage with the social environment in a way that does not overwhelm the child’s resources for interaction. Thus, inherent
behavioral systems may have the potential to balance out so that more sophisticated strategies to interact with the environment can arise. Future research should address this issue when investigating foster children’s socio-emotional development across childhood or even adolescence.

To sum up, we could show that the attachment relationship between (foster) mother and child is distinctively different in nature as compared to children raised by their biological parent. Foster children were more likely to display DSE behaviors, furthermore, we could identify some of the behavioral correlates of the construct. Moreover, we detected atypical patterns regarding the interplay between behavioral systems that were unique to foster children and that were not captured by traditional measures of attachment security per se. These findings are especially interesting as they add important knowledge regarding the nature of newly formed attachment relationships on the background of adverse social experiences. As a practical implication based on our observations we aim to emphasize the inevitable necessity of the foster parent to contingently provide a secure base instead of solely focusing on a perceived unrelatedness indicated by foster children’s atypical social behaviors.
4.4.5 Limitations

The study has several limitations. First, some of the results only represent tendencies, which means that statistical power of findings is somewhat limited. Also, we included 46 children, but the number of foster children was relatively small (n = 16). This uneven distribution was due to the study design. To get a comparison group for all data collected in the original Erlangen sample of foster children that was assessed longitudinally, an equally high number of control children was recruited concordantly. However, as foster children form a highly vulnerable sample, a substantial number of foster parents refused to attend any additional measuring beyond the 1 year assessment. In a drop-out analysis, however, we showed that the remaining sample of foster children did not differ from the original sample, neither in age, nor in any of the central study variables, nor in mental health status. In our statistical analyses we paid additional attention to the fact that data from small samples is especially sensitive to extreme values and that distributions are often non-parametric and adequate analyses were performed accordingly. Consequently, we expect significant results to be due neither to characteristics of the reduced sample nor to statistical artifacts.

However, it cannot be excluded that foster families’ characteristics and thus, recent caregiving experiences within the foster family might be substantially different across countries, but also when comparing foster families with biological control families. In fact, in the current sample foster mother’s often reported to already have raised own children, and thus, had a different parenting background than mother’s in the control sample. Furthermore, foster and control children significantly differed regarding their educational background. Hence, children may not only have experienced different caregiving environments during the early years, but also during the previous year. Indeed, the longitudinal study revealed that attachment security was significantly influenced by foster mother’s sensitivity and parenting style (Gabler et al., 2014, Lang 2014). Lang (2014) compared foster parents and mothers from the current sample of control children regarding parenting behaviors, but it only differed at the beginning of foster care. Thus, we do not expect parenting behaviors to account for group differences in the current study.

Further methodological limitations refer to our behavioral observations. For example, we did not include (foster) mother’s or the stranger’s behavior at any point of the study. In fact, it has been shown, that at least in infants- stranger behavior varies depending on the child’s age, which in turn affects children’s reactions (Mangelsdorf, 1992). However, in our study there were two research assistants acting as the unfamiliar adult randomly assigned to assessments. Furthermore, they were instructed to behave in a semi-standardized manner. In our assessment of the child’s communicative behavior towards the stranger in both the waiting room as well as the free play sessions, we controlled for experimenter effects by excluding responses to the stranger’s questions and only rated children’s self-initiated talk. A more general concern, however, refers to the fact of the stranger
consistently being young and female. Consequently, it cannot be said how children would behave towards adult males or older adults in general, but this is a general problem that refers to the major of studies including mother-stranger interactions. As we were interested in behavioral differences towards mother and stranger, here, it seemed plausible to not vary the gender of the interaction partner.

Studies on the etiology of DSE in foster children often include other behavioral correlates like temperament as well as certain characteristics on the foster child’s side (e.g., contact with birth family, age at placement, placement history). The current study, however, did not intend to reveal any of these relationships; rather did it focus on the nature of children’s behavioral organization as compared to control children. A detailed analysis of predictors of DSE in the original sample can be found elsewhere (Zimmermann, 2015).

Finally, in our detailed investigation of different behavioral systems, we have found foster children to display resistant behavioral patterns, some of which cannot be considered evolutionary useful adaptive responses to children’s current environment (i.e., DSE). Including data on the neural correlates potentially underlying these behaviors may represent another step towards the understanding of socio-emotional development in children at risk. Thus, in the following chapter, attachment security and other behavioral variables were related to neurophysiological data on social-information processing in the current sample of foster and control children.
Chapter 5: Neural Correlates of Facial Familiarity Processing in Foster Children and a Control Group

“The behavioral system includes not only its outward manifestations but also an inner organization presumably rooted in neurophysiological processes. This inner organization is subject to developmental change not only because it is under genetic guidance but also because it is sensitive to environmental influences. As the inner organization changes in the course of development, so do the outwardly observable behavioral manifestations and the situations in which they evoked.”

(Ainsworth, 1989, p.709f)

Almost three decades ago, Mary Ainsworth made these assumptions and, thereby, anticipated what is of major interest in current research: the convergence between traditional and neurobiological approaches to investigate the mechanisms underlying development. With this statement she also drew a line to Greenough et al.’s (1987) concept of genetically driven experience-expectant and experience-dependent processes (see Chapter 1). More precisely, it is theorized that there is a phylogenetically anchored attachment system that provides the infant with primary attachment strategies (e.g., proximity seeking) to establish repeated infant-caregiver interactions that result in the formation of an attachment relationship (Bowlby, 1982). However, the organism depends on individual experiences to be programmed in a way that increase the likelihood of surviving in a given environment. Thus, the attachment system is sensitive to the caregiving environment, which is reflected in secondary strategies (e.g., hyperactivation or deactivation of the attachment behavior system; Mikulincer & Shaver, 2010, p.22). Such adaptive responses come into effect when the infant is not optimally responded to. Following Ainsworth’s suggestions this inner organization of the infant’s social world is believed to operate at the level of neural circuits underlying behavior in social interactions.

Interestingly, the formation of attachment relationships is closely tied to the infant’s capacity to visually discriminate between caregiver and stranger faces (see Chapter 4). Thus, by examining the neural responses to facial familiarity we might reveal some of the neurophysiological processes that drive the activation of behavioral systems in interactions with caregiver and strangers. This approach is especially promising to the investigation of socio-emotional functioning in high-risk children, who have outlived a series of negative social experiences during a phase of rapid neural development (see section 1.3).
5.1 Theory

In this section, I will outline evidence for infant’s preparedness to face recognition and briefly explain underlying neuroanatomical systems. Furthermore, I will report findings from behavioral and neurophysiological studies on the discrimination of facial familiarity and elaborate the use of ERPs to caregiver and stranger faces in attachment research. Arguing that facial familiarity processing can serve as an indicator of children’s socio-emotional function I will report findings from studies with normative as well as high-risk samples, address gaps in the literature and present our research questions.

5.1.1 Theoretical Background: Important Aspects of Face Processing

The early stages of face processing

At birth, infants’ visual abilities are fairly limited and only provide them with a blurry view of their surroundings. However, from early on, infants are attracted to patterned shapes and the spatial frequency they can see rapidly increases over the first 3 months of life (Atkinson, 1995; Fantz, 1961, both cited in Bruce & Young, 2011). In his early investigations on infant visual acuity, Fantz (1961) also found 4-day-old infants to show a preference for face-like patterns over scrambled face patterns. Using a different methodological approach, this was confirmed in a well-known study by Goren, Sarty, and Wu (1975), who have found this preference in infants even as soon as 9 minutes after birth. More than a decade later, Johnson, Dziurawiec, Ellis, and Morton (1991), who used a variety of stimuli, partially replicated and extended these findings in newborns within the first hour of life. Subsequent studies tested the generalizability of these findings by, for example, examining the effects of face inversion (e.g., Mondloch et al., 1999) or contrast polarity (Farroni et al., 2005; Mondloch et al., 1999).

Bruce and Young (2011) concluded that infants indeed are attracted to face-like patterns soon after birth and suggested this preparedness to respond to faces may resemble an “innate releasing mechanism” that possibly serves an evolutionary function by driving the development of social interactions —especially those between infant and caregiver (Bruce & Young, 2011, p.365).

However, this assumption has been challenged by Simion, Cassia, Turati, and Valenza (2003) claiming that faces do not represent special stimuli in infant vision. Reviewing numerous face preference studies they argue that, at birth, infants might simply prefer a specific alignment of elements (e.g., patterns with more features in their top-half than in the bottom half) even when compared to more face-like stimuli (but see also Chien, 2011). Others claim that infants do not prefer faces per se but their underlying characteristics (e.g., visibility, contrast) that just happen to best fit
their limited visual abilities (see Bruce & Young, 2011). However, all of these explanations are not necessarily mutually exclusive. Finally, considering these skeptic voices Bruce and Young, (2011) conclude that even though infants’ attraction to faces may only reflect “coincident independent pattern preferences…”, it is more likely that they are inherently prepared to respond to objects that look a “bit like faces because itself confers some kind of benefit” (p.366). Most importantly, this bias—even if non-specific— might be sufficient to trigger and guide the infant’s specialization in face-processing by providing opportunities to learn about faces and the many aspects of social information they contain (also see Turati, 2004).

Regarding the memory of faces, studies investigating infants at an average of 50 hours after birth suggest that the infant’s ability to recognize the mother’s face emerges promptly after birth and requires very little exposure (Bushnell, 2001; Bushnell, Sai, & Mullin, 1989; Field, Cohen, Garcia, & Greenberg, 1984; Pascalis, de Schonen, Morton, Deruelle, & Fabre-Grenet, 1995; Walton, Bower, & Bower, 1992). However, the preference for the mother’s face strengthens with the amount of time the infant effectively spent with the mother (Bushnell, 2001). In addition, as infants are likely to orient towards the source of a sound from birth, voices play an important role in facilitating the process of becoming familiarized with the caregiver’s face (Mills & Melhuish, 1974; Sai, 2005). These studies provide evidence, that the ability to discriminate familiar and unfamiliar faces is driven by continuous and enriched early interactions, or in other words: experience.

Before taking a closer look on the role of experience of individual face processing in the course of postnatal learning, it should be noted that even though the newborn’s ability to recognize his/her mother’s face soon after birth is both impressive and intuitively plausible, it qualitatively differs from subsequent developmental stages. In fact, some studies found that face discrimination in infancy mainly depends on large, external features like hairstyle (Bushnell, 2003; Pascalis et al., 1995; but see Turati, 2008), and that this does not change before the second month of life (Bartrip, Morton, & De Schonen, 2001). Also, Johnson and de Haan (2001) claimed that regarding cortical specification it is only around the third month of life that facial representations, and thus, preferences for individual faces, become more adult like. At this age, children also start to become more sensitive to social information like the face’s gender and emotional expression, and their ability to discriminate familiar and unfamiliar faces becomes more robust (see Nelson, 2001). Based on evidence from ERP studies it can be said that at least 6 months after birth infants are able to discriminate between mother’s and stranger’s face (de Haan & Nelson, 1997) as well as faces and objects (de Haan & Nelson, 1999).
The role of experience in the discrimination of individual faces

There are numerous behavioral as well as neuropsychological studies—including some on atypical development—that provide evidence that the development of face recognition is highly influenced by early experiences (see Moulson, Westerlund, Fox, Zeanah, & Nelson, 2009). Reviewing numerous further studies on face recognition Nelson (2001) proposes that its development is an experience-expectant process (see Greenough et al., 1987). The central tenet of experience-expectant learning is that, at birth, relevant synaptic connections are already in place and that experience (here: exposure to faces) is needed to strengthen them and ensure their survival. Thus, at a very early stage, the brain is prepared to perceive specific visual input in order to establish the neural pathways fundamental to face recognition. Moreover, studies on early visual deprivation (e.g., in people born with cataracts, Le Grand et al, 2003) even suggest that for the related brain system to reach its full capacity the occurrence of certain experience within an early particular time period is crucial (Nelson, 2001, p.14). Once the system is set, it is assumed that specialization takes place. At this point, experience-dependent processes take over, allowing for individual experiences to shape, for example, an individual’s ability to discriminate facial familiarity or emotion expressions. Thereby, the face recognition system becomes attuned to a given social environment (for a discussion of alternative models see Nelson, 2001).

Regarding children’s socio-emotional development this adaptive function becomes strikingly evident. Certainly, as the infant’s social world expands it becomes an increasing necessity for him/her to identify the persons to whom he/she belongs and who care for him/her (de Haan & Carver, 2013). In a series of experiments Quinn, Yahr, Kuhn, Slater, and Pascalis (2002) found that 3- to 4-month-old infants show a spontaneous visual preference for female faces. Most notably, however, they could also show that infants, whose primary caregiver was male, and who, consequently, were less exposed to female faces, do not show this preference.

Another phenomenon in this context is referred to as “perceptual narrowing” (Pascalis, de Haan, & Nelson, 2002, p.1321), which emerges in the first year of life and applies to a number of perceptual and cognitive functions (e.g., speech, see Werker & Tees, 2005): According to this, infant’s regular interpersonal experiences facilitate the recognition and discrimination of faces that are encountered frequently and thus, are common in their environment. However, due to cortical specialization this goes along with a gradual decline in this capacity when it comes to less common faces (Nelson, 2001). Empirical evidence for this adaptive process comes from infant studies using stimuli that show faces from different species (Pascalis, de Haan, & Nelson, 2002) as well as different races (Kelly et al., 2007, but see Spangler et al., 2013). In the former study, 6-month olds showed to be capable of discriminating both human and monkey faces, while 9-month olds and
adults, however, showed a disadvantage as they were only able to discriminate faces of their own species. Interestingly, this effect could be prevented by regularly exposing the infant to monkey faces, again, emphasizing the crucial role of early experiences (Pascalis et al., 2005).

Also, regarding facial emotion processing, Pollak and colleagues could show that increased exposure to negative emotions are associated with a bias towards threatening or angry faces in maltreated children using behavioral (e.g., Pollak & Kistler, 2002; Pollak & Sinha, 2002; Pollak & Tolley-Schell, 2003) as well as neurophysiological methods (Pollak et al., 2001). They interpreted this bias as an adaptive mechanism as children growing up in abusive households may need to be more vigilant and alert to signals of threat that might occur rather unpredictably. In addition, under certain circumstances children from abusive households also showed heightened attention for sad faces (Romens & Pollak, 2012) and a threat related bias has also been associated with a diagnosis of PTSD in maltreated children (Pine et al., 2005). On a more general level, there is evidence, that the quality of the emotional environment affects the development of infants’ responses to facial emotion expressions even in non-abusive households (de Haan et al., 2004; Taylor-Colls & Pasco Fearon, 2015).

Taken together, these findings show that early experiences from repeated interactions with the caregiver influence the individual development of face processing. Furthermore, the visual system’s openness to experiences seems to serve an adaptive function.

The neuroanatomy of face processing

The recognition and processing of faces plays a central role in the regulation of social interactions as it conveys a range of different information required for the evaluation of the social environment. Indeed, information about one’s relationship with the other is retrieved „at a glance“ and provides the basis of any ongoing interaction. On a neurophysiological level, recognizing a face activates a network of person knowledge based on previous experience with the person and elicits an automatic emotional appraisal (Haxby & Gobbini, 2011).

Thus, it is obvious that, as proposed by Haxby (Haxby, 2001; Haxby & Gobbini, 2011) there is a rather distributed anatomical system including several brain areas that are engaged in facial processing. In their revised model, Haxby and Gobbini (2011) distinguish a “core” and an “extended system” for face perception (p.93). More precisely, they proposed that three dominant areas in the occipitotemporal extrastriate visual cortex (along with nearby cortices) constitute the core system: the inferior occipital gyrus (occipital face area, OFA), the lateral fusiform gyrus (fusiform face area, FFA), and the posterior superior temporal sulcus (pSTS). This core system is thought to be involved in the perception of faces, which comprises two distinct classes operations: the analyses of invariant
features relevant for identity recognition and of changeable features (e.g., eye gaze) that represent facial gesture (for a discussion see Haxby & Gobbini, 2011). Even though the core system is involved in the encoding of facial familiarity, brain areas constituting the “extended system” are central to the retrieval of person knowledge and the emotional response to that person. As an illustration, Gobbini, Leibenluft, Santiago, and Haxby (2004) found that areas associated with mentalizing (i.e., the medial prefrontal cortex, MPFC, and the temporoparietal junction, TPJ), show stronger responses to personally important as compared to famous or stranger faces, however, they are not affected by only visually familiar (“familiarized”) faces. Furthermore, they found the amygdala and insula to respond stronger to stranger as compared to familiar faces, which, here, might reflect an initial wariness towards strangers, but may generally relate to the faces’ salience. Interestingly, mothers have been found to show an increased amygdala response to their own children as compared to other children; which indicates that these neural processes are also linked to attachment (Leibenluft, Gobbini, Harrison, & Haxby, 2004). Furthermore, the posterior cingulate cortex and precuneus (PCC/PC) as well as other anterior regions seem to play a role in the retrieval of episodic memories that are connected to the familiar person (for an overview see Haxby & Gobbini, 2011). Taken together these brain areas constitute a distributed network involved in familiar face recognition and processing.

