Emotion
2018, Vol. 18, No. 4, 481–492

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1528-3542/18/$12.00 http://dx.doi.org/10.1037/emo0000360

Relations of Emotion-Related Temperamental Characteristics to Attentional Biases and Social Functioning

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The current study examined whether an important temperamental characteristic, effortful control (EC), moderates the associations between dispositional anger and sadness, attention biases, and social functioning in a group of preschool-aged children ($N = 77$). Preschoolers' attentional biases toward angry and sad facial expressions were assessed using eye-tracking, and we obtained teachers' reports of children's temperament and social functioning. Associations of dispositional anger and sadness with time looking at relevant negative emotional stimuli were moderated by children's EC, but relations between time looking at emotional faces and indicators of social functioning, for the most part, were direct and not moderated by EC. In particular, time looking at angry faces (and low EC) predicted high levels of aggressive behaviors, whereas longer time looking at sad faces (and high EC) predicted higher social competence. Finally, latency to detect angry faces predicted aggressive behavior under conditions of average and low levels of EC. Findings are discussed in terms of the importance of differentiating between components of attention biases toward distinct negative emotions, and implications for attention training.

Keywords: attention bias, dispositional anger and sadness, effortful control, eye-tracking, social functioning

Supplemental materials: http://dx.doi.org/10.1037/emo0000360.supp

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Attention bias toward negative emotional stimuli—often operationalized as increased attentional vigilance toward or difficulty disengaging attention from emotional content—may be related to the emergence and development of emotional disorders (e.g., anxiety) and behavioral problems, including aggressive behaviors and social withdrawal (Ford, Tamir, Gagnon, Taylor, & Brunye, 2012; Morales, Perez-Edgar, & Buss, 2015; Wadlinger & Isaacowitz, 2008). Consequently, understanding the origins of these attention biases and their role in predicting behavior problems and social functioning is of considerable interest. The goals of the current study were to identify early childhood temperamental correlates of selective visual attention toward angry and sad facial expressions, and to examine the associations of children's attention biases to normative patterns of social functioning (i.e., aggressive problems and social competence) among young children under age 5. In addition, the moderating role of effortful control in these associations was examined.

Relations Between Temperamental Negative Affect and Selective Attention

In their integrated model of information processing, Lemerise and Arsenio (2000) considered the importance of individual differences in affective experiences (both transitory affective states and predisposition to negative emotions) for understanding social information processing, proposing that individuals' emotional experiences might bias their attention toward information that is consistent with their own experienced emotions. In other words, when an individual is predisposed to negative emotions, he or she may be more likely to pay attention to negative emotional cues. Indeed, research suggests that affective experiences, whether temporary or trait-like, predict what information individuals choose to encode and/or attend to when confronted with emotional stimuli/situations (Stewart et al., 2010; Tamir & Robinson, 2007). In one

This article was published Online First September 4, 2017.

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This project was funded by Graduate and Professional Student Association Intramural Research Grant, Arizona State University to Sara Nozadi, and Eunice Kennedy Shriver National Institute of Child Health and Development grant (NICHD: R01HD068522), which partially supported the Tracy L. Spinrad and Nancy Eisenberg. We thank the children, parents, and teachers involved in the current study. In addition, we appreciate our undergraduate research assistants for their contributions.

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study, for example, children who were induced to experience negative emotions were more likely to attend to negative emotional stimuli than were children who were not induced to have negative mood (Kujawa et al., 2011). Further, research using both adult and school-aged populations has shown that high levels of trait-like or negative affectivity predict individuals' attention bias toward negative emotional stimuli (e.g., Helzer, Connor-Smith, & Reed, 2009; Morales, Taber-Thomas, & Perez-Edgar, 2017; Perez-Edgar et al., 2010; Rutherford, MacLeod, & Campbell, 2004; Stewart et al., 2010). For example, children with high levels of trait anxiety, a construct that overlaps considerably with temperamental fear, were more likely to attend to threat-related emotional stimuli (e.g., angry facial expressions) than were children with low levels of trait anxiety (e.g., Muris, de Jong, & Engelen, 2004; Vasey, El-Hag, & Daleiden, 1996).

The relation between children's dispositional negative emotionality and attention bias may depend on children's *effortful control* (EC; Lonigan, Vasey, Phillips, & Hazen, 2004; Vervoort et al., 2011). EC has been conceptualized as "the efficiency of executive attention, including the ability to inhibit a dominant response and/or to activate a subdominant response, to plan, and detect errors" (Rothbart & Bates, 2006, p. 129), and it is a particularly important tool for emotion regulation. Lonigan et al. (2004) proposed that the positive relation between temperamental negativity and attention bias is strongest under conditions of low regulation/EC because less regulated children may have difficulty redirecting their attention away from the aversive/negative stimulus or situation. Yet temperamental negativity may be unrelated to attentional biases when children have high levels of EC because such children should be able to redirect their attention away from negative stimuli (Lonigan et al., 2004).

There has been some support for the notion that regulation moderates the relation of temperamental negative emotionality to attention biases (Helzer et al., 2009; Lonigan & Vasey, 2009). For example, Susa, Benga, Pitica, and Miclea (2014) found that more temperamentally fearful 9- to 13-year-olds had relatively high attention bias toward threat-related stimuli under conditions of low attentional control (a component of EC). Similar relations have been found by other researchers (Helzer et al., 2009; Rothbart, Ellis, & Posner, 2004; Rueda, Posner, Rothbart, & Davis-Stober, 2004). Overall, this body of research suggests that temperamental negative emotionality increases children's risk for negative attention biases, particularly for children with low EC.

