Peer Victimization Predicts Neural Response to Simulated Social Feedback from Peers

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Abstract

Peer victimization is of growing concern as it is associated with negative outcomes, such as internalizing problems (Reijntes et al., 2010) and physical health complications (Hager & Leadbeater, 2016). Additionally, peer victimization is related to neural response to social feedback (Rudolph, Miernicki, Troop-Gordon, Davis, & Telzer, 2016; Will, van Lier, Crone, & Güroğlu, 2016). The current study examined the impact of peer victimization on neural response to social feedback using the Chatroom Interact Task, designed to simulate an online chatroom where participants believe they are interacting with peers. Forty-eight adolescents (*M*age = 17.42, *SD* = 0.96 years) participated in the study. The Social Experiences Questionnaire (SEQ) was administered to measure levels of peer victimization and the Chatroom Interact Task was completed in the MRI scanner to examine neural response to social feedback. Multiple regression models were estimated with level of peer victimization as the predictor variable, using Statistical Parametric Mapping 12. Two time points were utilized for the measure of peer victimization; early victimization (reported victimization at the first visit) and mean victimization (average experiences over all visits prior to the scan). Results indicated that there is a negative relationship between peer victimization and neural response to both positive (acceptance) and negative (rejection) social feedback compared to a neutral condition. There was no significant relationship found between peer victimization and neural response to acceptance versus rejection. This may suggest that individuals with greater experiences of peer victimization expect negative consequences from social interactions generally, thus demonstrating a blunted response to both positive and negative feedback. Future research should consider how the impacts of peer victimization vary longitudinally from adolescence to adulthood, as well as how prosocial behaviors can affect neural response to social feedback.

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Peer victimization can be defined as an individual experiencing targeted harm from a perpetrator of similar age (Olweus, 1993). It can come in many forms such as overt (physical and verbal), relational (manipulation and exclusion or rejection), and cyber aggression. Peer victimization is of concern because of associations between victimization and a myriad of mental (Reijntes et al., 2010) and physical health (Gini, 2009; Hager & Leadbeater, 2016; Biebl, DiLalla, Davis, Lynch, & Shinn, 2011) problems, such as depression and trouble sleeping. Exploring the potential unique and long-term impacts of these different types of victimization over time is imperative.

Extensive cross-sectional research on the effects of peer aggression on well-being and overall adjustment has been conducted, where levels of victimization are often measured using self-report questionnaires. A meta-analysis examining the effects of victimization on psychosocial maladjustment in children found that peer aggression was associated with increased experiences of loneliness, anxiety, and depression (Hawker and Boulton, 2000; Iyer-Eimerbrink, Scielzo, & Jensen-Campbell 2015; Nansel et al., 2001). Youth with more experiences of peer victimization have both decreased self-esteem and negative affect, and higher risk of suicidal ideation and attempts compared to youth without a history of victimization (Hawker & Boulton, 2000). Compared to uninvolved peers, increased victimization has been related to increased suicidal ideation and suicide attempts in both children and adolescents (Geoffroy et al., 2016; Van Geel, Vedder, & Tanilon 2014). Research also has suggested that peer victimization impacts child and adolescent peer relationships and adjustment. For example, Nansel and colleagues (2001) found that individuals involved in bullying (bullies and victims), as compared to their "non-involved" classmates, exhibited more fighting and poorer relationships with classmates, along with increased loneliness and poorer psychosocial adjustment.

