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Blushing in Early Childhood: Feeling Coy or Socially Anxious?

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Blushing has adaptive social functions. However, blushing is also assumed to be a hallmark of social anxiety and shyness. For the first time, blushing and its relation to the expressions of shyness and social anxiety was examined in early childhood. Four-and-a-half-year-old children ($N = 102$) were asked to perform (singing in front of an audience) and watched back their performance in the presence of that audience. Physiological blushing (blood volume pulse, blood volume, and cheek temperature) was measured, and positive (gaze and/or head aversion with smiling) and negative expressions of shyness (gaze and/or head aversion with negative facial expressions) were observed. In addition, both parents reported their child's social anxiety level. A higher level of blushing response was related to greater social anxiety in children who displayed few positive shy expressions, but not in children who displayed many positive shy expressions during the performance. Moreover, children who expressed many negative shy expressions were highly socially anxious, no matter their blushing. Our findings suggest that blushing appears to be an early indicator of social anxiety in children who are not able to successfully cope with fearful social situations. In contrast, blushing, in combination with positive shy behaviors, appears to be an adaptive social mechanism that may protect from heightened social anxiety.

Keywords: blushing, shyness, social anxiety, cheek temperature, blood flow

Supplemental materials: <http://dx.doi.org/10.1037/emo0000131.supp>

Darwin (1872) described blushing as “the most human of all human expressions” (p. 309). Yet, he concluded that blushing has no adaptive functions but rather is a side effect of human evolution. A century later, researchers assumed and tested the hypothesis that blushing does have signaling properties and might have important social functions in situations in which it typically occurs—when an individual is concerned about other people's evaluations (de Jong, 1999; de Jong & Dijk, 2013; Dijk, de Jong, & Peters, 2009; Keltner & Buswell, 1997; Leary & Meadows, 1991). Indeed, they found that blushing functions as a remedial and appeasement sign (de Jong, Peters, & De Cremer, 2003), signaling trustworthiness and prosocial behaviors (Dijk et al., 2009; Dijk, Koenig, Ketelaar, & de Jong, 2011). However, the majority of people who experience blushing consider it highly discomforting and undesirable, and some even develop blushing phobia (Bögels, Alberts, & de Jong, 1996; Mulkens, Bögels, de Jong, & Louwers,

2001). It is assumed that blushing is undesirable because it also signals uncomfortable, self-conscious emotions such as shyness and embarrassment in social situations in which people typically do not wish to expose these emotions because of the possibility that they might be judged negatively by their social environment (Crozier, 2007; Leary, Britt, Cutlip, & Templeton, 1992). Shy and socially anxious individuals are thought to be particularly prone to blushing in situations of social exposure or social evaluation (Buss, 1980; Crozier, 2004; Edelmann, 1990; Leary & Meadows, 1991) and developing concerns about it (Bögels et al., 1996; Bögels & Voncken, 2008) because they typically fear other people's evaluations (American Psychiatric Association [APA], 2013).

To date, the functions of blushing and the associations between blushing, social anxiety, and shyness have been investigated in adults. However, little is known about blushing in childhood. In the current study, we investigated blushing when it first develops—in early childhood (Buss, 1980; Leary et al., 1992). We explored the associations between blushing and social anxiety and the role of shy expressions in these associations. To our knowledge, this is the first study that investigated blushing in children and its association with expressions of shyness and social anxiety.

The Nature and Development of Blushing

Blushing is defined as an involuntary reddening of the face that occurs in emotionally charged situations when people experience undesired social attention (Drummond, 2012; Leary & Meadows, 1991). The reddening is due to an accumulation of blood in the superficial venous plexus of the facial skin, which is thought to be sympathetically driven (Drummond, 2012).

