Bullying Perpetration and Victimization in Early Adolescence: Physiological Response to Social Exclusion

Angela Mazzone*
University "G. d'Annunzio", Chieti-Pescara, Italy
Marina Camodeca
University of Milano Bicocca, Milan, Italy
Daniela Cardone,
University "G. d'Annunzio", Chieti-Pescara, Italy
Arcangelo Merla,
University "G. d'Annunzio", Chieti-Pescara, Italy

*****email address for correspondence**:** mazzoneangela@gmail.com

This is an Accepted Manuscript of an article published by Thomson Digital / for IOS Press in International Journal of Developmental Science, available online at:

https://content.iospress.com/articles/international-journal-of-developmental-science/dev170225/

doi: *10.3233/DEV-170225*

To cite this article: Mazzone, A., Camodeca, M., Cardone, D., & Merla, A. (2017). Bullying perpetration and victimization in early adolescence: Physiological response to social exclusion. *International Journal of Developmental Science*, *11*, 121-130.

Abstract

The present study investigated the associations between bullying perpetration and victimization and physiological reactivity to social exclusion. The participants were 28 early adolescents (17 boys and 11 girls; M_{age} = 11.55; SD = 1.34). Bullying perpetration and victimization were assessed by peer nominations. To elicit social exclusion, participants were first included and then excluded in a laboratory paradigm (Cyberball). Physiological reactivity (i.e., nose tip temperature) was detected through thermal infrared imaging during the computer simulation. Nose temperature variations during inclusion and exclusion were compared between each other. Results showed increasing skin temperature during exclusion, compared to inclusion, for the whole sample, indicating that being excluded affected physiological reactivity. However, victimization was associated with higher skin temperature during exclusion, compared to bullying. The present findings suggest the importance of combining behavioral and contact-free physiological measures when studying bullying perpetration and victimization by peers.

Keywords: Bullying, victimization, physiological reactivity, social exclusion, thermal infrared imaging

Bullying is an intentional and aggressive behavior among school-aged children that involves a real or perceived power imbalance. The behavior is repeated, or has the potential to be repeated, over time (Olweus, 1993). Bullying can take the form of repeated verbal and physical attacks, humiliation, and exclusion (Salmivalli, 2010). In the last thirty years, several studies tried to identify distinct behavioral and psychological profiles of children and adolescents involved in bullying and victimization. For instance, bullying has been associated with rule-breaking and high levels of callous-unemotional traits, including lack of emotional concern (e.g., feelings of remorse and empathy) and insensitive use of others (De Angelis, Bacchini, & Affuso, 2016). Victimized children seem to manifest a fearful and withdrawn temperament, together with increased anxiety, which lead them to seek for stable and quiet environments (Affrunti, Geronimi, & Woodruff-Borden, 2014; Boivin, Hymel, & Bukowski, 1995).

The physiological functioning of children and adolescents who bully and who are victimized by their peers should be investigated, in order to draw a complete picture of their social behaviors. Indeed, the ability to regulate the arousal level (i.e., physiological reactivity) is of great importance for emotional and social functioning, as well as for giving flexible and effective behavioral responses to the environmental demands (Murray-Close, 2012; Scarpa, 2015). We propose that studying the physiological arousal of early adolescents who bully their peers and who are victimized could give insight into their behavioral regulation. Furthermore, it could potentially have implications for research on adaptive and maladaptive psychosocial outcomes, and provide information for helping them to become more resilient when confronted with stressful events (Scheithauer, Alsaker, Wölfer, & Ruggieri, 2013).

The Association of Bullying and Physiological Functioning

According to the literature, a weak physiological reactivity (e.g., low heart rate at rest) in response to different kinds of stressors could be a biological risk factor for engaging in proactive aggression, which is deliberate and strategic (Hubbard et al., 2002; Woods & White, 2005). Two main theoretical frameworks are often used to explain the relationship between low arousal and aggression. The stimulation-seeking theory (Zuckermann, 1990) suggests that low arousal levels constitute an unpleasant state that proactively aggressive children try to overcome by means of aggressive actions. Indeed, aggressive behavior may be seen as a way to seek for stimulation and increase arousal to an optimal level (Raine, Venables, & Mednick, 1997). According to the fearlessness theory, a general lack of anxiety and inhibition is required to manifest proactive aggression (Raine, 2002; Raine et al., 1997). Specifically, the fearlessness theory suggests that biological markers, such as low resting heart rate, are associated with low levels of distress and anxiety, resulting in reduced sensitivity to punishment. For instance, fearless children may be less concerned about the consequences of their own actions (e.g., retaliation, punishment), which, in turn, facilitate involvement in aggression (Raine, 2002).

Due to the proactive features of bullying, one may expect that bullies could be under-aroused in response to stressful events (Woods & White, 2005). To the best of our knowledge, only two studies specifically addressed physiological arousal and bullying. Woods and White (2005) confirmed that bullies were under-aroused; however, they assessed arousal levels by self-reports, rather than by physiological measures. Contrasting findings were obtained by Bollmer, Harris, and Milich (2006), who found increasing arousal levels (i.e., skin conductance) among bullies, when recalling a bullying episode. However, reporting a bullying episode could be even amusing for bullies. Therefore, this kind of experimental task is not comparable with experiencing a stressful event. Given that findings on the association between bullying and physiological functioning are sparse and mixed, we propose that more research is needed to clarify how adolescents involved in bullying respond to social stressors.

