Social behavior in young twins : are fearfulness, prosocial and aggressive behavior related to frontal asymmetry?

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CHAPTER 5

General discussion

General discussion

The general aim of this thesis was to gain more insight in the neural correlates of temperament and social behavior in early childhood. We were specifically interested in frontal asymmetry (FA) in relation to fearfulness, prosocial behavior and aggressive behavior. Our results, described in Chapter 2, showed that individual differences in both fearfulness and FA are best explained by a combination of genetic influences (about a quarter of the variance) and unique environmental influences (about three quarters of the variance). In contrast to our expectations these influences on fearfulness and FA were not overlapping which indicates that on the level of developmental contributors our data do not support an association between fearfulness and FA in early childhood.

In Chapter 3 and Chapter 4 we examined two new tasks to measure social behavior in reaction to social exclusion and social judgments. The results in Chapter 3 consistently showed that the vast majority of the children compensated for social exclusion in the first trials of the Prosocial Owl Game (POG). Individual differences in prosocial behavior arose when the game was progressing. Similar to the Prosocial Cyberball Game for older children and adults (Riem, Bakermans-Kranenburg, Huffmeijer, & Van IJzendoorn, 2013; Vrijhof et al., 2016; Van der Meulen, Van IJzendoorn, & Crone, 2016; Van der Meulen et al., 2017) this newly developed POG successfully triggered prosocial compensating behavior. We hypothesized that individual differences would be explained by differences in approach and withdrawal tendencies as reflected by FA, however this was not the case.

In Chapter 4 we examined how children responded to social judgments from peers on their cuddly animal. We successfully adapted the Social Network Aggression Task (SNAT) used in older children and adults (Achterberg, Van Duijvenvoorde, Bakermans-Kranenburg, & Crone, 2016; Achterberg et al., 2017) and made an ethically accepted version for Early Childhood (SNAT-EC). In line with the SNAT for older children and adults we showed that young children responded in a more aggressive way after a negative social judgment than after a positive social judgment during the SNAT-EC. Contrary to our expectations, this reaction was not mediated by FA. In other words, negative social judgments did not induce relatively greater left frontal activity and left FA was not related to more aggressive behavior. In sum, the results of our newly developed tasks for social behavior in early childhood showed similar results of prosocial compensating behavior and aggressive behavior in response to social feedback in children as in adolescents and adults. However, FA was not related to this behavior.

In the following sections we will elaborate on our twin design, on the replicability of our findings, and on possible explanations for our results regarding FA. Next we will discuss the limitations and some directions for future research.

Behavioral genetics and replicability

All studies presented in this thesis included twin samples. Twin samples create great research opportunities for two distinct aims: examining heritability and testing the replicability of results. Using genetic modelling we investigated genetic and environmental influences on the traits. We examined the monozygotic (MZ)/dizygotic (DZ) correlations to estimate heritability as higher MZ correlations than DZ correlations suggest genetic influences on the trait. In addition, twin samples can be used for a test-replication design. During the past years the importance of replicability in research has been highlighted (see Pashler & Wagenmakers, 2012). Especially when examining new tasks in a study, it is important to replicate the outcomes of the study to enhance confidence in the validity and robustness of the findings. In this thesis we examined two newly developed tasks to measure prosocial and aggressive behavior in early childhood and we did so using a test-replication design. Two similar groups were created in which each child from a twin pair was randomly assigned to either the test or the replication sample.

Behavioral Genetics. This thesis showed that fearfulness, FA and prosocial compensating behavior are partly influenced by genetic factors. In Chapter 2 we used bivariate genetic modelling and showed that both fearfulness and FA were best explained by unique environmental influences (for about three quarters) and also for a part by genetic influences (for about one quarter). Our results were in line with previous studies (Anokhin, Heath, & Myers, 2006; Clifford, Lemery-Chalfant, & Goldsmith, 2015; Goldsmith, Buss, & Lemery, 1997; Lemery-Chalfant, Doelger, & Goldsmith, 2008; Smit, Posthuma, Boomsma, & De Geus, 2007; Van Houtem, Laine, Boomsma, Ligthart, Van Wijk, & De Jongh, 2013). However, in general these studies found larger genetic influences. The relative contribution of unique environmental versus genetic influences to personality traits seems to change over the lifespan and during childhood genetic influences seem to increase over the years (see a meta-analysis by Kandler & Papendick, 2017). Thus, developmental changes may explain the relatively low influence of genetics on fearfulness and FA in our study compared to other studies that examined 8-year-old children (Clifford et al., 2015; Lemery-Chalfant et al., 2008). In Chapter 3 we examined the MZ/DZ correlations to estimate the heritability of prosocial compensating behavior. As there was almost no variance in the first trials of the game (because most children compensated for exclusion) we estimated heritability over the second and third trials. In accordance with previous studies (see review by Knafo-Noam, Vertsberger, & Israel, 2018) we showed a large heritability component for prosocial compensating behavior.