The longitudinal impact of bullying and peer victimization on internalizing problems also has been investigated. The longevity of the effects of peer aggression are supported by findings which indicate that past victimization is associated with symptoms years later. For example, Zwierzynska and colleagues (2013) found that experiences of victimization in childhood are precursors to internalizing problems in adolescence. Specifically, being a victim from the ages of 7-10 put adolescents at higher risk of developing depression and emotional symptoms from the ages of 11-14. Over a two-year period, these individuals were more likely to have persistent depression (Zwierzynska, Wolke, & Lereya, 2013). Similarly, additional research found that victims of peer aggression at 13-years-old reported higher rates of suicidal ideation and attempts at age 15, compared to those who reported no experiences of victimization (Geoffroy et al., 2016). Reijntes and colleagues (2010) conducted a meta-analysis of longitudinal studies that examined the relationship between victimization and internalizing problems and found that peer victimization was associated with increases in depressive symptoms, withdrawal, and loneliness over time. Additional research has been conducted to understand the relationship between experiences of peer victimization and the development of mental illnesses. Bowes and colleagues (2015) found that compared with children who were not victimized, individuals who reported frequent victimization by peers at the age of 13 had over a two-fold increase in the chance of reporting depressive symptoms at the age of 18. This demonstrates the relationship between peer victimization and the development of mental illness later in life. The results from these longitudinal studies suggest that there are lasting consequences of early experiences of peer victimization and demonstrate the importance of considering preventative measures, particularly in school-aged children.

In addition to self-report measures, research has been conducted using biological measures to examine the impact of peer victimization. It is meaningful to consider that, in some cases, victimization may present itself in the form of social rejection. One paradigm commonly used to simulate peer rejection is the “Cyberball” task, a virtual ball-tossing game in which participants believe they are interacting with peers who toss the ball to them (inclusion) or pass the ball only to each other (exclusion; Williams & Jarvis, 2006). Several studies that have utilized this paradigm found that in both adolescents and adults, social exclusion, compared to inclusion, related to increased activity in the orbitofrontal cortex (Van der Meulen et al., 2017; Sebastian et al., 2011; Radke et al., 2018), medial prefrontal cortex (Sebastian et al., 2011), and dorsal ACC (Eisenberger, Lieberman, & Williams, 2003; Rudolph, Miernicki, Troop-Gordon, Davis, & Telzer, 2016; Will, van Lier, Crone, & Güroğlu, 2016). Additional findings have also implicated the dorsal ACC in neural response to social evaluation and rejection (Dedovic, Slavich, Muscatell, Irwin, & Eisenberger, 2016; Kawamoto et al., 2012). Increased response to social rejection in the dorsal ACC could imply that individuals with greater experiences of peer victimization have a stronger response to social evaluation, particularly when it is negative.

One important consideration regarding the Cyberball task is that participants are not choosing the individuals who they will be playing the tossing game with. Peers being unknown could have an impact on the magnitude of the experiences of being included or excluded. To explore this idea, Cacioppo and colleagues (2013) conducted a meta-analysis using both the Cyberball task and a re-living paradigm that involved reliving an unwanted rejection by a romantic partner. Both were used to consider potential differences in neural response that emerge when being rejected by strangers (Cyberball) versus a previous partner who rejected the participant in real-life (re-living paradigm). Results showed that when a participant was rejected in the Cyberball task, the left ACC, anterior insula, and left inferior orbitofrontal cortex were reliably activated. When participants were rejected in the reliving paradigm, however, there was increased activation in the right anterior insula, right ACC, left orbitofrontal cortex, and right caudate nucleus (Cacioppo et al., 2013). When comparing activated regions across paradigms, the anterior insula and left orbitofrontal cortex were recruited in both tasks. Conversely, it is seen that the right ACC and right caudate regions were activated only during the reliving paradigm. This distinction may suggest that rejection from strangers versus from individuals one knows will elicit different neural responses.

Neural responses to social feedback have also been associated with exclusion-related distress. In adolescents completing the Cyberball task, the subACC and insula were more strongly activated during exclusion compared to inclusion, and higher activation in these regions was also related to greater self-reported distress during exclusion (Masten et al., 2009). In adults, increased neural response in the dorsal ACC during exclusion compared to inclusion was associated with greater levels of self-reported distress (Eisenberger et al., 2003). Conversely, greater right ventral prefrontal cortex activation during exclusion was associated with reduced levels of self-reported distress (Eisenberger et al., 2003). An additional component to consider when examining social feedback and distress is rejection sensitivity and how this influences neural response to social interactions. Kross and colleagues (2007) found that low rejection sensitivity (RS) was associated with increased neural response to rejection versus acceptance in the left superior frontal cortex and the right dorsal superior frontal gyrus compared to high RS individuals. This increased neural activity was associated with lower levels of self-reported distress.