The Association of Victimization experiences and Physiological Functioning

Several studies found that children who are victimized by their peers manifest heightened physiological reactivity (e.g., alpha-amylase, skin conductance, blood pressure) to different social stressor tasks during experimental laboratory paradigm (Kliewer, Dibble, Goodman, & Sullivan, 2012; Wilson, Kliewer, Teasley, Plybon, & Sica, 2002). In addition, victims show high vigilance and increased distress levels in response to a variety of social stressors (e.g., social exclusion and rejection by peers, recalling a victimization episode), which may contribute to their dysregulated physiological functioning (Downey, Lebolt, Rincon, & Freitas, 1998; Rosen, Milich, & Harris, 2009; Ruggieri, Bendixen, Gabriel, & Alsaker, 2013a).

However, there is no clear and uniform association between physiological reactivity and victimization. For instance, findings regarding hypothalamic-pituitary-adrenal axis (HPA) response (i.e., cortisol reactivity) to social stressors are equivocal. In fact, some studies showed no association between victimization and cortisol response (Kliewer et al., 2012) while others even indicated a blunted cortisol reactivity in response to social stressors (Calhoun et al., 2014). A lack of concurrence between the abovementioned studies could be due to the different markers of physiological arousal adopted, which originate from different stress-related systems and underlie different time courses (Engert et al., 2014).

Moreover, further studies showed the importance of considering the interaction between biological risk factors and the characteristics of the social context. For instance, Rudolph, Troop-Gordon, and Granger (2011) found that children who were victimized by their peers showed depression and rumination in combination with a high anticipatory cortisol level, which in contrast, was a protective factor against rumination and depression in children with low experiences of victimization by their peers. In other words, children living in a non-threatening environment (i.e., low peer victimization) benefited from their sensitivity, whereas those living in a threatening environment (i.e., high peer victimization) were negatively affected by their own sensitivity to the context.

Despite literature investigating physiological response to social stressors among victimized children is larger than literature investigating physiological functioning among children who bully their peers, results are not always consistent between each other, which points to the need of further research, employing also other physiological markers.

The Present Study

A useful way to examine physiological arousal in front of social stressors is a virtual experience of social exclusion (Williams, Cheung, & Choi, 2000). Social exclusion is defined as the situation of being ignored, or isolated, by an individual, or a group of individuals, with the explicit or implicit declaration of dislike (Williams, 2007). Given the strong human need to belong and to perceive one's own existence as meaningful, being excluded is described as a painful experience, elicited even by brief episodes during laboratory paradigms (Eisenberger & Lieberman, 2004; Masten et al., 2009).

In the present study, thermal infrared imaging was used to monitor skin temperature in response to social exclusion during the Cyberball paradigm. Skin temperature has been suggested to be an indirect index of the Autonomic Nervous System's activity (Pavlidis, Eberhardt, & Levine, 2002; Rimm-Kaufman & Kagan, 1996). Up to date, several studies in the stress research field, suggested that thermal IR imaging is an efficient technique to estimate the sympathetic activity (Di Giacinto, Brunetti, Sepede, Ferretti, & Merla, 2014; Engert et al., 2014; Pavlidis et al., 2012).

In the present study, we used infrared imaging for theoretical and methodological reasons: a) The alterations in physiological arousal induced by social exclusion can be indirectly measured through skin temperature. In particular, increasing arousal is associated with variations in skin temperature (Paolini, Alparone, Cardone, van Beest, & Merla 2016); b) Due to its non-invasiveness (i.e., free-contact), infrared imaging is particularly useful in research with children and adolescents (Ebisch et al., 2012; Ioannou, Gallese, & Merla, 2014; Merla, 2014).

To the best of our knowledge, no studies investigated early adolescents' response to social exclusion through infrared imaging. Therefore, we aimed at comparing skin temperature during inclusion with skin temperature during exclusion. In line with a previous study investigating skin temperature variations in response to social exclusion in a sample of adult females (Paolini et al., 2016), we expected to find increasing skin temperature during social exclusion also in early adolescents participating in this study, regardless of their involvement in bullying. However, when looking at behaviors separately, we expected to find individual differences between early adolescents who bullied their peers and those who were victimized. Previous findings showed that proactive aggression and bullying behavior are associated with under-arousal in front of different kinds of social stressors (Hubbard et al., 2002; Woods & White, 2005) and that being victimized is associated with high arousal and distress (Kliewel et al., 2012; Rosen et al., 2009; Woods & White, 2005). In line with these studies, we expected to find a higher increase in skin temperature during exclusion among participants who were victimized in contrast to those who bullied their peers.

Method

Sample and Procedure

A sample of 28 early adolescents took part in the present study (17 boys and 11 girls; *M* = 11.55 years; *SD* = 1.3; range 9-14 years). Participants were part of a larger sample of pupils who were involved in a study about bullying at school. They were included in the present work if they had parental consent and if they were available to participate in the laboratory paradigm. They were all Italians and attended five schools located in southern-central Italy.