Overall, we found that genetic factors are involved in fearfulness, FA and prosocial behavior, which indicates that some of the negative results in this thesis do not merely reflect measurement error as the substantial correlations between children within MZ twin pairs would not emerge when only non-systematic error was at stake. However, we cannot ignore the fact that we also found substantial influence of unique environmental influences that include measurement error. Recently a longitudinal cross-cultural study showed that most variation in behavioral and emotional adjustments (based on self-reports of 8-12 year old children) was explained by within-person variability, rather than between-person or between-group variability (Deater-Deckard et al., 2018). The authors interpreted this within-person variability as measurement error (K. Deater-Deckard, personal communication, May 23, 2018).

Accordingly, we believe that measurement error also plays a role when collecting data using tests and observations.

Replicability. We developed two tasks to measure social behavior in response to social exclusion and social judgments in early childhood and used a test-replication design to examine the replicability of our outcomes. In Chapter 3 we investigated the POG and showed that prosocial compensating outcomes were comparable in the test and replication sample. In line with previous studies (Van der Meulen et al., 2016, Vrijhof et al., 2016) we found that children show prosocial compensating behavior during the POG. Especially during the first trails of each game most children compensated. Individual differences arose in the second and third trials of the game. We hypothesized that children that compensated more over all trials would also have higher ratings of prosocial behavior as reported by the parents or would donate more stickers to an unknown child. However, in both the test and the replication sample we found that the different indicators for prosocial behavior were not related. Other studies also failed to find associations between different prosocial responses in infants (Dunfield, Kuhlmeier, O'Connell, & Kelley, 2011; for a review see Thompson & Newton, 2013), adolescents (Vrijhof et al., 2016) and adults (Van der Meulen et al., 2016). Indeed, prosocial behavior has been suggested to be a multidimensional construct for which outcomes are dependent on context and the type of prosocial behavior measure (Paulus, 2018; Padilla-Walker & Carlo, 2015).

In Chapter 4 we investigated the SNAT-EC and validated our findings on aggressive behavior in response to negative social judgments in three samples: a pilot sample in which we tested our hypotheses and a test and replication sample in which we showed that the outcomes were replicated. By using a meta-analysis over the three samples we found a large effect size of social judgment on aggressive behavior. Thus, in line with previous studies in older children and adults (Achterberg et al., 2016, 2017) we showed that negative social judgments induce more aggressive behavior than positive social judgments. Contrary to results of studies in adults which consistently showed that aggressive behavior is related to left FA (see a recent review by Harmon-Jones & Gable, 2018), we did not find a relation between FA and aggressive behavior in early childhood.

Frontal asymmetry in early childhood

Contrary to our expectations, FA was not associated with fearfulness, prosocial behavior or aggressive behavior in early childhood. In Chapter 2 we hypothesized that fearfulness would be associated with relatively greater right frontal brain activity (or right FA), but our results showed no significant correlations. In addition, there was no overlap in genetic or environmental influences that explained the variance in both fearfulness and FA. Studies reporting associations between right FA and withdrawal behavior mainly focused on clinical samples with depression and anxiety problems (see meta-analysis by Thibodeau, Jorgensen, & Kim, 2006). Even though anxiety symptoms have been associated to fearfulness (Goldsmith & Lemery, 2000), it could be that a significant association between fearfulness and right FA is only present in populations with more severe fear/anxiety problems. In our study we included typically developing children and previous studies including similar samples also failed to show significant relations between fearfulness and FA (Fox, Henderson, Rubin, Calkins, & Schmidt, 2001; Howarth, Fettig, Curby, & Bell, 2016). In addition, a study including adults that distinguished between fear and anxiety only found an association between right FA and anxiety, not fear (Neal & Gable, 2017). To conclude, having a non-clinical sample with young children may explain why we did not find a significant association between FA and fearfulness.

