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Development of Shyness Across Adolescence: Reactivity, Regulation, or Both?

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The reactivity-regulation model suggests that the origins and maintenance of shyness results from relatively high levels of reactivity in combination with relatively low levels of regulation. Although this model has received some empirical support, there are still issues regarding directionality of the relations among variables and a dearth of studies examining the joint influence of reactivity and regulation on the prospective development of shyness. Using a longitudinal design, we first examined whether the relations among reactivity, regulation, and shyness were unidirectional or bidirectional in a sample of 1284 children (49.8% female, 84.1% White; mean parental education fell between associate degree/diploma and undergraduate degree) assessed annually across three waves from late childhood and early adolescence (M_{age} = 10.72 years) to adolescence (M_{age} = 12.42 years) and then examined whether reactivity and regulation interacted to influence the development of shyness over time. At Wave 1, shyness was related to higher levels of reactivity and lower levels of regulation at Wave 2, but neither reactivity nor regulation at Wave 1 predicted shyness at Wave 2. At Wave 2, shyness predicted greater reactivity at Wave 3, but shyness at Wave 3 was only predicted by lower levels of regulation at Wave 2. Contrary to the reactivity-regulation model of shyness, we found that relatively high levels of reactivity and low levels of regulation predicted a steep decrease in shyness over 3 years. These results are discussed in the context of the socioemotional difficulties experienced by shy individuals and demonstrate the importance of empirically evaluating long-standing models of personality development.

Keywords: shyness, adolescence, regulation, reactivity, temperament

Supplemental materials: https://doi.org/10.1037/dev0001159.supp

Shyness is a relatively stable temperamental characteristic that refers to inhibition, discomfort, and anxiousness in response to social novelty, with distinct psychological, behavioral, and physiological correlates throughout the life span (Caspi et al., 1988; Schmidt et al., 2017; Tang et al., 2020), although a majority of this work has focused on the childhood and adulthood periods (Coplan & Bowker, 2014; Jones et al., 1986; Schmidt & Schulkin, 1999). Psychologically, shyness is associated with increased risk for internalizing problems in childhood (Findlay et al., 2009; Poole et al., 2020); social anxiety disorder contemporaneously in adulthood (Heiser et al., 2003; Poole et al., 2017) and longitudinally from childhood to adolescence (Chronis-Tuscano et al., 2009) to adulthood (Tang et al., 2017); and decreased risk for externalizing problems in childhood (Sanson et al., 1996) and preadolescence (Oldehinkel et al., 2004). Behaviorally, shyness is associated with higher and increasing levels of avoidance in the context of social threat in childhood (Hassan & Schmidt, 2020); and greater behavioral manifestations of anxiety during social interactions in adulthood (Cheek & Buss, 1981; Schmidt & Fox, 1994). Physiologically, shyness is associated with biological correlates of stress-reactivity and vulnerability, including a higher and more stable heart rate in childhood (Kagan et al., 1988; Poole et al., 2018; Schmidt et al., 1999) and in adulthood (Schmidt & Fox, 1994); higher salivary cortisol during early childhood (Kagan et al., 1987; Kagan et al., 1988; Schmidt et al., 2007; Zimmermann & Stansbury, 2004) and relatively lower salivary cortisol levels in adulthood (Beaton et al., 2006; Beaton et al., 2013) and greater relative right frontal asymmetry (associated with avoidance related tendencies) during childhood (Fox et al., 1995; Fox et al., 2001; Poole et al., 2019; Poole & Schmidt, 2020a, 2020b; Schmidt et al., 1999) and adulthood (Schmidt, 1999).

We know, however, relatively little regarding shyness during the pre- and early adolescent periods, which is surprising given the

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saliency of peer relationships and heightened self-consciousness that are widely known to mark this time period (see Cheek et al., 1986). Given the unique developmental correlates of shyness on psychological, behavioral, and physiological levels across the life span, it is important to understand what factors may contribute to the development of shyness during pre and early adolescence.

There are several different theoretical perspectives on the origins and maintenance of shyness. One hypothesis is that shyness arises from an approach-avoidance motivational conflict (Asendorpf, 1990; Coplan et al., 2004; Schmidt & Buss, 2010; although see Hassan et al., 2021). Another hypothesis is that temperamental aspects of shyness (e.g., behavioral inhibition) may be linked to individual differences in the excitability of the central nucleus of the amygdala (e.g., Kagan, 1994; 1999); a brain area involved in threat sensitivity (LeDoux, 1996; Nader & LeDoux, 1999). A third model proposes that relatively high levels of emotional reactivity and relatively low levels of regulation linked to individual differences in temperament may contribute to the development of shyness (Eisenberg & Fabes, 1992).

More specifically, this latter model suggests that high levels of negative emotionality paired with low levels of regulation may lead to the ineffective modulation of distress in social interactions (Eisenberg & Fabes, 1992; Eisenberg et al., 1995). Here, negative reactivity, sometimes labeled negative emotionality, refers to the speed and intensity with which negative emotions are felt and displayed, whereas regulation refers to the processes (e.g., emotional, physiological, cognitive) which enable the modulation of reactivity in order to support goal directed behavior (Posner & Rothbart, 2000). Unregulated strong emotions may increase the likelihood of social interactions being perceived as uncomfortable or distressing, and repeated exposures to negative patterns of social interaction may lead to self-perceptions of low social competence and efforts to hide distress in social situations. These factors may work together to perpetuate shyness.