The existing body of research suggests a relationship between experiences of peer victimization and both psychological and biological outcomes. Most previous studies have examined the effect of early peer victimization experiences on symptoms later in life, as well as mean experiences of peer victimization and their impact on both internalizing symptoms and neural response to social feedback. However, there is limited research on early experiences of peer victimization and later neural response to social feedback. The studies which have been done show that peer victimization is associated with increased neural response to social exclusion, compared to inclusion, specifically in the dorsolateral anterior cingulate cortex (dACC) (Rudolph et al., 2016; Will et al., 2016), left amygdala, left parahippocampal gyrus, left inferior frontal operculum, and right fusiform gyrus (McIver et al., 2018). The relationship between peer victimization and neural response to social feedback is important to understand the impact of peer aggression on individuals. This is important due to the associations between peer victimization and negative outcomes, such as depression, suicidal ideation, and trouble sleeping.

The present study aimed to examine the relationship between peer victimization and neural response to social feedback, using the Chatroom Task completed in the MRI scanner. A second aim of the current study was to compare an early measure of peer victimization to an average measure of peer victimization as predictors of neural response to social feedback. It is hypothesized that individuals with greater levels of peer victimization will show increased response to rejection and acceptance compared to the control condition, as well as increased neural response to rejection compared to acceptance. It also was predicted that neural response will be similar when comparing the early and mean victimization variables, suggesting lasting effects of early peer aggression on neural response to social feedback.

Methods

Participants

Participants were 48 adolescents (27 females), ages 15 to 20 (*M*age = 17.42, *SD* = 0.96 years) at the time of the MRI scan visit. Individuals were a subset of a larger longitudinal study at Temple University called the Adolescent Cognition and Emotion (ACE) Project, and they received monetary compensation for their contributions to the study. Twenty (41.7%) participants reported their ethnicity as Caucasian, twenty-six as African American (54.2%), and two (4.2%) as more than one ethnicity. Additional descriptive statistics for participants are displayed in Table 1.

Measures

Peer Victimization. Peer victimization was measured using the Social Experiences Questionnaire (SEQ; Crick & Grotpeter,1996). This is a 15-item questionnaire that contains three scales measuring overt victimization, relational victimization, and prosocial behaviors from peers. Participants indicate the frequency with which peers attempt to harm them physically, peers threaten to harm their peer relationships, and they are the targets of peers' caring acts (Crick & Bigbee, 1998). The current study focused only on the peer victimization subscales. This study utilized and compared the earliest measure of peer victimization (from the first time participants completed the SEQ) and a mean measure of peer victimization (averaged across all visits).

Chatroom Interact Task. In order to simulate peer rejection and measure neural response to social feedback, participants completed the Chatroom Interact Task while undergoing an fMRI. This is a task studying reactions to social acceptance or rejection from virtual peers. Trials were arranged in three blocks so that the participants experienced one “accept” block where they were chosen by the virtual peer two thirds of the time, one “reject” block in which they were not chosen by the virtual peer two thirds of the time, and one block where they were choosing between their two virtual peers. There was also a neutral condition in which participants had to indicate which virtual peer had a dot placed over their face.

fMRI data processing. Preprocessing was performed using the Functional Connectivity (CONN) toolbox of Statistical Parametric Mapping (SPM12). This included realignment and un-warping, co-registration, segmentation, normalization, and smoothing. During pre-preprocessing, images were motion-corrected, registered with structural images, and normalized to the standard brain template from the Montreal Neurological Institute (MNI). Contrasts were created to compare neural response to conditions of acceptance versus rejection, acceptance versus neutral, and rejection versus neutral.

fMRI statistical analysis. Statistical models were created in SPM12 to examine the relationship between peer victimization and neural response to social feedback. Peer victimization, at either early or mean time point, was entered as the predictor variable and neural response during each of the contrasts was entered as the outcome. Voxel level significance was set at $p < .001$ for whole-brain analyses and cluster-level thresholds were set at $p_{\mathrm{FWE}} < .05$. T-contrasts were created to examine the significance of the potential positive and negative relationships.