In this thesis we also investigated the relation between FA and approach-related behavior. We hypothesized that prosocial compensating behavior would be related to relatively greater left frontal brain activity (left FA). We based our hypotheses on studies that investigated prosocial behavior in infants (helping and comforting behavior; Paulus, Kühn-Popp, Licata, Sodian, & Meinhardt, 2013) or in adults (donating behavior; Huffmeijer, Alink, Tops, Bakermans-Kranenburg, & Van IJzendoorn, 2012). In addition, as described in the previous section, prosocial behavior has been suggested to be a multidimensional construct (Paulus, 2018; Padilla-Walker & Carlo, 2015) which might also explain why we did not find a relation between

FA and prosocial compensating behavior. Thus, previous studies on which we based our hypotheses are in retrospect of limited value because they were carried out in other age groups or focused on other forms of prosocial behavior.

Furthermore, we hypothesized that aggressive behavior in early childhood would be associated with left FA. Even though there are studies investigating aggressive behavior in response to social judgments in early childhood (e.g. Dodge et al., 2003; Buckley, Winkel, & Leary, 2004) there is a lack of studies that relate this behavior to FA in children. On the other hand, there are a lot of studies that associate aggressive behavior to left FA in adults (see a recent review by Harmon-Jones & Gable, 2018). Still, our study did not find a relation between aggressive behavior in response to social judgments and FA in early childhood. There are several explanations for our results. Overall our hypotheses were mainly based on adults or infant studies examining FA (Thibodeau et al., 2006; Harmon-Jones & Gable, 2018; Paulus et al., 2013; Huffmeijer et al., 2012; Coan & Allen, 2004). The main issue is that results obtained with adults may not be directly generalizable to children.

First, potential developmental issues arise because of differences related to behavioral and neural measures obtained. Adults, of course, tend to provide much more and much 'cleaner' data than young children. Obtaining EEG data from children is challenging; the attention span of children is much shorter and long measurements lead to more rather than less artefacts (movements, eye blinks, changes in behavioral state like drowsiness; see Bell & Cuevas, 2012). In order to reduce these artefacts we adjusted the tasks for children in order to keep them motivated. For example, we included extra breaks during the SNAT-EC. Furthermore, as described in the discussion of Chapter 4, the frequency composition of the EEG is known to change over the course of development, but whether and how this affects FA is poorly understood (Saby & Marshall, 2012). Alpha band frequencies in children are based on developmental changes in the peak frequency of EEG (Marshall, Bar-Haim, & Fox, 2002). However, it is unknown whether the alpha frequency range of 6 – 10 Hz indeed corresponds to other measures of cortical tissue deactivation because this has not been examined in children. Future research should examine the development of the EEG frequency composition, 'alpha' bandwidth, and FA in children.

Second, there is still much debate about the minimum amount of EEG data needed for a reliable FA measurement. In our studies the number of trials used to compute FA is relatively small compared to adults studies. Based on the study by Tomarken and colleagues (1992) most researchers suggest that 8 minutes of resting EEG is necessary to obtain reliable FA (Tomarken, Davidson, Wheeler, & Kinney, 1992). However, a review by Allen and colleagues (2004) showed that shorter time frames are not less reliable (Allen, Coan, & Nazarian, 2004). Because children have more difficulty to remain calm and concentrated during the measurements it is necessary to compromise between the quality and quantity of the EEG data in early childhood. A study examining the development of EEG from 5 months till 4 years of age (Marshall et al., 2002) used a EEG rest measurement of less than 80 seconds to compute FA in 4 year old children. They used a mean number of artifact-free segments of 67 seconds (SD = 20); in our studies on average 63 segments per condition were included, leading to an average of somewhat more than 120 seconds in total (as we had two conditions for rest FA: eyes open and eyes closed). We therefore believe that our EEG rest measurement of three minutes with on average 63 segments per condition is sufficient to compute reliable FA. In Chapter 4 we based our minimum amount of trials on an adult study by Harmon-Jones & Sigelman (2001); they used a minimum criterion of 10 artifact-free seconds, which is similar to our minimum of 5 trials (equal to 10 seconds). Nevertheless, it is important for future studies to determine the optimal number of trials needed for reliable FA data in children.

Furthermore, in this thesis we used both so-called trait-related (measured during rest) and state-related (measured during a task) FA scores. In Chapter 2 we examined FA measured during rest in relation to parent-reported fearfulness rather than fear-inducing stimuli because we were interested in more stable, task-independent, traits. Other studies using parent-reported fearfulness and trait-related FA in children also failed to find significant relations (Diaz & Bell., 2012; LoBue, Coan, Thrasher, & DeLoache, 2011) or suggest more complex relationships. For trait-related FA the question may arise to what extent FA actually reflects a stable trait, as discussed more thoroughly in Chapter 2. It has been suggested that state-related fluctuations are also present during a rest measurement and as a result the maximum genetic influence on individual differences in FA cannot exceed 60% (Hagemann, Naumann, Thayer, & Bartussek, 2002; Smit et al., 2007). This may explain why we found large unique environmental influences on FA and somewhat lower genetic influences. However, even though our data showed only low heritability, it also shows that our data is not only driven by measurement error alone (which is included in the unique environmental influences).