There is some empirical support for the reactivity-regulation model proposed by Eisenberg and Fabes (1992) in studies that have used reactivity and regulation independently to predict shyness concurrently, and prospectively, though results have been somewhat mixed. For example, using a prospective design, one study examined the influence of different components of regulation (i.e., maternal reports of attention focusing, attention shifting, and inhibitory control) on trajectories of shyness from age 3 to 5 years (Eggum-Wilkens et al., 2016). In this study, inhibitory control was negatively associated with shyness growth, whereas attention shifting was positively associated with shyness growth. In a different study, using a sample of adults and self-reported shyness, shyness was positively associated with physiological reactivity, negative emotional intensity, and negative affect, and negatively associated with some temperamental measures of regulation concurrently (Eisenberg et al., 1995). These studies suggest that different components of regulation may be differentially implicated in contemporaneous and longitudinal associations between regulation and shyness, and that reactivity is at least contemporaneously associated with shyness positively, as predicted by the model (Eisenberg & Fabes, 1992). However, given that these studies examined reactivity and regulation separately, we cannot make inferences about the interaction of reactivity and regulation on the development of shyness, limiting us from fully evaluating the reactivity-regulation model of shyness.

In addition to a lack of clarity around the interaction of reactivity and regulation in the development of shyness, there are also issues around directionally. Specifically, it is unclear whether reactivity and regulation are driving shyness, if shyness is driving regulation and reactivity, or if these constructs are mutually reinforcing. While the studies previously mentioned have used reactivity and regulation to predict shyness, other researchers have used shyness to predict reactivity and regulation. Numerous studies have found positive concurrent relations between maternal reports of shyness and components of reactivity (e.g., negative affect; Coplan et al., 2004; Findlay et al., 2009); although one study by Sanson et al. (1996) found a negative association between shyness and teacher reported reactivity. This discrepancy may be due to differences in informants, given that shy children may feel more comfortable openly displaying emotions in the presence of primary caregivers rather than teachers with whom they may be less familiar.

Using a cross-lagged analysis to inform inferences of directionality, one study found that while parent-reported shyness predicted prospective parent- and teacher-reported sadness, sadness did not predict prospective shyness from 6 to 9 years (i.e., the relations between shyness and sadness were unidirectional; Eggum et al., 2012). These findings were not in line with predictions made by the proposed reactivity-regulation model of shyness (e.g., Eisenberg & Fabes, 1992); although it is possible that sadness may not be conceptually similar enough to reactivity to draw strong conclusions. Another study found that, in children, shyness was positively related prospectively to negative emotions (a potential proxy of reactivity) and attention focusing (one component of regulation), and negatively associated with attentional shifting (another component of regulation; Eisenberg et al., 1998). Here, it is important to note that in this study, both teacher and parent informants were used at several different time points, and the results were not always consistent. The negative relation between shyness and attentional shifting also has been observed concurrently in adults (Eisenberg et al., 1995). In terms of inhibitory control (another component of self-regulation) both positive (Gagne et al., 2013) and negative relations (Eisenberg et al., 1995; Simonds & Rothbart, 2004) have been found in children and adults. Together, these results further highlight that different components of regulation may be differentially related to shyness depending on context and age, and that the relation between shyness and regulation and shyness and reactivity may be bidirectional. It is possible that shyness influences regulation and reactivity across time, and regulation and reactivity influence shyness over time.

While some components of the reactivity-regulation model presented by Eisenberg and Fabes (1992) have been evaluated directly or indirectly, there are a number of important limitations that should be noted. First, some of these studies have been cross-sectional using an adult population (Eisenberg et al., 1995), and so we cannot make inferences about whether reactivity and regulation influence the *development* of shyness necessarily. While two studies (Eggum-Wilkens et al., 2016; Eisenberg et al., 1998) have used longitudinal designs to examine influence of different components of regulation and reactivity on the development of shyness trajectories, one study only examined regulation and not reactivity (Eggum-Wilkens et al., 2016), and the results were mixed based on the component of regulation being evaluated. To more fully

evaluate the model, it is also important to examine how reactivity and regulation *together* influence the development of shyness using a longitudinal approach. It is important to examine the interaction between reactivity and regulation because individuals who have relatively high levels of reactivity but also have relatively high levels of regulation may not exhibit the same development pattern of shyness when compared with individuals who also have relatively high levels of reactivity and low levels of regulation.

A second important limitation of previous work is that it has largely ignored the potentially bidirectional nature of associations between shyness and regulation and shyness and reactivity. This is an important point to address in order to more fully evaluate the model presented by Eisenberg and Fabes (1992), because some studies have found that shyness predicts prospective reactivity or regulation (e.g., Eggum et al., 2012; Eisenberg et al., 1998); and other studies have found that reactivity or regulation predicts shyness (e.g., Eggum-Wilkens et al., 2016; Eisenberg et al., 1995). In order to more accurately address the question of bidirectionality, it is important to implement a longitudinal design and statistical methods (i.e., cross-lagged analyses) that account for previous levels of shyness, regulation, and reactivity over time in the same study.