Little is known about temperamental correlates of attention biases during early childhood. Evidence suggests that EC develops rapidly between 3 and 7 years of age, and preschoolers demonstrate considerable individual differences in these skills (Kochanska, Murray, & Harlan, 2000; Rothbart, Ahadi, Hershey, & Fisher, 2001). Consequently, understanding the role that regulation may play in the relations between children's temperament and attention biases toward negative stimuli during preschool years may have important implications for prevention programs. Further, most researchers have only examined the association of temperamental fear or behavioral inhibition, a temperament characterized by high levels of fear reactivity to novel stimuli (Fox et al., 2005), to threat-related emotional information. Thus, the first goal of the present study was to examine young children's temperamental anger and sadness in relation to attention biases toward angry and sad emotional stimuli, with a focus on the moderating role of EC. We expected that children prone to anger or sadness would show heightened attention biases toward angry or sad stimuli, respectively, particularly under conditions of low EC. These hypotheses were guided by previous studies showing a relation between exposure to a specific type of emotion and increased sensitivity toward processing of that emotion, in both adults (Becker & Leinenger, 2011; Smith & Waterman, 2003) and children (e.g., Harrison & Gibb, 2015; Susa et al., 2014).

The Role of Attention Biases in Children's Social Functioning/Maladjustment

Social information processing model (Crick & Dodge, 1994; Dodge & Pettit, 2003) predict that individual differences in aggression can arise from increased attention toward and interpretation of potentially threat-related and hostile emotional information. In fact, attention bias toward angry facial expressions has been observed in children with high levels of aggressive behaviors (e.g., Chan, Raine, & Lee, 2010; Gouze, 1987), and children with attention bias toward anger are viewed as less socially competent than children who do not exhibit such biases (e.g., Gulley, Oppenheimer, & Hankin, 2014).

It is also possible that relations between threat-related attentional biases and aggressive behaviors are stronger, or only significant, for dysregulated children (Derryberry & Reed, 2002; Lonigan et al., 2004; Susa, Pitică, Benga, & Miclea, 2012). Children with high sensitivity to threat-related cues who are unable to employ effective coping strategies and to modulate distress might have difficulty controlling their subsequent behavioral responses. Thus, the relations between attentional biases toward threat and children's aggressive problems and poor social competence were expected to be stronger under conditions of low regulation/EC.

Attention bias toward sadness, although less studied than biases toward anger, typically has been examined in relation to maladaptive behaviors and outcomes, in particular, internalizing behavior problems and depressive symptoms (Gotlib & Joormann, 2010; Joormann & Gotlib, 2007; Siegle, Ingram, & Matt, 2002). However, attention bias toward sadness might also have some positive aspects. For instance, the results of several studies have shown that children's attention and sensitivity toward sadness is positively related to socially competent behaviors, including prosocial behaviors and sympathy—especially if children are able to regulate the emotional distress that may be elicited after observing and feeling another person's suffering (Hastings, Zahn-Waxler, Robinson, Usher, & Bridges, 2000; Vaish, Carpenter, & Tomasello, 2009). Children who are sensitive to detecting sadness in others—and also have the regulation needed to modulate their distress—are more likely to appropriately respond to others' emotions, to effectively communicate with them, and to display socially competent behaviors. Thus, in the current study, children with relatively high attention bias towards sadness were expected to exhibit high levels of social competence if they had high regulatory abilities.

Assessment of Attention Biases

In the current study, children's attention biases toward negative emotions were assessed with eye-tracking using measures similar to those from previous studies that measured attention biases in infants and children from clinical populations: children with au-

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tism and infants from high-risk families (e.g., Chawarska, Macari, & Shic, 2013; Chawarska, Volkmar, & Klin, 2010; Dodd et al., 2015; Harrison & Gibb, 2015). Traditional measures of attention biases (e.g., emotional Stroop task, dot-probe task) are not appropriate for children younger than age 5 because these assessments require participants to provide responses (e.g., behavioral reactions that rely on language or other cognitive and/or motor abilities; Algom, Chajut, & Lev, 2004; Perez-Edgar et al., 2010). Thus, eye-tracking technology is viewed as an excellent method to evaluate children's visual attention without requiring children to provide explicit behavioral or verbal responses (Balcetis & Dunning, 2006; Bögels & Mansell, 2004; Wadlinger & Isaacowitz, 2008). Consistent with previous studies, two different aspects of attention biases were assessed in the current study: (a) time to attend to or latency to fixate on the emotional stimuli, and (b) proportion of time looking at emotional stimuli (e.g., Dodd et al., 2015; Shechner et al., 2012).

The Current Study

Using a multimethod approach (e.g., adult-reports, eye-tracking), we sought to examine the moderating role of EC in (a) the relations between children's temperamental predispositions to negative emotions and attentional biases toward congruent emotional information, and (b) the relations of these attentional biases to indicators of social functioning among children under the age of 5. Specifically, the negative relations of temperamental anger and sadness to attentional biases toward congruent emotional expressions were expected to be stronger for children with low EC. Furthermore, the relations between attentional biases toward threat and children's aggressive problems and poor social competence, as well as the positive association between attention bias towards sad expressions and social competence, were expected to be stronger under conditions of low regulation/EC.

Method

Participants

Children who attended one of three preschools at a large university campus in the southwestern portion of the United States were recruited for the study. Consent forms were emailed to the parents or a hard copy was left in their child's mailbox. Parental consent was obtained from 80 children; however, the final sample included 77 children (41 males and 36 females; M_{age} = 4.25 years old, *SD* = .58, *Range* = 3.13–5.31 years). Two children refused to participate in the study, following the verbal assent procedure (one of these children did not speak English well) despite parental consent, and we could not obtain usable eye-tracking data from one child. Family income for the final sample ranged from 2 ($15,000-$30,000) to 7 ($100,000) with a median of 6 ($75,000-$100,000) and standard deviation of 1.46. Mothers' education ranged from 1 (*less than high school degree*) to 7 (*PhD, JD, or MD*) with a median of 6 (*Masters' degree or equivalent*). In terms of ethnicity, 21.7% of children were of Hispanic origin and 78.3% were non-Hispanic. Racial composition was Caucasian (70%), African American (5%), Asian (5%) and mixed race (20%).

Procedure

Upon receiving verbal assent from children, children participated in several tasks including two eye-tracking tasks to measure selective attention. At the end of the laboratory session, children received age-appropriate toys. The laboratory session lasted about 30 min.

Following children's participation in the laboratory session, an online questionnaire was sent to teachers and mothers asking them to report on children's temperamental characteristics (i.e., proneness to negative emotions, EC), as well as children's aggression and social competence. Teachers were paid for completing the online questionnaires. Given that mothers' response rate was low (60%) compared with teachers' response rate (100%), only teachers' survey data were used in the subsequent analyses.

