The Physiological Correlates of Children's Emotions in Contexts of Moral Transgression

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Abstract

Heightened attention to socio-moral conflicts and arousal at the prospect of committing moral transgressions are thought to increase the likelihood of negatively-valenced moral emotions (NVMEs; e.g., guilt) in children. Here, we tested this biphasic model of moral emotions with a psychophysiological framework. For a series of vignettes depicting moral transgressions, 5- and 8-year-olds (*N* = 138) were asked to anticipate their emotions as hypothetical victimizers. Their responses were coded for the presence and intensity of NVMEs. In addition, their heart rate (HR) was calculated for three intervals of interest: a baseline period, the presentation of vignettes, and the anticipation of emotions following vignettes. We used multilevel modelling to examine how change in children's HR across these intervals related to the intensity of their NVMEs. Those who experienced greater HR deceleration from baseline to vignettes *and* greater acceleration from vignettes to anticipated emotions reported more intense NVMEs. We discuss the potential attention- and arousal-related processes behind children's physiological reactivity and anticipated emotions in contexts of moral transgression.

Keywords: moral emotions, heart rate, psychophysiology, childhood

The Physiological Correlates of Children's Emotions in Contexts of Moral Transgression

Negatively-valenced moral emotions (NVMEs; e.g., guilt and sadness associated with violating one's own moral standards) have been conceptualized as self-evaluative emotions in moral contexts because they reflect an internalized understanding of moral rule validity and a willingness to assume responsibility for real or imagined wrongdoing (Malti & Ongley, 2014). NVMEs have been associated with moral action tendencies (i.e., less aggressive and more prosocial behavior) in numerous studies spanning childhood and adolescence (Malti & Krettenauer, 2013).

Developmental theorists have long argued that heightened attention to socio-moral conflicts triggers arousal at the prospect of committing moral transgressions (Eisenberg, 2000; Hoffman, 2000; Malti, 2015). This biphasic process is thought to increase the likelihood of anticipating NVMEs (Malti, 2015). However, this theoretical model has not been tested with a psychophysiological framework, which may shed empirical light on the purported attention- and arousal-related processes that accompany NVMEs. In the present study, we addressed this gap by assessing a sample of 5- and 8-year-olds' heart rate (HR) as they attended to vignettes depicting moral transgressions and anticipated emotions as hypothetical victimizers.

Although children as young as 3 years appear to grasp the concepts of right and wrong in the moral domain (Malti & Ongley, 2014), they often report positively-valenced emotions (PVEs), such as happiness or pride, in the role of victimizer (e.g., after hypothetically stealing a chocolate bar from another child). Researchers have dubbed this the "happy victimizer phenomenon", which has since been replicated across numerous studies and cultures (for reviews, see Arsenio, 2014; Malti & Ongley, 2014). By age 7 to 8, children report less PVEs and more NVMEs, such as guilt and sadness over wrongdoing. This shift towards acknowledging the negative consequences that transgressions have on others is likely due, in part, to co-developing facets of perspective-taking and self-regulation (Eisenberg, Spinrad, & Eggum, 2010; Malti & Ongley, 2014). Understanding this dichotomy of emotional responding in contexts of moral transgression is important because children who anticipate NVMEs, rather than PVEs, tend to be less aggressive and more prosocial (Malti & Krettenauer, 2013). Developmental theorists have argued that NVMEs stem from enhanced *attention* to socio-moral conflicts and *arousal* at the prospect of committing moral transgressions (Eisenberg, 2000; Hoffman, 2000; Malti, 2015). However, this theorizing has yet to receive empirical support from an assessment of children's physiological responding *in contexts of moral transgression*.

HR is a well-documented physiological correlate of attention and arousal (Bradley, 2009). HR reactivity, defined as the deviation of HR from a control value (i.e., HR acceleration or deceleration from baseline or a previous value), reflects an individual's physiological response to a stimulus or context given his/her previous level of arousal (Bradley & Lang, 2007). Developmental studies have associated distinct patterns of HR reactivity with attention and affective arousal. For example, findings with infants and young children suggest that HR decreases with outward attention and decreases further with sustained attention to various stimuli (Richards & Cronise, 2000; Richards & Gibson, 1997). This deceleration is thought to promote the intake and processing of external information, as HR variability, respiration, and distractibility simultaneously decrease (Lansink & Richards, 1997). Studies linking HR reactivity to affective arousal/stimuli have revealed mixed directional findings based on stimulus valence (Brouwer, Wouwe, Mühl, van Erp, & Toet, 2013) and most have been conducted with adults (see Balconi, Vanutelli, & Finocchiaro, 2014 for an exception). Interestingly, the active anticipation of *emotional* versus neutral content has been shown to increase HR (see Bradley & Lang, 2007).