The Present Study

The goal of the present study was to more fully test and evaluate the reactivity-regulation model of shyness (e.g., Eisenberg & Fabes, 1992) using two methods. First, in order to clarify some of the predictions made by the reactivity-regulation model of shyness, we examined whether the relations among reactivity, regulation, and shyness were bidirectional or unidirectional overtime using a cross-lagged design. Second, we examined whether the interaction between regulation and reactivity predicted the development of shyness over time.

It is important to use both a cross-lagged and a latent growth model separately because each level of analysis provides us with unique information that the other model does not. The cross-lagged model informs us about the directionality of the relations among reactivity, regulation, and shyness, whereas the latent growth model informs us about the influence of the interaction between reactivity and regulation in predicting the development of shyness over time, as suggested by the reactivity-regulation model of shyness (Eisenberg & Fabes, 1992).

We elected to focus specifically on the late childhood to early adolescence period. Although there has been relatively more work directed toward understanding shyness in childhood and adulthood than adolescence (see Jones et al., 1986; Coplan & Bowker, 2014; Rubin & Coplan, 2010; Schmidt & Schulkin, 1999; for reviews), the adolescent period is particularly salient for the development of shyness as this period is marked by significant developmental changes, including physical changes due to puberty, cognitive changes to formal operations, and social changes in which peers and peer relationships become particularly important (Cheek et al., 1986). Given these changes, it is important to note that during the adolescent period, shyness likely develops beyond its temperamental components, and may include the more social evaluative aspects such as impression management or self-consciousness (e.g., Poole et al., 2018; Schwartz et al., 1999).

We predicted that the relation between shyness and regulation and shyness and reactivity would be bidirectional. In line with the model of shyness proposed by Eisenberg and Fabes (1992), we also predicted that the interaction between regulation and reactivity would predict the development of shyness, such that individuals with relatively low levels of regulation and relatively high levels of reactivity would exhibit the highest shyness across time.

Method

Participants

The participants were 1284 students (49.8% female) from several elementary and high schools in Southern Ontario, Canada who were surveyed across three waves annually beginning in 2017 for a larger study examining psychological and physical health outcomes in adolescence. The focus of the present study was on the psychological and personality measures collected at Wave 1 (N = 1284; M_{age} = 10.72 years, SD_{age} = 1.73 years, $minimum_{age}$ = 7 years, $maximum_{age}$ = 14 years), Wave 2 (N = 1,006; M_{age} = 11.64 years, SD_{age} = 1.73 years, $minimum_{age}$ = 9 years, $maximum_{age}$ = 15 years), and Wave 3 (N = 851; M_{age} = 12.42 years, SD_{age} = 1.70 years, $minimum_{age}$ = 9 years, $maximum_{age}$ = 16 years) of data collection. The sample comprised primarily Canadian-born students (96.3%). Parent-reported race and ethnicity indicated that 84.1% of the children and adolescents were White, 2.8% were Hispanic, 2.1% were Asian, 1.7% were Black, .9% were Indigenous, 7.6% were Mixed Race, and .9% preferred not to answer. M levels of parental education fell between associate degree/diploma and undergraduate degree.

Procedure

Students were invited to participate in the study during visits to their schools. Each year, the survey was completed in two separate parts, both occurring within a 4-month period (January to April). Trained researchers and volunteers administered the surveys to participants in their classrooms during regular school hours. Participants received gifts (e.g., backpacks, pencils) as compensation. All students who participated in their first year were invited to participate again in subsequent years. Participants provided informed assent while their parents provided informed consent. The study was approved by the Brock University Research Ethics Board (Project Title: Brock Healthy Youth Project Protocol, Number: 16–0800).

Missing Data Analysis

Missing data occurred because some students did not complete all the questions in the survey (average missing data were 1.74% across visits), and because some students did not complete each part of the survey across visits. As mentioned in the procedure, each year the survey was split into two parts, and missing data were primarily due to absenteeism, but also occasionally due to time conflicts, students declining to participate in one part of the survey, and students moving from the school district. Sex, parental education, race, shyness, and emotional reactivity at Wave 1 did not predict missingness at Wave 2 (all $ps > .05$). However, binary logistic regressions revealed that age (χ^2 = 51.85, df = 1, $p <$

.001), emotion reactivity ($\chi^2 = 5.15$, $df = 1$, $p = .02$), and emotion regulation ($\chi^2 = 33.17$ $df = 1$, $p = .01$) at Wave 1 were predictive of missingness at Wave 2. Increases in age (Odds ratio [*OR*] = 1.21, 95% CI [1.18, 1.39]) and emotion reactivity (*OR* = 1.08, 95% CI [1.01, 1.16]) at Wave 1 significantly increased the odds of having missing data at Wave 2, whereas increases in emotion regulation (*OR* = .94, 95% CI [.89, .98]) at Wave 1 significantly decreased the odds of having missing data at Wave 2. Sex, race, parental education, and shyness at Wave 1 did not predict missingness at Wave 3 (all *p*s > .05). However, binary logistic regressions revealed that age ($\chi^2 = 54.33$, $df = 1$, $p < .001$) and emotion regulation ($\chi^2 = 7.08$, $df = 1$, $p = .01$) at Wave 1 predicted missingness at Wave 3. Increases in age (*OR* = 1.30, 95% CI [1.21, 1.39]) at Wave 1 significantly increased the odds of having missing data at Wave 3, whereas increases in emotion regulation (*OR* = 1.07, 95% CI [1.02, 1.13]) at Wave 1 significantly decreased the odds of having missing data at Wave 3. Full information maximum likelihood (FIML) was used to account for missing data in the cross-lagged and growth models. This approach uses all available raw data to simultaneously account for all the missing data and estimates model parameters and standard errors simultaneously, thus avoiding the biased parameter estimates that can occur with pairwise or listwise deletion (Schafer & Graham, 2002).