Peer nominations to assess bullying involvement were collected at school, whereas skin temperature in response to social exclusion was assessed during a laboratory session. Parents gave their written consent for their children's participation in the study. Confidentiality and anonymity of all information provided were assured. The study was conducted according to the Ethical Principles of Psychologists and Code of Conduct (APA) and to the Ethical Code of the Italian Association of Psychology.

Measures

Peer nominations. Bullying perpetration and victimization were assessed by a peer nomination measure that has been demonstrated to be valid and reliable in previous studies (Pozzoli, Gini, & Vieno, 2012). Peer nominations are widely used to investigate school-bullying, as bullying is a group phenomenon, in which all classmates can observe peers' interactions and could be directly or indirectly involved. Besides, peer nominations minimize the risk of social desirability and provide a weighted information about children's behaviors by a large number of classmates (Goossens, Olthof, & Dekker, 2006). Therefore, in line with previous literature, we assumed peers to be reliable informants to uncover bullying dynamics in the classroom (Monks & Smith, 2010).

Although a written definition of the term “bullying” was provided, participants were given a further oral explanation, in order to ensure their understanding of the difference between bullying and other types of aggressive behavior. Participants were then presented a list of items and were asked to nominate an unlimited number of classmates (including themselves) per each behavior described in the items. The bullying perpetration and victimization scales included 4 items each (e.g., *“Among your classmates, who is often aggressive with other peers, hitting, or pushing them away?”* and *“Among your classmates, who is threatened and offended?”*).

Each participant received nominations for both bullying perpetration and victimization scales by all classmates (even if not participating in the laboratory procedure). In order to control for classroom size, nominations received by each child were averaged across the four items and divided by the number of nominators. Thus, scores could range from 0 (*no nomination received*) to 1 (*nominations received by all classmates*). Means and standard deviations were as follows for bullying (M = .06; SD = .08; range: .00-.32) and victimization (M = .09; SD = .16; range: .00-.75). Reliability was α = .84 for both bullying and victimization.

Laboratory measurements – Baseline. Participants were assessed in a laboratory equipped for thermal infrared imaging. They were asked to sit in front of a computer and to reduce their movements as much as possible, so that we could properly video-record their facial thermal images through a thermal camera (see the following section). During the baseline and experimental procedure, parents and researchers observed participants through a one-way mirror. A researcher monitored the images and their quality through a laptop. Before detecting skin temperature, participants achieved a proper acclimatization to the room's environmental conditions (room temperature: 23 ± 1 °C; relative humidity: 50–55%; no direct sunlight and ventilation). After about 10 minutes, we recorded a thermal pre-stimulation measure, in order to monitor autonomic nervous system activity at rest (i.e., baseline phase lasting 1 minute). During the baseline, participants completed a computerized questionnaire assessing variables not considered in the present study.

Cyberball: Cyberball is an experimental paradigm, consisting of a virtual ball-tossing game, allowing the manipulation of social exclusion (Williams et al., 2000). Although it was originally developed for an adult population, different studies showed that it is also effective to elicit social exclusion in children and adolescents (Ruggieri, Bendixen, Gabriel, & Alsaker, 2013b; Scheithauer et al., 2013; Sijtsema, Shoulberg, & Murray-Close, 2011; Zadro et al., 2013). Following the procedure adopted in previous studies, participants were told that the goal of the study was to assess their mental visualization skills (Williams et al., 2000). Therefore, we explained that they were playing against the computer, but that they should imagine playing with their best friends (Sijtsema et al., 2011). The friends' names, suggested by each participant, appeared on the screen, near the figures representing the players. Each participant was represented by a hand at the bottom center of the screen and identified by the word "Me". The researcher underlined the importance of mentally visualizing and representing the scene throughout the game. Before starting to play, participants were asked to read on the laptop screen the following instructions:

> *"You are going to play a ball tossing game. Imagine you are playing with two of your best friends. When you receive the ball, throw it to one of them, by clicking on his/her name. Your performance with the game is not important. We are interested in your ability to represent the whole scene in your own mind. Where are you playing? How is the weather? Is it warm and sunny or cold and rainy? Imagine your feelings and thoughts if you would play this game with your friends in real life".*

Based on previous literature, we reasoned that using a simulated scenario of exclusion, but with real peers' names, would be an appropriate procedure (Shoulberg, Sijtsema, & Murray-Close, 2011; Sijtsema et al., 2011). Indeed, previous findings showed that only imagining being excluded by a peer constitutes a threatening experience during early adolescence (Sijtsema et al., 2011). Furthermore, participants were told that they were playing a simulated game, due to ethical and practical reasons. First, we did not want to deceive our participants, providing them with false or misleading information. Second, we wanted to avoid any strong emotional distress (i.e., we reasoned that involving participants' friends or confederate peers would have resulted in a stronger emotional distress during social exclusion). Third, we reasoned that this procedure is easier and more parsimonious than the one involving real players. Besides, confederate peers or participants' friends could decline to take part in the study and this, in turn, would have affected the design of the research. Although this procedure may elicit a less robust reaction compared to the original paradigm in which participants believe that they are playing with other people, previous findings suggest that people show signs of exclusion even when they are aware of playing against a computer (Zadro, Williams, & Richardson, 2004).