Measures

Eye-tracking measures. Children were seated 60 cm from the high-resolution 24-inch computer screen of a portable Tobii T120 eye tracker in a dimly lit room. The Tobii T120 includes an integrated camera placed underneath the computer screen, which uses infrared light to create reflection patterns on the corneas of children's eyes to record the eye movement patterns. Each participant's point of gaze was recorded at 120 Hz, and accumulated points of gaze were used to measure visual fixations at different points on the monitor. Our principal measures are fixations within predefined *areas of interest* (AOIs) on the screen, and eye movement latencies.

Children's point of gaze was calibrated using a standard five-point calibration system. Specifically, children were asked to follow a black dot inside a red circle moving five times around the computer screen. The quality of calibration was assessed by evaluating the offset of each gaze point from its intended target using estimates of accuracy provided by the eye tracker. This procedure provides spatial accuracy of about .5° visual angle in infants, children, and adults (Morgante, Zolfaghari, & Johnson, 2012). If the initial calibration was unacceptable or poor, the procedure was repeated up to three times until acceptable results were achieved.

Following calibration, children participated in two eye tracking tasks. Children were asked to remain still during both tasks and to freely watch the stimuli as they would watch a movie. The stimuli were colored photos of facial expressions of adults (i.e., angry, sad, and neutral expressions) taken from the NimStim-MacBrain Face Stimulus Set (Tottenham et al., 2009). The order of the tasks was counterbalanced across participants.

The *free-viewing* task tested for attention bias towards emotional faces. Stimuli were pictures of angry or sad facial expressions paired with neutral expressions (see Figure 1a). There were 28 trials in this task consisting of 14 angry and 14 sad pictures paired with neutral expressions of the same person (Figure 1a). Each trial was displayed on the screen for 2,000 ms and was followed by a 1,500-ms attention-getter (an animated picture with sound), which was shown to center the gaze prior to each trial. Each image measured 3.97 × 5.87 cm (3.84 × 5.67° visual angle); the distance of each image from the center of screen was 4.44 cm (4.29°).

Because our hypotheses involved children's attention towards emotional faces, AOIs were created as ovals containing each face (see Figure 1a and 1b). Fixations within each AOI were recorded.

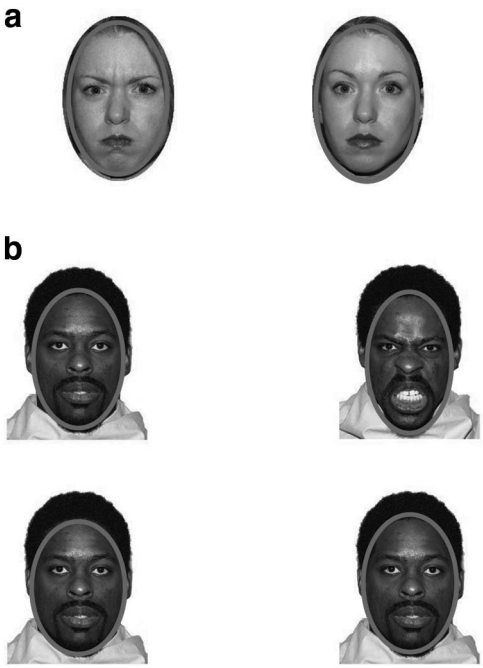

Figure 1. (a) An example of the free-viewing task. (b) An example of the visual search task. In both figures, the ovals around each face are showing areas of interest (AOI). Pictures are taken from The NimStim set of facial expressions following the author's permission.

Similar to previous work (e.g., Armstrong, Olatunji, Sarawgi, & Simmons, 2010), trials were considered missing if (a) fewer than 80 ms of fixation data were collected, (b) the point of gaze was not fixated at the attention getter before stimulus presentation, or (c) the fixation on either of the two AOIs occurred within 80 ms of stimulus onset, as this short duration would indicate that the point of gaze was shifted prior to stimulus onset. The number of missing trials across all participants was 59 trials (2.77% of missing data) with 30 and 29 missing trials involving angry and sad facial expressions across all children, respectively. Forty children missed at least one trial, and the number of missing trials ranged from 1 to 4 and 1 to 5 trials for angry and sad subsets, respectively. For each child, the average proportions of looking time (i.e., length of all fixations across trials) at angry and sad versus neutral emotional faces were calculated; values greater than .50 represented bias for the emotional face (Calvo & Lang, 2004).

The *visual search* eye tracking task tested for latency to detect facial emotions. The 32 stimuli each consisted of four faces, one of which was angry or sad, and the other three were neutral (16 angry and 16 sad facial expressions; see Figure 1b). AOIs were created for each face resulting in four AOIs for each trial. Each trial was presented for 2,000 ms and was followed by a 1,500 ms attention getter to center the gaze prior to the next trial. The size of each face image was 5.75 × 4.46 cm (5.56 × 4.31°). The criteria for missing trials were the same as described previously. The number of missing trials was 128 of 2,464 trials across all participants (5.19% missing data) with 61 and 67 missing trials involving angry and sad facial expressions, respectively. Forty children had at least one missing trial. The range of missing data for angry and sad trials included 1 to 7 for both angry and sad trials. For each trial, the latency to fixate the angry or sad face from stimulus onset was recorded. If the child did not detect the emotional face, then the latency was coded as 2,000 ms or the total trial time. Two composite scores were computed by averaging the latencies to detect angry or sad emotional faces across the trials.

Temperamental negative emotionality. On a 7-point scale (1 = *Extremely Untrue* to 7 = *Extremely True*), teachers rated children's proneness to distinct negative emotions using the anger/frustration (6 items; e.g., "Has temper tantrums when s/he doesn't get what s/he wants") and sadness (4 items; e.g., "Cries sadly when a favorite toy gets lost or broken") subscales of the Child Behavior Questionnaire Short Form CBQ (Putnam & Rothbart, 2006). The anger and sadness composites were calculated by averaging items within each subscale. The teacher-reported anger and sadness subscales have shown adequate criterion validity (e.g., relations with indicators of social functioning) and internal consistency (Eisenberg et al., 2001; Putnam & Rothbart, 2006; Teglasi et al., 2015; e.g., Cronbach's αs = .86 and .68, for teacher-reported anger and sadness in a study by Teglasi et al., 2015). The Cronbach αs for anger and sadness subscales in the current study were .83 and .70, respectively.

