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Peer Victimization and Selective Attention in Adolescence: Evidence from a Monozygotic Twin Difference Design

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Abstract

Peer victimization impacts 13% of adolescents worldwide (Currie et al., 2012). Despite its prevalence and associated adverse outcomes, global cognitive processes that could be affected by peer victimization have not been thoroughly investigated. Using a monozygotic (MZ) twin difference design that rigorously controls for the influence of genetic and familial level confounders, we examined the relation between peer victimization exposure and selective attention processes during an affective go/no go task. Twins who experienced more severe peer victimization were biased towards detecting goal relevant stimuli during the task. Our findings suggest an environmentally salient relation between peer victimization and goal oriented selective attention. Future work should investigate how this process might serve to enhance or buffer risk of peer victimization exposure for developing later adverse outcomes.

Keywords

peer victimization; peer relationships; attention; twins; bullying

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Peer victimization impacts many adolescents worldwide, with 13% of adolescents reporting being victimized at least twice a month (Currie et al., 2012). Peer victimization, or the experience of being a target of aggressive behavior by peers (Olweus, 1994), is associated with an increased risk of internalizing symptoms (Reijntjes et al., 2010), externalizing

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Compliance with Ethical Standards
Ethical approval: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent: Informed consent was obtained from all individual participants included in the study.

symptoms (Reijntjes et al., 2011), psychotic symptoms (Schreier et al., 2009), physical health problems (Gini & Pozzoli, 2009), and poor academic achievement (Espelage et al., 2013). Risk for these adverse outcomes not only occurs in adolescence, but also extends into adulthood (Takizawa et al., 2014, Copeland et al., 2013). Additionally, those victimized in adolescence struggle with developmentally normative tasks in adulthood (Kretschmer et al., 2018). Despite the prevalence of peer victimization and its numerous adverse associated outcomes, mechanisms linking peer victimization to increased vulnerability to such outcomes remain largely uninvestigated. Given links between child and adolescent psychopathology and cognitive impairments (Hosenbocus & Chahal, 2012), it may be beneficial to understand cognitive processes that could be impacted by peer victimization. One such process is goal oriented selective attention, a broad cognitive bias towards detecting stimuli that are relevant to one's present goal. Using a monozygotic (MZ) twin difference design that rigorously controls for several relevant confounding variables, we establish environmentally salient relations between peer victimization exposure and goal oriented selective attention.

Peer victimization and selective attention

Peer victimization experience can alter perceptions about the self and others. Rosen et al.'s (2007) model suggests that regular victimization experience fosters negative beliefs about the self as unworthy and others as being untrustworthy. Through repeated victimization experiences, a "victim schema" develops and stabilizes, guiding cognitions, affect, and behavior. This schema contributes to problems across multiple contexts by influencing one's selective attention, encoding, attributions, and affective responses (Crick & Dodge, 1994). The model proposes that those with this victim schema will attend toward threatening cues in social situations more than non-threatening cues. Additionally, the model suggests that this attentional bias will influence attributions of peer behavior, such that peer behavior is likely to be perceived as hostile. Indeed, peer victimization is related to negative perceptions about both the self and other peers, as well as hostile attributions about peers (Troop-Gordon & Ladd, 2005, Perren et al., 2012). The impact of peer victimization on selective attention is unlikely to be restricted to the social domain. Relations between peer victimization exposure and global selective attention processes, however, remain uninvestigated. Further, each of the aforementioned studies remains susceptible to genetic and family level confounding variables that can influence relations between peer victimization and cognitive processes under investigation.

Other relational life stressors are marked by impairments in selective attention towards affective stimuli that do not involve making explicit attributions about others' behavior. Abused children, for example, show selective attention towards threat related cues, as well as difficulty disengaging from them (Pechtel & Pizzagalli, 2011). Peer victimization exposure, too, might relate to selective attention towards negatively valenced affective stimuli. Yet we do not know how global selective attention toward negative stimuli could be impacted by peer victimization.

Monozygotic twin difference design

The most convincing design used to explore relations between an environmental variable and an outcome is the randomized control trial (RCT). In this design, participants are randomly assigned to different levels of an environmental variable while other confounding variables are held constant. An active manipulation of our environmental variable by randomly assigning participants to be exposed to peer victimization – as would be the case in a traditional RCT design – is unethical, limiting inference about peer victimization and its impact on selective attention. The MZ twin difference design, however, offers an alternative to the RCT. This design achieves rigorous control for a number of unmeasurable confounding variables by contrasting genetically identical individuals drawn from the same family environment, but who are exposed to varying naturally occurring experiences. When left uncontrolled, as is the case in many studies of peer victimization that include only one child per family, peer victimization may be confounded with differential environmental experiences through gene–environment correlations and/or environment–environment correlations (Vitaro et al., 2009). By controlling for these genetic and shared familial level environmental influences with our design, we establish environmentally salient relations between exposure to peer victimization and selective attention. Though this design has been used in the peer victimization literature to examine relations between peer victimization and psychopathology (Arseneault et al., 2008, Silberg et al., 2016, Singham et al., 2017, Vitaro et al., 2011), academic performance, (Vitaro et al., 2012), or HPA axis function (e.g. Brendgen et al., 2017; Ouellet-Morin et al., 2011), no studies have investigated relations between peer victimization and attentional processes.