These findings from neuroimaging studies provide great knowledge about the localization and functions of areas involved in face processing, still, they cannot inform about its time-course. In the current study, we chose an ERP approach to investigate children’s facial familiarity processing mainly for practical reasons. However, the method also has the advantage of excellent temporal solution, and thus, can illustrate how neurocognitive processes in response to faces unfold over time (de Haan, Johnson, & Halit, 2007).
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5.1.2 Face-sensitive ERP components in infancy and childhood

There are several ERP components that are related to face processing in infancy and childhood and the list presented here is not exhaustive. For the current study, we selected three well-studied components that can reliably be identified in preschoolers, to examine individual differences at different stages in the time-course of social information processing (see Todd et al., 2008). The P1 is a visually evoked component that has shown to be affected by the experience of early adverse rearing backgrounds. Furthermore, the Negative Central (Nc) and the N170 have repeatedly been found to be specifically sensitive to facial familiarity as well as aspects of social-emotional development in children (Carver et al., 2003; Dai et al., 2014; Moulson, Westerlund, et al., 2009; Parker & Nelson, 2005a; Swingler et al., 2007, 2010; Todd et al., 2008).

Overview of ERP components sensitive to facial processing in infancy and childhood

The ERPs of interest here reflect changes in brain activity that is recorded up to approximately 600 ms after the onset of a face stimulus, a time which already reflects varying neural processes. This temporal sequence starts at the level of encoding of visual features and leads to the retrieval of semantic information like person knowledge and emotional content activating a number of specific areas in the brain (Haxby & Gobbini, 2011). To illustrate this progress I will present the components in order of their chronological occurrence after the onset of the face stimulus.

P1

By approximately 100 ms following the onset of a visual stimulus, a positive deflection distributed over occipital electrode sites can reliably be observed from birth onward (e.g., Nelson & McCleery, 2008). The so-called P1 has repeatedly been reported in studies on face processing in infants (de Haan & Nelson, 1999), children (Carver et al., 2003; Mesquita et al., 2015; Moulson, Westerlund, et al., 2009; Taylor et al., 2004; Taylor, Edmonds, McCarthy, & Allison, 2001; Todd et al., 2008), as well as adults (e.g., Halit, de Haan, & Johnson, 2000; Itier, 2004), and is particularly likely to be sensitive to faces by 4 years of age (Itier, 2004; Taylor et al., 2004, 2001). However, it is unclear to which degree the processes underlying the P1 are specifically sensitive to faces as a distinct class of stimuli (see de Haan et al., 2003). Even though the P1 might possibly reflect an early stage of facial encoding as it is sensitive to low-level individual differences between faces and non-face stimuli (Rossion & Caharel, 2011), it is suggested that the activation of face representations in the brain does only appear at a later stage reflected by a negative component following the P1, namely the N170 (Rossion & Jacques, 2012).
The N170 is an occipital-temporal component and usually defined as the first negative peak following the P1. It was first related to facial processing in a series of experiments conducted by Bentin, Allison, Puce, Perez and McCarthy (1996). By now, the N170 has appeared in more than 200 studies that have investigated various aspects of human face-processing (Eimer, 2011), and there is consistent evidence that the adult N170 is sensitive to faces as compared to non-face stimuli (for an overview of the N170 “face effect” see Rossion & Jacques, 2012). Studies aiming to locate the source of the N170 yielded different findings and suggested activity in lateral occipitotemporal areas (e.g., the occipital face area, OFA; the fusiform face area, FFA; and the posterior superior temporal sulcus, STS) to underlie the component. This wide distribution is partly due to methodological issues, but also suggests that the N170 is generated by a number of brain processes operating simultaneously (see Eimer, 2011, p.229ff).

Occurring at longer latencies than in adults the N170 has also reliably been observed in children by 4 years of age (Kuefner, Heering, Jacques, Palmero-Soler, & Rossion, 2010; Taylor, McCarthy, Saliba, & Degiovanni, 1999; Todd et al., 2008). Additionally, studies of face processing in younger age groups commonly report two other face-sensitive components, namely the N290 and the P400, which are both said to become more fine-tuned to human faces with age and have been proposed as precursors of the adult-like N170 (see de Haan et al., 2003).

Facial Familiarity. It still seems to be a topic of debate whether the N170 is sensitive to facial familiarity. There is evidence suggesting that it reflects an advanced stage of the structural encoding of faces, which, however, precedes the recognition of facial identity (Eimer, 2000b). This view is supported by studies that did not find the N170 (but later ERPs) to be modulated by facial familiarity when familiarity was primed (Bentin & Deouell, 2000; Eimer, 2000a; Schweinberger, Pickering, Esther, Jentzsch, Burton, & Kaufmann, Jürgen, 2002). However, some findings are inconsistent with this claim and suggest processing at this stage to be more elaborate. For example, other priming studies have shown its susceptibility to top-down cognitive processes (e.g., Jemel, Pisani, Calabria, Crommelinck, & Bruyer, 2003). Regarding “truly” familiar faces, there is evidence that personal importance is likely to affect the N170 response (Caharel et al., 2002; Caharel, Courtau, Bernard, Lalonde, & Rebai, 2005; Caharel, Fiori, Bernard, Lalonde, & Rebai, 2006; Mesquita et al., 2015). As an example, Caharel et al., (2005) found N170 amplitudes to be larger in response to personally important faces (mother’s face, subject’s own face) than to less important faces (famous faces, unknown faces). The authors suggested that personally important faces activate robust representations in the brain that have evolved due to frequent exposure referred to as “optimal
perceptual learning” (Caharel et al., 2005, p.99). Studies investigating the N170 familiarity effect in children are scarce, the N170 appears to discriminate between caregiver and stranger faces (Dai et al., 2014; Parker & Nelson, 2005; Todd et al., 2008). To sum up, there is evidence that the N170 might be modulated by facial familiarity in children as well as adults, especially when they are of personal importance, however, the nature of processes driving the effect (and determining its direction) remains unclear.

\[ \text{Nc} \]

Finally, the Nc represents a well-studied component in the face-processing literature that differs from the components that have just been described in several ways. It is prominent in the fronto-central area of the scalp and is a mid-latency component occurring at approximately 550 ms. Also, it is not specifically related to face-processing, rather is it affected by stimulus probability as shown in the oddball paradigm\(^{15}\) (e.g., Courchesne, Ganz, & Norcia, 1981; Reynolds & Richards, 2005). However, as it appears to reflect the allocation of attentional resources in response to salient or interesting stimuli (de Haan & Nelson, 1997; Nelson, 1994), it is of major interest when studying the individual processing of faces that are assumed to vary in salience during the course of development.

\textit{Facial familiarity.} The Nc component has shown to discriminate between familiar and unfamiliar objects and familiar and unfamiliar faces in infants and preschoolers (Carver et al., 2003; Dawson et al., 2002; de Haan & Nelson, 1997, 1999; Moulson, Westerlund, et al., 2009; Todd et al., 2008; Webb et al., 2011). This familiarity effect, however, only occurs when stimuli are “truly familiar” rather than familiarized during a laboratory session (see Carver et al., 2003, p.149). Consequently, in line with what has been said above, the Nc component does not appear to reflect familiarity per se but the allocation of attentional resources elicited by stimulus salience. However, in infants the primary caregiver’s face is likely to represent both the more familiar as well as the more salient stimulus (see Todd et al., 2008). Studies with different age groups support this view as they show a qualitative changes in the Nc response over the first years of life (see section 5.1.3), which are likely to reflect a developmental shift relative to the changing salience of the caregiver’s and a stranger’s face.

\(^{15}\) the oddball paradigm is an experimental design where one stimulus is presented frequently (standard) and another stimulus is presented infrequently (oddball)
5.1.3 ERP Evidence for Individual Differences in Facial Familiarity Processing

*Facial familiarity processing and the developing infant–caregiver relationship*

The few ERP studies that have been conducted in the field give rise to the assumption that the neural correlates of caregiver and stranger face processing clearly relate to important aspects of normative socio-emotional development.

The Nc is of major interest in this field as it is associated with the attention children draw to a specific face stimulus. As mentioned above, it has been found to be larger in response to the mother’s face as compared to a stranger’s face in 6-month-old infants (de Haan & Nelson, 1997, 1999) as well as in typically developing—but not autistic—toddlers aged 12 to 17 months (Webb et al., 2011). Interestingly, older children seem to elicit larger Nc amplitude responses to a stranger’s face as compared to the mother’s face (Carver et al., 2003; Dawson et al., 2002; Moulson, Westerlund, et al., 2009; Todd et al., 2008).

The few major studies that have systematically investigated these developmental changes in Nc responses to mother and stranger faces stem from Leslie Carver’s research group. First, Carver et al. (2003) collected ERP data from toddlers assigned to three different age groups (18- to 24-months/24- to 45-months/45- to 54 month) using a passive viewing paradigm. Beside the typical pattern of Nc amplitude responses in the younger and the older age group, they have found the intermediate age group to not discriminate between the two faces. In a subsequent study Swingler (2008) examined 28- to 40-month-old toddlers, which regarding the salience of faces was proposed to be a transitional phase. However, her results give rise to the assumption, that toddlers continue to show heightened attention to the mother’s face for a longer period as previously suggested by Carver et al. (2003) and that the salience of faces, and thus, the neural responses they elicit vacillate frequently during the early years. Regarding both studies the authors proposed that these age-related changes in neural response patterns occur in conjunction with the formation of the child-caregiver attachment relationship (see Bowlby, 1982), and the child’s attentional focus increasingly shifting from the mother to a broader social world.

Interestingly, Swingler also extended Carver et al.’s work by directly relating neural responses to both faces to concrete behavioral variables the toddlers displayed during interaction with the mother (i.e., affect, attachment behaviors, play behaviors). Her main finding was that distress in separation from the mother was related to an increase in Nc amplitude responses to her face (Swingler, 2008). Furthermore, in another study, Swingler, Sweet, and Carver (2007) observed 6-months olds during a series of separations and reunions from the mother as this age marks the time point when the attachment relationship begins to consolidate. It was hypothesized that the progress in this transition, as reflected by a behavioral preference for the mother, will be related to a pronounced discrimination
of the mother’s from a stranger’s face. After building a composite out of ten distinct infant behaviors they found that enhanced proximity seeking was related to smaller Nc amplitudes in response to the mothers face. Furthermore, these behaviors were associated with larger Nc amplitudes to the strangers face, indicating a heightened attentional processing for processing the unfamiliar face (Swingler et al., 2007). The authors suggested that the findings reflect qualitative changes in behavioral systems like the attachment and exploratory system and, which could be added, the wariness system. Based on the same data, Swingler et al. (2010) published another study where they extracted three specific behaviors (distress upon separation, looking behavior upon separation and upon reunion). Infants, who displayed more distress upon separation from the mother showed larger P400 and (depending on hemisphere) larger Nc amplitudes to the mother’s face. Interestingly, increased looking behavior (i.e., visual search for mother when she was absent) was related to shorter latencies in both components, but not to their amplitude responses. This finding indicates that the speed of recognizing and processing a face is related to its current salience.

Taken together, this whole line of research provides preliminary evidence that developmental changes in the caregiver–child relationship are not only verifiable in outwardly observable behavior in interaction with the mother, but also in the neural responses to her and a stranger’s face. Furthermore, it suggests a direct relationship between both developmental domains.

Notably, the above studies have only theoretically implied the salience of familiar and unfamiliar persons, however, no study to date has directly investigated children’s behavioral and neural responses to caregivers and strangers at the same time. Also, even though it has been proposed that social information is processed differently depending on attachment security (Dykas & Cassidy, 2011), to our best knowledge there is no study that has related the quality of the attachment relationship (i.e., children’s attachment security) to mother and stranger face processing.
Facial familiarity processing in children from adverse rearing environments

The Bucharest Early Intervention project (BEIP, for a comprehensive overview see Nelson, Fox, & Zeanah, 2014) is a large scale investigation of the effects of early psychosocial deprivation. Moulson and colleagues (2009)\(^\text{16}\) collected ERP data from currently institutionalized, never-institutionalized and previously institutionalized children placed in foster care while passively viewing pictures of their primary caregiver’s and a stranger’s face. In total, the experiment was repeated at three measuring points within 42 months. There were three major findings to the investigation.

First, in response to all faces, institutionalized children elicited smaller amplitudes than non-institutionalized children. Although the effect was only consistently present for the early visually evoked potential P1 (in terms of statistical significance), waveforms indicated that other occipital components (P400, N170) were equally affected. Similar alterations of ERP amplitudes were found during a facial emotion expression task for the same sample. Also, Kishiyama, Boyce, Jimenez, Perry, and Knight (2009) found children with a low-SES background (as a possible indicator for early deprivation) to elicit smaller ERP amplitudes at occipital and central electrode sites as compared to high-SES children. Together with non-ERP studies (Tarullo, 2008, Marshall & Fox, 2004, Otero, 1997; Pliego-Rivero et al., 2003) the authors claim that this finding supports the assumption that early social deprivation—and, as a consequence, a lack of an appropriately stimulating environment—might lead to persistent cortical hypoarousal (also see Moulson, 2009).

Second, previously institutionalized children placed in foster care did show some—but not full—recovery regarding the dampened ERP amplitudes to faces. However, there was no effect of timing of intervention on ERP outcomes, and thus, the “existence and timing of sensitive periods in this developmental domain” remained subject to discussion (Moulson, Westerlund, et al., 2009, p.1052). Moreover, the third finding was rather surprising. In fact, despite the dramatically different caregiving background of institutionalized and never-institutionalized children groups did not differ in response to the caregiver and stranger faces at fronto-central sites (e.g., Nc), but to some extent at occipital sites (e.g., N170). However, findings were inconsistent across measurement points. It is surprising, however, that there were no significant interactions between group and facial type as—in terms of salience and prior exposure—caregiver and stranger faces are unlikely to be equal in institutionalized and non-institutionalized children.

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\(^{16}\) First results were presented by Parker 2005. However, I will focus on data reported by Moulson, 2009, who present data from the same sample (with an increased sample size) including 2 follow-up measurements. It should be noted, however, that findings from both studies are at least partly inconsistent.
Addressing this non-finding, in a recent study, Mesquita et al. (2015) investigated children’s facial familiarity processing in a sample of 3- to 6-year-old children currently living in Portuguese institutions. They extended the Bucharest findings by taking into account disordered child behavior and thereby found variations in institutionalized children’s response to familiar and unfamiliar faces. In particular, they report evidence that children displaying atypical social behavior are more likely than typically functioning children to elicit smaller P1 amplitudes in response to faces. Moreover, they also compared children showing two distinct atypical behavioral patterns, namely indiscriminant and inhibited attachment. Interestingly, inhibited children appeared to elicit larger N170 amplitudes to their caregiver’s face while the indiscriminant group failed to show a differential response to caregiver’s vs. stranger’s face in this early component. Even though the authors consider the latter finding to be exploratory, this study adds major evidence that it might not be institutionalization per se, but individual behavioral outcomes associated with early social experiences that affect children’s neural processing.

To conclude, by now, all we know about the impact of adverse rearing environments on facial familiarity processing is based on these two studies, and thus, exclusively stems from data assessed in (previously) institutionalized children. Furthermore, even though Mesquita et al. (2015) have considered the influence of atypical behavior, only a sub-sample of institutionalized children formed the “typical behavior” comparison group. Also, they relied on caregiver reports of children’s behavior. Finally, there is a gap in the literature regarding studies that investigate overt behavioral and neural responses to familiar and unfamiliar persons in children with different family rearing backgrounds.

5.1.4 Aims of the current study

Knowledge about the linkage between early adverse social experiences and children’s neural responses to social stimuli predominantly derives from studies measuring ERPs to facial emotion expression in maltreated (e.g., Pollak et al., 2001) and previously institutionalized children (Moulson, Fox, et al., 2009). Effects of early experiences on facial familiarity processing, however, have only been investigated in previously institutionalized samples (Mesquita et al., 2015; Moulson, Westerlund, et al., 2009). Given its potential relationship with important aspects of the caregiver–child attachment relationship (e.g., Swingler et al., 2010), the assessment of the neural processing of caregiver and stranger faces may provide insights that can be crucial to our understanding of socio-emotional development in foster children, especially with regard to persistent patterns of aberrant social behavior towards strangers (e.g., Oosterman & Schuengel, 2008).

To begin with, applying an ERP approach holds the possibility to gain knowledge on the time course of face processing (e.g., Todd et al., 2008). Thus, before addressing our three major research
questions I will briefly outline several pre-assumptions regarding the effects of facial familiarity on visually evoked potentials (P1, N170, Nc) within this time-course that are based on previous studies. It has been suggested that the P1 reflects low-level processes of visual perception (e.g., Rossion & Jacques, 2012), while the discrimination of familiar and unfamiliar faces has only been shown to occur at a later stage, namely the N170 time window (e.g., Todd et al., 2008). The Nc, representing even more advanced cognitive processing, has shown to be associated with attentional processing (e.g., Reynolds & Richards, 2005), and consequently, has been shown to be affected by the personal relevance of faces (e.g., Carver et al., 2003). Thus, we assumed the N170 and the Nc amplitude responses to be affected by facial familiarity.