Self-Report Measures

Shyness

Shyness was self-reported by children, and was measured using seven individual items from several scales, including the Shyness and Sociability Scale (Cheek & Buss, 1981); Preference for Solitude Scale (Burger, 1995), Early Adolescent Temperament Questionnaire, revised shyness subscale (Ellis & Rothbart, 1999), and the Social Anxiety Scale (Ginsburg, La Greca, & Silverman, 1998). Items included "I feel shy about meeting new people" and "I am quiet when I am with a group of other students my age." Children were asked to indicate how much they agreed with each statement on a scale from 1 (*strongly disagree*) to 4 (*strongly agree*), such that higher values were indicative of more shyness. A theoretical and empirically derived composite measure of shyness was created by summing the items. A factor analysis revealed that a one factor solution explained 25.1% (Wave 1), 39.3% (Wave 2), and 43.38% (Wave 3) of the variance in the data. Factor loadings ranged from .31 to .76. The composite measure of shyness demonstrated acceptable internal consistency at Wave 1 ($\alpha = .66$), Wave 2 ($\alpha = .67$), and Wave 3 ($\alpha = .70$). Supplemental Table 1 includes the full list of items included in the scale, as well as intercorrelations among the items.

Emotion Reactivity

Emotion reactivity was self-reported by children, and measured using three items from the Emotional Reactivity scale (Nock, Wedig, Holmberg, & Hooley, 2008). Items included "My feelings get hurt easily"; "When I am upset/angry it takes me a long time to calm down"; and "When something bad happens, other people tell me I overreact." Children were asked to indicate how much they agreed with each statement on a scale from 1 (*strongly disagree*) to 4 (*strongly agree*), such that higher values were indicative of more reactivity. A factor analysis revealed that a one factor solution explained 43.2% (Wave 1), 41.9% (Wave 2), and 44.1% (Wave 3) of the variance in the data. Factor loadings ranged from .63 to .68. This scale demonstrated acceptable internal consistency at Wave 1 ($\alpha = .69$), Wave 2 ($\alpha = .68$), and Wave 3 ($\alpha = .70$). Supplemental Table 2 includes the intercorrelations among the items included in this scale.

Emotion Regulation

Emotion regulation was self-reported by children, and measured using three items from the Difficulties With Emotion Regulation Scale (DERS, Gratz & Roemer, 2004). Items from this scale included "When I am upset or stressed, I have difficulty thinking about anything else"; "When I am upset or stressed, I start to feel bad about myself"; and "When I am upset or stressed, I have difficulty concentrating." Children were asked to indicate how much they agreed with each statement on a scale from 1 (*strongly disagree*) to 4 (*strongly agree*). For presentation purposes, the scale was reversed, such that higher values were indicative of more emotion regulation. A factor analysis revealed that a one factor solution explained 56.9% (Wave 1), 59.6% (Wave 2), and 61% (Wave 3) of the variance in the data. Factor loadings ranged from .34 to .91. This scale demonstrated acceptable internal consistency at Wave 1, ($\alpha = .78$), Wave 2 ($\alpha = .68$), and Wave 3 ($\alpha = .84$). Supplemental Table 3 includes the full list of items included in the scale, as well as intercorrelations among the items.

Parental Demographics

A demographics questionnaire was also completed by mothers, which included questions about place of birth, race, and parental education.

Statistical Analyses

To determine the longitudinal, potentially bidirectional associations among reactivity, regulation, and shyness, we used a cross-lagged design over three time points (Waves 1, 2, and 3), controlling for the child's age during the first visit and sex. Cross-lagged models allow for controlling of synchronous relations and autocorrelations while identifying time-lagged reciprocal effects of two variables assessed longitudinally, while controlling for random measurement errors (Kenny, 1975). This allows us to examine the main effect of reactivity and regulation on the development of shyness over time and empirically tease apart the directionality of these potential relations. For example, if we found shyness predicted regulation over time, but regulation did not predict shyness over time, we can determine that the relation between shyness and regulation is only unidirectional.

To determine the interactive influence of emotion reactivity and regulation on the development of shyness over time, trajectories of shyness were estimated using latent growth curve analysis where repeated measures of shyness were regressed on the number of visits to estimate rates of change at an individual level. Three waves of longitudinal data contributed to the models described below. Latent growth curve analysis provides estimates pertaining to variability in shyness at enrollment (i.e., intercept variance) and the possibility that individuals' levels of changes in shyness at

different rates (i.e., slope variance). In this model, we included emotion reactivity and regulation at Wave 1, and shyness for all three Waves. We adjusted for child's age at Wave 1 and sex. For all analyses, FIML was used to handle missing data. All analyses were conducted in Mplus Version 8 (Muthen & Muthen, 2000) with significance levels set at $\alpha = .05$.