Current study

We investigate relations between peer victimization and selective attention toward negative stimuli on an affective go/no-go task. Analyses are conducted in two steps: first, we examine relations that treat twins as individuals. These initial analyses allow us to understand the basic processes at play between peer victimization and our measure of selective attention; Second, we use a genetically informed monozygotic (MZ) twin difference design to elucidate relations between peer victimization experiences, selective attention, and discriminability of affective stimuli without the influence of genetic or family level confounders. Using signal detection theory, we measure both a participant's response bias to differentially valenced stimuli (selective attention) and their ability to correctly discriminate between correct and incorrect responses across valence (discriminability).

Guided by the work of Rosen et al. (2007) and Crick & Dodge (1994), we expect that:

1) Examining twins as a) individuals and using b) the MZ twin difference design, peer victimization will correlate with a response bias towards identifying negative distractor words as a target word, reflecting goal oriented selective attention toward detecting potentially threatening environmental stimuli.

2) Examining twins as a) individuals and using b) the MZ twin difference design, peer victimization will correlate with an increased ability to discriminate correct from incorrect responses when the correct response involves negatively valenced stimuli, given a predicted goal oriented selective attention toward detecting potentially threatening environmental stimuli.

Method

Participants

Families of twins identified through state birth records and community outreach in the Madison, Wisconsin, area were invited to participate in a longitudinal twin study (Schmidt et al., 2013). Twins included in this study were born between the years of 1991 and 2003; they joined the study during infancy or toddlerhood. We selected 60 same-sex monozygotic twin pairs (n = 34 female pairs) during adolescence (M = 15.39 years, SD = 1.74, range: 13-19 years) to complete a battery of neuroimaging, cognitive, and self-report measures in adolescence. Monozygosity was based on repeated parental reports on the Zygosity Questionnaire for Young Twins (Goldsmith, 1991), observational ratings by research staff, and DNA analysis for ambiguous cases. Twin pairs were selected for this laboratory visit if one or both twins were "at-risk" for developing anxiety in adolescence. Twins were considered "at-risk" if they were identified as highly fearful of strangers in infancy and toddlerhood (Brooker et al., 2013), scored in the top 20% on an observational measure of object fear in infancy and toddlerhood, or reported chronic anxiety on two or more occasions prior to adolescence. Here, we focus on data collected during adolescence. One pair was dropped from final analyses as they did not complete the questionnaires. Informed assent and consent was obtained from all twins and their parents included in the study. The Institutional Review Board at the University of Wisconsin—Madison approved all study procedures.

The adolescent subsample self-identified as 91.5% White, 3.4 % Hispanic, 3.4% bi-/multi-racial, 1.7% Black, and 1.7% Native American. Parents most frequently reported a college degree as their highest level of education (33.9% of mothers and 39.0% of fathers). Median family income was $90,001 to $100,000, near the top of the middle-class range. Parent education (measured in number of years of school completed) and family income were z-scored and then averaged together to create a socioeconomic status (SES) composite.

Procedures

Twins participated in a six-hour visit consisting of a battery of neuroimaging, cognitive, and self-report measures. Both twins completed the visit on the same day. Our cognitive task – the affective go/no-go task – is part of the Cambridge Neuropsychological Test Automated Battery (CANTAB) battery of executive function tasks (Robbins et al., 1994). Given visit schedule constraints, twins completed the task at different times during the visit. We found no effect of task order on our results and consequently do not include task order in our final models. Participants completed questionnaires on the day of the visit and diagnostic interviews prior to coming to the lab. These questionnaires asked twins to report on their own behaviors and experiences as well as the behaviors and experiences of their co-twin.

Measures

Peer victimization.—We measured peer victimization using the MacArthur Health and Behavior Questionnaire for Late Childhood and Adolescence (HBQ; Armstrong & Goldstein, 2003). Seven questions asked respondents to choose between two opposing options that were stated equivalently (e.g. “Kids say mean things to me” or “Kids don’t say mean things to me”, “Some kids at school verbally or physically threaten me” or “Kids at school don’t verbally or physically threaten me”). After selecting which option best described their experience, respondents rated it on a scale from 1 (sort of like me) to 3 (really like me). Responses were then converted to a six point Likert scale, with higher scores indicating more severe peer victimization. The seven peer victimization item responses were averaged to calculate total peer victimization subscale score for each individual – called the *bullied* subscale on the HBQ.