Blushing is typically accompanied by a feeling of self-consciousness (Leary et al., 1992), and it is assumed to appear with

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various self-conscious emotions such as embarrassment, shyness, shame, or social fear (Crozier, 2012; Edelmann, 2001; Leary & Toner, 2012). People may also blush when they experience pride when they, for example, receive a compliment or praise in public (Leary et al., 1992; Leary & Toner, 2012). The common feature of these situations is heightened self-awareness—the feeling of being socially exposed, being the center of other people’s attention, and/or being scrutinized (Buss, 1980; Eggum-Wilkens, Lemery-Chalfant, Aksan, & Goldsmith, 2015; Leary et al., 1992). In these situations, blushing is assumed to typically occur when an individual recognizes that there is a possibility of making a negative impression on other people whose approval an individual seeks (Castelfranchi & Poggi, 1990; Leary et al., 1992). Therefore, people blush when they experience that getting approval from important others is at stake (de Jong & Dijk, 2013). It is assumed that blushing serves an appeasement function because it communicates to the social environment that the person who blushes is sensitive to the judgments of the observers and cares about social norms. It emphasizes that an individual recognizes that he or she has committed or will commit a violation of a social norm and seeks appeasement (Castelfranchi & Poggi, 1990; de Jong, 1999; Keltner & Buswell, 1997). In turn, the blushing response may lessen the negative evaluation of other people and evoke affiliative behaviors of the social environment (de Jong, 1999).

Darwin (1872) assumed that children cannot blush until they develop self-consciousness. Buss (1980) agreed that blushing emerges when children acquire a sense of public self. Leary and colleagues (1992) proposed that blushing occurs when self-attention, or the ability to represent oneself in thoughts, emerges. From a developmental perspective, a concept of the self as an object appears in the second year of life (Lewis, 1995, 2000; Stegge, 2013). Already at this age, children may experience embarrassment as a consequence of being at the center of attention (exposure embarrassment; Lewis, 1995). At the age of 3, children develop internal standards against which they can judge their own behaviors and may experience embarrassment when they think that they may be judged negatively (Lewis, 2003; Stegge, 2013). From this perspective, it is possible that embarrassment, shyness, and blushing first appear at the age of 2. However, empirical research on the development of blushing is limited. Only a few studies have investigated the frequency of blushing in young children using self-reports or others’ reports of blushing (Buss, Iscoe, & Buss, 1979; Colonnese, Engelhard, & Bögels, 2010; Ginsburg, Riddle, & Davies, 2006; Shields, Mallory, & Simon, 1990). These studies reported that blushing occurs in children at least as young as the age of 4 years.

Measures of Blushing

Physiologically, blushing may be captured with blood flow and temperature changes (Shearn, Bergman, Hill, Abel, & Hinds, 1990). Blood flow is usually measured with photoplethysmography (e.g., Bögels, Rijsemus, & de Jong, 2002; Drummond et al., 2007). The fluctuating alternating current (AC) component of plethysmography is called blood volume pulse and represents fast changes in blood volume with each heartbeat (Swain & Grant, 1989). The direct current (DC) component corresponds to the average level of blood volume and represents blood pooling in the arteries, veins, and capillaries, which varies slowly (Allen, 2007;

Hertzman & Spealman, 1937; Nitzan, Babchenko, Khanokh, & Landau, 1998).

Another measure of blushing response is facial temperature. It is often incorporated additionally to blood flow (e.g., Mulkens et al., 2001; Mulkens, de Jong, & Bögels, 1997; Mulkens, de Jong, Dobbelaar, & Bögels, 1999; Voncken & Bögels, 2009). It has been reported that an increase in blood volume pulse reflects an increase in vasodilation, which leads to an increase in peripheral temperature (Peper, Harvey, Lin, Tylova, & Moss, 2007). Increases in blood volume pulse (AC reactivity), blood volume (DC reactivity), and temperature are taken to represent the physiological blushing response.

Past studies that measured physiological blushing typically included only one measure of blood flow: AC (e.g., Drummond et al., 2007) or DC (e.g., Gerlach, Wilhelm, Gruber, & Roth, 2001). Alternatively, some studies employed the additional measure of cheek temperature and analyzed it separately (e.g., Voncken & Bögels, 2009).

Blushing and Social Anxiety

Because socially anxious individuals fear negative evaluation, they seem to seek and display appeasement more than nonsocially anxious individuals (Stein & Bouwer, 1997). Furthermore, they find small errors and gaffes in social situations more embarrassing and expect a more negative evaluation of others (Dijk, de Jong, & Peters, *in press*), thereby blushing more easily and more frequently in various social contexts.