Procedure

Adolescents who participated in the ACE project attended multiple visits at Temple University prior to their MRI scan. Each visit was approximately six months after the previous one, with an average of four assessments preceding the scan. At the initial visit, procedures were reviewed with participants and they were asked to provide informed consent. Each of the visits consisted of participants filling out several self-report questionnaires, including the SEQ. At the scan visit, individuals were required to pass an MRI Safety Screening. This process included assessing for any potential risks for participation, such as checking for metal on the body. Subsequently, participants underwent an fMRI scan in which they completed the Chatroom Interact Task.

Results

The comparison of BOLD signal response to acceptance versus the control condition revealed significant negative associations between activation in the superior frontal gyrus and experiences of peer victimization reported at the early timepoint (Table 2, Figure 1). Similarly, results suggested a negative association between BOLD signal responses to rejection versus the control condition in the superior frontal gyrus and early reports of peer victimization (Table 3, Figure 3).

When BOLD signal responses to acceptance versus the control condition were compared, significant negative associations were revealed between activation in the medial frontal gyrus and experiences of peer victimization reported at the mean timepoint (Table 2, Figure 2). Likewise, results suggested a negative association between BOLD signal responses in the medial frontal gyrus to rejection compared to the control condition and mean reports of peer victimization (Table 3, Figure 4). There were no significant associations between BOLD signal response to acceptance versus rejection and self-reported early or mean experiences of peer victimization.

Discussion

The current study aimed to investigate whether self-reported experiences of peer victimization could be used to predict neural response to social feedback during the Chatroom Interact Task. More specifically, the relationship between early and mean reports of victimization and neural response to acceptance and rejection was examined. Results did not support the hypothesis that higher levels of peer victimization would be associated with increased neural response to social feedback. Rather, greater early and mean-reported levels of peer victimization were associated with decreased neural response to rejection compared to neutral and acceptance compared to neutral in the superior and medial frontal gyrus, respectively. In addition, there were no significant associations found between peer victimization and neural response to acceptance versus rejection. Results supported the second hypothesis that the relationships between peer victimization and neural response to social feedback would be similar for both early and average measures of peer victimization.

Findings are not consistent with previous research which suggested that increased experiences of victimization would be associated with increased neural response to social exclusion, specifically in the dorsal ACC (Rudolph et al., 2016; Will et al., 2016). In other words, the current study found that greater experiences of peer victimization were associated with reduced neural response to both positive (acceptance) and negative (rejection) social feedback compared to a neutral condition. One possible explanation for these results is that experiences of peer victimization may contribute to individuals expecting negative results from social interactions generally, which could result in a blunted response to any type of social feedback. This idea is supported by the optimal calibration hypothesis, which suggests that individuals who have experienced early-life chronic rejection should demonstrate a less sensitive social pain network (dACC and anterior insula; Chester, Pond Jr., Richman, & DeWall, 2012).

A related concept, rejection sensitivity, is also important to consider. One common theory for the development of rejection sensitivity is that it stems from childhood rejection (Downey & Feldman, 1996) and results in individuals who experience more rejection, e.g. through peer victimization, to be more sensitive to rejection, as demonstrated by an increased response to rejection. Research completed by Kross and colleagues (2007) found that low rejection sensitive individuals showed an increased response to rejection in the left prefrontal and right dorsal superior frontal gyrus compared to high RS participants. The results of the current study complement Kross's findings in that increased activation was found in the superior frontal gyrus in response to social exclusion versus neutral during the Chatroom Interact Task from individuals with fewer experiences of peer victimization (theoretically low RS individuals). This also relates to the optimal calibration theory because those who had been chronically victimized (high RS individuals) did not show increased activation in regions linked to emotion regulation, and this blunted response may be due to the expectation of negative consequences to social feedback.