Given that we do not observe peer victimization directly and our measure only included seven questions, we utilized a multi-informant approach to measure each twin’s experience of peer victimization and bolster the validity of our measurement. Twins reported on their own experience with peer victimization, as well as their co-twin’s experience with peer victimization. Here, we took twin A’s self-report of their *own* peer victimization experience and averaged it with twin B’s report of *twin A’s* peer victimization experience. We performed the same averaging scheme to calculate twin B’s peer victimization composite. Self (Cronbach’s alpha = .896) and co-twin (Cronbach’s alpha = .890) reports of bullying victimization were strongly correlated, $r = 0.64$, $p < 0.001$, indicating that twins were aware of their co-twin’s experience with peer victimization.

Response bias and discriminability.

Affective Go/No-Go Task.—We calculated response bias and discriminability from performance on the affective go/no-go task (AGN) from the CANTAB battery (Robbins et al., 1994). Participants were instructed to press a button when they saw target words and to avoid pressing a button when they saw distractor words. In total, participants completed two sets of 10 (2 practice and 8 scored) blocks of trials. Each word presentation was considered a trial and blocks were composed of 18 individual trials, for a total of 162 scored target trials and 162 scored distractor trials. Target and distractor words were either negative (e.g. depressed, shame, worry), neutral (e.g. move, ingredient, shape), or positive (e.g. joyful, confident, friendship) in content. Word content valence was operationalized at the beginning of each block, such that each block only included two types of word valence. Target and distractor word valences remained consistent within each block, but alternated among all three valances across blocks. Target word valence alternated every other block to create shift (e.g., positive-negative) and non-shift (e.g., negative-negative) blocks. Commission errors – or false alarms – occurred when participants pressed the button after viewing a distractor word. Omission errors – or misses – occurred when participants failed to press the button after viewing a target word. As is standard in this paradigm, button presses within 100ms of the stimulus onset were omitted from our analyses to control for guessing. To account for non-normality, three participants’ omission and commission error scores were winsorized, such that values above three standard deviations from the mean were converted to the value that was three standard deviations above the mean.

As a data reduction technique, we performed a factor analysis on commission and omission errors across valence and shift/non-shift blocks. An exploratory factor analysis identified a two-factor solution, with factor loadings supporting the clustering of AGN errors into broad total commission and total omission errors. Thus, our measures of response bias and discriminability collapsed across stimuli valence and shift/non-shift blocks. Table 1 shows the factor loadings of the AGN errors. We used broad total commission and total omission errors in our analyses instead of the factor scores to facilitate replication of our findings.

Signal detection theory.—Signal detection theory (SDT) quantifies the response of an observer to the presentation of a signal in the presence of noise (Green & Sweets, 1966). In our AGN task, participants respond during each trial by pressing a button when they believe a target word is present or by withholding a button press when they believe a distractor word is present. The four possible outcomes per trial are hits, misses (omissions), false alarms (commissions), and correct rejections (Figure 1). Guided by the work of Schulz et al. (2007), we calculated response bias (*c'*) and discriminability (*d'*) using the following formulas:

$$\text{Discriminability}: (d') = z(\text{pH}) - z(\text{pFA})$$

$$\text{Bias}: (c') = -(z(\text{pH}) + z(\text{pFA}))/2$$

Figure 2 provides a visualization of these measures for an illustrative participant. In the equations presented above, pH represents the proportion of hits (trials with a correct response to the target words) during the task, pFA represents the proportion of false alarms (i.e. commission errors), and z(*x*) represents the inverse transform of the cumulative normal distribution. *d'* is a measure of the sensitivity toward discriminating between a target word and a distractor word being present, independent of response biases. This is represented visually in Figure 2 as the distance between the signal and noise probability density distributions. A positive *d'* reflects an increased sensitivity to correctly discriminate a target word from distractor words, while a negative *d'* reflects a decreased sensitivity to correctly discriminate between target and distractor words. *c'* is a measure of participant response bias in identifying AGN word stimuli as a target or distractor word, independent of sensitivity. This is represented visually in Figure 2 as the distance from the cut-off point in which a participant decides a target word is present (criterion) to the point midway between the signal and noise probability density distributions. A negative *c'* indicates that a participant is more likely to identify any word as a target word, while a positive *c'* indicates that a participant is more likely to identify any word as a distractor word.