Effortful control (EC). Teachers rated (1 = *Extremely Untrue* to 7 = *Extremely True*) children's attentional focusing and inhibitory control using the Child Behavior Questionnaire Short Form (Putnam & Rothbart, 2006—6 items each), and on children's attentional shifting using the Child Behavior Questionnaire (CBQ; Rothbart et al., 2001—14 items). Sample items include "Can easily shift from one activity to another," "Is hard to get his/her attention when he/she is concentrating on something," and "Can wait before entering into new activities if s/he is asked to," for attention shifting, focusing, and inhibitory control, respectively. Teachers' reports of attentional focusing, inhibitory control and attention shifting subscales have demonstrated good reliability and validity in previous studies (e.g., αs = .91, .84 for attention focusing and inhibitory control measures reported by Blair & Razza, 2007; α = .85 for attentional shifting in Eisenberg et al., 2007; also see Eisenberg et al., 2001). Cronbach αs in the current study were .75, .80, and .72, for attentional shifting, focusing, and inhibitory control measures, respectively. Attentional focusing was significantly correlated with attentional shifting and inhibitory control, *rs* = .42 and .63, *ps* <.01, respectively, and the correlation between attentional shifting and inhibitory control was $r = .73$, $p < .01$. An EC composite was calculated by averaging scores on the three subscales.

Social outcomes. Children's aggressive behaviors, social competence and anxiety symptoms were rated by teachers using the anger-aggression and social competence subscales of the short form of Social Competence and Behavior Evaluation[1] (SCBE-30; LaFreniere, & Dumas, 1996). Each subscale consisted of 10 items. Sample items are "Opposes the teachers' suggestion" for the aggression subscale, and "Negotiates solutions to conflicts with other children" for the social competence subscale. All items were rated from 1 = *Extremely Untrue* to 7 = *Extremely True*. The

[1] Teachers also reported on children's anxiety symptoms using the anxiety-withdrawal subscale, which consisted of 10 items (e.g., "Worries"; α = .91). Results involving the anxiety symptoms are provided as supplementary online material (see supplemental Table).

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subscales of SCBE have shown good construct validity and test-retest and interrater reliabilities (ranging from .78 to .91) across different cultures (LaFreniere & Dumas, 1996; Sette, Baumgartner, & MacKinnon, 2015). The Cronbach's alpha reliabilities were .87 and .85 for aggressive behaviors and social competence subscales, respectively.

To reduce the overlap between items in the SCBE's aggression and the CBQ's anger subscales, three items from the SCBE with potentially large overlap were removed: (a) "Gets angry when interrupted," (b) "Irritable, gets mad easily," and (c) "Easily frustrated." The Cronbach's alpha reliability for the aggression scale with only 7 items was .76. The new composite score was computed and used in further analyses involving aggression.

Results

Preliminary Analyses

Descriptive statistics, sex differences and correlation analyses among all study variables are presented in Table 1; all variables were normally distributed. The correlations of other demographics (e.g., family income, parents' education) with study variables were not statistically significant; *r*s ranged from .01 to .16 (absolute values), *p*s $>$ .23. No significant relations were found in correlations among dispositional anger and sadness, EC, and eye-tracking variables. Analysis of relations between social functioning and eye-tracking variables revealed that longer time spent looking at angry faces was related to higher aggressive problems. Shorter latency to fixate on angry faces was also related to higher aggressive problems and lower social competence. Furthermore, a higher proportion of looking time at sad faces was associated with higher social competence, but it was unrelated to aggressive behaviors. Older children were faster to detect the emotional faces than younger children. Further, temperamental anger was positively related to temperamental sadness and aggressive behaviors, and was negatively related to children's EC and social competence. Teacher-reported dispositional sadness was negatively related to EC and social competence.

Gender differences were found only for social competence, aggressive behaviors, and EC. Girls were reported to be higher on social competence and EC than boys, whereas boys were reported to have higher aggressive behaviors than girls. Statistics regarding sex differences including *t* tests, Cohen's *d*s, *p* values, and 95% confidence intervals for effect sizes are reported in Table 1.

Differences between aspects of attention biases toward angry and sad facial expressions were also tested. Children were faster to detect angry than sad facial expressions, $t(76) = -3.18$, $p = .00$ (*M*s = 1.17 ms and 1.25 ms for latencies, respectively); $d = -.72$ (95% CI [−1.19 to −.26]). There was no significant difference between proportions of looking time at angry versus sad facial expressions $t(74) = 1.20$, $p = .23$ (*M*s = .57 and .56, respectively); the Cohen's *d* was .27 (95% CI [−.18 to −.73]).

Testing Hypothesized Path Models

To examine the possibility that EC moderated associations between dispositional anger and sadness to attention biases, we computed eight path models: four models for temperamental proneness to anger predicting attention bias toward anger, and four models for sadness reactivity predicting attention biases toward sadness. In models involving selective attention toward anger or sadness, analyses included only trials with angry or sad facial expressions (14 and 16 trials with each emotion for free-viewing and visual search tasks, respectively). All the hypothesized models were tested in M*plus* version 7.11 (Muthén & Muthén, 1998–2013), using full information maximum likelihood (FIML) estimation. All the estimated models (see below) converged with no error and fit the data well as indicated by the following fit indices: chi-square test (nonsignificant values indicate good fit), Comparative Fit index (CFI; values greater than .95 indicate good fit; Kline, 2010), and Root Mean Square Error of Approximation

Table 1
Zero-Order Correlations, Descriptive Statistics, and Sex Differences for Temperament, Age, and Eye-Movement Variables