Few studies have assessed children's HR in moral contexts. Films depicting an individual in distress have been used to evoke vicarious physiological responding in children. Overall, HR reactivity to such clips was negatively correlated with various measures of empathic concern and prosocial behavior, leading the authors to conclude that HR deceleration in response to others in need reflects an other-oriented focus of attention (e.g., Eisenberg et al., 1989; Eisenberg, Fabes, Miller, & Shell, 1990). A recent study by Barhight, Hubbard, and Hyde (2013) found that children who displayed HR acceleration in response to videos depicting bullying reported more intense negative emotions (primarily anger) after each video and were rated by peers as more likely to stop a bully. The upsetting nature of bullying, reflected by HR acceleration and reports of anger, may have motivated such children to intervene in real life. Collectively, these studies attest to children's physiological and affective responding as *onlookers* in contexts of empathy induction and severe transgression, but not as *hypothetical victimizers* in contexts of everyday moral transgression. As such, they tell us little about the physiological and psychological correlates of children's NVMEs.

Clinical-developmental approaches to the study of NVMEs (e.g., Malti, 2015) argue that children who anticipate strong NVMEs exhibit heightened attention to socio-moral conflicts and arousal at the prospect of committing moral transgressions (also see Hoffman, 2000). Here, we tested this biphasic model by assessing 5- and 8-year-olds' HR reactivity as they attended to vignettes depicting moral transgressions and anticipated emotions as hypothetical victimizers. We expected children with greater HR deceleration from baseline to vignettes (reflecting sustained attention to moral transgressions) *and* greater acceleration from vignettes to anticipated emotions (reflecting heightened arousal at the prospect of committing such transgressions) to anticipate stronger NVMEs.

Since the transition from early to middle childhood is characterized by increases in social understanding and self-regulatory capacities (Eisenberg et al., 2010; Malti & Ongley, 2014), we expected 8-year-olds to anticipate stronger NVMEs than 5-year-olds. The various components of emotions (e.g., physiological, motor, expressed) are thought to become increasingly coordinated across development (Izard & Ackerman, 1998), which suggests that our expected links between HR and NVMEs may also be stronger in older children. However, empirical findings on the coupling of physiology and reported emotions in early versus middle childhood have been mixed (Quas, Hong, Alkon, & Boyce, 2000), so our developmental hypotheses regarding HR reactivity and NVMEs remained open-ended. Finally, we controlled for sex in our analyses because sex differences in NVMEs have been documented (e.g., Malti, Gummerum, Keller, & Buchmann, 2009).

Method

Participants

A community sample of 64 5-year-olds (*M*age = 5.35, *SD* = .57, 31 girls [48%]), 74 8-year-olds (*M*age = 8.05, *SD* = .34, 39 girls [53%]), and their primary caregivers participated (*N* = 138, 70 girls [51%]). All children were fluent in English (speaking and comprehension), as were caregivers (speaking, comprehension, and writing). Families resided in a major Canadian city and were recruited from local community centers, events, and summer camps. Ethnic composition included 33% Western European, 12% South Asian, 10% East Asian, 7% Eastern European, 6% Caribbean, 2% African, 2% Central and South American, 2% South East Asian, 1% West and Central Asian, and 17% other/multiple origins (8% chose not to report). This distribution was representative of the suburban region from which it was drawn (Statistics Canada, 2012). The researchers' institution granted ethical approval.

Procedure

Children and caregivers attended the research laboratory for a single session. Written informed consent was obtained from caregivers and oral assent from children. With caregivers present, children were outfitted with physiological equipment. A moral emotion attribution task was then conducted with children in a separate room from caregivers. It was filmed for data analytic purposes and lasted approximately 20-30 minutes. Before the task, children were shown a 120-second film with neutral audio and visuals to acquire a baseline HR. Throughout the task, caregivers remained in a waiting area and completed a questionnaire. At study end, they were debriefed and children were awarded an age-appropriate book.

Measures

NVMEs and PVEs. Children's anticipated emotions and corresponding reasoning as hypothetical victimizers were assessed in response to six vignettes depicting moral transgressions. Two vignettes depicted intentional harm (e.g., pushing another child out of line to get the last piece of candy), two depicted exclusion (e.g., not letting another child play a computer game to get more playing time with another peer), and two depicted prosocial omission (e.g., eating two cupcakes instead of sharing one with another child). All had been extensively validated by previous research in the happy victimizer paradigm with same-aged samples (Malti & Ongley, 2014) and were accompanied by illustrations matched to the sex of the participating child. Three questions followed each vignette: *Question 1* asked, "How would you feel if you had done what *(hypothetical victimizer's name*) did?" If children said, "I don't know", they were asked, "If you had (*behavior of hypothetical victimizer*), would you feel a little good, a little bad, or a little good and bad?" *Question 2* asked, "Why would you feel (*anticipated emotion from Question 1*)?" Children's answers were recorded verbatim. *Question 3* asked, "How strongly would you feel (*anticipated emotion from Question 1*)?" Children answered by pointing to a 3-point scale depicting squares of increasing size. Prior to this, 5-year-olds were calibrated with a similar scale depicting animals of increasing size (i.e., a mouse, horse, and elephant corresponding to low, medium, and high intensity emotions, respectively) to ensure they understood the scale format.