Previous research has also found various associations between activation in brain regions related to social feedback. Studies have shown increased neural response during social exclusion compared to inclusion in regions related to social perception and evaluation, such as the orbitofrontal cortex and medial frontal cortex (Van der Meulen et al., 2017; Sebastian et al., 2011). Similarly, activation during exclusion versus inclusion was seen in certain brain regions that have been linked to processing conflict and negative affect, such as the orbitofrontal cortex, subACC, and dorsal ACC (Sebastian et al., 2011; Masten et al., 2009; Will, 2016). Cacioppo and colleagues (2013) found that the joint activation of the recruited regions during exclusion related to feelings of distress, social uncertainty, and rumination. Lastly, various studies have found associations between neural response to social feedback and activation of the social pain network, which includes the orbitofrontal cortex, dorsal ACC, and right ventral prefrontal cortex (Radke et al., 2018; Eisenberger et al., 2003; Rudolph et al., 2016). The current results yielded similar regions recruited in response to social feedback. This supports the role of these regions in response to social feedback, processing negative emotions and distress, and experiencing "social pain."

Findings from the current study also support the lasting effects of peer victimization. The early measure of peer victimization, compared to the measure of average experiences of peer victimization, was important in examining the potential longevity of the effects of peer victimization. Results showed that, although different regions were activated, the negative relationship between peer victimization and neural response to social feedback was seen when using both early and average measures. If bullying did not have a long-term impact on victims, one would expect to see different results between time points because victimization reported at the first visit would not necessarily have an effect on participants months later. Rather, increased victimization both over time and months in advance related to decreased neural response to social feedback. This is consistent with previous research suggesting that early victimization is associated with increased risk of developing depression and internalizing symptoms years later (Zwierzynska et al., 2013; Geoffroy et al., 2016; Reijntes et al., 2010; Bowes et al., 2015).

Results of this study suggest that there is a negative relationship between peer victimization and neural response to social acceptance and rejection and that the impacts of peer victimization have lasting effects on this neural response. Peer victimization has been of growing concern due to its prominence and long-term negative effects, including internalizing symptoms, such as increased feelings of loneliness, anxiety, negative affect, depression, suicidal ideation and attempt, and lower levels of self-esteem and social adjustment as compared to non-victimized individuals (Hawker & Boulton, 2000; Iyer-Eimerbrink et al., 2015; Geoffroy et al., 2016; Van Geel et al., 2014; Nansel et al., 2001). Similarly, individuals who have experienced peer victimization have been shown to have increased health complications as compared to non-victims (Hager & Leadbeater, 2016; Biebl et al., 2011; Gini, 2009). Given the associations between peer victimization and various negative outcomes, it is imperative that future research continue to explore these relationships and that preventative measures be taken in order to minimize the presence of peer victimization, both through intervention in classrooms as well as education to support positive social interactions outside of school. More recently, schools have begun to acknowledge the detrimental effects of peer victimization through anti-bullying campaigns. The recent research demonstrating the continued negative effects of peer victimization highlight that there is still much work to be done. Continued research clarifying the effects of peer victimization on mental and physical health and response to social feedback generally will be critical.

The current study exhibited various strengths including its significant results regardless of the conservative criteria used and the unique component of considering both early and mean measures of peer victimization. Another valuable element of this study was the use of the Chatroom Task because it incorporated the new interface of peer communication into our analysis of neural response to social feedback through the simulation of similar cyber experiences that adolescents are experiencing today. Furthermore, the use of the Chatroom paradigm allows participants to select who they would like to interact with, which in turn makes the feedback more personal. This component addresses previous findings that suggested differences in neural response to social feedback based on the relationship between the participant and individuals in the task (Cacioppo et al., 2013). Despite these strengths, there are some important limitations to consider. One limitation is the small sample size. Additionally, due to the nature of longitudinal studies, participants did not all complete the same number of visits prior to their MRI scan visit. Finally, the current study did not consider additional risk factors, such as levels of internalizing symptoms, or protective factors, such as social support, in the examination of the relationship between peer victimization and neural response to social feedback. Future research could consider how these factors potentially effect neural response to social feedback. Additionally, researchers should investigate how neural response to social feedback varies longitudinally, focusing on the changes from adolescence to adulthood. Another possible direction would be to consider neural response to rejection and acceptance using prosocial behaviors from peers as the predictor, to look at both protective factors and risk factors and how they relate to various outcomes over the lifespan. It may also be beneficial to utilize a newer measure of peer victimization, to incorporate the diverse forms of social communication that have become popular in recent years. One way in which this could be done would be to supplement the SEQ with a victimization scale focused on cyberbullying (Calvete, Orue, Estevez, Villardon & Padilla, 2010).