Results

Table 1 presents the Pearson's correlations, and the means, standard deviations, and ranges for study variables. The cross-lagged model will be presented first in order to evaluate whether the relations among reactivity, regulation, and shyness were unidirectional or bidirectional in nature. Next, the latent growth model will be presented to evaluate whether the interaction between reactivity and regulation predicted the development of shyness over time.

Unidirectional Versus Bidirectional Relations Among Reactivity, Regulation, and Shyness

Cross-lagged models provide us with three pieces of information, (a) the stability of constructs being evaluated, (b) the cross-sectional, reciprocal associations between constructs being evaluated, and (c) the cross-lagged associations between the constructs being evaluated, all while accounting for previous levels of the constructs being evaluated.

The cross-lagged analysis first revealed that emotion reactivity, emotion regulation, and shyness were stable across the three waves ($ps \leq .01$; Figure 1), and the cross-sectional associations between emotion reactivity and shyness, emotion regulation and shyness, and emotion regulation and emotion reactivity were significant across the three waves ($ps \leq .01$). The cross-lagged paths revealed that although shyness at Wave 1 significantly predicted emotion reactivity ($B = .04$, $p = .01$) and emotion regulation ($B = -.17$, $p < .001$) at Wave 2, emotion reactivity ($B = .09$, $p = .22$) nor emotion at Wave 1 ($B = .02$, $p = .79$) predicted shyness at Wave 2. Also, emotion reactivity ($B = -.17$, $p < .001$) at Wave 1 predicted emotion regulation at Wave 2, and this relation was bidirectional because emotion regulation ($B = -.07$, $p < .001$) at Wave 1 also predicted emotion reactivity at Wave 2. Shyness at Wave 2 predicted emotion reactivity ($B = .07$, $p < .001$), but emotion regulation only marginally ($B = -.03$, $p = .10$) at Wave 3. Although emotion reactivity ($B = -.01$, $p = .94$) at Wave 2 did not predict shyness at Wave 3, emotion regulation ($B = -.19$ $p = .02$) at Wave 2 did predict shyness at Wave 3. We also found that although emotion reactivity ($B = -.12$, $p < .001$) at Wave 2 did predict emotion regulation at Wave 3, this relation was no longer bidirectional, as emotion regulation ($B = -.05$, $p = .14$) at Wave 2 did not predict emotion reactivity at Wave 3. Table 2 presents the fit indices for the model.

Interaction of Reactivity and Regulation in Predicting the Development of Shyness Across Adolescence

Our unconditional latent growth model revealed significant individual variation in the intercept ($B = 15.94$, $p = <.001$) and linear slope ($B = 2.63$, $p = <.001$) of shyness across the three waves, permitting us to proceed with the conditional model. The conditional model was computed to test emotion reactivity and emotion regulation as predictors of individual variation in shyness trajectories. Table 3 includes statistical information for the full conditional model. These analyses revealed that although the interaction between emotion reactivity and regulation did not predict the intercept ($B = .001$, $p = .95$; baseline shyness), the interaction did predict the slope across the 3 years ($B = .03$, $p = .03$; growth of shyness).

As seen in Figure 2, and contrary to prediction of the reactivity-regulation model of shyness, relatively high levels of reactivity and low levels of regulation predicted a decrease in shyness over 3 years, whereas relatively high reactivity and high regulation predicted more stability in shyness over time. We also noted in the conditional model that sex predicted both the intercept ($B = .65$, $p = .02$) and slope of shyness ($B = .35$ $p = .05$). In order to better understand the influence of sex on the development of shyness, we ran a separate latent growth model, including only age and sex, and found that although sex predicted the intercept ($B = .90$, $p = .001$), such that females had higher shyness than males at baseline, sex was not predictive of the slope of shyness ($B = .29$, $p = .09$).

Discussion

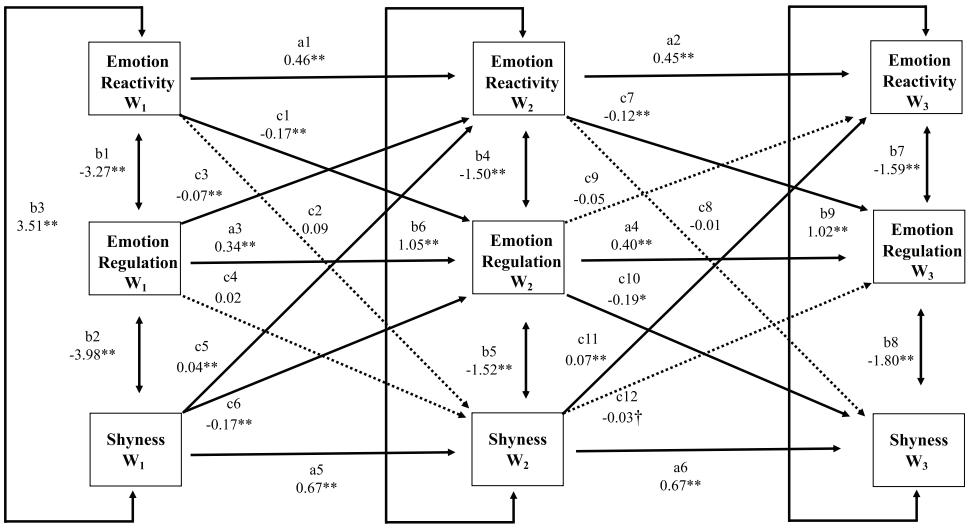
Using a three-wave, short-term longitudinal design, the purpose of the present study was to evaluate the reactivity-regulation model of shyness proposed originally by Eisenberg and Fabes (1992). This model suggests that shyness develops from relatively high levels of reactivity in combination with relatively low levels of regulation. To this end, we first used cross-lagged analyses to