Coding. Our coding method was adapted from past research on children's emotions and reasoning in contexts of moral transgression (e.g., Malti et al., 2009; Malti & Ongley, 2014). First, anticipated emotions following *Question* 1 were coded as 1 (*negatively-valenced emotion*) or 0 (*not negatively-valenced emotion*). Specifically, *bad*, *a little bad, sad*, *angry*, *fearful*, *embarrassed/ashamed*, and *guilty* responses were coded as 1 (*negatively-valenced emotion*), whereas *neutral*, *happy*, *proud*, *good*, *a little good*, and *other* responses were coded as 0 (*not negatively-valenced emotion*).

Next, the corresponding reasoning of responses coded as 1 (*negatively-valenced emotion*) was consulted to clearly distinguish NVMEs (e.g., "sad because pushing is not fair, he was in line first") from other negatively-valenced emotions (e.g., "bad because I might get into trouble for taking it"). Specifically, children's reasoning following *Question 2* was coded as 1 (*moral*), 2 (*sanction*s), 3 (*hedonism*), or 4 (*other*; see Malti et al., 2009). Thus, only responses coded as 1 (*negatively-valenced emotion*) for *Question 1 and* 1 (*moral*) for *Question 2* were considered NVMEs. In line with previous studies on moral reasoning (Frankfurt, 1988; Malti & Keller, 2010; Malti & Ongley, 2014), we included reasons based on fairness, other-oriented concern, and conflict resolution in the 1 (*moral*) category. Sanction-oriented negatively-valenced emotions were not considered NVMEs because they reflect an orientation toward negative, external consequences for the self, such as being punished by authority figures (e.g., teachers, parents) and rejected by peers. This is in line with the cognitive-structuralist moral developmental tradition, which distinguishes between children's internalized and externally-oriented justifications.

For comparative purposes, children's PVEs were also coded. Specifically, *happy, proud, good,* and *a little good* responses were coded as 1 (*PVE*), whereas *neutral*, *bad, a little bad, sad*, *angry, fearful*, *embarrassed/ashamed*, guilty, and *other* responses were coded as 0 (*not PVE*). Prior to final coding, two independent raters coded a random subsample (n = 26) of anticipated emotions and reasoning from all six vignettes. Cohen's κs were .99 and .94, respectively. Disagreements were discussed until a consensus was reached. For *Question 3*, the strength of resulting NVMEs/PVEs was scored as follows: 1 if the child pointed to the smallest square (i.e., not strong NVME/PVE), 2 if the child pointed to the middle-sized square (i.e., somewhat strong NVME/PVE), and 3 if the child pointed to the largest square (i.e., very strong NVME/PVE). A score of 0 was retained for other coded responses. Resulting intensity scores were averaged across vignettes (αs = .75 and .72 for NVMEs and PVEs, respectively). High scores indicated high levels of NVMEs/PVEs in anticipation of committing moral transgressions.

HR. Three-lead electrocardiogram (ECG) data were recorded from children throughout the study at a sampling rate of 2 kHz using a Biopac MP150 system (Biopac Systems Inc., Goleta, CA). Cardiovascular (ECG100C) electrodes were secured to the right collarbone and just below the ribs on both sides. Wires from each electrode were attached to a BioNomadix ECG belt fastened around the midsection that communicated wirelessly to a computer in an adjacent room. Data were acquired by AcqKnowledge 4.2 (Biopac Systems Inc., Goleta, CA) and subject to a band pass filter with a 1 Hz low frequency cut-off and a 35 Hz high frequency cut-off. They were then imported to Mindware HRV 3.0.9 (Mindware Technologies, Gahanna, OH) for visual inspection, cleaning, and HR calculation (see Rash & Prkachin, 2013).

The following intervals were extracted to represent HR at baseline, during vignettes, and during anticipated emotions, respectively: a 120-second baseline, 20 seconds from the beginning of each vignette, and 20 seconds from the beginning of *Question 2* following each vignette (i.e., "How would you feel if you had done what *(hypothetical victimizer's name*) did?" Recognizing that some children may have anticipated their emotions before *Question 2* finished, we included the entire question as part of the latter 20-second interval. Although the presentation of vignettes and response times for *Question 2* were not standardized during testing, these intervals ensured roughly uniform HR calculations across children: 91% of children heard the vignettes in 20 seconds or less, while 85% anticipated their emotions within 20 seconds.