References

Biebl, S.J.W., DiLalla, L.F., Davis, E.K., Lynch, K.A., Shinn, S.O. (2011). Longitudinal Associations Among Peer Victimization and Physical and Mental Health Problems. *Journal of Pediatric Psychology, 36,* 868-877.

Bowes, L., Joinson, C., Wolke, D., Lewis, G. (2015). Peer Victimisation During Adolescence and its Impact on Depression in Early Adulthood: Prospective Cohort Study in the United Kingdom. *BMJ, 350,* 1-9.

Cacioppo, S., Frum, C., Asp, E., Weiss, R.M., Lewis, J.W., Cacioppo, J.T. (2013). A Quantitative Meta-Analysis of Functional Imaging Studies of Social Rejection. *Scientific Reports, 3,* 1-3.

Calvete, E., Orue, I., Estevez, A., Villardon, L., & Padilla, P. (2010). Cyberbullying in adolescents: Modalities and aggressors' profile. *Computers in Human Behavior, 26,* 1128-1135.

Chester, D.S., Pond Jr., R.S., Richman, S.B., DeWall, C.N. (2012) The Optimal Calibration Hypothesis: How Life History Modulates the Brain's Social Pain Network. *Frontiers in Evolutionary Neuroscience, 2,* 1-8.

Crick, N. R., & Bigbee, M. A. (1998). Relational and Overt Forms of Peer Victimization: A Multiinformant Approach. *Journal of Consulting and Clinical Psychology, 66,* 337-347.

Crick, N.R., & Grotpeter, J.K. (1996). Children's Treatment by Peers: Victims of Relational and Overt Aggression, *Development and Psychopathology, 8,* 367-380.

Dedovic, K., Slavich, G.M., Muscatell, K.A., Irwin, M.R., Eisenberger, N.I. (2016). Dorsal Anterior Cingulate Cortex Responses to Repeated Social Evaluative Feedback in Young

Women with and without a History of Depression. *Frontiers in Behavioral Neuroscience, 10.*

Downey, G., Feldman, S.I. (1996). Implication of Rejection Sensitivity for Intimate Relationships. *Journal of Personality and Social Psychology, 70,* 1327-1343.

Eisenberger N.I., Lieberman, M.D., Williams, K.D. (2003). Does Rejection Hurt?: An fMRI Study of Social Exclusion, *Science, 302*, 290–292.

Geoffroy, M., Boivin, M., Arseneault, L., Turecki, G., Vitaro, F., Brendgen, M., Renaud, J., Séguin, J.R., Tremblay, R.E., Côté, S.M. (2016). Associations Between Peer Victimization and Suicidal Ideation and Suicide Attempt During Adolescence: Results from a Prospective Population-Based Birth Cohort. *Journal of the American Academy of Child and Adolescent Psychiatry, 55,* 99-105.

Gini, G., Pozzoli, T. (2009). Association Between Bullying and Psychosomatic Problems: A Meta-analysis. *Pediatrics, 123,* 1059-1065.

Hager, A.D., Leadbeater, B.J. (2016). The Longitudinal Effects of Peer Victimization on Physical Health From Adolescence to Young Adulthood. *Journal of Adolescent Health, 58,* 330-336.

Hawker, D.S.J., Boulton, M.J. (2000). Twenty Years' Research on Peer Victimization and Psychosocial Maladjustment: A Meta-Analytic Review of Cross-sectional Studies. *Journal of Child Psychology and Psychiatry, 41,* 441-455.