Our first major aim was to compare foster children’s neural processing of facial familiarity to an age matched control sample. In previously institutionalized children, P1 amplitudes have been found to be dampened (e.g., Mesquita et al., 2015; Moulson, Westerlund, et al., 2009), however, this issue has not yet been addressed in foster children without a history of institutionalization. Since the degree of deprivation may be less severe in foster children as compared to institutionalized children, we did not necessarily expect basic visual functions (as represented by the P1 amplitude response) to be impaired in foster children as well. However, the N170 has shown to be affected by prolonged exposure to a particular face (e.g., Caharel et al., 2002). Since foster children were not exposed to their foster mother’s face as long as control children were exposed to their biological mother’s face, consequently, we expected the effect of facial familiarity to vary with group status. Regarding the Nc studies suggest that recruitment of attentional resources results in larger amplitude responses to either the caregiver or the stranger’s face depending on aspect of socio-emotional development (e.g., Carver et al., 2003; Swingler et al., 2007). Since our previous findings suggest that during social interactions foster children clearly differ from control children in response to a stranger on a behavioral level (e.g., disinhibited social engagement, DSE, see Chapter 4), we expected Nc amplitude responses during facial familiarity processing to substantially differ in foster children as compared to control children. Thus, the first research question asked how neural responses to (foster) mother and stranger faces would differ with regard to group status and face type.
Our second major aim was to investigate effects of attachment security on facial familiarity processing in foster and control children. As suggested by Spangler and Zimmermann (1999) “including the physiological processes in addition to the psychological processes enables us” to gain further knowledge on “the function of the inner working model with respect to processes that are not accessible by verbal communication and that are not expressed through overt behavior.” (p.270). However, to our best knowledge, the studies conducted by Carver, Swingler, and their research group are the only studies relating changes in the attachment relationship (Carver et al., 2003) and attachment relevant behaviors (Swingler et al., 2007, 2010) to brain responses during mother-stranger face processing. Their findings suggest that ERP measures of facial familiarity processing can provide an insight to the inner organization that regulates the attachment system and underlies individual differences beyond age-related changes in behavior towards caregiver and strangers (Swingler et al., 2007, 2010).

To date, there has been no study investigating associations between the quality of the attachment relationship and ERP data in children neither in high-risk nor in normative samples. Given this void in the literature, we did not predict certain neural response patterns. However, based on attachment theory and previous research, several assumption were made. In line with what has been described above, we did not expect to find an effect of attachment as early as the P1 time window. However, referring to the N170’s sensitivity to facial familiarity, and thus, previous exposure to a particular face, we expected the quality of caregiving experiences (indexed by attachment security) to affect face processing as early as the N170 time window. Securely attached children are by theory likely to have frequently engaged in interactions, and thus, face to face contact with their caregiver, which was expected to result in different N170 amplitude responses to both faces. Also, as the attachment system is believed to regulate not only the child’s psychological but also physiological processes related to his/her social world (Spangler & Zimmermann, 1999), the attention drawn to familiar and unfamiliar faces, as represented by Nc amplitude responses, was expected to differ in securely attached children as compared to insecurely attached children.

Furthermore, we regard the neurophysiological measure of facial familiarity processing as a useful tool for the investigation of the newly established foster mother–child relationship. Previous findings suggest that foster children do not differ from control children with regard to attachment security (see Chapter 4). However, this attachment relationship may substantially differ from the bond between children and their biological caregivers and not serve the same developmental functions (Lyons-Ruth, 2015). Thus, we addressed the question whether attachment security would equally be related to facial familiarity processing in both foster children and control children. In brief, the second research question asked how foster and control children’s neural responses to (foster) mother and stranger faces are affected by attachment security.
Third, and finally, in an exploratory approach we were interested in associations between children’s behavioral and neural responses to caregivers and strangers. The only studies we know of that have directly correlated socio-emotional behavior during mother-stranger interactions with neural correlates of facial familiarity processing stem from two younger-aged normative samples (Swingler et al., 2007, 2010; Swingler, 2008). Here, peak amplitude and latency responses (with the latter referring to processing speed) have shown to be related to several behavioral variables. The current research aimed to extent these findings by investigating the relationship between behavioral and neural responses to person familiarity in foster and control children. Thus, in our third research question we asked how attachment behavior towards the (foster) mother and looking behavior towards the stranger would relate to Nc and N170 amplitude as well as latency responses in our preschool-aged sample.
Chapter 5: Neural Correlates of Facial Familiarity Processing in Foster Children and a Control Group

5.2 Methods

5.2.1 Participants

Foster care sample

The final foster sample included in the ERP analyses consisted of 13 foster children (8 male/5 female). Three more children were tested but excluded from further analyses due to non-compliance during the application of the cap \( n = 1 \), removal of the cap during the experiment \( n = 1 \) or an insufficient number of artifact-free trials \( n = 1 \). In cases where technical problems occurred before the experiment started, children could be re-assessed shortly after and still be included in the final sample \( n = 2 \). Foster children’s age ranged from 39 to 76 months \( (M = 53.67, SD = 11.98) \).

Control sample

For the ERP study the sample of children living with their biological mother consisted of 24 children (10 male/14 female) aged 41-70 months \( (M = 56.58, SD = 9.04) \). Another six children were tested but weren’t included in the final analysis because of technical problems occurring during the experiment \( n = 3 \), the child refusing to wear the cap \( n = 1 \), or because they did not provide a sufficient number of artifact free trials due to excessive movement or inattentiveness \( n = 2 \).

Foster children and control children included in the ERP analyses neither differed in age, \( t(35) = .28 \), ns, nor attachment security, \( t(35) = .22 \), ns. For a detailed description of the overall sample see Chapter 3.

5.2.2 Measures

Behavioral data

For analyses of relations between behavioral and neurophysiological data selected variables were derived from the behavioral part of the study (Chapter 4). More precisely, we used the AQS attachment security score to investigate the influence of attachment on the processing of (foster) mother\(^{17}\) and stranger faces. Furthermore, looking behavior towards the stranger and attachment behavior towards the mother were included to test relations with amplitude and latency responses in the face-sensitive components N170 and Nc.

\(^{17}\) For reasons of simplicity “(foster) mother” will be referred to as “mother” throughout the method and result section.
Across the total sample attachment security ranged from -.10 to .60 ($M = .32$, $SD = .19$) with a median of $Md = .35$. To compare children scoring high on attachment security with those who were rated less securely attached the total sample was split at the median leading to two groups. Table 14 shows that the distribution of children assigned to insecure or secure was comparable in foster and control children. Note that we use the terms secure and insecure for children scoring above and, respectively, below the sample median in the AQS attachment security rating. However, this may not necessarily resemble the traditional classification introduced by Mary Ainsworth (e.g., Ainsworth et al., 1978).

Table 14

<table>
<thead>
<tr>
<th>AQS Security Score and Frequency of Securely and Insecurely Attached Children by Group in Numbers. Pearson’s Chi² Test Results</th>
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</thead>
<tbody>
<tr>
<td>Attachment group</td>
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<tr>
<td>------------------</td>
</tr>
<tr>
<td>Secure</td>
</tr>
<tr>
<td>Insecure</td>
</tr>
</tbody>
</table>

**Neurophysiological data**

**Procedure**

The EEG assessment took place at the laboratory visit subsequently to the behavioral session. The experimenter explained the application procedure and took some time to familiarize the child to the EEG equipment. Knowing the child’s circumference in advance allowed to prepare an appropriate size cap (ActiCap, Brain Products, Gilching, Germany) while the behavioral session was still running. The child’s head then was measured to determine the vertex’s position and the cap was fitted accordingly. Then, the experimenter injected gel in each electrode using a syringe and gently rubbed the scalp to allow sufficient contact and lower impedances accordingly. Scalp impedances were ideally kept below 15 kΩ, however 15 to 30 kΩ was graded acceptable in some cases. The average scalp impedance was 6.74 kΩ, ($SD = 2.83$ kΩ) across all participants. One electrode was placed underneath the child’s right eye to record electro-ocular artifacts.

The child was seated in front of a computer screen that was surrounded by a blue shielding to block the child’s view of the room. One experimenter stood next to the child and led him/her through the session. Another experimenter was sitting behind a curtain operating the recording and observing the child via a webcam that was mounted on the monitor the child was looking at. To simplify subsequent artifact detection she manually set marker whenever the child blinked, looked away or talked. The child’s mother was also present in the room but told to remain silent and stay out of the child’s focus. She was, however, allowed to encourage the child during breaks.
**EEG recording**

EEG and EOG data were collected using 32 active electrode channels. Electrodes were placed in standard positions according to the international 10-20 system. EEG was recorded from Fp1, Fp2, Fz, F3, F4, F7, F8, FC1, FC2, FC6, Cz, C3, C4, T7, T8, CP1, CP2, CP5, CP6, TP9, TP10, Pz, P3, P4, P7, P8, Oz, O1, O2, PO9, PO10. One electrode was placed under the child’s right eye and used for EOG recordings. In cases where children refused the application of the EOG (n = 6) the electrode was put in position FC5. In all other cases, FC5 was interpolated offline. Electrode AFz served as the ground and FCz as the online reference. The signal was amplified with a gain of 20,000 continuously recorded with a sampling rate of 250Hz (BrainAmp amplifier, Brain Products, Gilching, Germany). Stimuli were presented via a second computer using an experiment generating software (Inquisit 3, Millisecond Software, Seattle, Washington). Both computers were interfaced so that onset, offset and type of stimuli could manually be marked in the continuous EEG/EOG documentation for offline segmentation. During testing filters were applied so that only a bandwidth ranging from 0.01 to 100Hz was recorded.

**Assessment and analysis of Event-Related Potentials**

**Stimuli.** Each child’s mother was photographed at their visit to the laboratory at the University of Erlangen-Nuremberg. Pictures of their faces were taken against a blue background while sitting in an upright position and looking straight into the camera. Mothers were told to put on a friendly face but not show their teeth while smiling. Photographs were then imported into Adobe Photoshop 5.0 were they were cropped and placed on a grey background layer. Also, all color information was removed and images were adjusted in figure-ground ratio, position, contrast and lightning if necessary. In addition to the mother’s face the unfamiliar face stimulus (stranger) was randomly selected from a pool of stimuli processed with pictures of other female participants from the same study; however, pictures of mothers who wore glasses were always paired together. To maintain a foveal angle of 7.9° x 6.6°, and thus, minimizing eye movement picture size on screen was 9 cm x 7.5 cm at a distance of 65 cm.

**ERP data collection.** ERPs were recorded while children were shown facial images of their mother or a stranger. In this experiment each trial consisted of a 300 ms fixation period during which a small yellow star appeared in the center of the screen followed by the presentation of the stimulus (mother/stranger) for 700 ms and a post-stimulus recording period of 600 ms during which the screen was black. The subsequent intertrial interval varied randomly between 500 and 1000 ms. The
presentation of stimuli was semi-randomized, not allowing for more than 3 stimuli of the same face type (mother vs. stranger) to appear in a row and the frequency of appearance was counterbalanced with 80 trials per condition. The experiment consisted of 8 blocks of 20 trials each allowing for small breaks in between blocks. The end of each block was indicated by the appearance of a colorful comic. To motivate children to keep their attention focused on the screen they were told to wait for the comic and tell the experimenter when it appears. After each block children received tokens (stickers) that could be traded into a present afterwards. The ERP testing was over after the total of 160 trials or when the child became too fuzzy to focus.

The average number of trials that could be used for further analyses was 38.97 (SD = 13.10) per condition. The number of trials did not significantly differ neither between conditions ($M_{\text{mother}} = 37.97, SD = 13.93; M_{\text{stranger}} = 39.97, SD = 13.32$), $t(36) = -1.62, p = \text{ns}$, nor between groups ($M_{\text{control group}} = 41.31, SD=13.79; M_{\text{foster group}} = 34.65, SD = 10.9$), $t(35) = 1.50, p = \text{ns}$. The number of trials is comparable to other studies using a similar paradigm in this age group (e.g., Carver et al., 2003).

**ERP editing and reduction.** Data was edited offline using BrainVision Analyzer (Version 2.4., Brain Products, Gilching, Germany). First, a raw data inspection was made manually to take out intervals were eye movement artifacts occurred. To detect these artifacts markers that were set during the testing were used for orientation and typical patterns in the EOG and the frontopolar electrodes (Fp1/2) were identified visually. Subsequently, a 0.30Hz high-pass, a 30Hz low-pass filter, and a 60Hz notch filter (all having a 24dB/oct gradient) were applied offline. When necessary bad channels were replaced via interpolation by spherical splines (order of splines = 4), a reliable method that uses information from all other channels to compute a new channel. The average number of replaced channels was .88 ($SD = 1.66$) across all participants. The continuous data then was re-referenced to the average signal (average reference), and the implicit online reference was reused as channel FCz. After segmenting data by mother and stranger condition we ran an automatic artifact rejection not allowing for voltage steps of more than 100 µV (gradient criterion), differences of two values in one segment of more than 150 µV (difference criterion) and/or an amplitude exceeding 100 µV or falling below -100 µV respectively (amplitude criterion). Segments including at least one affected channel were removed. Since we showed a fixation cross for 300 ms prior to the actual stimulus we chose the interval from -500ms to -300 ms for subsequent baseline correction. This way we made sure, that activity elicited by the fixation cross did not affect the actual baseline. After that, we calculated a grand average for each condition (mother/stranger). Participants whose data provided less than 15 remaining segments per condition were not included in further analyses.
**ERP measures.** To detect components of interest we drew assumptions based on the literature and visually inspected the grand average waveforms to select electrodes where peaks were most prominent. Next, peak information (amplitude in mV, latency in ms) specified for each component and subject was extracted. Finally, peak latency\(^{18}\) and mean amplitude values of +1 sampling point around the designated individual peak were exported into the data analysing software SPSS 23.0. Note that unlike the P1, the Nc and the N170 are negative going components, therefore, more negative amplitudes indicate a larger response.

ERP component scoring. The P1, indicated by a positive deflection, was defined as the maximum positive peak at occipital sites occurring between 80 and 220 ms. To detect possible hemisphere effects both O1 (left hemisphere) and O2 (right hemisphere) were included in the analyses. Furthermore, the N170 was defined as the most negative peak distributed over posterior electrode sites occurring between 150 and 370 ms after stimulus onset. It was found to be most prominent at parietal-occipital sites PO9 (left hemisphere) and PO10 (right hemisphere). Finally, in accordance with the literature, the Nc was defined as the most negative peak at fronto-central electrode-sites occurring between 250 and 520 ms after stimulus onset following an earlier negative peak. Previous studies with young children have found the Nc to be prominent over distributed scalp regions and have included a number of electrodes (e.g., Carver et al., 2003; Swingler et al., 2007). In the current study, we have followed this approach for detailed analyses of effects. We found the negative deflection to be prominent over midline leads Fz, FCz, Cz, and, the lateral lead pairs F3/4, C3/4\(^{19}\). Table 15 gives an overview of electrode sites for scoring the P1, N170, and Nc, and Figure 7 shows their position on the scalp.

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\(^{18}\) Peak latency was only included in correlational analyses of associations between neural and behavioral variables

\(^{19}\) Note that in our study FC1/2, that are closely located to the online reference, in several cases appeared as flat lines (possibly due to bridging of the gel) and, therefore, were not included in the analyses
Table 15
Electrode Sites Used for Scoring Components and Referring Within-Subjects Factors (Hemisphere, Lead Position)

<table>
<thead>
<tr>
<th>Component</th>
<th>Lead position</th>
<th>Hemisphere</th>
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<tbody>
<tr>
<td></td>
<td>left</td>
<td>right</td>
</tr>
<tr>
<td>P1</td>
<td>O1</td>
<td>O2</td>
</tr>
<tr>
<td>N170</td>
<td>PO9</td>
<td>PO10</td>
</tr>
<tr>
<td>Nc</td>
<td>frontal</td>
<td>F3</td>
</tr>
<tr>
<td></td>
<td>frontocentral</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>central</td>
<td>C3</td>
</tr>
</tbody>
</table>

Figure 7. Electrode placement according to the 10-20 system. Colored electrode sites represent leads included in the analyses of P1 (orange), N170 (yellow), and Nc (blue).
5.2.3 Analysis plan and statistical considerations

To examine our first research question on differences in foster children and control children, neural patterns of facial familiarity processing brain electrical activity of the P1, the N170 and the Nc component’s peak amplitude in response to mother and stranger faces were separately subjected to a repeated measure design. Repeated measure ANOVAs were conducted with group status (foster group, control group) as the between-subjects factor and face type (mother, stranger) as the within-subjects factor. In previous studies on facial familiarity processing in children several effects were found at single lead locations only (e.g., Carver et al., 2003; Parker & Nelson, 2005b; Swingler et al., 2010). Thus, we included electrode site as an additional within-subjects factor referred to as hemisphere (left, right) and/or lead position (frontal, fronto-central, central) as depicted in Table 15. Consequently, when the main analysis showed interaction effects including hemisphere and/or lead position, during post-hoc testing ANOVAs were not only applied for each group separately, but also for certain locations at the scalp. This exploratory procedure allowed us to identify and locate effects more precisely. Regarding the second research question on effects of attachment security on (foster) children’s facial familiarity processing the same procedure was performed. Here, the dichotomized variable attachment security (insecure, secure) was included as an additional between-subjects factor beside group status, considering the possibility of interaction effects between those variables. ERP amplitude responses were not correlated with age, and, as mentioned above, control and foster children did not differ regarding age at the time of the ERP assessment. Thus, it was not assumed necessary to include age as a covariate in the analyses. The third research question on brain-behavior associations was investigated by correlating each component amplitude and latency responses with two previously selected continuous behavioral variables.