Data from all three intervals were cleaned and outputted in 10-second segments to facilitate ease of processing (while ensuring reliable HR calculations; Rash & Prkachin, 2013). If more than 20% of a 10-second data segment required significant editing, it was excluded from further analysis (overall exclusion rate = 6%). Missing data were handled in HLM 7 (Raudenbush, Bryk, Cheong, Congdon, & Du Toit, 2011) using full information maximum likelihood (FIML) estimation (see Enders, 2010). For each child, HR was calculated for each interval (i.e., the baseline period, each vignette, and each anticipated emotion following vignettes). Since HR reactivity from baseline to vignette *and* vignette to anticipated emotion was reliable across vignettes (αs = .77 and .79, respectively), HR data were aggregated across the six vignettes and anticipated emotions (internal consistency was even higher for *absolute* HR values during vignettes and anticipated emotions [αs = .95 and .96, respectively]). Thus, the following

HR variables were considered in analyses for each child: baseline HR, HR during vignettes (aggregate), and HR during anticipated emotions (aggregate).

Analytic Approach

Given the nested structure of our data (i.e., repeated measures of HR nested within children), we used multilevel modeling in HLM 7 (Raudenbush et al., 2011) to assess HR reactivity in relation to NVMEs/PVEs. First, we identified the best-fitting trajectory of children's HR from baseline to vignettes to anticipated emotions with three progressively complex models of change: HR stability (i.e., unconditional), linear HR, and quadratic HR. We coded the linear factor as 0 (*baseline HR*), 1 (*HR during vignettes*), and 2 (*HR during anticipated emotions*). To compare the fit of these nested models, we used the likelihood ratio (LR) test (West, Ryu, Kwok, & Cham, 2011). We then proceeded to test a series of two-level MLMs relating HR at Level 1 to NVMEs/PVEs (intensity scores), age, sex (girls = -0.5, boys = 0.5), and the interactions of NVMEs/PVEs x age and NVMEs/PVEs x sex at Level 2. NVMEs/PVEs and age were grand-mean centered.

Results

Descriptive Statistics

Descriptive statistics of study variables are displayed in Table 1. Higher NVMEs were associated with lower PVEs and greater HR acceleration from vignettes to anticipated emotions. Higher PVEs were associated with less HR acceleration from vignettes to anticipated emotions. Older children exhibited higher NVMEs (in line with our developmental hypothesis for NVMEs) and lower baseline HRs than younger children. Across the six vignettes, children anticipated NVMEs 67% of the time and PVEs 18% of the time. Ninety-two percent of children reported at least one NVME and 63% reported four or more. Forty-nine percent of children reported at least one PVE and 8% reported four or more.

Multilevel Models Relating HR Reactivity to NVMEs and PVEs

The quadratic model (deviance = 2338.40, 10 estimated parameters) fit the HR data better than the linear model (LR = 9.68, $df = 4$, $p = .045$), which fit better than the stability model (LR = 37.33, $df = 3$, $p < .001$). Thus, the mean-level development of HR across the three intervals (i.e., baseline, vignettes, and anticipated emotions) was best characterized by an initial, non-significant linear decrease (fixed effect = -0.46, $p = .467$) that varied significantly between children (random effect = 13.61, $p = .004$), followed by a significant quadratic increase (fixed effect = 0.76, $p = .01$) that also varied significantly between children (random effect = 2.11, $p = .029$). We proceeded to relate the significant between-child variability in these linear and quadratic components to varying levels of NVMEs and PVEs.

NVMEs significantly interacted with the linear, $\gamma_{13} = -1.78$, $p = .036$, and quadratic, $\gamma_{23} = 0.79$, $p = .046$, components of HR (controlling for age and sex; see Table 2). As depicted in Figure 1, simple slopes analysis revealed a significant linear decrease in HR from baseline to vignettes for children with high (+1 *SD*) NVMEs only, $b = -1.88$, $p = .03$. The quadratic upturn in HR from vignettes to anticipated emotions was significant for those with high, $b = 1.38$, $p = .001$, and medium, $b = 0.73$, $p = .011$, NVMEs only. This finding is in line with our hypothesis that children with greater HR deceleration from baseline to vignettes *and* greater acceleration from vignettes to anticipated emotions would anticipate stronger NVMEs. To maintain parsimony and ease the interpretability of simple effects, we dropped non-significant interactions of NVMEs × age/sex (see West et al., 2011).