Table 1
Pearson's Correlations, M, Standard Deviation (SD), and Range for Study Measures

Variables	1	2	3	4	5	6	7	8	9	*M* (*SD*)	Range
1. Emotion Reactivity W 1	—	.58**	.43**	−.57**	−.41**	−.30**	.35**	.26**	.21**	5.57 (2.24)	3–12
2. Emotion Reactivity W 2	—	—	.51**	−.42**	−.57**	−.37**	.29**	.30**	.25**	5.67 (2.09)	3–12
3. Emotion Reactivity W 3	—	—	—	−.28**	−.33**	−.54**	.20**	.24**	.31**	5.80 (2.15)	3–12
4. Emotion Regulation W 1	—	—	—	—	.50**	.38**	−.33**	−.23**	−.22**	6.32 (2.58)	3–12
5. Emotion Regulation W 2	—	—	—	—	—	.48**	−.31**	−.32**	−.31**	6.49 (2.41)	3–12
6. Emotion Regulation W 3	—	—	—	—	—	—	−.17**	−.21**	−.35**	6.39 (2.47)	3–12
7. Shyness W 1	—	—	—	—	—	—	—	.65**	.55**	18.87 (4.58)	7–24
8. Shyness W 2	—	—	—	—	—	—	—	—	.66**	18.28 (4.77)	7–24
9. Shyness W 3	—	—	—	—	—	—	—	—	—	18.00 (5.02)	7–24

Note. W = wave.
** $p < .01$.

Figure 1
Cross-Lagged Model Including Relations Among Emotion Reactivity, Emotion Regulation, and Shyness at Waves 1, 2, and 3 Across Adolescence



Note. Solid lines denote significant paths. W = wave; a = autocorrelations; b = synchronous correlations; c = cross-lagged correlations.
† $p < .10$. * $p \leq .05$. ** $p \leq .01$.

empirically test this model by examining the directionality of relations among reactivity, regulation, and shyness overtime during the pre and early adolescent period.

Our results revealed that although shyness at Wave 1 predicted reactivity and regulation, both reactivity and regulation did not predict shyness at Wave 2. The unidirectional nature of these relations was conserved over time, because although shyness at Wave 2 predicted reactivity at Wave 3, shyness at Wave 3 was only predicted by lower levels of regulation at Wave 2. We also found that the relations among reactivity and regulation were negative and bidirectional from Wave 1 to Wave 2, but only unidirectional later, as greater levels of reactivity at Wave 2 only predicted lower levels of regulation at Wave 3.

We also found that, contrary to predictions of the reactivity-regulation model of shyness (Eisenberg & Fabes, 1992), relatively high levels of reactivity and low levels of regulation predicted a *decrease* in shyness over 3 years, whereas relatively high levels of reactivity and high levels of regulation predicted more stability in shyness over time.

Unidirectional Versus Bidirectional Relations

We found that the relations between reactivity and regulation and shyness were unidirectional over time. Early on, we found that shyness predicted greater emotional reactivity and less emotion regulation. Our results from Wave 1 to Wave 2 are in line with the extant literature suggesting that shyness is related to sensitivity in several different domains. Physiologically, infants and children classified as behaviorally inhibited (a hypothesized temperamental antecedent of shyness) and shy have higher and more stable heart rates at rest, higher levels of baseline salivary cortisol, and greater cortisol reactivity in response to a stressor than uninhibited children or nonshy children (Garcia-Coll et al., 1984; Kagan et al., 1987; Kagan et al., 1988; Kagan et al., 1984; Schmidt et al., 1997; Talge et al., 2008; Zimmermann & Stansbury, 2004). Behaviorally, shyness is also positively associated with indices of fear and anxiety during social stressors in childhood, and children classified as high shy display more anxious behaviors during a self-presentation task than low shy children (Schmidt et al., 1999; Talge et al., 2008). As previously mentioned, shyness is also associated positively with reactivity from a temperamental perspective (Coplan et al., 2004; Findlay et al., 2009). Taken together, findings from different studies converge with our results suggesting that shyness is associated with higher levels of reactivity. Given that previous studies examining relations between shyness and reactivity have been either cross-sectional in nature (Coplan et al., 2004; Eisenberg et al., 1995; Findlay et al., 2009; Schmidt et al., 1999); or did not account for previous

Table 2
Fit Indices for Cross-Lagged and Latent Growth Curve Models

Model	χ^2	*df*	CFI	TLI	RMSEA	90% CI_{RMSEA}
Cross-lagged	105.33**	15	.96	.89	.07	.06–.08
Latent growth	7.24	6	.99	.99	.01	0–.05

Note. CFI = comparative fit index; TLI = Tucker-Lewis index; RMSEA = root mean square error; CI = confidence interval.
** $p \leq .01$.