Statistical analyses were carried out using IBM SPSS 23.0. The assumption of normal distributions was confirmed on all ERP variables by Kolmogorov Smirnov’s test. Mauchly’s test was used to validate the use of repeated measures ANOVAs. If the assumption of sphericity was violated, Greenhouse Geisser correction was applied to correct the degrees of freedom. In the main analyses, partial eta squares were used as a measure of effect sizes indicated as \( \eta_p^2 \) (see 4.4.4). The design of follow-up analyses was dependent on the data structure and comprised t-tests as well as ANOVAs. Post-hoc pairwise comparisons made upon more than two categories were Bonferroni corrected. Correlational analyses including behavioral variables were performed using Spearman’s Rho, as these were not normally distributed. All assumptions were tested two-sided and statistical significance was defined as a \( p \leq .05 \), while alpha errors ranging from .05 to .1 indicate tendencies.
5.3 Results

In the following, results are presented in order of the research questions in three separate sections. First, differences between foster children and control children ERP amplitude responses to both faces were investigated, and, second, securely attached and insecurely attached (foster) children were compared regarding these responses. All findings are listed separately for each of the three components of interest, namely P1, N170 and Nc. Descriptive data for each component can be found in the Appendix. Here, each component’s amplitude response is shown, first, by group (Appendix A), and, second, by attachment status (Appendix B). Third, we report findings regarding our research question on associations between neural correlates of facial familiarity processing and children’s behavioral responses during social interactions including both the components’ amplitude as well as their latency responses.

5.3.1 Differences between foster and control children

In this section, I report results regarding our first research question on differences between foster and control children’s ERP amplitude responses to mother and stranger faces. However, since previous research on effects of face type has shown inconsistencies, findings that do not include group status as a factor will be reported as well.

\[ P1 \text{ amplitude responses} \]

For P1 amplitude responses the 2 face type x 2 hemisphere x 2 group repeated measures MANOVA with Nc amplitude responses as the dependent variable revealed no significant effects, which means that foster children did not differ from control children regarding this component, and, that it was not sensitive to facial familiarity. Neither were there any differences regarding hemispheres.

\[ N170 \text{ amplitude responses} \]

The 2 face type x 2 hemisphere x 2 group repeated measures MANOVA with N170 amplitude as the dependent variable revealed several main and no interaction effects. Comparing foster and control children showed a significant difference between groups with mean values being larger (more negative) in the control group \((M = -1.87, SD = 4.99)\) than in the foster group \((M = 3.94, SD = 6.79)\), \(F(1,35) = 8.84, p = .005, \eta^2_p = .20\). Also, main effects for hemisphere and face type were significant. Mean values indicated that amplitudes, were larger on the left \((M = -3.61, SD = 6.50)\) than on the right hemisphere \((M = -1.12, SD = 5.20)\), \(F(1,35) = 5.36, p = .027, \eta^2_p = .13\). Regarding the main effect for face type, the mother face condition elicited larger amplitudes in all children regardless of
group status ($M_{mother} = -.88, SD = 6.53; M_{stranger} = 1.23, SD = 7.08$), $F(1,35) = 5.10, p = .030, \eta^2_p = .13$.

Figure 8 depicts the grand average waveforms for both groups in response to the mother’s and the stranger’s face at both the left and the right hemisphere.

![Figure 8. Grand average waveforms for N170 amplitude response (microvolt) to faces by group status and face type. Presented at lateral parietal-occipital leads PO9 (left hemisphere) and PO10 (right hemisphere).](image)

Importantly, we are aware that there seems to be a visually evoked potential, probably due to the presentation of the fixation cross starting at -300 ms (see Figure 8). The graph indicates that this waveform, which emerged prior to stimulus presentation, differed between both groups. Thus, it is not clear whether decreased amplitudes in foster children were specific to face processing. However, since the P1 component, which precedes the N170, did not show a main effect for group status it is likely that the effect is specific to face-sensitive processing represented by the N170 component. Still, results should be interpreted cautiously.
5.3 Results

Nc amplitude responses

To investigate whether foster and control children would show different responses to faces with regard to Nc amplitudes, separate analyses were conducted, first, for lateral leads, and, second, for midline leads (see method section). Figure 9 shows the grand average waveforms of the Nc response to mother and stranger faces in the control group and foster group at all relevant electrode sites.

Figure 9. Grand average waveforms for Nc amplitude responses (microvolts) to mother (orange) and stranger (blue) faces for the control group (left) and the foster group (right). All electrode sites relevant for the analyses are depicted (lateral leads: F3/4 and C3/4, midline leads: Fz/FCz/Cz).
**Lateral leads**

To analyze group effects at lateral leads, a 2 face type x 2 group x 2 hemisphere x 2 lead position repeated measures MANOVA was conducted. It revealed several main effects. Regarding group status, there was no significant main effect $F(1,35) = 1.54$, $p = \text{ns}$, and the main effect for face type only reached marginally significance, $F(1,35) = 2.78$, $p = .10$, $\eta_p^2 = .07$. There were, however, highly significant main effects for hemisphere $F(1,35) = 14.76$, $p = .000$, $\eta_p^2 = .30$, and lead position, $F(1,35) = 23.92$, $p = .000$, $\eta_p^2 = .41$. All main effects were qualified by a marginally significant interaction between face type, hemisphere, and lead position $F(1,35) = 3.70$, $p = .06$, $\eta_p^2 = .10$.

To reveal effects underlying the 3-way interaction, we conducted several separate analyses in an exploratory approach. First, we analyzed effects of lead position hence conducting separate analyses for frontal leads (F3/4) and central leads (C3/4). Second, we analyzed hemisphere effects, which means that we conducted separate repeated measures ANOVAs for leads located on the left (F3, C4) and leads located on the right (F4, C4) hemisphere. Since we did not have any pre-assumptions on which particular electrode sites effects would occur, all effects, including those that only emerged during post-hoc testing, will be reported.

First, when looking at the frontal lateral lead pair F3/4 only, there were no effects regarding group status. In accordance with the above findings, we found a significant main effect for hemisphere, $F(1,35) = 8.28$, $p = .007$, $\eta_p^2 = .19$, which was qualified by a marginally significant interaction between hemisphere and face type, $F(1,35) = 3.49$, $p = .07$, $\eta_p^2 = .09$. Further testing revealed, that, at the left hemisphere only, Nc amplitude responses in the stranger face condition were significantly larger than responses in the mother face condition ($M_{\text{stranger}} = -9.68$, $SD = 5.14$; $M_{\text{mother}} = -8.32$, $SD = 5.33$), $t(36) = -1.95$, $p = .06$.

Also, at the central lead pair C3/4 there was no significant main effect for group status, $F(1,35) = .25$, $p = \text{ns}$. Again, a main effect for hemisphere occurred, $F(1,35) = 10.44$, $p = .003$, $\eta_p^2 = .23$ with amplitudes being larger on the left ($M = -6.10$, $SD = 3.26$) than on the right hemisphere ($M = -4.60$, $SD = 3.71$). Furthermore, there was a marginally significant main effect for face type, $F(135) = 3.04$, $p = .09$, $\eta_p^2 = .08$, which was qualified by a significant interaction between face type and group status, $F(135) = 5.41$, $p = .03$, $\eta_p^2 = .13$. The interaction is visualized in Figure 10. Follow-up testing revealed that the foster group showed larger Nc responses in the stranger face condition ($M = -6.56$, $SD = 3.63$) than in the mother face condition ($M = -4.86$, $SD = 4.13$), $t(12) = 2.31$, $p = .04$, whereas the control group did not significantly discriminate between the two faces at central leads ($M_{\text{mother}} = -5.27$, $SD = 3.35$; $M_{\text{stranger}} = -5.03$, $SD = 3.12$), $t(23) = -.52$, $p = \text{ns}$.
Second, on the left hemisphere only, the above reported main effect for face type, that was found when including all lateral leads, reached significance, $F(1,33) = 4.83, p = .04, \eta^2 = .12$. However, it was qualified by a marginally significant interaction between face type and group, $F(1,33) = 3.48, p = .07, \eta^2 = .09$. Mean values indicated and follow-up $t$-tests confirmed that, again, the control group did not discriminate between faces ($M_{mother} = -6.95$, $SD = 3.12$, $M_{stranger} = -7.10$, $SD = 2.67$), $t(33) = .33, p = ns$, while the foster group tended to elicit larger Nc amplitude responses to the stranger face than to the mother’s face ($M_{mother} = -7.58$, $SD = 4.68$; $M_{stranger} = -9.47$, $SD = 4.96$), $t(12) = 2.05, p = .06$. As can be seen in Figure 11, there were no effects on the right hemisphere.

![Figure 10](image1.png)  
**Figure 10.** Nc amplitude responses in the mother and stranger face condition by group, collapsed over central leads C3/4. Means and standard errors. Note that scale is inverted.

![Figure 11](image2.png)  
**Figure 11:** Nc amplitude responses in the mother and stranger face condition at lateral leads for foster group and control group by hemisphere. Left hemisphere = averaged over F3/C3, and, right hemisphere = averaged over F4/C4. Means and standard errors. Note that scale is inverted.
To sum up, the main analysis for the Nc amplitude response at lateral leads showed, that collapsed over frontal and central leads group effects were mainly obscured. By conducting follow-up tests for both hemispheres separately, we found that, at the left hemisphere only, foster children elicited larger Nc amplitude responses to the stranger’s than to the mother’s face. Similarly, we found the same group and face type interaction effect at central leads while, at frontal leads, foster children and control children did not show differential neural processing patterns.

**Midline leads**

To analyze effects at midline leads, we included Nc amplitude responses at lead positions Fz, FCz, Cz. The 2 face type x 3 lead position x 2 group repeated measures MANOVA solely revealed a highly significant main effect for lead position, $F(2,70) = 13.14, p = .000$.

Post-hoc pairwise comparisons revealed that Nc amplitude responses were more negative at Fz ($M = -7.78, SD = 4.17$) as compared to FCz ($M = -6.61, SD = 3.78$) and Cz ($M = -5.22, SD = 3.91$) with all Bonferroni corrected pairwise comparisons being significant, $p < .01$. However, there were no other effects including group status or face type.
5.3.2 Effects of Attachment

To explore the role of the (foster) mother–child relationship in the neural response to mother’s and stranger’s face in the foster and control group we conducted our analyses in concordance with the previous section but included attachment security (secure, insecure) as an additional between-groups factor. As effects regarding all other factors have already been reported, and because this follows our research questions, only main effects of attachment as well as any two and three way interactions between attachment, face type, and group were of interest. As we have previously found effects to be lateralized, in case of an interaction including the factor hemisphere, we were looking at each hemisphere separately.

\textit{P1 amplitude responses}

Analyzing P1 amplitude responses, the 2 face type x 2 group x 2 attachment x 2 hemisphere repeated measures ANOVA revealed no significant main effect for attachment. However, two marginally significant 3-way interactions occurred. First, there was an interaction effect between hemisphere, face type and attachment, $F(1,35) = 3.38, p = .08, \eta_p^2 = .09$, and, second, the analysis revealed an interaction between hemisphere, group and attachment, $F(1,35) = 3.08, p = .09, \eta_p^2 = .09$.

Looking at each hemisphere separately, post hoc testing revealed that there were no effects on the left hemisphere, but on the right hemisphere. Here, securely attached children’s P1 amplitude responses were found to be sensitive to facial familiarity, $F(1,16) = 3.65, p = .07, \eta_p^2 = .19$, with mean values indicating that they elicited larger P1 amplitude responses to their mother’s as compared to the stranger’s face ($M_{mother} = 33.73, SD = 14.84; M_{stranger} = 31.54, SD = 14.63$). This right lateralized main effect for face type was not found in their insecurely attached counterparts, $F(1,17) = 1.42, p = \text{ns}$. The interaction between group and attachment, did not reach significance neither on the left nor on the right hemisphere, $F_{left}(1,33) = .06, p = \text{ns}$, and $F_{right}(1,33) = .50, p = \text{ns}$.

For reasons of completeness, we conducted further tests to reveal the second three way interaction reported above. Finally, it was found to be based on the effect that only securely attached children from the control, but not from the foster group elicited larger P1 amplitudes on the right ($M = 34.19, SD = 10.07$) as compared to the left hemisphere ($M = 31.48, SD = 9.78$), $F(1,12) = .5.52, p = .04, \eta_p^2 = .32$. 
**N170 amplitude responses**

For N170 amplitude responses, the 2 face type x 2 hemisphere x 2 attachment x 2 group repeated measures ANOVA revealed a significant main effect for attachment, $F(1,33) = 7.00$, $p = .017$, $\eta^2_p = .16$, but no interaction effects. Mean values indicated that regardless of face type and group status securely attached children elicited larger N170 responses ($M = -2.42$, $SD = 5.84$) than insecurely attached children ($M = 2.63$, $SD = 5.74$). This effect is visualized in Figure 12, which shows the grand average waveforms for the N170 response in securely as compared to insecurely attached children at both hemispheres (PO9, PO10) separately.

**Figure 12.** Grand average waveforms for N170 amplitude responses (microvolts) in securely (red) and insecurely (blue) attached children at electrodes PO9 (left hemisphere) and PO10 (right hemisphere). Collapsed over face type and group status.
5.3 Results

*Nc amplitude responses*

Figure 13 shows the Nc amplitude collapsed over faces and groups in securely and insecurely attached children at all electrode sites that were included in the analysis of the Nc amplitude response.

![Diagram of Nc amplitude responses](image)

**Figure 13.** Grand average waveforms for Nc amplitude responses (microvolts) in securely (red) and insecurely (blue) attached children. Collapsed over face type and group status. All electrode sites relevant for the analyses are depicted (Lateral leads: F3, F4, C3, C4, and midline leads: Fz, FCz, Cz).
Chapter 5: Neural Correlates of Facial Familiarity Processing in Foster Children and a Control Group

**Lateral leads**

To examine effects at lateral leads a 2 × 2 attachment × 2 group × 2 hemisphere × 2 lead position (frontal, central) repeated measures MANOVA was conducted. There was no evidence for a main effect of attachment on Nc amplitude responses at lateral leads, $F(1,33) = 1.90, p = \text{ns}$. However, apart from previous reported effects adding attachment to the analysis revealed marginally significant four way interactions between lead position, hemisphere, attachment and group, $F(1,33) = 3.89, p = .06, \eta^2_p = .11$, and, also between lead position, hemisphere, attachment and face type, $F(1,33) = 3.13, p = .09, \eta^2_p = .09$. To reduce the complexity of the analysis and for reasons of comparison we conducted separate analyses for both frontal and the central lateral lead pairs in accordance to our analyses in the previous section.

Testing effects at the frontal lateral lead pair F3/4 the repeated measures MANOVA revealed no evidence for a main effect of attachment, $F(1,33) = 1.09, \text{ns}$. However, a marginally significant interaction between attachment and hemisphere, $F(1,33) = 3.63, p = .07, \eta^2_p = .10$, occurred. This was qualified by a significant 3-way interaction between attachment, group and hemisphere, $F(1,33) = 5.54, p = .03, \eta^2_p = .14$.

Follow-up t-tests yielded no effects on the left hemisphere. On the right hemisphere, however, insecurely attached children tended to elicit larger Nc amplitude responses than securely attached children ($M_{\text{insecure}} = -8.94, SD = 3.85; M_{\text{secure}} = -6.62, SD = 3.89$), $F(1,33) = 2.90, p = .10, \eta^2_p = .08$. Still, the interaction between group and attachment, did not reach significance neither on the left nor on the right hemisphere, ($F_{\text{left}}(1,33) = .55, p = \text{ns}$, and $F_{\text{right}}(1,33) = .27, p = \text{ns}$). As we were not interested in any other interaction effects, no subsequent testing was performed.

At the central lateral lead pair C3/4 the 2 × 2 attachment × 2 group × 2 hemisphere repeated measures MANOVA yielded a marginally significant four-way interaction between all factors, $F(1,33) = 3.18, p = .08, \eta^2_p = .09$.