Iyer-Eimerbrink, P.A., Scielzo, S.A., Jensen-Campbell, L.A. (2015) The Impact of Social and Relational Victimization on Depression, Anxiety, and Loneliness: A Meta-Analytic Review. *Journal of Bullying and Social Aggression, 1.*

Kawamoto, T., Onoda, K., Nakashima, K., Nittono, H., Yamaguchi, S., Ura, M. (2012). Is Dorsal Anterior Cingulate Cortex Activation in Response to Social Exclusion Due to Expectancy Violation? An fMRI Study. *Frontiers in Evolutionary Neuroscience 4.*

Kross, E., Egner, T., Ochsner, K., Hirsch, J., Downey, G. (2007). Neural Dynamics of Rejection Sensitivity. *Journal of Cognitive Neuroscience, 19,* 945-956.

Masten, C.L., Eisenberger, N.I., Borofsky, L.A., Pfeifer, J.H., McNealy, K., Mazziotta, J.C., Dapretto, M. (2009). Neural Correlates of Social Exclusion During Adolescence: Understanding the Distress of Peer Rejection. *Social Cognitive and Affective Neuroscience*, *4,* 143–157.

McIver, T.A., Bosma, R.L., Sandre, A., Goegan, S., Klassen, J.A., Chiarella, J., Booij, L., Craig, W. (2018). Peer Victimization is Associated with Neural Response to Social Exclusion. *Merrill-Palmer Quartley, 64,* 135-161.

Nansel, T.j., Overpeck, M., Pilla, R.S., Ruan, J., Simons-Morton, B., Scheidt, P. (2001). Bullying Behaviors Among US Youth: Prevalence and Association with Psychosocial Adjustment. *JAMA, 285,* 2094-2100.

Olweus, D. (1993). Bullying at School: What We Know and What We Can Do. *Psychology in Schools, 40,* 699-700.

Radke, S., Seidel, E.M., Boubela, r.n., Thaler, H., Metzler, H., Kryspin-Exner, I., Moser, E., Habel, U., Derntl, B. (2018). Immediate and Delayed Neuroendocrine Responses to Social Exclusion in Males and Females. *Psychoneuroendocrinology, 93,* 56-64.

Reijntes, A., Kamphuis, J.H., Prinzie, P., Telch, M.J. (2010). Peer victimization and internalizing problems in children: A meta-analysis of longitudinal studies. *Child Abuse and Neglect, 34,* 244-252.

Rudolph, K.D., Miernicki, M.E., Troop-Gordon, W., Davis, M.M., Telzer, E.H. (2016). Adding Insult to Injury: Neural Sensitivity to Social Exclusion is Associated with Internalizing Symptoms in Chronically Peer-Victimized Girls. *Social Cognitive and Affective Neuroscience,* 829-842.

Sebastian, C.L., Tan, G.C.Y., Roiser J.P., Viding, E., Dumontheil, I., Blakemore, S. (2011). Developmental Influences on the Neural Bases of Response to Social Rejection: Implications of Social Neuroscience for Education. *NeuroImage, 57,* 686-694.

Van der Meulen, M., Steinbeis, N., Achterberg, M., Bilo, E., Van den Bulk, B.G., van IJzendoorn, M.H., Crone, E.A. (2017). The Neural Correlates of Dealing with Social Exclusion in Childhood. *Neuropsychologia, 103,* 29-37.

Van Geel M., Vedder, P., Tanilon, J. (2014). Relationship Between Peer Victimization, Cyberbullying, and Suicide in Children and Adolescents. *JAMA Pediatrics, 168,* 435-442.

Will, G.-J., van Lier, P. A. C., Crone, E. A., Güroğlu, B. (2016). Chronic Childhood Peer Rejection is Associated with Heightened Neural Responses to Social Exclusion During Adolescence. *Journal of Abnormal Child Psychology, 44*, 43–55.

Williams, K.D., Jarvis, B. (2006). Cyberball: A Program for Use in Research on Interpersonal Ostracism and Acceptance. *Behavior Research Methods, 38,* 174-180.

Zwierzynska, K., Wolke, D., Lereya, T.S. (2013) Peer Victimization in Childhood and Internalizing Problems in Adolescence: A Prospective Longitudinal Study. *Journal of Abnormal Child Psychology, 41,* 309-323.