Variable	1	2	3	4	5	6	7	8	9	10
1. Teacher-reported dispositional anger	1.00									
2. Teacher-reported dispositional sadness	.55**	1.00								
3. Teacher-reported effortful control (EC)	−.62**	−.37**	1.00							
4. Age	.21	.25*	−.17	1.00						
5. Proportion of looking time at angry faces	.19	−.07	−.01	.11	1.00					
6. Latency to detect angry faces	−.16	−.21	.12	−.43**	−.15	1.00				
7. Proportion of looking time at sad faces	−.01	−.10	.13	−.02	.23*	−.01	1.00			
8. Latency to detect sad face	−.09	−.21	.12	−.34**	.02	.47**	−.01	1.00		
9. Aggressive behaviors	.42**	.15	−.48**	.17	.35**	−.23*	.06	−.13	1.00	
10. Social competence	−.61**	−.42**	.69**	−.19	−.06	.26*	.28*	.07	−.65**	1.00
N	76	76	76	72	75	77	75	77	74	75
M	3.27	3.34	.00	4.27	.57	1.17	.56	1.25	1.35	4.09
SD	1.55	.90	.84	.57	.08	.19	.07	.23	.61	.80
Sex differences										
t value	1.53	.45	−2.92*	1.33	−.22	.30	−.94	−1.59	2.59*	−2.26*
Cohen *d*	.35	.06	−.53	.31	−.05	.07	−.22	−.36	.60	−.52
95% Confidence interval for Cohen *d*	−.10	−.40	−.99	−.15	−.05	−.38	−.67	−.81	.14	−.98
	.81	.51	−.07	.78	.40	.52	.24	.09	1.06	−.06
p value	.13	.65	.03	.19	.83	.77	.35	.12	.01	.03

* $p < .05$. ** $p < .01$.

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(RMSEA; values less than .05 indicate good fit; Hu & Bentler, 1999).

In each model, the eye-movement variable (proportion of looking time or latency to fixate on emotional faces across all trials) was regressed onto children's dispositional anger or sadness proneness, EC, and the interaction between anger/sadness proneness and EC. The predictors and moderator were mean centered prior to the analyses. In addition, given that age was associated with latency to fixate on emotional faces, age was used as a covariate in all models. The significant interactions were further examined by estimating and testing simple slopes at the mean and +/− 1 *SD* of the moderator (Aiken & West, 1991).

For testing the associations among components of selective attention and behavior outcomes, eight additional path models were estimated. The procedures employed for testing and probing/plotting interactions were identical to those explained above.

Relations of temperament to attention biases. Results for models testing EC as a moderator of relations between anger reactivity and attention bias toward anger are presented in the first section of Table 2. The interaction between anger and EC was significant when predicting duration of time looking at angry faces. Tests for simple effects revealed that anger-proneness was positively related to duration of looking at angry faces, but only for children with average and low levels of EC, βs = .29 and .52, *p*s = .03 and .00 (Figure 2; β = .04, *p* = .83 for children with high levels of EC). Interestingly, the proportion of looking at angry faces was relatively high for children with high levels of EC, regardless of their anger-proneness (albeit nonsignificant), β = .24, *p* = .09. For the model predicting latency scores, only age was a significant predictor. On average, older children were faster in detecting angry among neutral faces.

With regard to sadness, children's sad reactivity and EC were not directly related to children's proportion of looking time at sad faces, but the interaction between temperamental sadness and EC was significant (see Table 2). Children who were prone to sadness spent less time looking at sad faces if they were also high in EC, β = −.37, *p* = .04. However, for children with average and low EC, sadness proneness was unrelated to the time looking at sad faces, βs = −.10 and .16, *p*s = .42 and .29, respectively (see Figure 3). Similar to the results for anger, age predicted latency to fixate on sad faces.

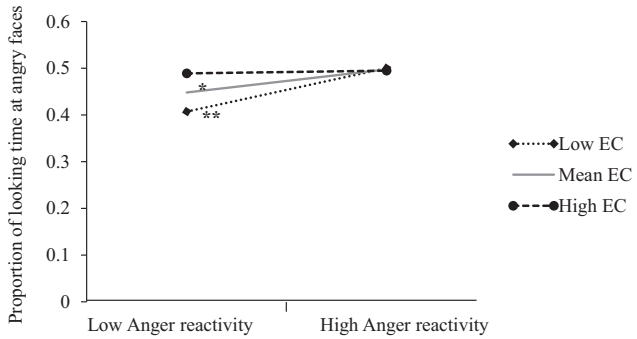

Figure 2. The interaction between anger reactivity and effortful control (EC) in predicting proportion of looking time at angry faces. *x* axis values ranged from 1 to 6.67. * $p < .05$. ** $p < .01$.

Relations between attention biases and social adjustment. With regard to the models involving aggression, the proportion of looking time at angry faces and low EC were related to high levels of teacher-reported aggressive behaviors. Further, there was an interaction between the latency to fixate angry faces and EC when predicting aggression (Table 3). For children with high and average levels of EC, latency to detect angry faces was not related to aggressive behaviors, β*s* = −.21 and .17, *p*s = .10 and .13. However, for children with low levels of EC, fast detection of angry faces was associated with high aggression, β = −.44, *p* = .00 (Figure 4). When predicting aggression from attention bias to sadness, only a negative relation between EC and aggression was found (see Table 4).

Social competence was also positively predicted by latency to detect angry faces, but not latency to detect sad faces, or proportion of looking time at sad faces. The proportion of looking time

Table 2
Unstandardized and Standardized Parameter Estimates for the Associations Between Anger and Sad Reactivity, EC, and Eye-Tracking Variables

Predictors	Model 1 Proportion of looking time	*p* value	95% confidence interval	Model 2 Latency to detect the emotional face	*p* value	95% confidence intervals
R-square	.124			.216		
Dispositional anger	.015* (.294)	.037	[.001, .030]	−.010 (−.079)	.552	[−.041, .022]
Effortful control (EC)	.023 (.235)	.094	[−.004, .050]	−.007 (−.030)	.824	[−.066, .052]
Dispositional Anger × EC	−.017* (−.248)	.029	[−.032, −.002]	.031 (.196)	.064	[−.002, .064]
Age	.020 (.144)	.222	[−.012, .053]	−.146** (−.443)	.000	[−.216, −.077]
	$\chi^2(3) = 2.23$, $p = .53$ CFI = 1.00, RMSEA = .00			$\chi^2(1) = .66$, $p = .42$ CFI = 1.00, RMSEA = .00		
R-square	.086			.157		
Dispositional sadness	−.008 (−.103)	.424	[−.028, .012]	−.021 (−.085)	.475	[−.080, .37]
Effortful control (EC)	.009 (.107)	.377	[−.011, .030]	.008 (.031)	.789	[−.052, .069]
Dispositional Sadness × EC	−.025* (−.265)	.021	[−.047, −.004]	.041 (.133)	.216	[−.024, .105]
Age	.004 (.028)	.809	[−.025, .032]	−.129** (−.327)	.004	[−.217, −.042]
	$\chi^2(5) = .2.70$, $p = .75$ CFI = 1.00, RMSEA = .00			$\chi^2(1) = .01$, $p = .91$ CFI = 1.00, RMSEA = .00		