Post-hoc testing revealed that this interaction was due to a significant interaction of face type, attachment and group, $F(1,33) = 6.90, p = .01, \eta^2_p = .17$, that appeared on the left hemisphere only, while there were no effects on the right hemisphere. Interestingly, this 3-way interaction was congruently found at fronto-central/central midline leads. Thus, after reporting our analysis at midline leads, in an extra section, I will explain the interaction effect including all electrode sites that captured it.
5.3 Results

Midline leads

At midline leads, regarding the within-subject factor lead position, Mauchly’s test of sphericity was found to be significant, and thus, Greenhouse Geisser correction was applied where necessary. The 2 face type x 3 lead x 2 group x 2 attachment analysis yielded no main effect for attachment, $F(1,33) = 1.33, p = \text{ns}$. However, the graph depicted in Figure 14 suggested that mean values for secure and insecure children diverged getting from frontal to central scalp locations with securely attached children’s Nc amplitude responses decreasing. However, the assumed interaction between attachment and lead location did not reach significance, $F(1.20,39.42) = 2.63, \varepsilon = .60, p_{\text{adj}} = .11, \eta^2_p = .07$.

Thus, in an exploratory approach we used the graph as a guideline: As it indicated the FCz and Cz to be sensitive for effects of attachment, we ran another analysis with Nc amplitude response to mother and stranger faces at FCz/Cz as the dependent variable. Collapsed over FCz/Cz a well pronounced interaction between attachment and face type emerged, $F(1,33) = 5.27, p = .03, \eta^2_p = .14$. This interaction was qualified by a significant interaction between attachment, group and face type, $F(1,33) = 6.43, p = .02, \eta^2_p = .16$. Not finding these effects to be significant when including Fz suggests, that frontal and central leads reflect different neural processing patterns, an assumption that is in line with our previous findings regarding lead position\textsuperscript{20}.

![Figure 14](image)

**Figure 14.** Nc amplitude responses at Fz, FCZ, Cz, collapsed over face type and group status for insecurely (red) and securely (blue) attached children. Means and Standard Errors. Note that scale is inverted.

\textsuperscript{20} e.g., in section 5.3.1 we found that group status significantly interacted with face type at central leads only
Analyses of the interaction between face type, attachment and group at affected leads

Finding the three-way interaction to be prominent at the closely located electrode sites C3, Cz, FCz, we adapted our original analysis plan and built a composite over these leads. The following section will explain the three-way interaction at this newly built region of interest.

Running a 2 face type x 2 attachment x 2 group repeated measures ANOVA with Nc amplitude responses in the left lateralized region of interest, the 3-way interaction between face type, attachment, and group emerged and was found to be significant, $F(1,33) = 8.62, p = .01, \eta_p^2 = .21$. It qualified a significant interaction effect between attachment and face type, $F(1,33) = 6.39, p = .02, \eta_p^2 = .16$, and, face type and group, $F(1,33) = 9.39, p = .004, \eta_p^2 = .22$. The main effect for attachment did not reach significance, $F(1,33) = 2.58, p = .12$. An inspection of Figure 15, that shows the nature of the three way interaction, suggested different processing patterns that depended on group status.

**Figure 15.** Nc amplitude responses to mother’s and stranger’s face for securely and insecurely attached children in the foster and the control group (averaged over FCz, Cz, C3). Means and Standard Errors. Note that the scale is inverted.
Follow-up repeated measures ANOVAs for both groups separately confirmed that, in the control group only, insecurely attached children tended to elicit larger Nc amplitudes responses than securely attached children regardless of face type, $(M_{\text{insecure}} = -6.82, SD = 2.76; M_{\text{secure}} = -4.70, SD = 3.05)$, $F(1,22) = 3.28, p = .08, \eta^2 = .13$. In the foster group, the main effect for attachment was not significant, $F(1,11) = .48, p = \text{ns}$. This means, that in the foster group, attachment security did not “buffer” enhanced Nc amplitude responses. Instead, in foster children only, attachment significantly interacted with face type, $F(1,11) = 9.27, p = .011, \eta^2 = .46$. Post-hoc tests showed that, similar to the control group, insecurely attached foster children elicited enhanced Nc amplitudes in response to both the mother’s and the stranger’s face condition $(M_{\text{mother}} = -7.21, SD = 4.47; M_{\text{stranger}} = -7.18, SD = 2.74)$, without discriminating between face types, $t(7) = -9.03, p = \text{ns}$. Indeed, for securely attached foster children the graph shows relatively small Nc amplitude responses to the mother’s face $(M = -3.33, SD = 3.97)$, whereas their Nc amplitude responses in the stranger face condition seemed to be enhanced despite security in attachment $(M = -7.94, SD = 5.74)$. Consequently, in securely attached foster children, Nc amplitude responses to the mother’s face were significantly smaller as compared to the stranger’s face, $t(11) = 5.32, p = .006$.

In brief, securely attached control children elicited smaller Nc amplitude responses than insecurely attached children to both faces. Foster children showed a similar effect, however, in the foster group the stranger face condition elicited large Nc amplitudes responses regardless of attachment.

5.3.3 Brain-behavior correlations

To analyze the general relationship between children’s behavioral responses to the mother and the stranger their neural processing of mother and stranger faces we correlated variables using Spearman’s Rho. Correlations were computed among the Nc and N170 amplitude and latency responses to both the mother’s and the stranger’s face and two behavioral variables. These variables were attachment behavior towards the mother and looking behavior towards strangers as they indicate children’s behavioral responses to familiar and unfamiliar persons. As our previous findings did not suggest any hemisphere interactions on the N170 response (but on the Nc response), N170 analyses were performed on N170 amplitude and latency responses collapsed over PO9/10. In the following, I will report major findings $(p<.05$, two-tailed) for amplitude and latency responses separately.
Amplitude responses

When collapsed over groups our correlational analyses revealed no significant relationships neither for N170 nor for Nc amplitude response to mother and stranger faces.

Latency responses

Regarding the N170 latency responses, we found no relations with the behavioral variables; however, several significant relationships occurred for Nc latency responses. In particular, behavioral looking behavior towards the stranger showed to be negatively related to Nc latency responses to the unfamiliar face. This suggests that the more children watched the stranger when being approached by her, the faster was their neural processing of unfamiliar faces at electrode sites likely to reflect attentional processing. More precisely, looking behavior was negatively correlated with Nc latencies at F3, F4 and FCz with $r(37) = -0.43, p = .008$; $r(37) = -0.36, p = .03$, and $r(37) = -0.42, p = .01$, respectively. There were no relations including neural and behavioral responses related to the mother.

The reported findings occurred when including the total sample. However, as our behavioral analyses showed, foster children were likely to elicit enhanced looking behavior, it is unclear, if effects are due to group effects rather than representing overall brain-behavior correlations. When looking at both groups separately, the relation was apparent in both groups, however, possibly due to decreased sample size, it was only prominent at fewer electrode sites. Interestingly, however, there were brain-behavior correlations that were unique to the foster sample, that were obscured when looking at the total sample. More precisely, attachment behavior appeared to be negatively related to the N170 latency response to the mother’s face in foster children, $r(13) = -0.61, p < .05$, but not control children, $r(24) = -0.14, p = ns$. Regarding the different sample sizes we suggest the effect to be unique to foster children. Thus, increased attachment behaviors in foster children are associated with faster neural processing of the mother’s face at parietal-occipital leads.
5.4. Discussion

Referring to the literature on face-sensitive ERP components, we had several pre-assumptions regarding the time-course of facial familiarity processing. As will be further discussed below, in the current study we expectably found effects of facial familiarity to occur at occipital-parietal electrode sites as early as the N170 time window, as well as at fronto-central sites during the later Nc time window. The early evoked P1, however, was not affected by facial familiarity. As the P1 is known to be based on “low-level visual information” (Rossion & Jacques, 2012, p.127) this finding confirms that (foster) mother and stranger faces did not substantially differ in terms of basic visual cues like, for instance, luminance or contrast, which further validates the use of the stimuli.

In the following section, I will present results in three parts that are aligned in order of the major research questions. Thus, I will report effects on the ERP components’ amplitude responses to (foster) mother and stranger faces, first, with regard to group status, and, second, with regard to attachment security while considering possible interaction effects. Each of these two research questions will be discussed separately for the P1, the N170, and the Nc component. Main effects of facial familiarity where not of major interest in the current study, however, for their explanatory value, they will be discussed in more detail when explaining effects of experiences on the N170 amplitude response. In the third part, I will discuss associations that we found between behavioral variables and characteristics of the N170 and Nc responses to (foster) mother and stranger faces.

5.4.1 How do neural responses to faces differ with regard to group status and facial familiarity

\textit{P1 amplitude responses}

In the current study, foster children and control children did not differ regarding the size of the P1 amplitude responses and there was no effect of facial familiarity. Previous studies with children with a history of institutionalization, however, have found dampened P1 amplitude responses to faces, which has been interpreted as a sign of cortical hypo-arousal due to experiences of early deprivation (Mesquita et al., 2015; Moulson, Fox, et al., 2009; Moulson, Westerlund, et al., 2009). These diverse findings may be due to sample characteristics that imply several explanations. First, foster children’s previous experiences may not be comparable to those of institutionalized children, of whom most have been affected by social deprivation from early on. This does not mean that neglect within a family environment is considered less severe; however, the heterogeneity of previous experiences in our foster sample may have obscured the effect of early deprivation on the
P1 amplitude response. Second, findings from one study suggests that even within a group of institutionalized children only a subgroup showed dampened P1 amplitudes which was associated with atypical social behavior (Mesquita et al., 2015). Thus, different mechanisms underlying children’s heterogeneous behavioral organization may have obscured effects in our sample. Third, it is possible that 1 year of living within the foster home may have been sufficient for a catch-up. This explanation is supported by findings from Moulson (2009) who found the P1 (and other component’s) amplitude responses in an intervention group to fall in between institutionalized and control children. Future research including larger sample sizes may be able to further reveal conditions under which subgroups are affected by what has been interpreted as cortical hypo-arousal.

N170 amplitude responses

As expected we found both groups to differentially process faces as early as the N170 time window. Interestingly, in our sample, N170 amplitude responses were clearly dampened for foster children as compared to control children, suggesting that we found an effect of possible hypo-arousal, yet, at a later processing stage. Also, there was a main effect for facial familiarity on the size of the N170 amplitude with amplitudes being smaller, or less negative, in the stranger face condition as compared to the mother face condition. What does it mean when amplitudes are smaller in one condition as compared to the other condition? There are several interpretations and they are mainly based on familiarity effects. Thus, I will discuss the familiarity effect in more detail and then transfer the findings to explain group differences.

Effects of facial familiarity. Our first finding is that there was a familiarity effect after all, which is in line with our expectations as well as with other studies who found the N170 to be sensitive to facial familiarity and also to the salience of faces in children and adults (e.g., Caharel et al., 2002, 2006; Dawson et al., 2002; Mesquita et al., 2015; Parker & Nelson, 2005b; Todd et al., 2008; Wild-Wall, Dimigen, & Sommer, 2008). However, it contradicts previous findings suggesting not the N170—but later components—to be sensitive to variations in facial familiarity (e.g., Bentin & Deouell, 2000; Eimer, 2000b; Schweinberger, Pickering, Jentzsch, Burton, & Kaufmann, 2002). Notably, studies not finding the effect, used famous faces instead of truly familiar faces (also see Rossion & Jacques, 2012). In fact, there is evidence that the N170 response is actually different for personal important faces as compared to famous faces (Caharel et al., 2006), which suggests it to be sensitive to personal salience rather that familiarity per se. Apart from their personal salience, Wild-Wall, Dimigen, & Sommer (2008) suggest that facial familiarity may affect the N170 as it implies the activation of mental representations. Naturally, these are stronger in familiar, and thus well-
known, than in unfamiliar faces. In fact, there is evidence that the N170 is affected by facial priming, which support the notion of the N170s susceptibility to top-down cognitive processes (Caharel, Jacques, D’Arripe, Ramon, & Rossion, 2011; Jemel et al., 2003). Inevitably, the mother’s face represents both a personally relevant face as well as a well-known face. As a consequence, studies comparing mother and stranger faces have repeatedly found the familiarity effect at this early processing stage (e.g., Dai et al., Todd et al., 2008, Parker and Nelson, 2005).

The direction of the effect. Furthermore, in our study, familiar faces elicited larger N170 amplitude responses than unfamiliar faces in both groups, which is in line with previous neurophysiological findings (Caharel et al., 2006, 2011; Dai et al., 2014; Wild-Wall et al., 2008) as well as evidence from a brain imaging study that shows the M17021 to be larger to familiar than to unfamiliar faces (Kloth et al., 2006). To explain this effect of facial familiarity, authors often refer to the activation of “robust representations”, an assumption that is based on behavioral studies showing facilitated (e.g., faster) processing of familiar faces (Tong & Nakayama, 1999). Some suggest that facilitated visual coding of a familiar face is due to the “extensive visual experience” participants have with it (Rossion & Jacques, 2012, p.113). Supporting this view, in our study, post hoc testing of N170 latencies indeed revealed the N170 amplitude response to be significantly faster in the mother face than in the stranger face condition, \( p < .01 \). Furthermore, as proposed by Haxby and Gobbini (2011) familiar face perception implies the activation a larger neural network, which has been suggested to reflect in larger ERP amplitudes to familiar faces as compared to unfamiliar faces (Herzmann, Schweinberger, Sommer, & Jentzsch, 2004; Taylor et al., 2009)22. Neuroimaging studies support this view by showing more distributed cortical activation in response to personally familiar faces (Leibenluft et al., 2004).

However, regarding the direction of the effect there is conflicting evidence. To demonstrate, other studies have shown the opposite pattern with children eliciting larger N170 amplitudes to unfamiliar faces than to familiar faces, still referring to the concept of robust representations (e.g., Dawson 2002, Todd et al., 2008, Parker and Nelson, 2005). However, as priming appears to elicit smaller N170 amplitudes (Jemel et al., 2003) it may be argued that looking at overlearned (familiar) faces result in smaller N170 amplitudes as coding information is retrieved more easily. The current study cannot solve this conflict, however, I will offer two further suggestions explaining our finding of larger N170 amplitudes to familiar as compared to unfamiliar faces.

21 M170 is a neural marker for face processing in magnetoencephalographic studies that is associated with the N170 response at the scalp

22 Herzmann et al. (2004) assessed the activation of stored structural representation by the N250 component, that was found to increase from unfamiliar over famous to familiar faces
First, finding the same effect on the N170 amplitude response to facial familiarity, Wild-Wall, Dimigen, & Sommer (2008) addressed the possibility that the N170 may have simply merged with a later component, the N250. In fact, the N250 has repeatedly shown to be larger in response to repeated faces, especially when faces are familiar (e.g., Schweinberger et al., 1995, also see Kuefner, 2010, p.17). Supporting this view, studies with children have repeatedly reported late and wide N170 amplitude responses to faces (Taylor, 2001, 2004, Kuefner, 2010). In their systematic investigation on the N170 topographical specificities in several age groups, Kuefner and colleagues (2010) clearly stated that this specific “N170 phenomenon arises from the merging of two negative peaks, the N170 and the N250” (p.16), arguing that they show less temporal separation in young children as compared to older children and adults. In the current study, the N170 was defined as the first negative deflection following the P1, however, individual data indeed suggested the occurrence of twin peaks in the N170 time window. Thus, it cannot be excluded that effects of an N250-like response, that has built up on the N170, affected the components properties (see Wild-Wall et al., 2008).

Second, in our study, children were shown positive facial expressions, which may have also influenced the N170 amplitude response that is supposed to reflect “more intense structural encoding processes” to emotional expressions (Wild-Wall et al., 2008, p.146). Indeed, there is evidence for interaction effects between facial familiarity and emotional expression suggesting facilitating processing of happy familiar but not unfamiliar faces that could have affected the N170 in our study (Wild-Wall et al., 2008, but see Todd et al., 2008).

Finally, it is generally possible that diverging findings regarding the direction of the N170 familiarity effect in different investigations are partly due to study characteristics like stimuli properties as well as measuring issues. Summing up, in our study the N170 has shown to be larger to the mother’s (friendly) face as compared to the stranger’s (friendly) face. It is suggested that this effect is due to facilitated processing as the N170 response also showed to be faster to mother than to stranger faces.

_Differences between foster and control children._ Finally, we found distinct group differences in facial processing regardless of face type. In our study, foster children elicited smaller amplitudes to both faces as compared to control children. Indeed, foster children’s N170 amplitude responses did not fall below the zero level, which has been observed in other studies with pre-school age children (Kuefner et al., 2010), but, in our study, was unique to the foster sample. Previous studies have shown smaller amplitudes in a series of face-sensitive components when comparing children with early experiences of social deprivation to control children (Moulson, Fox, et al., 2009; Moulson, Westerlund, et al., 2009) as well as when comparing currently institutionalized children that show atypical versus typical social behavior (Mesquita et al., 2015). However, in our study, only the N170,
but not the early P1, was affected. Thus, it is possible, that the extent to which early facial processing stages are impaired depends on specific sample characteristics. Consequently, it is possible that in most foster children the early home environment or recent experiences within the foster home did provide sufficient sensory input to acquire basic perceptual skills for the P1 to function normally. However, the N170, which is involved in more elaborate processing, may be more dependent on early contingent face to face interactions, which may have lacked equally in foster children. Thus, foster children’s experiences may have led to a less pronounced neural network that in turn respond to social cues with relative hypoactivation within the N170, but not the P1, time window.