For comparative purposes, we re-ran the aforementioned model with PVEs instead of NVMEs. Controlling for age and sex, PVEs significantly interacted with the quadratic component of HR, $\gamma_{21} = -1.19$, $p = .023$. Simple slopes analysis revealed a significant quadratic upturn from vignettes to anticipated emotions for children with low, $b = 1.42$, $p < .001$, and medium, $b = 0.72$, $p = .012$, PVEs only. Age was positively associated with baseline HR, but not the linear and quadratic components of HR. Sex yielded non-significant associations. Again, non-significant interactions of PVEs x age/sex were dropped from the model.

Discussion

NVMEs, such as guilt and sadness over wrongdoing, have long been considered key, motivational elements of other-oriented, prosocial behaviors (Malti & Ongley, 2014) and empirical studies have consistently linked them to aggressive and prosocial conduct across development (Malti & Krettenauer, 2013). However, the purported attention- and arousal-related processes that accompany (and potentially give rise to) children's NVMEs have not been empirically tested with an assessment of physiological responding in contexts of moral transgression. Here, we assessed 5- and 8-year-olds' HR reactivity as they attended to vignettes depicting moral transgressions and anticipated emotions as hypothetical victimizers. Specifically, we tested the following biphasic model of moral emotions: heightened attention to socio-moral conflicts *and* arousal in anticipation of committing moral transgressions are associated with more intense NVMEs.

As expected, children with high levels of NVMEs experienced significant HR deceleration from baseline to the presentation of vignettes (regardless of age and sex; see Figure 1). A number of developmental studies have linked HR deceleration to sustained, outward attention (Richards & Cronise, 2000; Richards & Gibson, 1997), and, as a result, less distraction (e.g., Lansink & Richards, 1997). From this perspective, children with greater HR deceleration during vignettes may have been taking in and processing more information. Armed with this information, they may have been more equipped to consider the negative consequences of the transgressions (thereby increasing the likelihood of NVMEs). Children with low levels of NVMEs and high levels of PVEs, on the other hand, did not show significant HR deceleration during vignettes. Such children may have paid less attention to the vignettes, perhaps stemming from high levels of distractibility and/or indifference to the content. Alternatively, focusing on the vignettes' non-moral aspects (e.g., personal gains) may have required less informational intake (as reflected by less HR deceleration). Overall, this finding aligns with past studies by Eisenberg and colleagues (1989, 1990), in which children who experienced significant HR deceleration during empathy-inducing films were more likely to help others in a later task, and scored higher on empathy and prosociality. Thus, in addition to empathy-inducing contexts, HR deceleration in response to everyday moral transgressions may reflect an other-oriented focus of attention. More generally, this finding lends further support to longstanding theorizing on the critical role of attention in NVMEs (Eisenberg, 2000; Hoffman, 2000; Malti, 2015).

Also in line with our hypothesis, children with high, and, to a lesser extent, medium levels of NVMEs experienced a significant upturn in HR from vignettes to anticipated emotions (regardless of age and sex; see Figure 1). Children with low NVMEs and high PVEs showed an increase in HR during anticipated emotions, but not a *significant* quadratic upturn. As per Eisenberg (2000) and Hoffman (2000), this graded increase in HR suggests that children who anticipated strong NVMEs experienced commensurate affective arousal at the prospect of committing moral transgressions. Alternatively, HR acceleration at this anticipatory stage may have reflected the complex cognitive components of NVMEs, which require significant self- and other-oriented perspective-taking skills, and reflection over moral standards and norms (Malti & Ongley, 2014). Indeed, studies (albeit with adults) have demonstrated that HR accelerates during the mental imagery of an emotional stimulus or event (see Bradley & Lang, 2007) with greater increases during unpleasant versus pleasant imagery and further increases as the arousal of the mental image increases (e.g., Witvliet & Vrana, 1995). Taken together, these studies support the notion that anticipating strong NVMEs requires greater mentation than anticipating less intense NVMEs or PVEs. For example, anticipating happiness after stealing a chocolate bar may require a child to reflect (primarily) upon his or her love of chocolate. Anticipating an NVME, such as guilt, after the same act may require the child to consider the fairness of the situation, the original owner's feelings, and relevant moral norms, all in addition to his or her love of chocolate.

In line with our developmental hypothesis and previous findings from the happy victimizer paradigm (Arsenio, 2014; Malti & Krettenauer, 2013), 8-year-olds anticipated more frequent and intense NVMEs than 5-year-olds. This developmental increase likely reflects a shift towards acknowledging the negative consequences that transgressions have on others, which may stem, in part, from co-developing facets of perspective-taking and self-regulation (Malti, 2015; see Eisenberg et al., 2010). Although older children had lower baseline HRs (reflecting a normative decrease in HR across childhood; see Wrzus, Müller, Wagner, Lindenberger, & Riediger, 2014), we did not find developmental differences in the *relations* of HR reactivity and NVMEs/PVEs. Thus, the physiological correlates of NVMEs/PVEs in early versus middle childhood appear to be similar. Younger and older children may have been engaging in similar attention- and arousal-related processes in anticipation of NVMEs/PVEs.