Note. The standardized parameter estimates are presented in parentheses. *p* values and 95% confidence intervals correspond to unstandardized coefficients.
* $p < .05$. ** $p < .01$.

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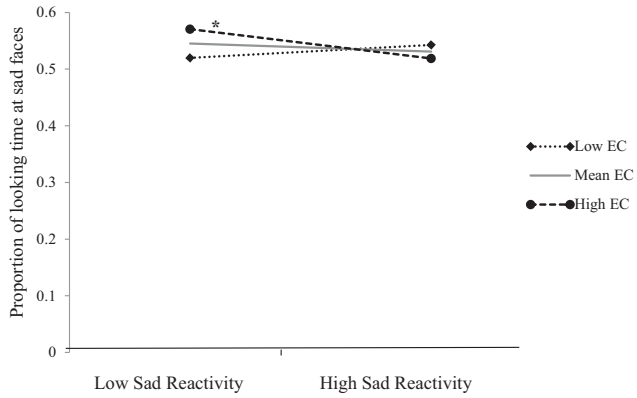

Figure 3. The interaction between sad reactivity and effortful control in predicting proportion of looking time at sad faces. *x* axis values ranged from 1.14 to 5.29. $^{*}p < .05$.

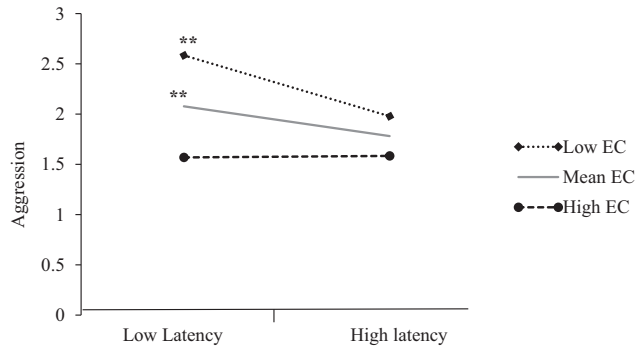

Figure 4. The interaction between latency to fixate at angry faces and EC in predicting aggressive behaviors. *x* axis values ranged from .78 to 1.70. $^{**}p < .01$.

at angry faces was unrelated to social competence. In all models, EC directly and positively predicted social competence (see Table 3 and 4). None of the interaction effects was significant.

Discussion

Attention biases toward negative emotional stimuli are thought to be related to the emergence and development of internalizing and externalizing symptoms (Grafton et al., 2014; Weierich et al., 2008). Thus, identifying early predictors of attention biases, factors that may protect children from developing these biases, and potential risks that they may pose for social functioning has clear value. Consistent with the Lonigan et al. (2004) model, EC moderated associations between children's predisposition to distinct negative emotions (i.e., anger and sadness) and proportion of looking time at respective emotional faces. Moreover, the relations of different indicators of attention bias to children's aggression and social competence generally were not dependent on the levels of EC (with one exception). The two aspects of attention bias differentially predicted social adaptation in unique ways.

Temperament and Attention Bias

For the most part, our results were consistent with previous empirical evidence suggesting that the relation between negative affectivity and sensitivity to negative emotional information is dependent upon children's regulatory skills (e.g., Lonigan & Vasey, 2009; Susa et al., 2014). However, the pattern of results we observed was different across anger and sadness and for different components of attention biases. EC moderation was found only for duration of attention. For children with average or low levels of EC, proneness to frustration/anger predicted more time looking at angry faces, suggesting that proneness to anger biased less regulated children toward angry faces. Children with high regulatory skills were relatively high in proportion of looking time at angry

Table 3
Unstandardized and Standardized Parameter Estimates for the Associations of Selective Attention Towards Anger and EC With Social Functioning

Predictors	Model 1 Aggressive behaviors	*p* value	95% confidence interval	Model 2 Social competence	*p* value	95% confidence interval
R-square	.407			.486		
Proportion of looking at angry faces	2.450^{**} (.331)	.001	[1.038, 3.862]	−.397 (−.040)	.644	[−2.079, 1.286]
EC	$-.337^{**}$ ($-.475^{**}$)	.000	[−.472, −.202]	$.634^{**}$ (.660)	.000	[.470, .797]
Proportion Scores × EC	−.133 (−.156)	.111	[−2.966, .306]	.086 (.007)	.932	[−1.830, 1.997]
Age	.084 (.080)	.425	[−.123, .291]	−.086 (−.061)	.493	[−.330, .159]
Sex	.027 (.022)	.822	[−.209, .263]	.112 (.070)	.420	[−.160, .384]
	$\chi^2(1) = 1.16$, $p = .28$ CFI = 1.00, RMSEA = .05			$\chi^2(4) = 4.79$, $p = .31$ CFI = .98, RMSEA = .05		
R-square	.367			.521		
Latency to fixate at angry faces	−.528 (−.165)	.133	[−1.217, .161]	$.834^{*}$ (.193)	.030	[.79, 1.589]
EC	$-.341^{**}$ (−.479)	.000	[−.480, −.201]	$.620^{**}$ (.643)	.000	[.462, .777]
Latency Scores × EC	1.159^{**} (.283)	.003	[.386, 1.931]	−.061 (−.011)	.889	[−.920, .798]
Age	.028 (.026)	.819	[−.211, .267]	.032 (.022)	.814	[−.231, .294]
Sex	−.005 (−.004)	.970	[−.252, .243]	.153 (.095)	.264	[−.115, .421]
	$\chi^2(1) = .05$, $p = .82$ CFI = 1.00, RMSEA = .00			$\chi^2(2) = .98$, $p = .61$ CFI = 1.00, RMSEA = .00		

Note. The standardized parameter estimates are presented in parentheses. *p* values and 95% confidence intervals correspond to unstandardized coefficients. EC = Effortful control.
$^{*}p < .05$. $^{**}p < .01$.