Interestingly, studies with the Bucharest sample have shown that in institutionalized children basic perceptual skills like facial emotion and facial familiarity processing have evolved despite severe early deprivation (Moulson, Fox, et al., 2009; Moulson, Westerlund, et al., 2009). Thus, it is possible, that brain activation is generally affected by early adverse experiences in terms of cortical hypoarousal as the neural system did not receive the expected overall social input, while the input, on the other hand, may still be enough to develop basic perceptual skills.

If such basic processing skills are not affected by cortical hypoactivation, then what could be problematic about it? Research to date may not be able to provide a final answer. However, cortical hypoactivation has shown to be related to atypical social behavior like social disinhibition in studies on global measures of brain activity (Tarullo et al., 2011) as well as in studies suggesting hypoactivation in face-sensitive brain regions (Mesquita et al., 2015). Integrating findings from the behavioral part of our analyses that show enhanced social disinhibition in foster children provides supporting evidence for this relationship.
Facial familiarity and group status. Even though consistent with previous findings (e.g., Moulson, Westerlund, et al., 2009), we were surprised not to find any interaction effects between group status and face type in our study. This means that group differences regarding individual experiences (e.g., the amount time children have spent with their (foster) mother) did not modulate the N170 familiarity effect. This finding may be explained referring to priming or repetition studies suggesting the facial familiarity effect to require relatively short familiarization with the stimulus (Caharel, Jacques, D’Arripe, Ramon, & Rossion, 2011; Jemel et al., 2003; but see Schweinberger, Pickering, Jentzsch, Burton, & Kaufmann, 2002). In line with this argument, behavioral studies suggest that, for example, the other-race effect, diminishes with relatively little exposure to faces from other races (Spangler et al., 2013). Thus, our findings indicate that recent long-term exposure (during 1 year in the foster home) rather than lifelong experiences with the foster mother’s face have been sufficient to elicit the N170s facial familiarity effect and thus, to even out group differences regarding the amount of experiences as well as their timing. However, it would be interesting, how much experience is actually necessary to elicit the facial familiarity effect on the N170 and also how robust the effect is with regard to sensitive periods for learning. Here, it would be highly interesting to include faces of foster children’s biological mothers, but this was not possible due to issues of data protection.

Future research on mother-stranger face processing should include personally irrelevant faces but familiarized faces to detangle effects of personal importance and priming on the N170 amplitude. Furthermore, one could also include children’s processing of familiar and unfamiliar objects to test for a general familiarity processing effect. This paradigm has already successfully been implied in studying differences in facial familiarity processing in children with autism spectrum disorder compared to delayed developing and normally developing children (Dawson et al., 2002).
5.4. Discussion

Nc amplitude responses

The Nc component has repeatedly been associated with enhanced attentional processing (e.g., Reynolds & Richards, 2005) and its response to the stranger’s face has been shown to be influenced by different aspects of the mother–child relationship (e.g., Carver et al., 2003; Swingler et al., 2010). Thus, with regard to their heightened attention towards strangers on the behavioral level revealed (Chapter 4) we expected Nc amplitude response variations between foster children and control children. As we have conducted a detailed analysis of effects at widely distributed electrode sites, I will first report the main findings regarding facial familiarity processing occurring across different regions where the Nc was found to be prominent. Then, I will report effects of group status that interacted with facial familiarity in certain regions of the scalp only.

The analysis including frontal and central lateral leads (F3/4, C3/4) showed that the stranger face, in tendency, elicited larger Nc amplitudes than the mother’s face. Also, Nc amplitude responses appeared to be larger at frontal leads. Looking at the frontal lead pair separately, we could not find an interaction effect between group and face type, but again, the stranger elicited larger amplitude responses than the mother face which is in line with previous research (e.g., Carver et al., 2003; Todd et al., 2008). At the central lead pair C3/4 and the frontal-central lead FCz, however, the interaction between group and face was significant. In contrast to the main effect of face type at frontal leads, here, only foster children elicited larger amplitudes to the stranger face as compared to the mother’s face. At midline leads the Nc amplitude response was most prominent at the frontal lead Fz, however, there were no effects for face type at midline leads. Here, the interaction of face and group also appeared, however, the effect was not significant.

The interaction between facial familiarity and group status. Regarding our specific hypothesis of an interaction between face type and group status results were dependent on lead location. More precisely, at fronto-central/central leads, but not frontal leads, only foster children showed the expected effect of eliciting larger Nc amplitude responses to the stranger face than to the mother face. There are two according remarks to be made at this point.

First, it is possible, that the stranger face effect, that when collapsed over all electrode sites occurred regardless of group status, may be driven by the foster group’s Nc amplitude responses at more central leads. Second, fronto-central/central leads and frontal electrode sites may reflect independent neural processes, which may be responsible for the co-occurrence of different effects. Indeed source analysis have shown different cortical areas as potential generators of the Nc response including those that are responsive to the stimuli’s emotional significance (e.g., amygdala activation
relayed in neocortical areas, see Eimer & Holmes, 2007) as well as areas involved in attentional and recognition memory (e.g., the anterior cingulate and frontal cortex; see Reynolds & Richards, 2005). Testing effects of familiarization and attention on the Nc component conducting source analysis, Reynolds & Richards (2005), suggested some effects to depend on the region of interest, however, study paradigms were not comparable to ours. Other studies analyzing the relationship between socio-emotional development and the Nc amplitude response to mother and stranger faces in normative samples have also repeatedly found a number of significant effects to occur at the frontal lead pair only (Carver et al., 2003; Swingler et al., 2010).

Furthermore, taken into account foster children’s distinct behavioral responses to the foster mother (i.e., increased dependency and attachment behaviors), it is surprising that we did not find any neural patterns indicating that foster children differ from control children with regard to responses to the foster mother’s face. As Swingler (2008) has found association between neural responses to the mother’s face at F7, a left lateralized electrode, and attachment as well as play behaviors, in an explorative approach, we included (foster) children’s neural responses to mother and stranger faces at F7 post hoc. Indeed, here, we found a significant interaction between group and face, F(1,35) = 6.58, p = .02, e = .16. Follow-up analyses showed that in the mother face condition only, foster children elicited larger amplitudes than control children \( M_{foster} = -12.59, SD = 5.51; M_{control} = -9.03, SD = 4.61; t(35) = 2.09, p = .04 \). This finding indicates that foster children indeed process the (foster) mother’s face differently than control children; however, as the F7 is not located near the source of the Nc, it is hard to draw assumptions on the meaning of this effect. Further research, however, may reveal sources possibly underlying the left lateralized frontal response, while the current data can only suggest differential processing to take place at this site.

To conclude, there is a possibility that the face and group interaction effect only occurring at fronto-central/central leads is due to specific cortical structures and processes that are differentially activated in foster children and control children. However, the present data does not provide sufficient data for subsequent source analyses; also, the study did not intend to investigate different ERP generators. Further research may address this issue by applying a detailed analysis of the Nc familiarity effect over distributed electrodes sites within the frontal, fronto-central and central region of the scalp.
5.4. Discussion

Hemisphere effects on the N170 and the Nc amplitude response to faces. In our analyses the N170 as well as the Nc amplitude was found to be larger on the left hemisphere than on the right hemisphere, and several effects showed to be left laterализed as well. This left hemisphere dominance in both face sensitive components has not been expected, as it is at odds with the widespread assumption of a right hemisphere advantage for faces (Leehey, Carey, Diamond, & Cahn, 1978). However, our results do not stand alone. In fact, a left hemisphere dominance for faces has repeatedly found in the developmental ERP studies by Swingler (2010) and Carver (2003). Also Kuefner and colleagues (2010) comparing different age groups stated that in children’s grand averaged waveforms “the right lateralization of the N170 was not clear at all” (p.11). Interestingly, there is evidence that the left hemisphere is especially responsive to positive facial expressions (Nakamura, Maess, Knösche, & Friederici, 2014). As we have used friendly faces this finding may further explain the hemisphere effect found in our study.

5.4.2 How are neural responses to (foster) mother and stranger faces in foster children and a control sample affected by attachment security

P1 amplitude responses

Our analyses comparing securely attached to insecurely attached children with regard to P1 amplitude responses revealed no significant effects. Marginally significant interaction effects including attachment and hemisphere indicated that securely attached control children showed a certain hemisphere effect with larger amplitudes on the right than on the left hemisphere regardless of face type. Indeed, the right hemisphere has been discussed to be particularly associated with attachment (Schore, 2000). However, we do not know of any ERP study confirming this effect, and hemisphere differences per se were not the focus of our study. In line with our specific hypotheses, we did not find attachment security to generally affect face processing as early as the P1 time window. This is also in concordance with our non-findings of effects of group status at this early stage, suggesting that both securely and insecurely attached children showed comparable basic processing abilities.
As expected, the N170 amplitude response clearly differed between securely attached and insecurely attached children. More precisely, securely attached children showed increased N170 amplitude responses than insecurely attached children regardless of group status. However, as foster children have shown to elicit smaller N170 amplitude than control children the effect added up in insecurely attached foster children showing the smallest deflections during this elaborated stage of facial processing. As attachment security directly relates to experiences with the (foster) mother we expected attachment security to modulate the perception of the (foster) mother’s face. Surprisingly, there were no significant interactions involving face type. However, as this is the first study relating attachment security to early facial processing this finding needs replication.

In sum, we again found children’s socio-emotional experiences to have a strong effect not on facial familiarity processing in particular, but facial processing per se. Our findings suggest that securely attached children regardless of whether they are raised in a foster home or within their biological family show greater activation in cortical areas related to the encoding of facial information than their insecurely attached peers.

Interpreting this result in line with the argumentation applied to group effects on the N170 response, it is suggested that contingent social interactions with the primary attachment figure may result in the formation of robust mental representations associated with an elaborated neural network (e.g., Herzmann et al., 2004). When faced with social stimuli, this network may get activated which then reflects in large N170 responses. If this assumption is true, it could be said that securely attached children show an expertise in the processing of social stimuli. Future research should address this question by, for example, conducting a facial recognition task. Furthermore, it would be interesting whether the effect is face-specific. To address this question, future research should include ERPs to faces as well as objects.

The current data does not allow to make any assumptions on the causality of the effect. Indeed, it is possible that children with less processing activity in response to social cues were less likely to develop secure attachments to their (foster) mother. In this sense, this group of children could also be viewed as less responsive to changes in the social environment in terms of susceptibility (Ellis, Boyce, Belsky, Bakermans-Kranenburg, & Van IJzendoorn, 2011), which in turn may have hindered socio-emotional development. However, this interpretation clearly needs further empirical support, and, to detangle cause and effect, longitudinal assessments would necessary.
5.4. Discussion

\textit{Nc amplitude responses}

Collapsed over face types and groups, there was no main effect for attachment on the Nc amplitude, neither at lateral nor at midline leads. At the frontal lead pair, however, a marginally significant interaction of attachment and hemisphere occurred with insecurely attached children eliciting larger amplitudes to faces than securely attached children at the right hemisphere only. Interestingly, the influence of attachment increased at central leads, where, again, a left hemisphere dominance occurred. Also, the nature of the interaction between attachment and the Nc amplitude responses was different at frontal as compared to central leads. These findings, again, may suggest both lead positions to reflect activation of different cortical sources (see above).

The interaction between attachment security, facial familiarity, and group status. In a newly calculated central left lateralized region (FCz/Cz/C3) a triple interaction between attachment, face and group was well pronounced. Follow-up analyses showed that in the control group insecurely attached children elicited larger Nc amplitude responses to faces regardless of face type, while in the foster group a different pattern emerged. I will first focus on the effect of attachment in the control group and then discuss effects in the foster group.

The first finding suggests, that insecurely attached children showed enhanced attentional processing to faces as compared to securely attached children\textsuperscript{23}, at least in the control group. There are two major arguments that may explain the effect. First, as theorized by Bowlby (1982) internal working models of attachment are indicative of the child’s perception of his/her own worthiness as well as children’s appraisal of their social partners (Bretherton, Ridgeway, & Cassidy, 1990). In this sense increased attention to social stimuli may represent enhanced vigilance or at least an increased effort in the evaluation of the faces’ meaning. Thus, faces may generally represent more ambiguous social cues to insecurely attached children than to securely attached children. Second, insecurely attached children are likely to lack a feeling of safety especially in novel situations. This novelty effect may have been “boostered” by the lab assessment that is completely unfamiliar and potentially stress inducing for children. Securely attached children, however, may have felt more confident by the presence of the mother. Thus, the lab environment may have increased activation of the attachment system, which may in part account for the presence of the effect. However, no effects for face type, occurred, which is surprising, as experiences with the attachment figure are associated with different regulatory strategies that are also reflected on a psychophysiological level (Spangler & Grossmann, 1993). Future research may be able to reveal differences in mother’s face processing.

\textsuperscript{23} Note that a similar effect was found at the right frontal lead.
when differentiating between ambivalent and insecure-avoidant attached children. As our attachment measure did not account for these differences possible effects might have been obscured.

Finally, we were looking at the Nc amplitude responses at the left lateralized central region of interest in the foster group. Here, a different processing pattern emerged. In fact, in foster children Nc amplitude responses were large in response to both the mother and the stranger face. In contrast to securely attached control children, securely attached foster children did not seem to require less attentional resources than their insecurely attached peers during face processing. As suggested by the significant interaction between attachment and face type that was unique to the foster sample, the effect of attachment appeared to be less generalized as it could not show across both face. In fact, it was indicated that securely attached foster children elicited smaller amplitudes to the mother’s face, while foster children’s Nc amplitude responses to the stranger face in the central left lateralized region of the scalp were large regardless of the quality of the attachment relationship.

This finding is especially interesting as it suggests the nature of attachment security in foster children to be substantially different than in control children, which supports a recent claim made by Lyons-Ruth (2015). Thus, we found foster children to be assessed as securely attached to their foster mother applying traditional observational methods, while, on a neurophysiological level attachment did not seem to serve the same psycho-social functions. Furthermore, the finding is in concordance with behavioral studies, including our own, that suggest children from adverse rearing backgrounds to be capable of forming a secure attachment relationship to new caregivers, while relicts of atypical social behavior, namely disinhibited social engagement, are rather resistant to positive change. Despite its striking plausibility, the effect has to be interpreted only cautiously due to small cell frequencies that may have compromised the analyses.

Future research should address this exploratory finding including a larger sample of foster children. This would optimally provide the possibility of analyzing differences in Nc amplitude responses to stranger face with regard to marked signs of atypical social behavior. Indeed, Mesquita et al. (2015) have found ERP evidence for differential facial processing in institutionalized children with atypical behavior as compared to children with typical behavior, suggesting that not all children’s neural processing is affected by early experiences of pathogenic care.
5.4. Discussion

5.4.3 How do neural responses to mother and the stranger faces relate to specific observable behavior towards (foster) mother and stranger

Our assessments provided extensive data on both behavioral and neural responses to familiar and unfamiliar persons as an indicator of children’s psycho-social functioning. This gave us the possibility to conduct further analyses on the correlations between certain behavioral variables (i.e., attachment behaviors, looking behavior) and Nc and N170 amplitude and latency responses to facial familiarity processing beyond our investigation of group differences and attachment security.

Our findings on brain-behavior associations were restricted to a significant correlation between children’s looking behavior toward strangers and Nc latency response to stranger faces. This finding, however, is interesting per se. While the N170 represents an elaborated facial encoding stage, the Nc reflects retrieval of attentional resources likely to be influenced by cortical processes triggered by amygdala activation in response to salient stimuli (see de Haan, 2011, p. 737). In fact, social encounters require fast cognitive appraisal of the situation to prepare the organism for response actions. In our study we have found children’s looking behavior directed towards the stranger in an ambiguous novel situation (the waiting room) to negatively relate to Nc latency responses to the stranger’s face on a number of corresponding electrode sites. This means that children showing enhanced looking behavior towards the stranger also show faster neural processing of unfamiliar faces which is likely to reflect enhanced attentional processing to unfamiliar faces. Our finding on looking behavior is particularly supported by evidence suggesting Nc latencies in the mother-stranger paradigm to be specifically related to visual behaviors in response to separation and reunion with the mother (Swingler et al., 2010). Thus, drawing a post hoc assumption, we suggest that children who direct more looking behaviors towards the stranger do this in order to surveille the social situations and possibly because they are especially sensitive to social cues. This vigilance then in turn may also reflect an advantage regarding a faster recruiting of neural resources.

Interestingly, there was another brain-behavior correlation that was unique to the foster sample as it appeared neither in the control group nor in the total sample. In the foster group only, attachment behaviors were negatively related to the N170 latency responses to the mother’s face. In other words, increased attachment behaviors in foster children were associated with faster neural processing of the mother’s face with regard to the N170 response. As discussed in previous sections the N170 is associated with facilitated processing to faces that might be a result of robust mental representations due to extensive visual experiences. In line with this argument we have also reported faster N170 latency responses to the mother’s face as compared to the stranger’s face that is likely to represent faster structural encoding. Consequently, our finding on attachment behaviors would then indicate that children showing more attachment behaviors may also have increased visual experience with the
mother’s face. This interpretation seems plausible as these children might actually be exposed to the mother’s face more intensely as they may repeatedly back-check with her and initiate close contact with her. However, it is not immediately clear why this effect is unique to foster children. Our behavioral analyses suggest that in foster children dependency and attachment behaviors are characteristic of the foster mother – child relationships and thus may serve a specific developmental function, which is supported by this particular brain-behavior association, but would need further studies to be explained. Also, as attachment behaviors are more pronounced in foster children, statistical artifacts may play a role here.