Despite its strengths, such as a large sample size within a psychophysiological framework and an externally-valid moral emotion attribution task (Malti & Ongley, 2014), the present study had several limitations. Future studies should take a multi-measure approach to assessing children's physiological responding in contexts of moral transgression. HR reactivity is dually innervated by the parasympathetic and sympathetic nervous systems (Bradley & Lang, 2007), leaving our results open to multiple mechanistic interpretations (e.g., HR acceleration reflecting affective arousal and/or cognitive load). Although HR can be reliability interpreted in light of study context and previous findings, pairing HR with a measure of electrodermal activity (solely innervated by the fibers of the sympathetic nervous system; Dawson, Schell, & Filion, 2007) may ease the interpretability of physiological findings. Lastly, we were unable to make causal claims about the flow of influence between HR and NVMEs/PVEs.

The present findings extend current theorizing on children's NVMEs within a psychophysiological framework and are relevant to educators and practitioners who wish to foster NVMEs in children. In conjunction with regulatory strategies to decrease HR and lessen distractibility, attempts to shift or enhance the attention of children to socio-moral conflicts may increase their likelihood of anticipating NVMEs and engaging in corresponding moral reasoning. In addition, the use of rational explanations to illustrate the negative consequences that moral transgressions have on others may increase the likelihood of NVMEs and help children adjust their behavior accordingly (see Hoffman, 2000). Future research should bridge the gap between the physiological correlates of emotions in contexts of interpersonal victimization and the development of psychopathology and socially adaptive behaviors, such as aggression, peer exclusion, and helping.

References

Arsenio, W. (2014). Moral emotion attributions and aggression. In M. Killen & J. Smetana (Eds.), *Handbook of moral development* (2nd ed., pp. 235-255). New York, NY: Psychology Press.

Balconi, M., Vanutelli, M. E., & Finocchiaro, R. (2014). Multilevel analysis of facial expressions of emotion and script: Self-report (arousal and valence) and psychophysiological correlates. *Behavioral and Brain Functions, 10*, 1 -14. doi:10.1186/1744-9081-10-32

Barhight, L. R., Hubbard, J. A., & Hyde, C. T. (2013). Children's physiological and emotional reactions to witnessing bullying predict bystander intervention. *Child Development, 84*(1), 375-390. doi:10.1111/j.1467-8624.2012.01839.x

Bradley, M. M. (2009). Natural selective attention: Orienting and emotion. *Psychophysiology, 46*(1), 1-11. doi:10.1111/j.1469-8986.2008.00702.x

Bradley, M. M., & Lang, P. J. (2007). Emotion and motivation. In J. T. Cacioppo, L. G. Tassinary, & G. Berntson (Eds.), *Handbook of psychophysiology* (3rd ed., pp. 581–607). New York, NY: Cambridge University Press.

Brouwer, A., van Wouwe, N., Mühl, C., van Erp, J., & Toet, A. (2013). Perceiving blocks of emotional pictures and sounds: Effects on physiological variables. *Frontiers in Human Neuroscience*, *7*, 1-10. doi:10.3389/fnhum.2013.00295

Dawson, M. E., Schell, A. M., & Filion, D. L. (2007). The electrodermal system. In J. T. Cacioppo & L. G. Tassinary (Eds.), *Handbook of psychophysiology* (2nd ed., pp. 200-223). Cambridge, UK: Cambridge University Press.

Eisenberg, N. (2000). Emotion, regulation, and moral development. *Annual Review of Psychology*, *51*, 665-697. doi:10.1146/annurev.psych.51.1.665.

Eisenberg, N., Fabes, R. A., Miller, P. A., Fultz, J., Shell, R., Mathy, R. M., & Reno, R. R. (1989). Relation of sympathy and personal distress to prosocial behavior: A multimethod study. *Journal of Personality and Social Psychology*, *57*(1), 55-66. doi:10.1037/0022-3514.57.1.55

Eisenberg, N., Fabes, R., Miller, P. A., & Shell, R. (1990). Preschoolers' vicarious emotional responding and their situational and dispositional prosocial behavior. *Merrill-Palmer Quarterly, 36*(4), 507-529.

Eisenberg, N., Spinrad, T. L., & Eggum, N. D. (2010). Emotion-related self-regulation and its relation to children’s maladjustment. *Annual Review of Clinical Psychology*, *6*, 495-525. doi:10.1146/annurev.clinpsy.121208.131208

Enders, C. K. (2010). *Applied missing data analysis.* New York, NY: Guilford Press.

Frankfurt, H. G. (1988). *The importance of what we care about: Philosophical essays*. Cambridge, UK: Cambridge University Press.