During the first two minutes of the game (*inclusion* phase), subjects received the ball as often as other players. In this phase, 39 ball throws occurred among the three players and each participant received the ball about one third of the times, which is an equal share between the players. After this inclusion phase, Cyberball was programmed for excluding the participants for the remaining part of the game (e.g., they did not receive the ball anymore: *exclusion* phase), lasting about two minutes, in which 40 throws occurred between the other two players. All participants experienced the same condition.

Following the procedure adopted by Bolling and colleagues (2011), when the Cyberball was over, the experimenter asked each participant some questions about the game (e.g. *"How was the game"?* or *"Did you enjoy the game"?*). All participants verbally confirmed feeling excluded at some point during the game. This provided further evidence that the experimental paradigm was effective. At the end of the experimental procedure, participants were thanked and fully debriefed (i.e., they were told that the game was pre-programmed to exclude them after receiving the ball for a preset number of tosses).

Data recording and data reduction analysis

During baseline, inclusion, and exclusion phases, facial thermal imprints were recorded through an infrared digital thermal camera, which is a free-contact device able to detect skin temperature variation during sympathetic nervous system arousal (Anbar, 2002). Based on previous studies on primates and humans, we considered nose tip as the region of interest, as it is one of the facial areas most responsive to emotional and distressful stimuli (Engert et al., 2014; Nhan & Chau, 2010; Shastri, Merla, Tsiamyrtzis, & Pavlidis, 2009).

Thermal IR (Infrared) imaging was performed by means of a digital thermal camera FLIR SC660 (640 × 480 bolometer FPA, sensitivity: <30mK@30◦C). The acquisition frame rate was set to 1 Hz. A visual inspection of the changes in facial thermal imprints in all subjects was performed to qualitatively investigate the autonomic responses of the participants throughout the experiment. Thermal signals have been extracted through a tracking software, developed with Matlab algorithms (MATLAB 2013a, The MathworksInc., Natick, MA). The tracking algorithm is based on the 2-D cross-correlation between a template region, chosen by the user on the initial frame, and a similar ROI (Region Of Interest) in a wider searching region, expected to contain the desired template in each of the following frames (Tangherlini, Merla, & Romani, 2006). In this way, it is possible to automatically extract the thermal signals in defined ROIs during the whole experiment.

The tracking algorithm has been extensively tested in previous studies (Ebisch et al., 2012; Engert et al., 2014; Manini et al., 2013). The extracted thermal data have been filtered subsequently with a low-pass filter (fcut−off = 0.01 Hz), to eliminate breathing effects (Ebisch et al., 2012). Means and standard deviations of nose temperature in Celsius degrees were as follows for baseline (*M* = 34.80° C; *SD* = 2.06° C), inclusion (*M* = 34.72° C; *SD* = 2.11° C), and exclusion (*M* = 35.29; *SD* =2.12° C) phases.

Data were then transformed into *z*-scores in order to normalize them and perform a group comparison. The mean value of thermal signals of the nasal tip for all subjects for each experimental phase was calculated (i.e., average on 1 minute for baseline and on 2 minutes for inclusion and exclusion phases). These data where then used for statistical analysis.

Results

Nose temperature variations during baseline, inclusion, and exclusion phases were compared with each other with t-test analyses for paired samples (Bonferroni corrections); effect sizes were calculated converting *t*-values into *r*-values (Field, 2009). Results showed that nose temperature during baseline (M = -.17; SD = 1.19) did not differ from nose temperature during inclusion (M = -.43; SD = .49) ($t(27)$ = .96; p = .347; r = .15). Coherently with our hypothesis, nose temperature significantly increased during exclusion (M = .70; SD = .71) in comparison to baseline ($t(27)$ = -2.71; p = .012; r = .46) and inclusion ($t(27)$ = -5.89; $p < .001$; r = .75). An example of facial thermal imprints is depicted in Fig. 1 (for colour figure see online supplementary materials).

[Fig. 1]

Bullying perpetration and victimization variables were not normally distributed; therefore, the scores on these scales were normalized using the SPSS Van der Waerden ranking procedure. Normalized scores were used and reported throughout the results section. Two subjects presented extreme values (one in the bullying scale and the other one in the victimization scale). However, given that neither the Grubbs' test indicated them as significant outliers, nor removing them changed the main results, we decided to keep them in the analyses. A non-significant correlation was found between bullying and victimization (r = .07).

Correlations were calculated among temperatures in the three phases and bullying perpetration and victimization (Table 1). Significant differences in the strength of the correlations were tested using Fisher *r*-to-*z* transformation. A comparison between mean temperatures associated with bullying and victimization was computed:

Being victimized was associated with a larger skin temperature increase during exclusion, compared to enacting bullying.

[Table 1]

Besides, although not hypothesized, we found that correlations between inclusion temperature and bullying perpetration and between exclusion temperature and bullying perpetration significantly differed between each other (z = 2.20; p = .028), indicating that scores on bullying were associated with higher temperature during inclusion than during exclusion. Coefficients for being victimized did not differ significantly between each other.

Discussion

In the present study, we aimed at investigating whether nose tip temperature variations were associated with the experience of being excluded during a laboratory paradigm. To the best of our knowledge, this is the first study investigating the association between bullying perpetration and victimization and the autonomic thermal response to social exclusion in a sample of early adolescents.