Table 1. *Descriptive statistics for demographics at time of scan*

	Participant
Age	17.42*(0.96)*
Male	21(43.8%)
Female	27(56.3%)
Caucasian	20(41.7%)
African American	26(54.2)
More than one ethnicity	2(4.2%)
Low Socioeconomic Status	21(43.8%)
High Socioeconomic Status	26(54.2%)

Table 2. *Results of the accept vs. neutral, whole brain FWE-corrected p < 0.05*

Timepoint	+/- effects	Region	MNI coordinates	K_e	p_{FWE}
Early	-	Superior Frontal Gyrus	16 64 14	421	0.008
Mean	-	Medial Frontal Gyrus	8 50 -12	1494	0.000

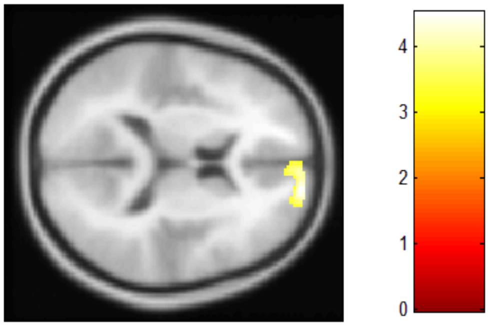

Figure 1. Results of the early timepoint: accept vs. neutral, whole brain FWE-corrected $p < 0.05$ (see Table 2).

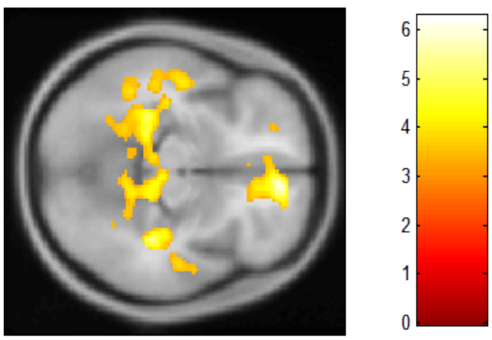

Figure 2. Results of the mean timepoint: accept vs. neutral, whole brain FWE-corrected $p < 0.05$ (see Table 2).

Table 3. *Results of the reject vs. neutral, whole brain FWE-corrected $p < 0.05$*

Timepoint	+/- effects	Region	MNI coordinates	K_e	p_{FWE}
Early	-	Superior Frontal Gyrus	16 64 14	634	0.001
Mean	-	Medial Frontal Gyrus	8 50 -12	1656	0.000

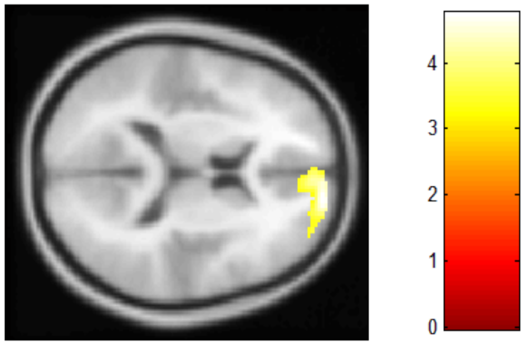

Figure 3. Results of the early timepoint: reject vs. neutral, whole brain FWE-corrected $p < 0.05$ (see Table 3).

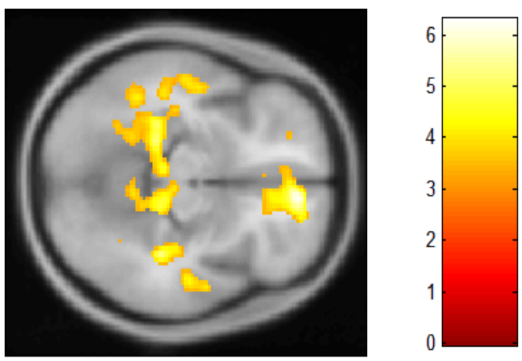

Figure 4. Results of the mean timepoint: reject vs. neutral, whole brain FWE-corrected $p < 0.05$ (see Table 3).