Hoffman, M. L. (2000). *Empathy and moral development: Implications for caring and justice*. New York, NY: Cambridge University Press.

Izard, C. E., & Ackerman, B. P. (1998). Emotions and self-concept across the life span. In M. P. Lawton (Series Ed.) & K. W. Schaie (Vol. Ed.), *Annual review of gerontology and geriatrics: Focus on emotion and adult development* (Vol. 17, pp. 1-26). New York, NY: Singer Publications.

Lansink, J. M., & Richards, J. E. (1997). Heart rate and behavioral measures of attention in six-, nine-, and twelve-month-old infants during object exploration. *Child Development, 68*(4), 610-620. doi:10.1111/j.1467-8624.1997.tb04224.x

Malti, T. (2015). *Toward an integrated clinical-developmental model of guilt.* Manuscript under revision.

Malti, T., Gummerum, M., Keller, M., & Buchmann, M. (2009). Children’s moral motivation, sympathy, and prosocial behavior. *Child Development, 80,* 442-460. doi:10.1111/j.1467-8624.2009.01271.x

Malti, T., & Keller, M. (2010). Development of moral emotions in cultural context. In W. Arsenio & E. Lemerise (Eds.), *Emotions, aggression, and morality in children: Bridging development and psychopathology (pp. 177-198).* Washington: American Psychological Association.

Malti, T., & Krettenauer, T. (2013). The relation of moral emotion attributions to prosocial and antisocial behavior: A meta-analysis. *Child Development*, *84*(2), 397-412. doi:10.1111/j.1467-8624.2012.01851.x

Malti, T., & Ongley, S. (2014). The development of moral emotions and moral reasoning. In M. Killen & J. Smetana (Eds.), *Handbook of moral development* (2nd ed., pp. 163-183). New York, NY: Psychology Press.

Quas, J., Hong, M., Alkon, A., & Boyce, W. T. (2000). Dissociations between psychobiologic reactivity and emotional expression in children. *Developmental Psychobiology, 37*(3), 153-175. doi:10.1002/1098-2302(200011)37:3<153::aid-dev4>3.0.co;2-y

Rash, J. A., & Prkachin, K. M. (2013). Cardiac vagal reactivity during relived sadness is predicted by affect intensity and emotional intelligence. *Biological Psychology, 92*(2), 106-113. doi:10.1016/j.biopsycho.2012.11.009

Raudenbush, S. W., Bryk, A. S., Cheong, Y. F., Congdon, R., & Du Toit, M. (2011). *HLM 7: Hierarchical linear and nonlinear modeling.* Lincolnwood, IL: Scientific Software International.

Richards, J. E., & Cronise, K. (2000). Extended visual fixation in the early preschool years: Look duration, heart rate changes, and attentional inertia. *Child Development*, *71*(3), 602-620. doi:10.1111/1467-8624.00170

Richards, J. E., & Gibson, T. L. (1997). Extended visual fixation in young infants: Look distributions, heart rate changes, and attention. *Child Development, 68*(6), 1041-1056. doi:10.1111/j.1467-8624.1997.tb01983.x

Statistics Canada. (2012). Mississauga, Ontario, census profile, 2011 census (Catalogue number 98-316-XWE), released October 24, 2012: http://www12.statcan.ca/census-recensement/2011/dp-pd/prof/index.cfm?Lang=E

West, S. G., Ryu, E., Kwok, O., & Cham, H. (2011). Multilevel modeling: Current and future applications in personality research. *Journal of Personality*, *79*(1), 2-50. doi:10.1111/j.1467-6494.2010.00681.x

Witvliet, C. v., & Vrana, S. R. (1995). Psychophysiological responses as indices of affective dimensions. *Psychophysiology, 32*(5), 436-443. doi:10.1111/j.1469-8986.1995.tb02094.x

Wrzus, C., Müller, V., Wagner, G. G., Lindenberger, U., & Riediger, M. (2014). Affect dynamics across the lifespan: With age, heart rate reacts less strongly, but recovers more slowly from unpleasant emotional situations. *Psychology and Aging, 29*(3), 563-576. doi:10.1037/a0037451s

Table 1

Descriptive Statistics and Correlations between Study Variables

Variables	1	2	3	4	5	6	7	*M*(*SD*)
1. NVMEs	-							1.51(0.83)
2. PVEs	-.65***	-						0.41(0.59)
3. Baseline HR	.07	-.06	-					90.79(10.22)
4. HRR vignettes	-.16†	.15†	-.29***	-				0.38(4.14)
5. HRR emotions	.18*	-.22**	-.09	-.44***	-			2.13(4.12)
6. Age	.19*	-.11	-.28***	.12	.17†	-		-
7. Sex	-.02	-.02	-.05	-.03	-.05	-.06	-	-