Anxiety symptoms.—We created an anxiety composite from symptom counts of social phobia and generalized anxiety disorder on two separate instruments. Trained interviewers administered the Diagnostic Interview Schedule for Children-IV (DISC-IV) to twin participants via a phone interview (Shaffer et al., 2000) before their visit (*M* = 15.22 months, *SD* = 12.94). Participants also reported on their anxiety symptoms using the MacArthur Health and Behavior Questionnaire for Late Childhood and Adolescence on the day of the laboratory visit (Armstrong & Goldstein, 2003). Similar to the *bullied* scale on the HBQ, this measure asked respondents to choose between two opposing options that were stated equivalently (e.g. "I don't worry bad things are going to happen" or "I worry bad things are going to happen"). After selecting which option best described them, participants rated it on a scale from 1 (sort of like me) to 3 (really like me). Responses were then converted to a six point Likert scale, with higher scores indicating more severe anxiety. We omitted obsessive compulsive disorder (OCD) symptoms from these analyses because the data were highly positively skewed, such that the vast majority reported zero symptoms. Descriptive statistics for our composite measure of anxiety and each subscale can be found in Table 2; 22.03% of the sample met diagnostic criteria for having a social phobia disorder and 5.93% of the sample met diagnostic criteria for having a general anxiety disorder.

Depression symptoms.—We measured depression symptom count using the same Diagnostic Interview Schedule for Children-IV (DISC-IV; Shaffer et al., 2000). Descriptive statistics for this measure can be found in Table 2; 2.54% of the sample met diagnostic criteria for having a depressive disorder.

Data analytic approach

Twins as individuals.—Before using the MZ twin difference design, we conducted analyses that treats each twin as an individual. Doing so provides the context for our MZ difference analyses by examining the relations at play between peer victimization and our signal detection measures. For these analyses, we used linear-mixed effects models that allowed the residuals of the covariance structure for each twin within a pair to be correlated. While our models account for issues of non-independence created by familial clustering, estimates do not identify the source of phenotypic association. Thus, parameter estimates are interpreted at the level of individual differences (Sayer & Klute, 2005, Planalp et al., 2017).

MZ twin difference design.—Following our individual analyses, we turned to our MZ twin difference design. In standard biometric twin models, the cumulative unobserved genetic effects are the same for members of an MZ twin pair. When reared together, the cumulative, unobserved family environmental effects (i.e. shared environment) is likewise the same for members of an MZ twin pair. Thus, observable differences between a set of MZ twins is due to unobserved factors that are unique to each member of the pair (i.e. unique environment plus measurement error). We calculated MZ intrapair twin difference by first randomly assigning twin order. Then, the score of one twin is subtracted from the score of their co-twin, thus creating a difference score that is due to *unique environmental effects*. Twin order remains the same for all variables of interest. Regression models examine the association between difference scores on the predictor variable and difference scores on the outcome. For our analyses, we use the equation; $\Delta Y_i = \beta_0(X_i) + \beta w(\Delta X_i)$. Here, the coefficient βw gives the expected change in the difference between Twin 1 and Twin 2 in family *i* on the unique environmental outcome variable (ΔY) for each unit of change in the difference between the twins on the unique environmental predictor variable (ΔX). β_0 is the intercept in these models, representing the pair average of family *i* on our outcome variable.

Results

Descriptive statistics

Table 3 includes the descriptive statistics for all variables and the bivariate correlations between pairs of variables. We coded gender such that .5 represented females and −.5 represented males. In Table 3, we see that our peer victimization variable is related to gender and SES, highlighting the need to use those demographic variables as covariates. As expected, our measures of discriminability and response bias are independent. Discriminability was related to depression and anxiety, such that increased symptoms of both were related to a decreased sensitivity to correctly discriminate between target and distractor words.

Twin similarity

We computed the intraclass correlation (ICC) between individuals within a twin pair for each family for our measures of interest (Table 4). The ICC is an estimate of co-twin similarity (shared variance). The factors responsible for that shared variance include all genetic effects and shared (by co-twins in the same family) environmental effects. To the extent that the ICC is < 1.00, non-shared environmental effects are implicated (in addition to potential measurement error).

Based on these ICC values, 31% of the variance (100% - 69%) in peer victimization experiences can be attributed to non-shared environmental experiences (plus measurement error). Here, 100% refers to the upper bound for all familial (shared environment and genetic factors) and non-shared environmental influences. 69% represents the observed co-twin similarity (shared variance). The factors responsible for that shared variance include all genetic effects and shared (by co-twins in the same family) environmental effects. The remaining variance (i.e. 31%) reflects non-shared or unique environmental effects. MZ twins in our sample have differential peer victimization experiences that cannot be accounted for by either their shared genetic risk or shared family level environmental factors. The outcome variables *c'* and *d'* have ICC values of .31 and .72 respectively, reflecting that 69% of the variance in response bias and 28% of the variance in stimuli discriminability can be attributed to unique non-shared environmental experiences (plus measurement error). The ICC values for the AGN outcome and symptom measures highlight the substantial variability to be explained by unique non-shared environmental experience. The existence of this non-shared variance across measures is crucial for the MZ twin difference design to be useful.