Blushing is now considered to be a typical physiological response not only of heightened social anxiety but also of social anxiety disorder (SAD; APA, 2013, p. 204; Bögels et al., 2010). Furthermore, blushing is assumed to be an early indicator of the development of social anxiety (Voncken & Bögels, 2009), as it occurs earlier in life, before fears and concerns typical of social anxiety may be assessed. In addition, blushing may have an important role in the maintenance of social anxiety (Bögels, 2006). Because socially anxious individuals have heightened self-focused attention during social situations (Bögels & Mansell, 2004), they may be especially sensitive to their interoceptive cues (Domschke, Stevens, Pfliegerer, & Gerlach, 2010) and become aware of their blushing, which may give rise to dysfunctional and catastrophizing thoughts (Dijk, Voncken, & de Jong, 2009; Domschke et al., 2010). These thoughts, in turn, can further lead to fear and avoidance of social situations and heightened social anxiety (Bögels et al., 2010; Bögels & Lamers, 2002).

Studies that have empirically linked blushing to social anxiety in adults supported the hypothesis that blushing is related to social anxiety (e.g., Bögels & Lamers, 2002; Dijk et al., 2009; Drummond & Lazaroo, 2012; Gerlach et al., 2001; Voncken & Bögels, 2009). The recent meta-analysis on blushing and social anxiety (Nikolić, Colonnese, de Vente, Drummond, & Bögels, 2015) confirmed that socially anxious people perceive themselves as blushing more than nonsocially anxious people. The effect size found in the same meta-analysis on physiological blushing and social anxiety was small but significant. Although the hypothesis that blushing is related to social anxiety is partly supported in adults, it is still unclear whether blushing is related to social anxiety already in early childhood.

Blushing and Shyness

A self-conscious emotion that typically accompanies blushing is shyness (Crozier, 2007). Shyness is usually discussed as a form of social fear, tension, and concern (Buss, 1980); as discomfort, inhibition, and reticence in the presence of others (Jones, Briggs, & Smith, 1986); and as a tendency to avoid social situations and withdraw due to feeling nervous or uncomfortable (Henderson & Zimbardo, 1998; Rubin, Coplan, & Bowker, 2009). Recent studies (Colonnesi, Napoleone, & Bögels, 2014; Reddy, 2005) have added a new component to the research of shyness by distinguishing between the more positive and more negative aspects of shyness during infancy and childhood. From this perspective, shyness is defined as the behavioral and emotional ambivalence during social situations, expressed by both approach and withdrawal from an interaction (Asendorpf, 1990; Lewis, 2001), experienced as a more positive or more negative affect, and therefore expressed in a more positive or a more negative way (Colonnesi et al., 2014; Reddy, 2005).

Behaviorally, children express shy emotion with gaze and/or head aversion and body touching with or without a smile (Colonnesi, Bögels, de Vente, & Majdandžić, 2013; Colonnesi et al., 2014; Reddy, 2000, 2005). Expressed in a negative way, shyness involves inhibited and withdrawn social behaviors (Buss & Goldsmith, 2000; Leary, 2001), with aversions and negative facial expressions (Colonnesi et al., 2014). Expressed in a positive way, shyness includes a coy smile—smiling with a simultaneous aversion of a gaze and/or head just before the decline of the peak of the smile (Asendorpf, 1990; Colonnesi et al., 2013, 2014; Reddy, 2000, 2005). Coy smiles in childhood typically occur in social situations such as greeting a stranger or performing in public and are seen as a behavioral strategy that has a function to resolve a conflict between competing feelings of interest (excitement and pleasure) and wariness (discomfort and fear) in the child (Thompson & Calkins, 1996). They have also been documented in adults and have been shown to consist of a gaze and/or head aversion just before the peak of the smile, usually with hand movements to the face and attempts to control the smile (i.e., nervous, silly smile; Keltner, 1995; Keltner & Buswell, 1997). Positive shy expressions are assumed to be a consequence of the approach–avoidance conflict in social situations with dominant approach motivation and a reflection of competing goals (e.g., interacting with another person or learning from situations that provoke interest vs. avoiding potential threat and consequent harm), whereas negative shy expressions are thought to represent avoidance-dominant motivation expressed through withdrawn behaviors that mostly reflect fear and discomfort (Asendorpf, 1989; Asendorpf & Meier, 1993; Colonnesi et al., 2014; Rubin et al., 2009).