Note. NVMEs = negatively-valenced moral emotions. PVEs = positively-valenced emotions. HR = heart rate. HRR vignettes = HR reactivity from baseline to vignettes. HRR emotions = HR reactivity from vignettes to anticipated emotions. Age = exact years until study date. Sex = girls (-0.5), boys (0.5). NVMEs/PVEs (intensity scores) ranged from 0-3. $^{\dagger}p < .10$. $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

Table 2

Multi-level Model Relating HR Reactivity to NVMEs

Fixed Effect	Coefficient	*SE*	*t*
Baseline HR (b_0)			
Intercept (γ_{00})	91.22***	0.82	111.34
Age (γ_{01})	-2.18***	0.58	-3.76
Sex (γ_{02})	-1.22	1.63	-0.75
NVMEs (γ_{03})	1.64	1.12	1.47
Linear HR (b_1)			
Intercept (γ_{10})	-0.40	0.62	-0.66
Age (γ_{11})	0.51	0.50	1.03
Sex (γ_{12})	-0.25	1.24	-0.21
NVMEs (γ_{13})	-1.78*	0.84	-2.12
Quadratic HR (b_2)			
Intercept (γ_{20})	0.73**	0.28	2.57
Age (γ_{21})	-0.06	0.22	-0.27
Sex (γ_{22})	0.03	0.57	0.06
NVMEs (γ_{23})	0.79*	0.39	2.02

Random Effect	Variance Component	$□^2$(df)	*p*
Baseline HR ($□_0$)	82.30	2010.57(125)	.000
Linear HR ($□_1$)	12.89	176.04(125)	.002
Quadratic HR ($□_2$)	2.03	162.24(125)	.014
Level-1 error (ε_t)	5.62		

Note. HR = heart rate. NVMEs = negatively-valenced moral emotions. $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

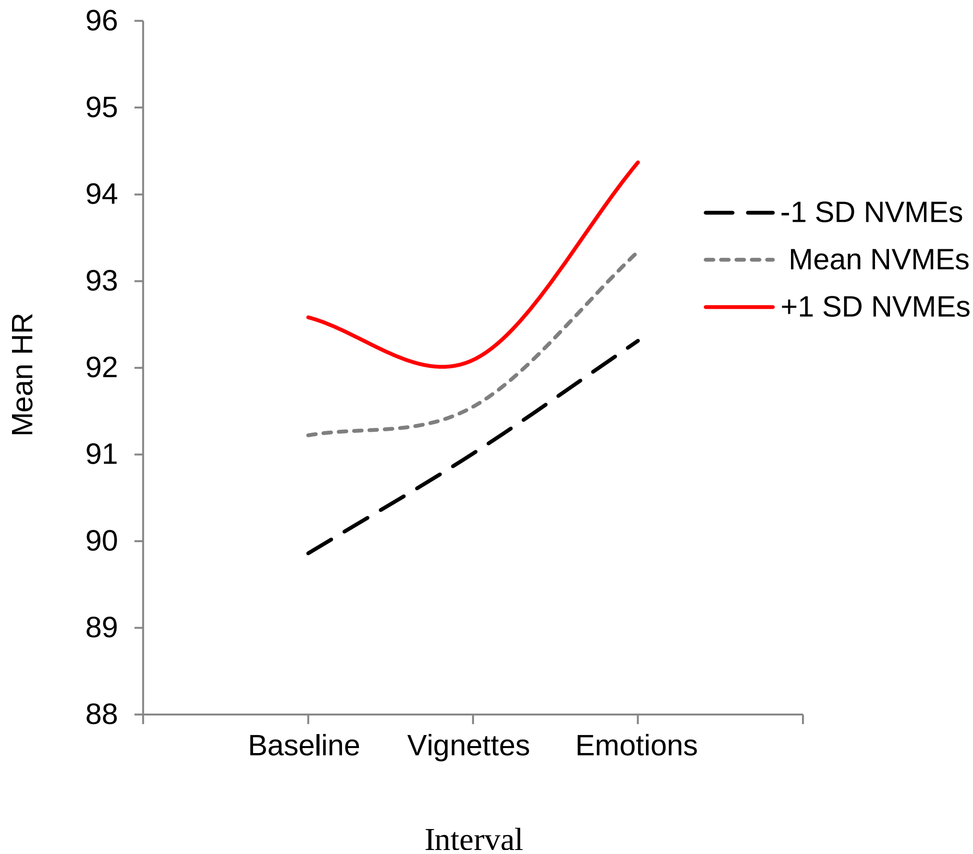

Figure 1. HR reactivity at low (-1 *SD*), medium, and high (+1 *SD*) levels of NVMEs.
Note. HR = heart rate. NVMEs = negatively-valenced moral emotions.