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Table 4
Unstandardized and Standardized Parameter Estimates for the Associations of Selective Attention Towards Sadness and EC, With Social Functioning

Predictors	Model 1 Aggressive behaviors	*p* value	95% confidence interval	Model 2 Social competence	*p* value	95% confidence interval
R-square	.313			.530		
Proportion of looking at sad faces	.945 (.111)	.306	[−.863, 2.75]	2.195* (.190)	.022	[.314, 4.076]
EC	−.364** (−.511)	.000	[−.509, −.219]	.610** (.637)	.000	[.452, .767]
Proportion Scores × EC	−1.918 (−.187)	.072	[−4.010, .173]	.552 (.040)	.621	[−1.635, 2.740]
Age	.096 (.100)	.352	[−.118, .331]	−.097 (−.067)	.426	[−.334, .142]
Sex	.055 (.061)	.577	[−.184, .331]	.125 (.078)	.358	[−.141, .392]
	$\chi^2(1) = .22$, $p = .64$ CFI = 1.00; RMSEA = .00			$\chi^2(2) = 2.19$, $p = .34$ CFI = 1.00, RMSEA = .04		
R-Square	.337			.490		
Latency to fixate at sad faces	−.112 (−.042)	.714	[−.708−.485]	−.216 (−.061)	.489	[−.829, .401]
EC	−.352** (−.492)	.000	[−.503, −.201]	.637** (.663)	.000	[.473, .801]
Latency Scores × EC	.095 (.027)	.801	[−.645, .835]	.058 (.012)	.882	[−.711, .811]
Age	.169 (.090)	.444	[−.150, .342]	−.127 (−.089)	.333	[−.378, .135]
Sex	−.126 (.046)	.685	[−.212, .323]	.121 (.076)	.385	[−.152, .395]
	$\chi^2(2) = 1.04$, $p = .79$ CFI = 1.00, RMSEA = .00			$\chi^2(2) = 1.70$, $p = .43$ CFI = 1.00, RMSEA = .00		

Note. The standardized parameter estimates are presented in parentheses, EC = Effortful control.
* $p < .05$. ** $p < .01$.

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faces, regardless of temperamental anger/frustration. Although the latter result was nonsignificant, it was unexpected and may indicate that children with high regulatory skills did not need to avoid angry faces. Perhaps highly regulated children seek more information about others' emotions, particularly in situations that are not overly upsetting for them, because it might be useful in terms of social interactions. Alternatively, it is possible that highly regulated children use overexposure to angry faces (signifying threat) as a regulatory skill to cope with their negative emotions and emotional arousal—a similar technique used in exposure therapy to help patients regulate their negative emotions (Moyal, Henik, & Anholt, 2014).

In contrast to the findings for anger, children with high levels of dispositional sadness spent less time looking at sad faces if they were also high in EC. These children appeared to shift their attention away from the sad faces (Gotlib & Joormann, 2010; Lochman & Dodge, 1994; Tiedens, 2001). Overall, the results of current study suggest that EC moderates the relation between temperamental negative reactivity and attention biases, but it is important to differentiate between different types of negative emotions when considering such moderation.

Contrary to our expectation, dispositional anger and sadness were unrelated to latency to fixate on emotional stimuli, a measure thought to reflect increased sensitivity and hypervigilance to detect the stimuli. We expected the sensitivity toward negative emotional information for children prone to negative emotions to appear in two stages of information processing. The first stage involved the initial stage of information processing, during the initial exposure of stimulus, when we measured how fast children detected the emotional face. The next stage involved the amount of time children spent dwelling on the emotional stimuli. Latency to fixate on the negative emotional stimuli perhaps reflects a reactive response, whereas the proportion of time looking may reflect a deliberate and nonreactive response (effortful processing of stimuli), leading to maintained attention. Our finding that children's temperamental characteristics were related to eye-tracking variables during the free-viewing but not visual search task may indicate that temperamental characteristics are more important in guiding children's attention during the processing (proactive) than initial (reactive) stage of information processing.

Alternatively, it may be that the detection of negative stimuli is not a valid measure of attention biases but instead reflects children's ability to detect the "non-matching" facial expression. In the current study, older children were faster to detect the emotional face among three neutral faces than were younger children. This possibility merits further investigation.

Attention Bias and Social Functioning

Relations of latency to detect emotional faces to social outcomes. Fast detection of angry faces predicted a high level of aggressive behavior for children who were low in EC. This result was consistent with previous behavioral studies on the importance of biases in social information processing, specifically vigilance toward threat-related and hostile emotional cues in the emergence and development of aggressive behaviors (Dodge et al., 2015; Pettit, Lansford, Malone, Dodge, & Bates, 2010). Indeed, heightened sensitivity toward threat in the absence of regulatory skills may increase the risk for impulsively employing maladaptive responses (to protect against threat), including aggressive behaviors.

The lack of relation between latency to detect sad facial expressions and different aspects of social functioning may be attributable to the task that we used in the current study, in which one emotional face was paired with three neutral faces. The similarity between sad and neutral faces (Joormann & Gotlib, 2006) may have caused the detection of sad among neutral faces to be more difficult than detection of angry facial expressions. Future researchers should consider pairing sad faces with other types of emotional faces, including angry or happy faces. Further, this nonsignificant relation also may indicate that hypervigilance to-

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ward sadness is not as important as vigilance toward anger or pertinent in understanding externalizing behavior problems.

Relations of proportion of looking time to social outcomes. Analyses of attention bias in the free-viewing task indicated that duration of time looking at angry faces predicted high levels of children's aggression, regardless of level of EC. Children who focus on information pertaining to anger in their environment may be more likely to become aroused by threat-related cues, and consequently process this information in a hostile way, thus generating hostile reactions. Indeed, heightened sensitivity in processing of angry emotional information (e.g., words, aggressive social interactions) has been found in aggressive adults and school-age children (Chan et al., 2010; Lin et al., 2016). Results of the current study suggest that the same process occurs among young children.