5.4.4 Summary

Applying a neurophysiological approach when comparing high and low risk samples, the current investigation could show that facial processing —that is fundamental to adequate psycho-social functioning— is particularly sensitive to early adverse experiences. It was indicated that adverse rearing backgrounds affect the growing organism on multiple levels possibly comprising the child’s flexible psycho-social adjustment in later stages of development. Integrating results regarding ERP responses to faces at different stages during the time course of facial familiarity processing, we found that the early P1 amplitude response neither was affected by facial familiarity nor did foster and control children elicit different processing patterns at this early stage, nor did attachment security affect early facial processing. Regarding later processing stages, our findings suggest that recognizing a familiar face involves a greater neural network that is activated as early as the N170 time window. Furthermore, at this stage, foster children showed dampened amplitudes, however, others have found dampened amplitude responses in institutionalized children even at an earlier stage. Similarly, we found attachment to affect facial processing as early as the N170 time-window in a way that suggests that securely attached children have increased expertise in face processing possibly due to having experienced more frequent face to face interaction. Finally, it was not until the Nc time window, reflecting advanced cortical processing, that foster children and control children differed with regard to facial familiarity. Here, we found foster children to show enhanced attentional processing in response to stranger faces. This effect was stable even when including attachment security in the analysis. In control children, however, attachment security seemed to decrease the need for the relocation of attentional resources when processing social stimuli, which, on a neurophysiological level, may at least in part be a consequence of facilitated face processing as early as the N170 time window. Finally, our neurophysiological and behavioral findings provide further evidence that individual behavioral responses occurring during mother-stranger interaction are related to facial familiarity processing in normative development as well as in children at risk.
5.4.5 Limitations

There are several limitations to the study, some of which have already been described in the behavioral part of the study (see section 4.6.7). As noted earlier, there seemed to be a visually evoked potential, probably due to the presentation of the fixation cross at -300 ms (see Figure 8), which may have affected subsequent components. Considering this limitation the baseline correction was applied to activity prior to the fixation cross. Still, it is unclear if decreased N170 amplitudes are due to differences in the processing of face stimuli per se. However, as the face-sensitive P1 component, which precedes the N170, did not show between subject effects we did not expect N170 effects to be due to prior processing differences. Nevertheless, results should be interpreted cautiously.

Furthermore, in our neurophysiological investigation, possible due to the small sample size, a number of effects only reached marginally significance, thus, their validity may be limited. Also, as studies with children vary upon the electrode sites included, it seemed reasonable to apply an exploratory approach. Still, it may be critical that some effects only emerged during post-hoc testing. Nevertheless, our findings suggested certain effects to be evident in particular brain regions, but they clearly need replication in a larger sample. The next limitation concerns the age range of our sample. Notably, neural structures develop rapidly during the early years and 3 to 6 years may be too wide to capture important developmental aspects of facial familiarity processing. As it was shown by Carver et al. (2003), the neural processing of the mother’s and a stranger’s face underlies significant changes over the preschool years. In the current study, however, we focused on group differences in two age-matched samples and thus, we assume our results to be due to different relational experiences rather than age effects. Furthermore, it has to be noted, that foster children are not a homogeneous sample in terms of their prior experiences, and, they have also different (sub-) clinical symptoms (Zimmermann, 2015). For example, it may be crucial to differentiate between disinhibited and inhibited as well as typical and atypical social behavior (see Mesquita et al., 2015). Again, heterogeneity in our sample may have obscured specific processing patterns that are crucial to our understanding of different pathways leading to distinct behavioral outcomes. In line with this argument, it could be very informative to include a categorical measure of attachment that distinguishes between insecure-avoidant and insecure-ambivalent attached children. Especially, with regard to attentional processing of familiar faces it could be assumed, that in insecure ambivalent — as compared to insecure avoidant— the use of hyperactivating strategies may be evident even on a neural level. Still, with regard to our study aims and sample characteristics (e.g., age range, sample size) using a dimensional measure was the better choice. Also, it has to be noted, that our results are correlational and that we cannot make any statement about the direction of effects. In the particular case of foster children, effects of intervention are of major interest. It has shown that improvements in the caregiving environment have positive effects on a behavioral (e.g., Gabler et al., 2014) as well
as on a neurophysiological level (Moulson, Fox, et al., 2009; Moulson, Westerlund, et al., 2009). Thus, future studies may include more than one measuring point assessing ERPs in relation to aspects of the attachment relationship, first, at time of placement, and second, after a certain amount of time spent within the foster home.

A final methodological limitation refers to the fact that we have only included female faces. In the current study caregivers were all female, however, with regard to reticence towards strangers and processing stranger faces, including male caregiver faces and male stranger faces may provide a more precise picture of the child’s inner organization with regard to its actual social environment.
Chapter 6: General Discussion

6.1 Overview and Integration of Main Findings

In this dissertation I have presented results from a study examining the impact of early adverse experiences on difficulties in psycho-social functioning that has been shown in studies on attachment and related disorders (e.g., Gabler et al., 2014; Jonkman et al., 2014) as well as those focusing on neurophysiological correlates of face processing (e.g., Mesquita et al., 2015; Moulson, Fox, et al., 2009). The current study compared pre-school aged foster children and an age matched control group considering both children’s behavioral as well as neural responses towards (foster) mothers and strangers. While Chapter 1 and 2 provided a comprehensive overview of our theoretical as well as our methodological approach (i.e., ERP assessment), while Chapter 3 described overall study parameters.

In Chapter 4 a behavioral system approach was applied to examine the nature of foster children’s attachment relationship with their foster mother as well as their behavior around unfamiliar adults by using observational and interview data. Foster children were found as likely to be securely attached to their foster mother as control children. However, foster mother’s reported increased disinhibited social engagement towards strangers in their foster children as compared to control mothers. Observing children in a standardized laboratory interaction with (foster) mother and an unfamiliar stranger, foster children were found to elicit specific behavioral patterns that could not be found in control children. In particular, they elicited increased attachment behaviors towards the foster mother, and, simultaneously, increased social interactive behaviors towards the stranger, indicated by enhanced looking behavior and frequent verbal initiations that were also more intimate than in control children. Interestingly, when being alone with the stranger during free play sessions foster children were more inhibited. In particular, control children were more likely to look at the stranger as compared to foster children. In free play with the (foster) mother, foster children were looking more at her than control children, who, however, initiated more verbal communication towards their mother.
Chapter 6: General Discussion

Chapter 5 presented data on (foster) children’s neural responses to (foster) mother and stranger faces assessed during a passive viewing paradigm. Three face sensitive components, the P1, the N170 and, the Nc were examined with regard to first, group status, and, second, attachment security. Foster children and control children’s P1 amplitude responses were found to be comparable large, also, attachment security had no effect despite a lateralization effect. Significant group differences, however, occurred at later stages of face processing. The N170 that in the current study was also found to be sensitive to facial familiarity was decreased in foster children as compared to control children, and, in insecurely attached children as compared to securely attached children.

Furthermore, facial familiarity appeared to significantly interact with group status during the Nc time window. Foster children were more likely to elicit heightened attentional processing in response to the stranger face than to the (foster) mother’s face, while control children did not differ between face types. Attachment security seemed to effect processing captured by the right lateralized frontal lead, but this was only the case in securely attached control children. More striking, when building a composite over the left lateralized central scalp area (C3, Cz, FCz) securely attached children seemed to elicit smaller Nc amplitude responses to faces in general. However, this main effect did not reach significance as attachment appeared not to have the same function in foster children. While securely attached foster children elicited smaller amplitudes to the foster mother’s face, their attentional processing in response to the stranger’s face was still enhanced.

Examining associations between behavioral measures derived from the first part of the current study, we found brain-behavior correlations only for the speed of face processing (latency responses). Interestingly, Nc latency responses were negatively related to children’s looking behavior towards the stranger during the waiting room procedure. In foster children only, decreases in N170 latency responses to the foster mothers face were associated with frequent attachment behaviors towards her. Thus, it was indicated that faster face processing was related to enhanced behavioral responses directed to that particular person.
In Chapter 1 I have outlined the concept of experience-expectant and experience-dependent processes with the former relating to sensitive periods for the maturation of specific developmental domains like face processing. As stated by Nelson et al. (2011), the concept may also apply to the development of attachment relationships, meaning that children, who have not experienced a primary caregiver to be continuously available early in life may show enduring deficits regarding the formation of attachment relationships to new caregivers. In concordance with other studies, we have found children to be capable to form secure attachment relationships to their foster parents. This may, on the one hand, be due to the fact that foster children from birth have been living within a family environment. Indeed, studies have shown, that children also get attached to maltreating or neglecting caregivers, even though rates of insecure patterns were relatively high (Egeland & Sroufe, 1981; Stronach et al., 2011). On the other hand, it is also possible, that the sensitive period to form attachment relationships remains open for an extended time of development. On a neurophysiological level, we have found an early face-sensitive component to be affected by early experiences in the way, that foster children as well as insecurely attached children elicited dampened amplitudes in response to faces. This may be a sign of poorer previous social interactions, an interpretation that can be drawn from findings on cortical hypoarousal in children experiencing early social deprivation (Mesquita et al., 2015; Moulson, Fox, et al., 2009; Moulson, Westerlund, et al., 2009; Tarullo et al., 2011).

Even more relevant to our study are experience-dependent processes that refer to individual differences regarding the quality of the newly formed attachment relationship. Interestingly, our findings suggest that foster children after one year with the foster family are as likely to be securely attached as control children; however, the nature of children’s inner organization of their social world still appeared to be quite different from what was observed in control children. Moreover, this was apparent on a behavioral as well as on a neurophysiological level. First, on a behavioral level, it seemed that foster children were highly sensitive to changes in the social environment. As observed in a series of previous studies (e.g., Chisholm et al., 1995; Zimmermann, 2015) foster children in our study showed atypical social behaviors towards strangers. However, it occurred that, at the same time, they needed the foster mother’s proximity, or in other words: constant re-assurance of a secure base. When being left alone with the stranger, foster children appeared to be more inhibited, hence, their behavior seemed to highly depend on context factors. On a neurophysiological level, the stranger face seemed to be highly salient for foster children as it elicited heightened attentional processing. The overall pattern of increased attentional processing to both faces in insecurely attached children suggests that this salience may be a sign of increased vigilance. In foster children, the salience of the stranger face may originate from adverse experiences within the early caregiving environment and may have already developed early in life. This may explain why foster children still
show increased looking behavior towards the unfamiliar adult in the waiting room procedure. The fact that on a behavioral as well as on a neurophysiological level the effect was present despite security in attachment, may inform our understanding of why some behavioral patterns are rather resistant to change.

Finally, the distinct nature of the attachment relationship between foster children and foster mother should not lead to premature conclusions on its development in future years. In fact, heightened dependency and attachment behaviors can be viewed as a sign of foster children’s behavioral reorganization in light of the significant changes made during a relatively short time of life. In fact, as proposed by Sroufe (1979) development can be viewed as a series of reorganizations that come in phases followed by “consequent changes in focal developmental issues” (Sroufe, 1979, p.836). This aspect is especially important when looking at the development of attachment and dependency in foster children. While in normative development with the mental representation of the caregiver as a secure base, overt attachment behaviors and increased dependency become replaced by more sophisticated strategies, in foster children, such behaviors may serve important developmental functions, and thus, may be crucial for the establishment of a strong new relationship.

In this sense, development does not proceed in a linear manner, and this may be important to acknowledge for researchers as well as for practitioners and caregivers. In this transitional phase, the foster mother providing a secure base may be fundamental as it enables foster children to learn how to deal with novel social situations and this experience may be a central key to successful psycho-social adjustment.

With this investigation, I could show that early adverse experiences have a strong impact on children’s development in different domains of psycho-social functioning. Furthermore, in foster children, alterations observed on a behavioral as well as on a neurophysiological level seem to occur simultaneously. These findings may be restricted to a particular sample as well as particular functions, however, they can add to our understanding of the interrelatedness between overt social behavior and the neural correlates of socio-information processing. When we recognize these connections, we may also understand why some behaviors are resistant to change despite environmental improvements.
6.2 Concluding Remarks

The early years in a child’s life represent a window of striking plasticity in terms of early social learning as well as brain development. Both domains, however, are not independent of each other. On the one hand, continuous social experiences guarantee the input necessary for the maturation of brain structures that are fundamental to an individual’s survival. On the other hand, varying early experiences are assumed to shape the brain’s architecture in a way that helps the individual to adapt to its particular environment (Greenough et al., 1987; Kolb & Gibb, 2011). It can be assumed that such individual differences in the neural circuits underlying social information processing highly influence the way individuals perceive and appraise novel social situations. Consequently, children’s behavioral reactions are organized according to what they experienced in previous similar interactions (also see Crick & Dodge, 1994). However, while some neural or behavioral patterns work within the particular caregiver–child relationship, they may compromise the development of more reliable social relationships or may be dysfunctional in future situations with novel social partners. As a consequence, adaptive functioning in early life also includes the risk of leading to a pathway of future maladjustment (Cicchetti, 2002), which seems to be especially true for adverse relational experiences during a phase of rapid brain development.

When working with children or adults stemming from maltreating rearing background it is crucial to continuously provide the positive relational experiences (e.g., emotional availability, acceptance, interpersonal regulation) that have lacked. This may then lead to secure attachment representations in later life (Saunders, Jacobvitz, Zaccagnino, Beverung, & Hazen, 2011). However, change and positive adaption can only be initiated when these novel experiences actually affect how the brain functions, and thereby, facilitate psychological adjustment in the long run. Indeed, as stated by Kandel (1998) effective therapy has an impact on brain functioning as it induces a learning process that affects neural structures. Thus, ongoing repetition of experiences seems to work as the brain gets capable of strengthen neural connections needed to facilitate change in behavior (Kandel, 1998).

I want to end up this dissertation with words by Cathy Malchiodi, a childhood trauma therapist, who stated: “If I had to sum up my core beliefs about therapeutic work with children, the most important aspect is the relationship” (Malchiodi, 2014). Keeping this statement in mind may encourage practitioners as well as caregivers to focus on providing the reliable support of an emotionally available and caring adult.
Chapter 7: German Summary / Deutschsprachige Zusammenfassung

7.1 Titel

Der Einfluss früher Erfahrungen auf neuronale und behaviorale Korrelate der psychosozialen Anpassung: Eine Studie zu Bindung, sozialer Interaktion und Gesichterverarbeitung bei Pflegekindern und einer Kontrollgruppe

7.2 Theoretische Einleitung

In den 1950er Jahren lenkte John Bowlby mit seinem Bericht für die Weltgesundheitsorganisation die Aufmerksamkeit auf die Wichtigkeit früher Fürsorgeerfahrungen für die kindliche Entwicklung. Seither wurde das Thema vielfach wissenschaftlich aufgegriffen und hat damit unser Verständnis der sozio-emotionalen Entwicklung und so auch die öffentliche Meinung entscheidend mitgeprägt. Mit zunehmendem Einbezug neurowissenschaftlicher Methoden hat sich in den letzten Jahrzehnten unser Wissen über den Einfluss früher Beziehungserfahrungen auf die körperliche und dabei vor allem auf die Gehirnentwicklung entscheidend weiterentwickelt und die Prägnanz des Themas weiter verschärft.


Das Ziel der dieser Arbeit zugrunde liegenden Studie war es, solche Zusammenhänge weiter aufzuklären, indem einerseits die Bindungsorganisation und das Verhalten von Pflegekindern gegenüber fremden Personen näher beleuchtet, und andererseits neurophysiologische Korrelate der sozialen Informationsverarbeitung mittels ereigniskorrelierter Potentiale bei der Verarbeitung vertrauter und unvertrauter Gesichter untersucht wurden.
7.3 Studiendesign und Methoden

Der vorliegenden Studie ging eine längsschnittliche Untersuchung von Pflegekindern voraus, wobei insbesondere die Bindungsentwicklung im ersten Jahr in der Pflegefamilie im Mittelpunkt stand. Während diese Untersuchung an zwei deutschen Standorten durchgeführt wurde, wurden für die vorliegende Arbeit alle 24 Pflegekinder, die aus dem Raum Erlangen/Nürnberg rekrutiert worden waren, die Längsschnittstudie vollständig abgeschlossen hatten und den Alterskriterium entsprachen (3 bis 6 Jahre), zu einem weiteren Erhebungstermin eingeladen. Letztlich nahmen hiervon 16 Kinder (9 weiblich/7 männlich) mit ihrer Pflegemutter teil, wobei die Drop-out Analyse keine signifikanten Unterschiede bezüglich Alter zu Beginn des Pflegeverhältnisses, Bindungssicherheit, Abhängigkeit, enthemmten Verhalten gegenüber Fremden oder Verhaltensauffälligkeiten ergab. Die Kontrollgruppe bestand aus 24 Kindern (14 weiblich/16 männlich) mit vergleichbarer Altersverteilung.