Shyness in children is hypothesized to serve important social functions. Specifically, positive expressions of shyness may regulate and reduce arousal in an anxiety-provoking situation, while at the same time they allow the individual to engage in the social situation (Colonnesi et al., 2014). They are assumed to reflect children's motivation to interact with the social environment and to avoid possible harm (such as being negatively evaluated) at the same time (Thompson & Calkins, 1996). Moreover, positive shy expressions are hypothesized to have an appeasement function: Just as with blushing, positive shy expressions may serve as a placation for a social infraction that a person committed or will

possibly commit (Keltner & Anderson, 2000; Keltner, Young, & Buswell, 1997). The expressions of positive shyness are thought to evoke affiliative behaviors of other people and increase interpersonal liking (Colonnesi et al., 2014; Keltner & Buswell, 1997). As a consequence, individuals who express positive shyness are likely to obtain positive experiences in social situations, learn from new social situations, and build self-esteem through surmounting the social challenges (Thompson & Calkins, 1996). Recently (Colonnesi et al., 2014), it has been empirically confirmed that positive expressions of shyness are negatively related to social anxiety in toddlers. Furthermore, in a recent study conducted by Colonnesi, Nikolić, de Vente, and Bögels (2015), a positive trend was found between children's positive shy expressions and their understanding of beliefs and false beliefs, which is assumed to play an important role in the development of social competencies and social success. Thus, positive shy expressions seem to have an adaptive social function already in early childhood.

Unlike expressions of positive shyness, children may express negative shyness when they do not have the capacity to adaptively cope with the demands of the challenging social situation (Colonnesi et al., 2014). Withdrawal from the social situation may also have a regulatory function, but at a cost. Withdrawal behaviors such as fretting or crying may signal that the child is distressed and wants to be removed from the situation and may help reduce heightened arousal in the situation (Thompson & Calkins, 1996). Although this strategy may have a regulatory function, it is not seen as adaptive because the withdrawn child has fewer opportunities to engage in the social situation that is the source of anxiety. In the long run, these children miss the opportunity to learn to cope with social challenges and to become more confident as a consequence of the successful coping with the social challenges; in contrast to children who successfully cope with social situations, they may become even more withdrawn and inhibited in social situations (Colonnesi et al., 2014; Thompson & Calkins, 1996). Thus, unlike positive shy expressions, which are assumed to be protective against social anxiety in children, negative expressions of shyness seem to lead to avoidance of social situations and heightened social anxiety (Asendorpf, 1990; Colonnesi et al., 2014; Reddy, 2001).

Although a few studies have reported that temperamentally shy adults blush more in embarrassing situations than individuals who do not find themselves shy (Hofmann, Moscovitch, & Kim, 2006) and that individuals who feel more embarrassed during an embarrassing episode in lab settings also blush more than people who feel less embarrassed (Drummond & Lim, 2000), it is not yet clear how blushing relates to shyness in childhood and, in particular, to the more positive component of shyness, such as a coy smile, which is assumed to be an adaptive social strategy and a coping mechanism that can protect from social anxiety (Colonnesi et al., 2014).

It has been proposed that blushing may signal a high level of ambivalent arousal (van Hooff, 2012). According to van Hooff (2012), blushing may be a sign of coyness (i.e., coy blush) and can be seen as resulting from the motivational conflict: Just as a coy smile, it suggests that an individual feels pleasure (or attraction) and discomfort in a social situation at the same time. A person who blushes signals an ambivalent state: The person feels uncomfortable and wants to avoid the social situation, but at the same time the blush signals that the person cares about the social situation and shows a wish and motivation to engage in it. Hence, for some

individuals, blushing may not be a sign of social fear, but rather of the ambivalent state of experiencing positive affect and discomfort at the same time.