As expected, longer time spent looking at sad faces and high levels of EC uniquely and directly predicted children's higher levels of social competence. Two particularly important components of social competence are the abilities to initiate and maintain interpersonal relations and to achieve social goals (Spence, 2003). Thus, socially competent children may be more likely to have awareness of and alertness toward sad signals/cues in their environments (as well as high levels of EC; see Eisenberg, Spinrad, & Eggum, 2010) than their less socially competent peers, which can facilitate successful peer and social interactions. Heightened sensitivity to sadness has been identified as essential for successful social interactions (Eisenberg, Smith, & Spinrad, 2011). It should be noted that in the current study we used a global measure of social competence. Thus, examining how attention biases toward different emotions may relate to various aspects of socially competent behaviors (e.g., sympathy, prosocial behaviors) should be considered by future researchers.

Although not the main focus of this study, a positive relation between proportion of looking time and anxiety symptoms was found such that children who spent less time looking at angry faces and had low levels of EC also had higher levels of anxiety symptoms. This finding suggests that anxious children may avoid looking at angry faces. The literature in this area, however, has been mixed. Although there are some studies that have reported avoidance of threat-related cues in anxious children (Koster, Crombez, Verschuere, & De Houwer, 2004), other researchers have shown that selective attention toward threat-related stimuli may be a risk marker for anxiety (Gamble & Rapee, 2009; Seefeldt, Kramer, Tuschen-Caffier, & Heinrichs, 2014). Given the inconsistences in the literature, more eye-tracking research should be conducted among nonclinical and among different ages.

In sum, our results indicate that relations between attention bias toward negative emotional information and social functioning are direct and independent of the effects of children's regulation skills. For the most part, selective attention processes and EC additively predicted various aspects of social functioning.

Strengths, Limitations, and Directions for Future Research

We tested the moderating role of regulation in relations between temperament, attention biases, and social functioning during a developmental period that is marked by rapid development of regulatory skills (Rothbart et al., 2001) using eye-tracking technology, an alternative to traditional measures of behavioral responses that may be confounded by errors of execution such as response freezing (Armstrong & Olatunji, 2012). Despite its strengths, the current study had several limitations that need to be taken into account. The first limitation of this study was solely focusing on teachers' data to assess children's temperament and social adjustment because of low response rate from parents. Because teachers are more likely to observe children in social settings and with peers, we believe that they are accurate reporters of children's behavior problems and social competence (Hussong, Zucker, Wong, Fitzgerald, & Puttler, 2005). Furthermore, previous research has shown moderate consensus between mothers' and teachers' reports of children's temperament and social behaviors (Eisenberg et al., 2006; Sulik, Eisenberg, Silva, Spinrad, & Kupfer, 2013). Using the limited mother-reported data we obtained, we found that—with the exception of reports of anger and sadness—mothers' and teachers' reports of EC (and its indicators) and social functioning were correlated with each other, rs arranged from .49 to .27, ps $< .05$. Nevertheless, not including data obtained from other reporters or using behavioral measures is considered a major limitation of the current study, which may have caused inflations in correlations among negative emotionality, and behavior problems with EC. As such, a teacher who perceives a child as reactive to negative emotions is more likely to rate the child as less regulated and less socially competent. Thus, future researchers need to consider using a multimethodological approach including multiple reporters and observational measures to measure EC (e.g., "Simon Says"; Spinrad, Eisenberg, & Gaertner, 2007 task) to test the current study's models.

Another limitation of this study was its relatively small sample size, which may have undercut the statistical power needed to detect significant effects (Type II error), the precision of parameter estimates (Type I error) and our ability to estimate more complex models (i.e., moderated mediation). The required sample to estimate the model with 3 predictors and 2 control variables given a medium effect size was estimated to be 92, and our sample size was 77. Given this small sample size and to ensure clear communication of our results and accuracy of parameter estimates, we have reported the confidence intervals along with standardized and unstandardized coefficients (Kelley & Maxwell, 2003, 2008). We obtained a number of significant findings with this modest sample size (with most of results having moderate effect sizes and relatively narrow confidence intervals), suggesting that the issues under investigation are promising and merit further attention. For example, we were unable to examine the mediating role of attention biases in the relations between temperament and social functioning or to test whether such mediation is moderated by children's self-regulation. A rigorous test of this moderated mediation model, particularly using longitudinal data and a large sample, may provide more insights into the mechanisms that link temperament to later social functioning.

In addition to associations between temperamental characteristics and attention biases, a number of parent-related factors, including parents' verbal and nonverbal modeling of fear/anxiety and intrusive/controlling parenting behaviors, have been suggested to be positively related to children's attention biases toward negative stimuli (e.g., threat; Field, 2006; Rachman, 1991; Rapee, 2012). Through observations of others' verbal or nonverbal expressions of negative emotions (observational/vicarious learning), humans and nonhuman primates may learn what stimuli/situations

to avoid or that warrant vigilance (Field & Purkis, 2011; Hadjikhani, Hoge, Snyder, & de Gelder, 2008; Rapee, 2012). Thus, future research needs to also take into account the role that parenting factors (e.g., regulatory skills and attention bias) may play in the emergence of children's attention biases during early childhood.

Despite these limitations, the current study contributes to our understanding of the relations between children's temperament, selective attention toward negative emotional content, and relations to social functioning in important ways. Understanding the significance of regulation in these associations has potential to improve identification of high-risk children for developing attention biases and maladjustment, and to help shape effective intervention programs, including attention training programs that have found to be effective for reducing attention biases (Julian, Beard, Schmidt, Powers, & Smits, 2012; Najmi & Amir, 2010). Although many attention training programs have focused on modifying individuals' biases toward negative emotional information (once these biases have emerged), the results of the present study suggest that early intervention programs may help to reduce the risk for developing these biases by improving children's regulatory abilities.

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Received May 18, 2016
Revision received June 26, 2017
Accepted June 26, 2017 ■

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