7.4 Bindung und soziale Interaktion bei Pflegekindern und einer Kontrollgruppe


wenn sich bezüglich der Bindungssicherheit keine Unterschiede zeigen. Insgesamt legen die Befunde daher nahe, die spezifische Bindungsbeziehung zwischen Pflegekindern und ihren Pflegeeltern differenzieter zu betrachten, um diese noch besser zu begreifen und so auch optimal auf die Bedürfnisse der Kinder und auch mögliche damit einhergehende Sorgen der Pflegeeltern, eingehen zu können.

7.5 Neurophysiologische Korrelate der Gesichterverarbeitung bei Pflege- und Kontrollkindern

In Kapitel 5 wurden Pflege- und Kontrollkinder hinsichtlich neuronaler Korrelate bei der Verarbeitung des Gesichtes der Bezugsperson (Pflegemutter, Mutter) und einer fremden Person verglichen, wobei in einem zweiten Schritt der Einfluss der Bindungssicherheit berücksichtigt wurde. Die wenigen Studien mit Risikostichproben deuten darauf hin, dass Heimkinder generell niedrigere Amplituden in Reaktion auf vertraute wie auch unvertraute Gesichter zeigen, was zusammen mit Studien zur globalen Gehrinaktivität auf eine kortikale Hypoaktivierung in Folge früher Deprivationserfahrung hindeuten (Mesquita et al., 2015; Moulson, Fox, et al., 2009; Moulson, Westerlund, et al., 2009; Tarullo et al., 2011). Studien mit sich normal entwickelnden Säuglingen und Kindern haben gezeigt, dass die Verarbeitung des mütterlichen bzw. eines unvertrauten Gesichtes in Zusammenhang mit tatsächlichen Verhaltenskorrelaten sowie angenommenen qualitativen Veränderungen in der Mutter-Kind Beziehung stehen (e.g., Carver et al., 2003; Swingler et al., 2007).


Anhand von Korrelationen der Amplituden wie auch Latenzen, also die Geschwindigkeit der neuronalen Verarbeitung von Gesichtern, mit aus Kapitel 4 entnommenen Verhaltensvariablen (Blick zur Fremden, Bindungsverhalten) zeigten sich signifikante Zusammenhänge bezüglich der neuronalen und behavioralen Reaktionen gegenüber fremden Personen. Hier wurde besonders deutlich, dass Kinder, die die Fremde in der Wartezimmersituation länger ansahen bzw. beobachteten, im Bereich der Nc auch schneller auf das Gesicht der Fremden reagierten. Sie schienen also schneller ihre Aufmerksamkeit in Anbetracht des fremden Gesichtes zu lokalisieren, was als ein Zeichen von Vigilanz gedeutet werden könnte. Zudem trat ein weiterer Effekt nur in der Pflegekindergruppe auf. Hier zeigte sich, dass je mehr Bindungsverhalten Pflegekinder gegenüber ihrer Pflegemutter zeigen, desto schneller reagieren sie auf neuronaler Ebene (N170) auf ihr Gesicht. Dies betont wiederum die Bedeutung der Pflegemutter in der psychosozialen Entwicklung von Pflegekindern, und zeigt, dass bevor gesteigertes Bindungsverhalten beobachtbar wird, auf neuronaler Ebene bereits spezifische Prozesse ablaufen, die auf die Salienz der Bindungsperson zurückzuführen sein könnten.
7.6 Gesamtdiskussion


Letztlich lässt sich sagen, dass es für die Arbeit oder auch das Zusammenleben mit betroffenen Kindern essentiell ist, als Bezugsfigur fortwährend eine sichere Basis darzustellen und so neue korrigierende Beziehungserfahrungen anzubieten. Tatsächlich hat sich gezeigt, dass die Erfahrung einer neuen Bezugsfigur (z. B. Therapeuten) trotz negativen Beziehungserfahrungen zu einem sicheren Arbeitsmodell von Bindung im Erwachsenenalter führen kann (Saunders et al., 2011). Unter Einbezug dessen, dass mentale Prozesse und Verhalten stets ein Produkt zugrundeliegender Gehirnfunktionen darstellen, kann Intervention als ein Lernprozess verstanden werden, bei dem sich durch andauernde Wiederholungen auf neuronale Verbindungen gestärkt werden, was dann auch zu langfristigen Verhaltensänderungen führen kann (siehe hierzu Kandel, 1998). In diesem Sinne erscheint es notwendig dieser Arbeit mit erhöhtem Verständnis entgegenzukommen und fortlaufende positive Beziehungsangebote dauerhaft aufrecht zu erhalten.
References


Hove and New York: Psychology Press.


## Appendix A

### Table A1
*Means and Standard Deviations for P1 Amplitude Responses (Microvolts) in Mother and Stranger Face Condition by Group*

<table>
<thead>
<tr>
<th>Electrode site</th>
<th>Control group</th>
<th>Foster group</th>
<th>both groups</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n = 24</td>
<td>n = 13</td>
<td>N = 37</td>
</tr>
<tr>
<td></td>
<td>M(SD) mother</td>
<td>M(SD) stranger</td>
<td>M(SD) mother</td>
</tr>
<tr>
<td>O1</td>
<td>31.90 (9.86)</td>
<td>31.07 (10.57)</td>
<td>31.22 (10.72)</td>
</tr>
<tr>
<td>O2</td>
<td>34.49 (10.01)</td>
<td>33.90 (10.68)</td>
<td>32.95 (12.29)</td>
</tr>
<tr>
<td>collapsed over</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>electrodes</td>
<td>33.20 (9.54)</td>
<td>32.48 (10.20)</td>
<td>32.09 (10.99)</td>
</tr>
</tbody>
</table>

*Note.* O1 = left hemisphere, O2 = right hemisphere.

### Table A2
*Means and Standard Deviations for N170 Amplitude Responses (Microvolts) in Mother and Stranger Face Condition by Group*

<table>
<thead>
<tr>
<th>Electrode site</th>
<th>control group</th>
<th>foster group</th>
<th>both groups</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n = 24</td>
<td>n = 13</td>
<td>N = 37</td>
</tr>
<tr>
<td></td>
<td>M(SD) mother</td>
<td>M(SD) stranger</td>
<td>M(SD) mother</td>
</tr>
<tr>
<td>PO9</td>
<td>-4.48 (7.25)</td>
<td>-2.74 (6.58)</td>
<td>-2.09 (7.53)</td>
</tr>
<tr>
<td>PO10</td>
<td>-1.34 (5.73)</td>
<td>1.09 (6.23)</td>
<td>0.33 (7.65)</td>
</tr>
<tr>
<td>collapsed over</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>electrodes</td>
<td>-2.91 (5.33)</td>
<td>-0.83 (5.68)</td>
<td>-0.88 (6.53)</td>
</tr>
</tbody>
</table>

*Note.* PO9 = left hemisphere, PO10 = right hemisphere.
Table A3
Means and Standard Deviations for Nc Amplitude Responses (Microvolts) in Mother and Stranger Face Condition by Group at Lateral Leads

<table>
<thead>
<tr>
<th>Electrode site</th>
<th>Control group</th>
<th>Foster group</th>
<th>both groups</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n = 24</td>
<td>n = 13</td>
<td>N = 37</td>
</tr>
<tr>
<td></td>
<td>M(SD)</td>
<td>M(SD)</td>
<td>M(SD)</td>
</tr>
<tr>
<td></td>
<td>mother-stranger</td>
<td>mother-stranger</td>
<td>mother-stranger</td>
</tr>
<tr>
<td>F3</td>
<td>-7.70 (5.05)</td>
<td>-9.49 (5.85)</td>
<td>-8.33 (5.33)</td>
</tr>
<tr>
<td></td>
<td>-8.65 (3.76)</td>
<td>-11.58 (6.79)</td>
<td>-9.68 (5.14)</td>
</tr>
<tr>
<td>F4</td>
<td>-6.97 (4.66)</td>
<td>-9.08 (6.21)</td>
<td>-7.71 (5.27)</td>
</tr>
<tr>
<td></td>
<td>-7.29 (3.24)</td>
<td>-9.08 (5.44)</td>
<td>-7.92 (4.16)</td>
</tr>
<tr>
<td>C3</td>
<td>-6.19 (3.39)</td>
<td>-5.67 (4.11)</td>
<td>-6.01 (3.61)</td>
</tr>
<tr>
<td></td>
<td>-5.55 (2.95)</td>
<td>-7.36 (3.81)</td>
<td>-6.19 (3.41)</td>
</tr>
<tr>
<td>C4</td>
<td>-4.35 (3.96)</td>
<td>-4.05 (4.90)</td>
<td>-4.24 (4.25)</td>
</tr>
<tr>
<td></td>
<td>-4.51 (3.92)</td>
<td>-5.76 (4.10)</td>
<td>-4.95 (3.98)</td>
</tr>
</tbody>
</table>

Note. F3 and C3 = left hemisphere, F4 and C4 = right hemisphere.

Table A4
Means and Standard Deviations for Nc Amplitude Responses (Microvolts) in Mother and Stranger Face Condition by Group at Midline Leads

<table>
<thead>
<tr>
<th>Electrode site</th>
<th>Control group</th>
<th>Foster group</th>
<th>both groups</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n = 24</td>
<td>n = 13</td>
<td>N = 37</td>
</tr>
<tr>
<td></td>
<td>M(SD)</td>
<td>M(SD)</td>
<td>M(SD)</td>
</tr>
<tr>
<td></td>
<td>mother-stranger</td>
<td>mother-stranger</td>
<td>mother-stranger</td>
</tr>
<tr>
<td>Fz</td>
<td>-6.35 (4.31)</td>
<td>-8.50 (5.04)</td>
<td>-7.11 (4.63)</td>
</tr>
<tr>
<td></td>
<td>-7.77 (3.52)</td>
<td>-9.69 (7.24)</td>
<td>-8.45 (5.12)</td>
</tr>
<tr>
<td>FCZ</td>
<td>-6.07 (3.75)</td>
<td>-6.43 (5.74)</td>
<td>-6.20 (4.47)</td>
</tr>
<tr>
<td></td>
<td>-6.08 (3.66)</td>
<td>-8.75 (4.37)</td>
<td>-7.02 (4.07)</td>
</tr>
<tr>
<td>Cz</td>
<td>-5.15 (3.46)</td>
<td>-5.05 (4.97)</td>
<td>-5.12 (3.98)</td>
</tr>
<tr>
<td></td>
<td>-4.80 (4.71)</td>
<td>-6.30 (5.26)</td>
<td>-5.33 (4.89)</td>
</tr>
<tr>
<td>collapsed over</td>
<td>-5.86 (3.18)</td>
<td>-6.66 (4.59)</td>
<td>-6.14 (3.69)</td>
</tr>
<tr>
<td>midline leads</td>
<td>-6.22 (3.48)</td>
<td>-8.25 (5.19)</td>
<td>-6.93 (4.21)</td>
</tr>
</tbody>
</table>
Appendix B

Table B1
Means and Standard Deviations for P1 Amplitude Responses (Microvolts) in Mother and Stranger Face Condition by Attachment. Collapsed over groups.

<table>
<thead>
<tr>
<th>Electrode site</th>
<th>Secure</th>
<th>Insecure</th>
<th>both</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mother</td>
<td>stranger</td>
<td>mother</td>
</tr>
<tr>
<td>O1</td>
<td>30.85</td>
<td>30.37</td>
<td>31.58</td>
</tr>
<tr>
<td></td>
<td>(11.72)</td>
<td>(11.74)</td>
<td>(9.99)</td>
</tr>
<tr>
<td>O2</td>
<td>33.74</td>
<td>31.54</td>
<td>32.21</td>
</tr>
<tr>
<td></td>
<td>(14.84)</td>
<td>(14.63)</td>
<td>(9.64)</td>
</tr>
<tr>
<td>collapsed over</td>
<td>32.29</td>
<td>30.95</td>
<td>32.76</td>
</tr>
<tr>
<td>O1/O2</td>
<td>(12.75)</td>
<td>(12.68)</td>
<td>(10.13)</td>
</tr>
</tbody>
</table>

Note. O1 = left hemisphere, O2 = right hemisphere.

Table B2
Means and Standard Deviations for N170 Amplitude Responses (Microvolts) in Mother and Stranger Face Condition by Attachment. Collapsed over groups.

<table>
<thead>
<tr>
<th>Electrode site</th>
<th>Secure</th>
<th>Insecure</th>
<th>both</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mother</td>
<td>stranger</td>
<td>mother</td>
</tr>
<tr>
<td>PO9</td>
<td>-4.81</td>
<td>-2.01</td>
<td>.49</td>
</tr>
<tr>
<td></td>
<td>(7.16)</td>
<td>(7.16)</td>
<td>(7.11)</td>
</tr>
<tr>
<td>PO10</td>
<td>-.99</td>
<td>0.14</td>
<td>3.48</td>
</tr>
<tr>
<td></td>
<td>(6.48)</td>
<td>(8.38)</td>
<td>(7.48)</td>
</tr>
<tr>
<td>collapsed over</td>
<td>-3.90</td>
<td>-.93</td>
<td>1.98</td>
</tr>
<tr>
<td>PO9/10</td>
<td>(5.45)</td>
<td>(7.20)</td>
<td>(6.29)</td>
</tr>
</tbody>
</table>

Note. PO9 = left hemisphere, PO10 = right hemisphere.
Table B3
Means and Standard Deviations for Nc Amplitude Responses (Microvolts) in Mother and Stranger Face Condition by Attachment at Lateral Leads. Collapsed over groups.

<table>
<thead>
<tr>
<th>Electrode site</th>
<th>Secure mother</th>
<th>Secure stranger</th>
<th>Insecure mother</th>
<th>Insecure stranger</th>
<th>both mother</th>
<th>both stranger</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M(SD)</td>
<td>M(SD)</td>
<td>M(SD)</td>
<td>M(SD)</td>
<td>M(SD)</td>
<td>M(SD)</td>
</tr>
<tr>
<td>F3</td>
<td>-7.60 (5.76)</td>
<td>-8.92 (5.92)</td>
<td>-9.02 (4.95)</td>
<td>-10.40 (4.31)</td>
<td>-8.33 (5.33)</td>
<td>-9.68 (5.14)</td>
</tr>
<tr>
<td>F4</td>
<td>-5.94 (4.99)</td>
<td>-7.30 (3.92)</td>
<td>-9.38 (5.10)</td>
<td>-8.51 (4.40)</td>
<td>-7.71 (5.27)</td>
<td>-7.92 (4.16)</td>
</tr>
<tr>
<td>C3</td>
<td>-5.03 (3.41)</td>
<td>-5.43 (3.70)</td>
<td>-6.93 (3.64)</td>
<td>-6.90 (2.88)</td>
<td>-6.01 (3.61)</td>
<td>-6.19 (3.34)</td>
</tr>
<tr>
<td>C4</td>
<td>-3.24 (3.46)</td>
<td>-4.14 (3.85)</td>
<td>-5.20 (4.78)</td>
<td>-5.71 (4.04)</td>
<td>-4.24 (4.25)</td>
<td>-4.95 (3.98)</td>
</tr>
</tbody>
</table>

Note. F3 and C3 = left hemisphere, F4 and C4 = right hemisphere.

Table B4
Means and Standard Deviations for Nc Amplitude Responses (Microvolts) in Mother and Stranger Face Condition by Attachment at Midline Leads. Collapsed over groups.

<table>
<thead>
<tr>
<th>Electrode site</th>
<th>Secure mother</th>
<th>Secure stranger</th>
<th>Insecure mother</th>
<th>Insecure stranger</th>
<th>both mother</th>
<th>both stranger</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>M (SD)</td>
</tr>
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<td>-8.07 (6.10)</td>
<td>-7.44 (4.81)</td>
<td>-8.80 (4.13)</td>
<td>-7.11 (4.62)</td>
<td>-8.45 (5.12)</td>
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<tr>
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<td>-6.51 (4.80)</td>
<td>-7.55 (4.24)</td>
<td>-7.50 (3.30)</td>
<td>-6.20 (4.47)</td>
<td>-7.02 (4.07)</td>
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<tr>
<td>Cz</td>
<td>-3.57 (4.10)</td>
<td>-4.22 (6.06)</td>
<td>-6.59 (3.35)</td>
<td>-6.38 (3.27)</td>
<td>-5.12 (3.98)</td>
<td>-5.33 (4.89)</td>
</tr>
<tr>
<td>collapsed over midline leads</td>
<td>-5.03 (3.34)</td>
<td>-6.27 (5.05)</td>
<td>-7.19 (3.78)</td>
<td>-7.56 (3.23)</td>
<td>-6.14 (3.69)</td>
<td>-6.93 (4.21)</td>
</tr>
</tbody>
</table>