We found that nose tip temperature increased during social exclusion. Literature suggested that increasing skin temperature constitutes a peripheral sympathetic response to stress (Pavlidis et al., 2002; Shastri et al., 2009); however, to the best of our knowledge, only one study investigated the autonomic thermal signature associated with the experience of being excluded, in a sample of adults (Paolini, et al., 2016). Consistently with Paolini and colleagues (2016), we found that also early adolescents manifest increasing skin temperature in response to exclusion. In contrast, IJzerman and colleagues (2012) observed that social exclusion is associated with a skin temperature decrease on the index finger of the non-dominant hand. However, the discrepancy between the two studies might be explained by the distinct region of interest in which temperature was detected. Consistently with this assumption, previous studies found an inverse trend between face and hand skin thermal variations, indicating that threatening experiences produce cooling on the hands and warming on the face (Rimm-Kaufman & Kagan, 1996).

Interestingly, the physiological response to social exclusion arose when participants were confronted with a simulated exclusion scenario, confirming the validity of our experimental paradigm and the theoretical approaches claiming that people respond to social cues, rather than (exclusively) to real agency (Kothgassner et al., 2014; Sijtsema et al., 2011; Zadro et al., 2004).

However, we also found that autonomic activity in response to exclusion varied depending on participants' involvement in bullying. In particular, temperature variations between inclusion and exclusion suggested that bullying perpetration was associated with relatively low responsiveness in front of social exclusion. Coherently with the fearlessness theory, a low arousal may indicate a scarce fear of punishment and of threatening social cues (Scarpa, 2015) and may enable early adolescents to strategically plan their social behaviors. For instance, they could manipulate the environment to their own advantage (e.g., taking revenge for having been excluded; trying to regain power and dominance over the group) (Olthof, Goossens, Vermande, Aleva, & Van der Meulen, 2011; Woods & White, 2005). An alternative explanation may be that early adolescents who bully others do not feel emotional and social bonds with their peers; therefore, they may not perceive social exclusion as a threat to their need to belong.

In contrast, victimization was associated with a higher arousal level (i.e., increasing nose tip temperature) during the exclusion condition, compared to bullying perpetration. We may assume that the increasing arousal reflects an adaptive response to a stressful situation, as the sympathetic activation could prepare the body to react when confronted with a threatening event. However, this finding could also indicate that victimized preadolescents are particularly sensitive to rejection and vigilant in front of threatening social cues (Downey et al., 1998; Rosen et al., 2009).

Strengths, Limitations and Indication for Future Research

Although previous literature consistently suggested that social exclusion is equally stressful for boys and girls (Williams, 2007), a larger sample would allow testing for possible gender differences. However, the small sample size is a common weakness in studies based on laboratory procedures, given the difficulties in participants' recruitment and data processing (Engert et al., 2014; Paolini et al., 2016).

The small sample size also affected a low variability in bullying perpetration and victimization, whose scores were relatively low. Although peer nominations do not provide a standard mean, we may infer that early adolescents who participated in our study were not the most aggressive or victimized ones. However, the fact that we found significant skin temperature variations associated with bullying perpetration and victimization leads to the assumption that these differences could be even larger if scores on these scales were higher.

Future research may also include other bullying roles (e.g., bully/victim; defender of the victim; passive bystander), which would allow to compare how early adolescents differently involved in bullying dynamics respond to social exclusion, and to test if autonomic differences among groups are plausible. We suggest that it would be worthy to investigate bully/victims' physiological reaction to exclusion, given that these children, who both react with aggression and are victimized, manifest several behavioral problems and a dysregulated physiological functioning (Woods & White, 2005). This pattern could make them reactive in front of an experience of social exclusion and likely prone to manifest physiological arousal (e.g., skin temperature increase).

Future studies should also administer post-experimental questionnaires aimed at detecting manipulation checks (e.g., perception of ball tosses), as well as mood, perception of ostracism, and reported basic need threats (i.e., belonging, self-esteem, control, and meaningful existence) (Williams et al., 2000). Indeed, new knowledge could be added to the literature by investigating the associations between these measures and skin temperature. We also suggest that future research should combine thermal infrared imaging and other measures of physiological arousal (e.g., skin conductance) in order to broaden the literature about social stress and physiological reactivity. Finally, longitudinal designs could shed light on the causal links between involvement in bullying as perpetrators or victims and physiological arousal during social exclusion.

This study also presents strength points. From a methodological point of view, the main novelty lies in the use of thermal infrared imaging with a sample of early adolescents. Thermography is a new and promising technique in the field of developmental psychology, due to its free contact and non-invasive procedure. Another important methodological strength is the multi-informant approach (i.e., peer-reports and physiological measures), which reduces possible biases due to shared methods variance. Besides, the use of physiological measures may help in clarifying previous inconsistencies in the literature about reactions to social exclusion, likely due to self-report biases (Bernstein, Claypool, Young, Tuscherer, Sacco, & Brown, 2013).

In conclusion, based on the results of the present study, practical implications may also be traced. We propose that intervention programs aimed at addressing social exclusion should take into account experiences of bullying perpetration and victimization. For instance, victimized early adolescents may benefit from an intervention program including strategies focused on arousal and behavioral regulation in front of a stressful event, such as exclusion. On the opposite, given that early adolescents who perpetrate bullying are less sensitive to a social stressor, such as exclusion, they may benefit from intervention programs aimed at strengthening their sense of social and emotional belongingness to the group.