Individual analyses

For the individual analyses, we used linear mixed-effects models to account for dependence created by familial clustering (Sayer & Klute, 2005). These analyses included covariates of age, gender, and SES. Given that depression diagnosis is related to AGN performance in adolescence (Kilford et al., 2015; Maalouf et al., 2012) we also included anxiety and depression symptoms as covariates. Variables in the models were mean centered.

Table 5 shows results for the bias (*c'*) model. The intercept for the bias model was significant, indicating that on average, individuals were more likely to identify *any* word as a distractor word. Peer victimization and bias were negatively related, such that adolescents who experienced more peer victimization were more likely to endorse *any* word as a target word. Females were more likely to identify *any* word as a target than males, and individuals from higher SES families were also more inclined to identify *any* word as a target. Bias was not related to age, anxiety symptoms, or depression symptoms.

Table 6 shows results for the discriminability (*d'*) model. The intercept for the discriminability model was significant, indicating that on average, individuals were more sensitive toward discerning a correct response. Discriminability was not related to peer victimization. Older participants showed increased sensitivity to detect the correct response, and individuals from higher SES families also had an increased sensitivity to detect the correct response. Discriminability was not related to gender, anxiety symptoms, or depression symptoms.

MZ difference analyses

We now turn to tests central to our hypotheses, focusing on MZ twin differences in the peer victimization, signal detection, and symptom measures. Unlike individual analyses, these analyses control for a variety of relevant genetic and shared family level environmental confounding variables. Thus, the design inherently controls for age, gender, and SES, such that they do not need to be included in the models. Like our individual analyses, these analyses included covariates of MZ differences in anxiety and depression symptoms. Variables in the models were mean centered.

Table 7 shows the results for the bias (*c'*) model. A negative B value reflects that the twin who is higher on the predictor variable is more likely to identify any word as a target word, whereas a positive B value reflects that the twin who is higher on the predictor variable is more likely to identify any word as a distractor word. MZ differences in peer victimization were negatively related to MZ differences in bias, such that the twin who experienced more peer victimization was more likely to endorse *any* word as a target word. MZ differences in bias were not related MZ differences in anxiety or depression symptoms.

Table 8 shows results for the discriminability (*d'*) model. MZ differences in discriminability were not significantly related to MZ differences in peer victimization, MZ differences in anxiety symptoms, or MZ differences in depression symptoms.

Discussion

Our findings provide evidence for an environmentally salient link between peer victimization and goal oriented selective attention. MZ differences in peer victimization were related to a response bias, such that the twin who experienced more peer victimization was more likely to endorse *any* word regardless of valence as a target word. Conceptually, this reflects a broad cognitive bias towards detecting stimuli that are relevant to one's present goal. The goal, in this case, is to detect target words. MZ differences in peer victimization were not related to an increased ability to discriminate between target and distractor words across valence. With our MZ twin difference design, these differences are not attributable to the twin's genetic makeup or their shared family environment, suggesting that experiences twins have outside of their home or other shared environments impact the relation between peer victimization exposure and response bias. Unexpectedly, we did not find a relation between peer victimization and discriminability when treating twins as individuals or examining MZ twin differences. Our initial hypotheses, however, were specific to negatively valenced stimuli. Although these hypotheses and our hypotheses about response bias proposed specific directional predictions based on target word valence, our factor analysis unexpectedly supported collapsing participant responses across target word valence.

Previous work indicates that peer victimization biases selective attention towards detecting potentially threatening stimuli in social situations (Troop-Gordon & Ladd, 2005, Perren et al., 2012). Our findings suggest that peer victimization could enact changes on broad selective attention processes toward detecting goal relevant stimuli. Previous work has not examined relations between peer victimization and broad selective attention processes. Given the broad nature of changes in this selective attentional process, we expect that they would also influence the detection of threatening social cues in social situations. Building on Crick and Dodge's (1994) social information-processing framework, we expect that chronic peer victimization exposure alters selective attention processes to prioritize encoding environmental cues consistent with one's situational goals. Adolescents who have experienced chronic peer victimization may have situational goals that are influenced by their stabilized "victim schema," driving attention towards identifying potential social threats. Consequently, this goal driven selective attention might influence the development of psychopathology, future social interactions, and the onset of future behavioral problems.

A challenge of studying peer victimization is that a wide range of confounding factors, both genetic and familial, can contribute to the varying ways people experience and report peer victimization. Although some relevant confounders and demographic variables like gender and age can be controlled for, most research designs do not account for interplay between gene-environment and environment-environment confounds. By studying MZ twins who are matched on both genetic makeup and shared environment, many unobserved confounding factors are inherently controlled for, and the remaining MZ twin difference can better illuminate associations between peer victimization and measures of selective attention.