Finally, following Chapter 2 and 3 in which our results suggest that FA (measured during rest) is only related to temperament or behavior in a more complex way we examined FA in Chapter 4 differently. Coan and Allen (2004) reviewed FA studies and proposed that FA should be studied as a moderator or mediator of emotion- and motivation related construct, such as aggression. We therefore collected state-related FA measured during the SNAT-EC and hypothesized that aggressive behavior after a negative social judgment would be mediated by greater left frontal activity. Nevertheless, our results did not support this hypothesis; a negative social judgment was not associated with relatively greater left frontal brain activity and left FA was not related to more aggressive behavior. This is especially surprising as a recent review suggests that individual differences in FA are more pronounced when an emotion is evoked than at rest (Reznik & Allen, 2018). However, possibly developmental issues like the EEG frequency composition, alpha bandwith determination or the minimum amount of EEG data to compute FA as described above may be involved when examining the mediating role of state-related FA in early childhood.

Limitations & future directions

The studies presented in this thesis have some limitations that should be addressed in future research. First, the studies described in this thesis were part of the larger, longitudinal L-CID study with a broader focus than just the EEG measurement. Several other measurements were included as well, both individual tasks as well as parent-child interactions tasks, resulting in a duration of approximately 3 hours per lab visit. Each co-twin was randomly assigned to the EEG block or the behavioral block as their first task. It is quite challenging for children this age to sit still during EEG measurements, and in combination with tiredness from the other tasks, this may have caused an increase in movement and ocular artifacts in the EEG data. About 33-50% of the data was unavailable because of artifacts, technical problems or refusal, however, such attrition rates are common in early childhood (see Bell & Cuevas, 2012). Besides, our sample was quite large compared to other EEG-studies with children, resulting in sufficient EEG-data for the analysis.

Secondly, all data used in this thesis were measured at one time point. Recent FA research has shown the importance of longitudinal data as studies have shown that some associations emerge over a longer time period (for instance see Goldstein et al., 2018). In addition, causality and direction can only be examined in longitudinal designs. Longitudinal behavioral data with two time points for the EEG data will be available in the future within the L-CID project, but for the current thesis such data were unavailable.

Further, the generalizability of findings from twin research to singletons may be questioned. However, research has shown that singletons and twins do not differ on temperament (Goldsmith & Campos, 1990), personality (Johnson, Krueger, Bouchard, & McGue, 2002) or externalizing behavior (Robbers et al., 2010) which suggests that twins and singletons are not so different from each other after all. Still, with regard to internalizing problems Robbers and colleagues (2010) suggest that twins may help each other against developing internalizing problems in early adolescence. Whether such protective factors for twins compared to singletons are already present in early childhood is unknown and future research should investigate the differences between twins and singletons more thoroughly.

Concluding remarks

In the current thesis we examined FA in relation to fearfulness, prosocial behavior and aggressive behavior. Based on the literature asymmetric frontal brain activity was a likely candidate to explain individual differences in approach and withdrawal related behavior in young children. However, our results showed no associations between fearfulness, prosocial behavior or aggressive behavior and FA in 4-6 year old children. We did show that genetic influences were involved in fearfulness and prosocial behavior in 4-6 year old children (see Chapter 2). Furthermore, in this thesis we presented two new tasks (POG and SNAT-EC) with which we showed that young children show similar increases in prosocial behavior in response to social exclusion and aggressive behavior in response to social judgments as older children, adolescents and adults, with comparable effect sizes (see Chapter 3 and 4). We showed that the POG and SNAT-EC are reliable measures and may conclude that the studies in this thesis can be used as a basis for follow-up research. In combination with the Prosocial Cyberball Game (PCG; Riem et al., 2013; Vrijhof et al., 2016; Van der Meulen, et al., 2016; 2017) and the SNAT (Achterberg et al., 2016, 2017) that measure the same social constructs in older children, adolescents and adults, the POG and SNAT-EC make it possible to use the tasks in longitudinal designs from early childhood to adulthood. The data collected for this thesis will be of increasing value in the coming years in which longitudinal data will be collected to investigate temperament and social behavior in children aged 4-13 years old (see Euser et al., 2016). The role of FA remains unclear but new insights may be revealed when the children grow older.

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