References

Affrunti, N. W., Geronimi, E. M. C., & Woodruff-Borden, J. (2014). Temperament, peer victimization and nurturing parenting in child anxiety: A moderated mediation model. *Child Psychiatry & Human Development, 45,* 483-492. doi: 10.1007/s10578-013-0418-2

Anbar, M. (2002). Assessment of physiologic and pathologic radiative heat dissipation using infrared imaging. *Annals of the New York Academy Science, 972,* 111-118. doi: 10.1111/j.1749-6632.2002.tb04560.x

Bernstein, M. J., Claypool, H. M., Young, S. G., Tuscherer, T., Sacco, D. F., & Brown, C. M. (2013). Never let them see you cry: Self-presentation as a moderator of the relationship between exclusion and self-esteem. *Personality and Social Psychology Bulletin, 39,* 1293-1305. doi: 10.1177/0146167213495281

Bolling, D. Z., Pitskel, N. B., Deen, B., Crowley, M. J., Mayes, L. C., & Pelphrey, K. A. (2011). Development of neural systems for processing social exclusion from childhood to adolescence. *Developmental Science, 1,* 1-14. doi: 10.1111/j.1467-7687.2011.01087.x

Boivin, M., Hymel, S., & Bukowski, W. (1995). The roles of social withdrawal, peer rejection and victimization by peers in predicting loneliness and depressed mood in childhood. *Developmental Psychopathology, 7,* 765-785. doi: 10.1017/S0954579400006830

Bollmer, J. M., Harris, M. J., & Milich, R. (2006). Reactions to bullying and peer victimization: Narratives, physiological arousal and personality. *Journal of Research in Personality, 40,* 803-828. doi: 10.1016/j.jrp.2005.09.003

Calhoun, C. D., Helms, S. W., Heilbron, N., Rudolph, K. D., Hastings, P. D., &

Prinstein, M. J. (2014). Relational victimization, friendship and adolescents' hypothalamic-pituitary-adrenal axis responses to an in vivo social stressor. *Development and Psychopathology, 24,* 605-618. doi: 10.1017/S0954579414000261

De Angelis, G., Bacchini D., & Affuso, G. (2016). The mediating role of domain judgement in the relation between the Big Five and bullying behaviours. *Personality and Individual Differences, 90,* 16-21. doi: 10.1016/j.paid.2015.10.029

Di Giacinto, A., Brunetti, M., Sepede, G., Ferretti, A., & Merla, A. (2014). Thermal signature of fear conditioning in mild post-traumatic stress disorder. *Neuroscience, 266,* 216-223. doi: 10.1016/j.neuroscience.2014.02.009

Downey, G., Lebolt, A., Rincon, C. & Freitas, A. (1998). Rejection sensitivity and children' interpersonal difficulties. *Child Development, 69,* 1074-1091. doi: 0009-3920/986904

Ebisch, S. H. J., Aureli, T., Bafunno, D., Cardone, D., Romani, G. L., & Merla, A. (2012). Mother and child in synchrony: Thermal facial imprints of autonomic contagion. *Biological Psychology, 83,* 123-129. doi: 10.1016/j.biopsycho.2011.09.018

Eisenberger, N. I., & Lieberman, M. D. (2004). Why rejection hurts: A common neural alarm system for physical and social pain. *Trends in Cognitive Science, 8,* 294-299. doi: 10.1016/j.tics.2004.05.010

Engert, V., Merla, A., Grant, J. A., Cardone, D., Tusche A., & Singer T. (2014). Exploring the use of thermal infrared imaging in human stress research. *Plos One, 9(3),* 1-11. doi:10.1371/journal.pone/0080782

Field, A. (2009). *Discovering Statistics using SPSS. III Edition.* London: Sage.

Goossens, F. A., Olthof, T. & Dekker, P.H. (2006). New participant role scales: Comparison of various criteria for assigning roles and Indications for their validity. *Aggressive Behavior, 32,* 343-357. doi: 10.1002/ab.20133

Hubbard, J. A., Smithmyer, C. M., Ramsden, S. R., Parker, E. H., Flanagan, K. D., Dearing, K. F., … Simons, R. F. (2002). Observational, physiological, and self-report measures of children's anger: Relations to reactive versus proactive aggression. *Child Development, 73,* 1101–1118. doi: 10.1111/1467-8624.00460

IJzerman, H., Gallucci, M., Pouw, W. T., Weiβgerber, S. C., Van Doesum, N. J., & Williams, K. D. (2012). Cold-blooded loneliness: Social exclusion leads to lower skin temperatures. *Acta Psychologica, 140,* 283-288. doi: 10.1016/j.actpsy.2012.05.002

Ioannou, S., Gallese, V., & Merla, A. (2014). Thermal infrared imaging in psychophysiology. *Psychophysiology, 51,* 951-963. doi:10.1111/psyp.12243

Kliewer, W., Dibble, A. E., Goodman, K. L., & Sullivan, T. N. (2012). Physiological correlates of peer victimization and aggression in African American urban adolescents. *Development and Psychopathology, 24,* 637-650. doi: 10.1017/S0954579412000211

Kothgassner, O. D., Kafka, J. X., Rudyk, J., Beutl, L., Hlavacs, H., & Felnhofer, A. (2014). Does social exclusion hurt virtually like it hurts in real life? The role of agency and social presence in the perception and experience of social exclusion. *Proceedings of the International Society for Presence Research,* 45-56.