In our study, peer victimization and selective attention were measured concurrently. It remains unclear if the effects demonstrated in our study endure over time. Work by Singham et al. (2017) investigating relations between MZ differences in peer victimization and adverse mental health outcomes demonstrated that many of these effects (e.g. anxiety, depression) did not persist from early to middle adolescence. Singham et al. (2017) did find, however, that the association between MZ differences in peer victimization and a parent reported measure of inattention persisted over time. This parent report may capture some of the selective attentional processes we have measured in our study. Longitudinal designs utilizing cognitive measures of selective attention are necessary to investigate the potency of the effects demonstrated in our study over time.

Given that we utilize an MZ difference design, our primary goal was to limit the variability in each twin pair's living situation; thus, we studied twins living together in their parents' home. The association that we observed between peer victimization and goal oriented selective attention may not be specific to middle adolescence. There is evidence, however, that unique environmental factors have a greater impact on the risk of experiencing peer victimization in middle to late adolescence than in early adolescence (Eastman et al., 2018). Therefore, we might not expect to find an environmentally salient relation between peer victimization and goal oriented selective attention during early adolescence. An investigation of this relation prior to middle adolescence is necessary to determine the developmental specificity of the association.

Although our MZ difference design affords control for several pertinent confounding variables, generalization to non-twin populations might be limited. Twin relationship closeness could serve as an additional protective factor against the adverse effects of peer victimization, given work demonstrating that social support serves as a protective factor against the adverse effects of peer victimization (e.g. Hodges et al., 1999; Brendgen & Poulin, 2018). Further research is needed to both demonstrate the generalizability of our findings to non-twin populations and to investigate how twin relationship closeness could influence the relation between peer victimization exposure, adverse outcomes, and potential cognitive mechanisms connecting them.

Further, our work investigates associations between peer victimization and selective attention, yet prior investigation of trans-diagnostic processes has focused on psychophysiological dysregulation via the hypothalamic-pituitary-adrenal (HPA) axis (Brendgen et al., 2017; Ouellet-Morin et al., 2011). Stressors during adolescence, such as peer victimization, might impact the neural circuits implicated in both cognitive and affective processes via dysregulated HPA axis output of glucocorticoid hormones (Lupien et al., 2009). In our work, peer victimization exposure was related to goal oriented selective attention. The downstream effects of HPA axis dysregulation on neural circuitry dense with glucocorticoid receptors (e.g., amygdala-vmPFC circuit) (Sánchez, et al., 2000) that is implicated in both cognitive and affective processes might underlie our findings. A complete understanding of the link between peer victimization exposure and goal oriented selective attention necessitates the study of potential mechanisms across multiple domains of functioning.

Our study has limitations. First, our measure of peer victimization focuses on overt, direct victimization behaviors. Peer victimization can also take on more indirect forms, such as social exclusion or gossiping (Crick & Bigbee, 1999). Future studies should include measures of both direct and indirect peer victimization to investigate if there are marked differences between these two forms of victimization and their impact on goal oriented selective attention. We also utilized self-report measures of peer victimization instead of less subjective, observational measures. To bolster the validity of our measurement, however, we used a multi-informant approach, including co-twin reports of their twin's peer victimization experience in our composite. Additionally, our DISC-IV symptom measures were not measured on the same day of the visit to reduce participant burden during the visit. These symptom measures, however, were not our primary measures of interest, and they focused on symptoms experienced in the past year. Moreover, our anxiety composite also included data from the HBQ, which was collected on the same day as the laboratory visit. Our sample is small and community based. Most participating families were Caucasian, well educated, upper middle-class families in Wisconsin. The demographics of our sample limits generalizability of our findings to more diverse populations in which both the likelihood of experiencing peer victimization and the nature of peer victimization experiences may be different.

Despite these limitations, our results provide evidence for an environmentally salient relation between peer victimization exposure and broad goal oriented selective attention, which, with our MZ twin difference design cannot be attributed to the twin's genetic makeup or their shared family environment. This environmentally salient link between peer victimization and goal oriented selective attention is a strong candidate for future mechanistic investigation linking peer victimization to negative adverse outcomes. Future work should investigate how this mechanism may enhance or even buffer risk for developing later adverse outcomes.

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	Participant Action: Presses button, indicating target word is present	Participant Action: Withholds response, indicating distractor word is present
Target word present	**Hit**	**Miss (Omission error)**
Distractor word present	**False alarm (Commission error)**	**Correct reject**

Fig. 1.
Four possible outcomes in the affective go/no go task.