Table 3
Full Conditional Model for Shyness Latent Growth Curve

Level	Estimate	Standard error
Intercept	15.61**	1.32
Sex	.65*	.27
Age	−.24**	.08
Emotion reactivity	.44*	.44
Emotion regulation	−.35*	.14
Emotion Reactivity × Emotion Regulation	.001	.02
Slope	−2.71**	.87
Sex	.35*	.18
Age	.10	.05
Emotion reactivity	.17	.12
Emotion regulation	−.12	.09
Emotion Reactivity × Emotion Regulation	.03*	.02

Note. Males coded as 1, females coded as 2.
* $p \leq .05$. ** $p \leq .01$.

levels of reactivity when they have been longitudinal (e.g., Eisenberg et al., 1998), information about the directionality of these relations has been lacking. By using a cross-lagged design, our results suggest that shyness may be leading to the development of reactivity, rather than the other way around.

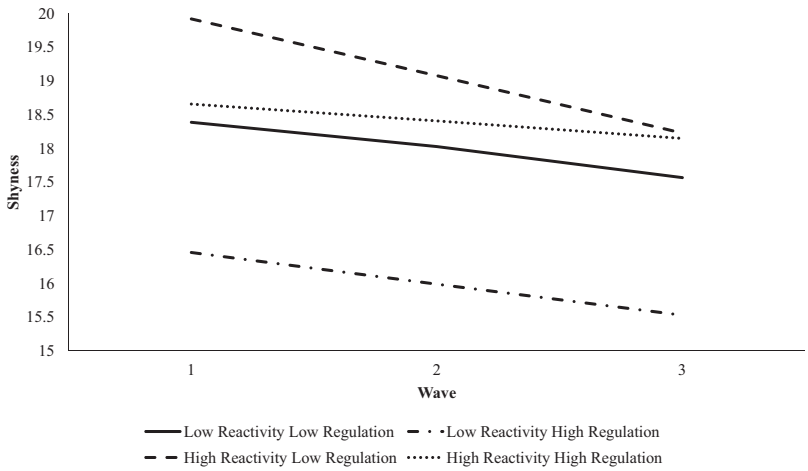
Although our analyses were correlational in nature, and we cannot determine *why* shyness is associated with greater reactivity over time, we speculate that this may be due to environmental experiences that shy children may be more susceptible to encountering. For example, shyness has been associated with parenting characterized by lack of encouragement of children's independence and high levels of overprotectiveness (Bögels & van Melick, 2004; Rubin et al., 1999). These parenting practices may lead to lower levels of social competence and lack of autonomy and may lead to higher levels of reactivity over time.

Further, encouraging the child's independence and allowing the child to engage in social experiences without overcontrol may be particularly important for shy children who are temperamentally predisposed to engaging in avoidance. Indeed, shyness is associated with avoidance-related internalizing difficulties (Findlay et al., 2009); making fewer initiations to start conversations, speaking less in social situations, and higher levels of avoidance in the context of social threat (e.g., Asendorpf & Meier, 1993; Coplan et al., 2008; Crozier & Perkins, 2002; Evans, 2001; Hassan & Schmidt, 2020). The clinical literature has shown repeatedly engaging in social avoidance leads to fear and overarousal when avoided social situations are encountered in the future. Shyness may predispose individuals to cognitive and behavioral avoidance due to the experience of strong negative emotions, which may then feedback and perpetuate strong negative emotions when social situations are undoubtedly encountered again in the future (Manfro et al., 2008).

We found that shyness led to less regulation from Wave 1 to Wave 2. Children classified as shy tend to display greater increases in right frontal brain activity during a social stressor, which is associated with self-regulatory difficulties (Schmidt et al., 1999). Shyness also has been negatively associated with cognitive self-regulation (Blankson et al., 2011; Ludwig & Lazarus, 1983; Wolfe et al., 2014; although see Hassan et al., 2019), as well as some temperamental indices of self-regulation (Eggum-Wilkens et al., 2016; Eisenberg et al., 1995; Eisenberg et al., 1998; Simonds & Rothbart, 2004). Our results suggest that this pattern extends to emotion regulation problems longitudinally across adolescence, while taking into account previous levels of shyness and regulation.

Although shyness was related to both greater reactivity and poorer regulation from Wave 1 to Wave 2, shyness only led to greater reactivity and no longer predicted less regulation from Wave 2 to Wave 3. One possible explanation for why only poorer regulation led to greater shyness later on may be related to the

Figure 2
Trajectories of Shyness Predicted by Emotion Reactivity and Regulation Across Adolescence, Controlling for Children's Age and Sex



Note. Values are plotted at one standard deviation above and below the mean for illustrative purposes. Standard error bars are not depicted because of the complex factor loading matrix in growth curve analyses where a two-way interaction over time is interpreted as a three-way interaction.

developmental changes that are occurring during adolescence, including physical and cognitive changes, and peer relationships becoming increasingly important (Cheek et al., 1986). It is possible that during this period where peers are at the forefront, relatively low levels of self-regulation may lead to poorer modulation of arousal and fear, which may reduce opportunities for social exchanges thereby perpetuating shyness. In support of this idea, shyness is indeed associated with greater avoidance in some social situations (Asendorpf & Meier, 1993; Coplan et al., 2008; Crozier & Perkins, 2002; Evans, 2001; Hassan & Schmidt, 2020), and so we speculate that lower levels of self-regulation may increase the likelihood of using avoidance as a coping strategy in social situations, which may function to perpetuate shyness. This pattern may become intensified as adolescents are experiencing physical changes and more sophisticated cognitive development, which may interact to increase feelings of self-consciousness.