Manini, B., Cardone, D., Ebisch, S. J. H., Bafunno, D., Aureli, T., & Merla, A. (2013). Mom feels what her child feels: Thermal signature of vicarious autonomic response while watching children in a stressful situation. *Frontiers in Human Neuroscience, 7,* 1-10. doi: 10.3389/fnhum.2013.00299

Masten, C. L., Eisenberger, N. I., Borofsky, L. A., McNealy, D. H., 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. doi: 10.1039/scan/nsp007

Merla, A. (2014). Thermal expression of intersubjectivity offers new possibilities to human-machine and technologically mediated actions. *Frontiers in Psychology, 5,* 1-6. doi: 10.3389/fpsyg.2014.00802

Monks, C., & Smith, P. (2010). Peer, self and teacher nominations of participant roles taken in victimization by five and eight years-old. *Journal of Aggression, Conflict and Peace Research, 2,* 4-14. doi: 10.5042.jacpr.2010.0532

Murray-Close, D. (2012). Psychophysiology of adolescent peer relations I: Theory and Research findings. *Journal of Research on Adolescence, 23,* 236-259. doi:10.1111/j.1532-7795-2012.00828.x

Nhan, B. R., & Chau, T. (2010).Classifying affective states using thermal infrared imaging of the human face. *IEEE Transaction on Biomedical Engineering*, *57,* 979–987. doi: 10.1109/TBME.2009.2035926.

Olthof, T., Goossens, F. A., Vermande, M. M., Aleva, E. A., & Van der Meulen, M. (2011). Bullying as strategic behavior: Relations with desired and acquired dominance in the peer group. *Journal of School Psychology, 49,* 339-359. doi: 10.1016/j.jsp.2011.03.003

Olweus, D. (1993). *Bullying at school: What we know and what we can do.* Cambridge, MA: Blackwell.

Paolini, D. Alparone, F. R., Cardone, D., van Beest, J., & Merla, A. (2016). "The face of ostracism": The impact of social categorization on the thermal facial responses of the target and the observer. *Acta Psychologica, 163,* 65-73. doi: 10.1016/j.actpsy.2015.11.001

Pavlidis, I., Eberhardt, N. L., & Levine, J. A. (2002). Seeing through the face of deception. *Nature, 415,* 35-37. doi: 10.1038/415035a

Pavlidis, I., Tsiamyrtzis, P., Shastri, D., Wesley, A., Zhou, Y., Lindner, P., … Bass, B. (2012). Fast by nature-how stress patterns define human experience and performance in dexterous tasks. *Scientific Reports, 2 (305),* 1-9. doi: 10.1038/srep00305

Pozzoli, T., Gini, G., & Vieno. A. (2012). The role of individual correlates and class norms in defending and passive bystanding behavior in bullying: A multilevel analysis. *Child Development, 83,* 1917-1931. doi: 10.1111/j.1467-8624.2012.01831.x

Raine, A. (2002). Biosocial studies of antisocial and violent behavior in children and adults: A review. *Journal of Abnormal Child Psychology, 30,* 311-326. doi: 10.1023/A:1015754122318

Raine, A., Venables, P. H., & Mednick, S. (1997). Low heart rate at age 3 years predisposes to aggression at age 11 years: Evidence from the Mauritius Child Health Project. *Journal of American Academy of Child and Adolescent Psychiatry, 36,* 1457-1464. doi: 10.1097/00004583-199710000-00029

Rimm-Kaufman, S. E., & Kagan, J. (1996). The psychological significance of changes in skin temperature. *Motivation and Emotion, 20,* 63-76. doi:

10.1007/BF02251007

Rosen, P. J., Milich, R., & Harris, M. J. (2009). Why's everybody always picking on me? Social cognition, emotional regulation and chronic peer victimization in children. In M. J. Harris (Ed.), *Bullying, rejection, and peer victimization: A social cognitive neuroscience perspective* (pp. 79-100). New York, NY: Springer.

Rudolph, K.D., Troop-Gordon, W., & Granger, D. A. (2011). Individual differences in biological stress responses moderate the contribution of early peer victimization to subsequent depressive symptoms. *Psychopharmacology, 214,* 209-219. doi: 10.1007/s00213-010-1879-7

Ruggieri, S., Bendixen, M., Gabriel, U., & Alsaker, F. (2013a). Do victimization experiences accentuate reactions to ostracism? An experiment using cyberball. *International Journal of Developmental Science, 7,* 25-32. doi: 10.3233/DEV-1312114

Ruggieri, S., Bendixen, M., Gabriel, U., & Alsaker, F., (2013b). The impact of ostracism on the well-being of early adolescents. *Swiss Journal of Psychology, 72,* 103-109. doi: 10.1024//1421-0185/a000103

Salmivalli, C. (2010). Bullying and the peer group: A review. *Aggression & Violent Behavior, 15,* 112-120. doi:10.1016/j.avb.2009.08.007