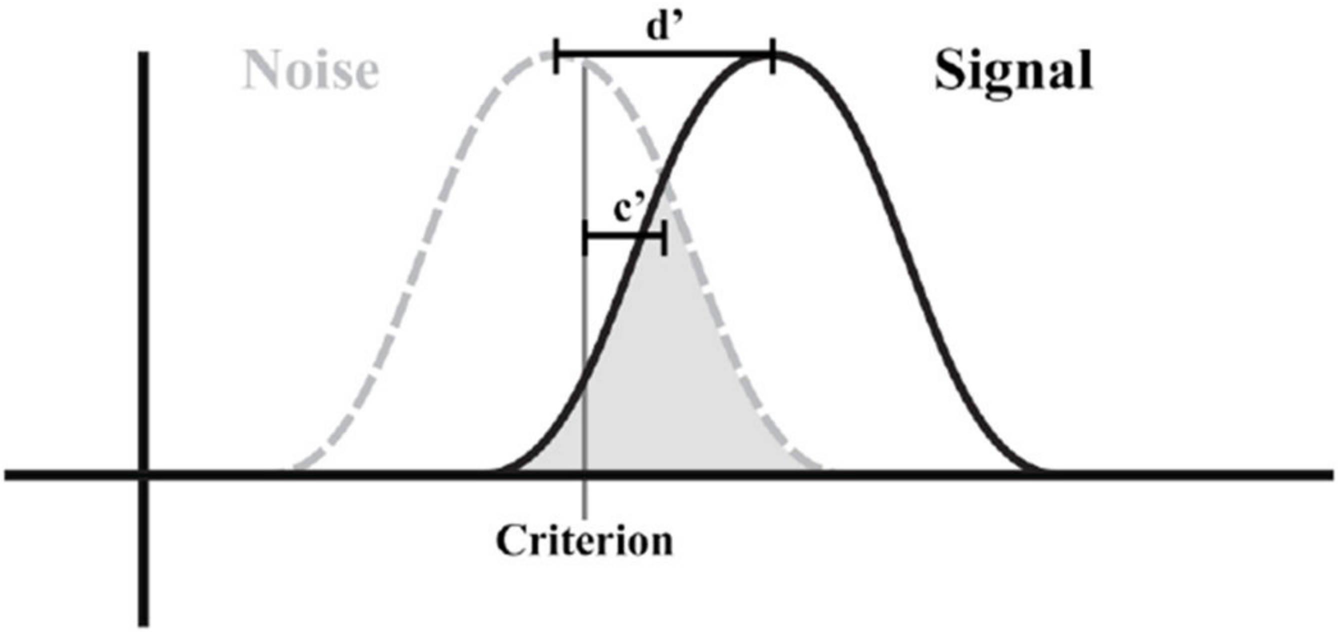

Fig. 2.

Visual representation of signal detection theory (SDT). Black distribution (signal) represents the probability density distribution of identifying a target word. Dashed gray distribution (noise) represents the probability density distribution of identifying a distractor word. *d'* represents the distance between the signal and noise probability density distributions. Light gray represents the overlap between the two probability density distributions. Criterion is the cut-off point in which a participant decides a signal (target word) is present. *c´* measures the distance of the criterion to the point midway between the two distributions.

Table 1.

Factor loadings of affective go/no-go errors.

	Factor 1 Loading	Factor 2 Loading
Com Non-shift Neg	**0.96**	0.02
Com Non-shift Neu	**0.90**	−0.11
Com Non-shift Pos	**0.93**	0.11
Com Shift Neg	**0.91**	0.06
Com Shift Neu	**0.89**	−0.15
Com Shift Pos	**0.92**	0.05
Omi Non-shift Neg	0.04	**0.90**
Omi Non-shift Neu	−0.14	**0.85**
Omi Non-shift Pos	0.03	**0.92**
Omi Shift Neg	0.13	**0.87**
Omi Shift Neu	−0.09	**0.87**
Omi Shift Pos	0.01	**0.91**

Note: Com = commission errors, Omi = omission errors, Neg = negative words, Pos = positive words, Neu = neutral words

Table 2.

Descriptive statistics for anxiety and depression measures.

	Mean	SD	Range
HBQ social anxiety	3.04	1.01	1.43 - 2.86
HBQ overanxious	2.95	0.81	1.46 - 5.08
DISC-IV social phobia symptom count	3.92	3.90	0 - 13
DISC-IV general anxiety symptom count	3.29	2.46	0 - 10
DISC-IV depression symptom count	4.64	4.46	0 - 19

Note: The number of symptoms that participants can endorse on the DISC-IV differs across types of psychopathology. Each section has different diagnostic cut-off points.

Table 3.

Descriptive statistics and intercorrelations between variables.