Interaction of Reactivity and Regulation in Predicting Shyness Across Adolescence

One important prediction of the reactivity-regulation model of shyness is that relatively high levels of reactivity paired with relatively low levels of regulation interact in the development of shyness (Eisenberg & Fabes, 1992). However, when examining the interaction of reactivity and regulation in predicting trajectories of shyness across three years, we failed to find support for this hypothesis. Instead, we found that relatively high levels of reactivity and low levels of regulation predicted a decrease, rather than increase, over time, whereas relatively high levels of reactivity and high levels of regulation predicted relative stability in shyness over time. We also did not find that the interaction of reactivity and regulation predicted individual differences in baseline shyness (at Wave 1).

Although the present study precludes a direct examination of exactly *why* individuals with relatively higher and lower levels of reactivity and regulation exhibited linear decreases in shyness over time, we can speculate. It is possible that individuals with relatively high levels of reactivity and regulation have experienced strong negative emotions in social situations at least from late childhood (Wave 1). We speculate that they may have learned to more effectively regulate these emotions consistently into adolescence, leading to relative stability in shyness overtime.

On the other hand, perhaps individuals with relatively high levels of reactivity and low levels of regulation experience difficulty regulating their strong negative emotions in social situations during late childhood, leading to high levels of perceived shyness, but as they move into adolescence they may find a more stable social circle as peers become increasingly important (Cheek et al., 1986), leading to relatively lower levels of perceived shyness. However, these explanations are highly speculative and should be interpreted with the appropriate caution until we are able to examine them empirically.

Limitations

Strengths of the present study include the use of a large sample, a prospective longitudinal design, theoretically driven data analytic approaches, and an empirical examination of a longstanding model of the development of shyness during a relatively understudied period of human development (i.e., adolescence). The present study also should be interpreted in the context of its limitations.

First, we used measures of self-report rather than direct observation. Direct observation measures of social behavior are ostensibly more objective than self-report measures. Part of this decision was due to the natural trade-off between gathering a large sample in a school setting with time constraints, to use statistical methods such as latent growth modeling and collecting behavioral data, which may require more time. However, the measures we used were reliable and based on existing conceptualizations of shyness, reactivity, and regulation. The use of children's self-report rather than maternal or paternal reports of children and adolescent's personality and behavior may reduce some of the limitations associated with questionnaire-based assessments, although the use of a single informant may still be considered a limitation when examining complex developmental questions. Future work should consider using multiple informants and different sources of measures (e.g., observations) to enhance the reliability of the findings. Relatedly, given the nature of the study, we were unable to validate our measures of shyness, reactivity, and regulation, although it is important to note that these scales were constructed using existing theories of the aforementioned constructs and were internally consistent.

Second, another important limitation to consider is that we used a reversed emotion dysregulation scale as an index of regulation, and our measure of reactivity was less broad than some other measures used in the literature (e.g., Rothbart et al., 2001). That being said, we believe that we were still evaluating an important hypothesis effectively within the limitations of the measures we had access to in the present study.

Third, our sample was typically developing, primarily White, and middle class, and so it is possible that our results may not be generalizable to nontypically developing children and from ethnically and economically diverse backgrounds.

Lastly, although we were able to examine a longstanding model of the development of shyness, we only examined the interaction of reactivity and regulation across adolescence. It is possible the reactivity-regulation model may be more relevant earlier in childhood, or later than adolescence (Eisenberg & Fabes, 1992). As highlighted by Rothbart's model of temperament, aspects of regulation develop later than reactivity, and work to modulate reactivity (Rothbart & Derryberry, 1981). Given that the present study was conducted across adolescence, we were unable to examine the nonlinear relations between reactivity and regulation when these constructs were first emerging early in development. Future studies should use behavioral indices of shyness, reactivity, and self-regulation to replicate and extend the results from the present study in a less homogenous sample of individuals using a larger developmental window, as well as examining the interaction of reactivity and regulation in the development of externalizing behaviors in addition to internalizing behaviors such as shyness.

Conclusions

Using a three-wave prospective, longitudinal design in a sample of typically developing adolescents, we found that the associations between shyness and reactivity and shyness and regulation were unidirectional in nature. We also examined a longstanding model

of the development of shyness empirically. Our results suggest that reactivity and regulation did interact to predict the development of shyness, but not in the hypothesized direction, as relatively high levels of reactivity and low levels of regulation predicted a decrease in shyness across adolescence. The present study demonstrates the importance of empirically evaluating longstanding models of personality development using methods that account for previous levels of the constructs being tested whenever possible in order to ascertain the unidirectional and bidirectional nature of the constructs.

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