Scarpa, A. (2015). Physiological arousal and its dysregulation in child maladjustment. *Current Directions in Psychological Science, 24,* 345-351. doi: 10.1177/0963721415588920

Scheithauer, H., Alsaker, F., Wölfer, R., & Ruggieri, S. (2013). Cyberball: A reasonable paradigm for research in developmental science? *International Journal of Developmental Science, 7,* 1-6. doi: 10.3233/DEV-13000071

Shoulberg, E.K., Sijtsema, J.J., & Murray-Close, D. (2011). The association between valuing popularity and relational aggression: The moderating effects of actual popularity and physiological reactivity to exclusion. *Journal of Experimental Child Psychology, 110*, 20-37. doi: 10.1016/j.jecp.2011.03.008

Shastri, D., Merla, A., Tsiamyrtzis, P., & Pavlidis, I. (2009). Imaging facial signs of neurophysiological responses. *IEEE Transactions of Biomedical Engineering, 56,* 477-485. doi: 10.1109/TBME.2008.2003256

Sijtsema, J. J., Shoulberg, E. K., & Murray-Close, D. (2011). Physiological reactivity and different forms of aggression in girls: Moderating role of rejection sensitivity and peer rejection. *Biological Psychology*, *86,* 181-192. doi: 10.1016/j.biopsycho.2010.11.007

Tangherlini, A., Merla, A., & Romani, G. L. (2006). Field-warp registration for biomedical high- resolution thermal infrared images. *Conference Proceedings IEEE Engineeiring in Medicine and Biology Society, 1,* 961-964. doi: 10.1109/IEMBS.2006.260664

Williams, K. D. (2007). Ostracism. *Annual Review of Psychology, 58,* 425-452. doi: 10.1146/annurev.psych.58.110405.085641

Williams, K. D., Cheung, C. K., & Choi, W. (2000). Cyberostracism: Effects of being ignored over the internet. *Journal of Personality and Social Psychology, 79,* 748-762. doi: 10.1037//0022-3514.79.5.748

Wilson, D. K., Kliewer, W., Teasley, N., Plybon, L., & Sica, D. A. (2002). Violence exposure, catecholamine excretion and blood pressure nondipping status in African American male versus female adolescents. *Psychosomatic Medicine, 64,* 906–915. doi: 10.1097/01.PSY.0000024234.11538.D3

Woods, S., & White, E. (2005). The association between bullying behavior, arousal levels and behavior problems. *Journal of Adolescence, 28,* 381-395. doi: 10.1016/j.adolescence.2004-09.002

Zadro, L., Hawes, D. J., Iannuzzelli, R. E., Godwin, A., MacNevin, G., Griffiths B., & Gonsalkorale, K. (2013). Ostracism and children: A guide to effectively use the cyberball paradigm with a child sample. *International Journal of Developmental Science, 7,* 7-11. doi:10.3233/DEV-1312112

Zadro, L., Williams, K. D., & Richardson, R. (2004). How low can you go? Ostracism by a computer is sufficient to lower self-reported levels of belonging, control, self-esteem and meaningful existence. *Journal of Experimental Social Psychology, 40,* 560-567. doi:10.1016/j.jesp.2003.11.006

Zuckermann, M. (1990). The psychophysiology of sensation seeking. *Journal of Personality, 58,* 313-345. doi: 10.1111/j.1467-6494.1990.tb00918.x

Bio Sketches

Angela Mazzone obtained her PhD in Psychology from "G. d'Annunzio" University, Italy. Her research interests include school bullying and its associations with moral emotions and moral disengagement. She is also interested in behavioral and physiological responses to social exclusion in children and adolescents.

Marina Camodeca, PhD, is Assistant Professor in the Department of Psychology, University of Milan Bicocca, Milan, Italy. Her research interests include bullying and victimization in toddlerhood, childhood and adolescence, with a particular focus on socio-emotional competence and moral disengagement.

Daniela Cardone, PhD, is a Research fellow in the Department of Neurosciences, Imaging and Clinical Sciences at "G. d'Annunzio" University, Italy. Her research interests include the investigation of neurophysiological processes by Thermal infrared imaging and Functional near-infrared spectroscopy.

Arcangelo Merla, PhD, is Associate Professor in the Department of Neurosciences, Imaging and Clinical Sciences at "G. d'Annunzio" University, Italy. His research interests include the investigation of neurophysiological processes by Thermal infrared imaging and Functional near-infrared spectroscopy.

Table 1

Correlations Between Temperatures in the Three Phases and Scores on Bullying Perpetration and Victimization, and Test of Difference with Fisher r-to-z Transformation.

	Bullying	Victimization	z-score
Baseline	.02	-.19	.78
Inclusion	.38*	.02	1.40
Exclusion	-.31[a]	.28[b]	-2.29*

Note. Correlations in rows with different superscripts significantly differ from each other.

*p < .05.

Fig 1.

Facial thermal imprints during Baseline (a), Inclusion (b) and Exclusion (c). Cool and dark colors (e.g. blue) indicate lower temperature, whereas warm and light colors (e.g., yellow) indicate higher temperature.

Note. Recognizable facial features were covered to obscure participant's identity.