	1	2	3	4	5	6	7	8	9	10	11	12
1. Age	1											
2. Gender (females higher)	0.01	1										
3. SES	−0.19*	−0.05	1									
4. Peer victimization	−0.01	−0.41***	−0.46***	1								
5. Bias (*c'*)[1]	0.01	−0.15	−0.13	−0.07	1							
6. Discriminability (*d'*)[1]	0.17	0.12	0.31***	−0.48***	−0.13	1						
7. False Alarms	−0.15	0.01	−0.17	0.45***	−0.62***	−0.68***	1					
8. Misses	−0.08	−0.17	−0.28**	0.30***	0.72***	−0.72***	0.03	1				
9. Hits	0.08	0.17	0.28**	−0.30***	−0.72***	0.72	−0.03	−1	1			
10. Correct rejections	0.15	−0.01	0.17	−0.45***	0.62***	0.68***	−1	−0.03	0.03	1		
11. Anxiety Composite[1]	0.08	0.24*	−0.28**	0.15	0.00	−0.21*	0.16	0.15	−0.15	−0.16	1	
12. Depression Symptoms	0.09	0.19*	−0.23*	0.09	0.05	−0.24*	0.13	0.20*	−0.20*	−0.13	0.44***	1
Mean	15.39	57.63%	0.00	1.80	−0.01	1.57	40.39	40.92	121.08	121.61	0.15	4.64
SD	1.74	-	0.77	0.72	0.42	0.92	28.82	30.33	30.33	28.82	0.83	4.46

[1]See text for computation of the bias and discriminability scores as well as the anxiety composite

Note:

* $p < .05$

** $p < .01$

*** $p < .001$

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Table 4.

Intraclass (ICC) correlations illustrating the degree of similarity within MZ co-twin pairs on peer victimization and SDT measures. All *ps* < .007.

	ICC
Peer victimization	0.69
False alarms (Total commission errors)	0.47
Bias (*c′*)	0.31
Discriminability (*d′*)	0.72
Misses (Total omission errors)	0.51
Hits	0.51
Correct rejections	0.47
Anxiety composite	0.60
Depression symptoms	0.58

Table 5.

Regression analyses predicting bias, *c’* on AGN task (individual).

	B	SE	*F*	*df*	*p*	95% CI
Intercept	0.17	0.08	5.39	1, 60.64	.02	0.14, 0.34
Peer Victimization	−0.27	0.07	14.03	1, 109.21	<.001	−0.40, −.12
Gender	−0.33	0.10	9.59	1, 65.50	.003	−0.52, 0.12
Age	−0.02	0.03	0.34	1, 53.85	.56	−0.07, 0.03
SES	−0.18	0.07	7.27	1, 65.98	.009	−0.31, −0.05
Anxiety Composite	0.02	0.02	0.12	1, 108.87	.73	−0.09, 0.12
Depression Symptoms	0.01	0.01	0.85	1, 109.82	.36	−0.01, 0.03

Note: B values are unstandardized

Table 6.

Regression analyses predicting discriminability, *d’* on AGN task (individual).

	B	SE	*F*	*df*	*p*	95% CI
Intercept	1.45	0.16	83.99	1, 61.49	< .001	1.15, 1.75
Peer Victimization	−0.20	0.13	2.26	1, 108.12	.13	−0.50, 0.06
Gender	0.20	0.22	0.83	1, 66.97	.36	−0.22, 0.62
Age	0.12	0.06	4.56	1, 53.71	.04	0.01, 0.23
SES	0.28	0.14	4.00	1, 66.88	.05	0.01, 0.56
Anxiety Composite	−0.16	0.10	2.47	1, 108.72	.12	−0.35, 0.04
Depression Symptoms	−0.01	0.02	0.52	1, 107.42	.47	−0.05, 0.02

Note: B values are unstandardized

Table 7.

Regression analyses predicting bias, *c'*, on AGN task (MZ difference).

	B	SE	*F*	*df*	*p*	η_p^2	95% CI
Intercept	−0.05	0.06	0.64	1, 55	.43	0.01	−0.16, 0.07
Δ Peer Victimization	−0.45	0.11	17.43	1, 55	< .001	0.24	−0.67, −0.24
Δ Anxiety Composite	0.06	0.08	0.59	1, 55	.45	0.01	−0.10, 0.23
Δ Depression Symptoms	0.01	0.02	0.89	1, 55	.35	0.02	−0.01, 0.04

Note: B values are unstandardized

Table 8.

Regression analyses predicting discriminability, *d'*, on AGN task (MZ difference).

	B	SE	*F*	*df*	*p*	η_p^2	95% CI
Intercept	0.09	0.09	1.13	1, 55	.21	0.02	−0.08, 0.27
Δ Peer Victimization	0.15	0.17	0.84	1, 55	.36	0.02	−0.18, 0.49
Δ Anxiety Composite	−0.26	0.13	3.87	1, 55	.06	0.07	−0.52, 0.01
Δ Depression Symptoms	0.01	0.02	0.25	1, 55	.62	0.01	−0.03, 0.05

Note: B values are unstandardized