The Present Study

Although blushing may have a positive social value, many people who blush are socially anxious (Nikolić et al., 2015). Some of these individuals even develop SAD and blushing phobia (Bögels et al., 2010). Because blushing and social anxiety share a common feature—fear of negative evaluation—it is probable that they are related to each other. However, a recent study (aan het Rot, Moskowitz, & de Jong, 2015) found that blushing in adults may be related not only to negative but also to positive affects in everyday situations: The authors found that blushing is related to shame in people who blush frequently but also that blushing is associated with positive affects in people who do not blush frequently. Hence, it is possible that, although undesirable and discomforting, blushing occurs with positive affects and signals the ambivalent mix of positive affect and discomfort. Experienced as ambivalence in a social situation, blushing may serve adaptive social functions, as does shyness when expressed in a positive way. Because blushing and positive expressions of shyness seem to help individuals adaptively regulate their emotions and successfully cope with challenging interpersonal situations, it is possible that positively shy individuals who successfully cope with challenging social situations and gain positive experiences from these events are not socially anxious, even when they blush and are concerned with other people's evaluations. In other individuals who do not adaptively cope with challenging social situations, but rather avoid them and withdraw, it may be expected that blushing is experienced as distressing and that it is related to negative feelings, social fear, and social anxiety.

To date, little is known about blushing in children. To our knowledge, this is the first study that has examined physiological blushing in young children. We investigated the associations between blushing, positive and negative expressions of shyness, and levels of social anxiety in a social performance task. Because blushing is considered to typically occur with self-conscious emotions such as shyness, we expected blushing to be connected to the expressions of shyness in the present study. Considering that both shyness and blushing may have negative as well as positive connotations, we hypothesized that blushing was related to both positive and negative expressions of shyness. Moreover, we expected blushing to be related to social anxiety already in early childhood, but only in children who do not use adaptive social strategies to cope with a challenging social situation. Specifically, we expected that in children who expressed shyness in a more positive way, blushing should not be related to social anxiety, as those children used adaptive mechanisms to cope with the social situation. In children who expressed shyness in a more negative way, blushing should be related to social anxiety, as these children did not use adaptive strategies to cope with the social situation.

Method

Participants

One hundred and ten children (54 boys) with an average age of 53.26 months ($SD = 0.63$) who took part in a longitudinal study on

the development of anxiety and visited the lab when they were 4.5 years old participated in the present study (for a more detailed description of the sample, see de Vente, Majdandžić, Colonnese, & Bögels, 2011). Families were recruited during the pregnancy with a first child through midwives, advertisements, and leaflets. Parents were mostly Caucasian (93%) with middle- and high-class backgrounds with a relatively high educational level ($M = 6.97$, $SD = 1.17$, on a scale of 1 [primary education] to 8 [university]). The study was approved by the ethics committee of the university. Parents provided informed consent prior to participation.

Setting and Procedure

Two related tasks were conducted during a lab visit of the child with the father: a performance and a watching-back task. Figure 1 shows the setting of the tasks. A wooden stage was placed in the room with a microphone and spotlight in front of it and a covered TV to the right of it. Three small chairs were placed (for the father, the experimenter, and the strange woman with the camera) in front of the stage. Children were invited to perform a song they liked. The child could choose a costume and dress up—for example, in a shiny blouse. To measure blushing, photoplethysmograph sensors and a thermometer were attached to the left cheekbone. To record baseline physiological measures, participants sat on the podium for 2 min. Following the baseline, participants were asked to stand on stage and sing a song of their choice in front of three audience members: a test leader, the father, and an unknown woman who was recording the performance. The mean duration of the performance task was 77.89 s ($SD = 35.33$). After the performance, the child and the father were asked to sit on the podium. After recovering for 1 min, participants were asked to watch their recorded performance (if they performed during the social performance task) with their father and the test leader on a TV screen. The mean duration of the watching-back task was 56.60 s ($SD = 34.62$). For some children, the performance task lasted longer than the watching-back task because these children took some time before starting singing (because of changing their mind about the song they would perform or displaying latency in responding to the test leader's announcement) and watched back only the actual performance.

Recording of Blushing Response

Multichannel physiological recordings were made with a custom-made blood pulse measurement amplifier. Blushing response (blood volume pulse and blood volume) was measured with an infrared-reflective photoplethysmograph transducer that was both AC and DC coupled. As a result, the transducer was able to record both slow (DC) and fast-changing signals (AC). Cheek temperature was monitored unilaterally with a platinum PT1000 temperature sensor fastened to the skin next to the infrared probe of the plethysmograph transducer. Signals were sampled at 200 Hz by a National Instruments NI6224 data acquisition system and analyzed using Vsrp98 software (Molenkamp, 2011) on a personal computer.

Coding of Children's Expressions of Shyness

The coding system from the study of Colonnese et al. (2014) was used in order to code children's positive and negative expressions

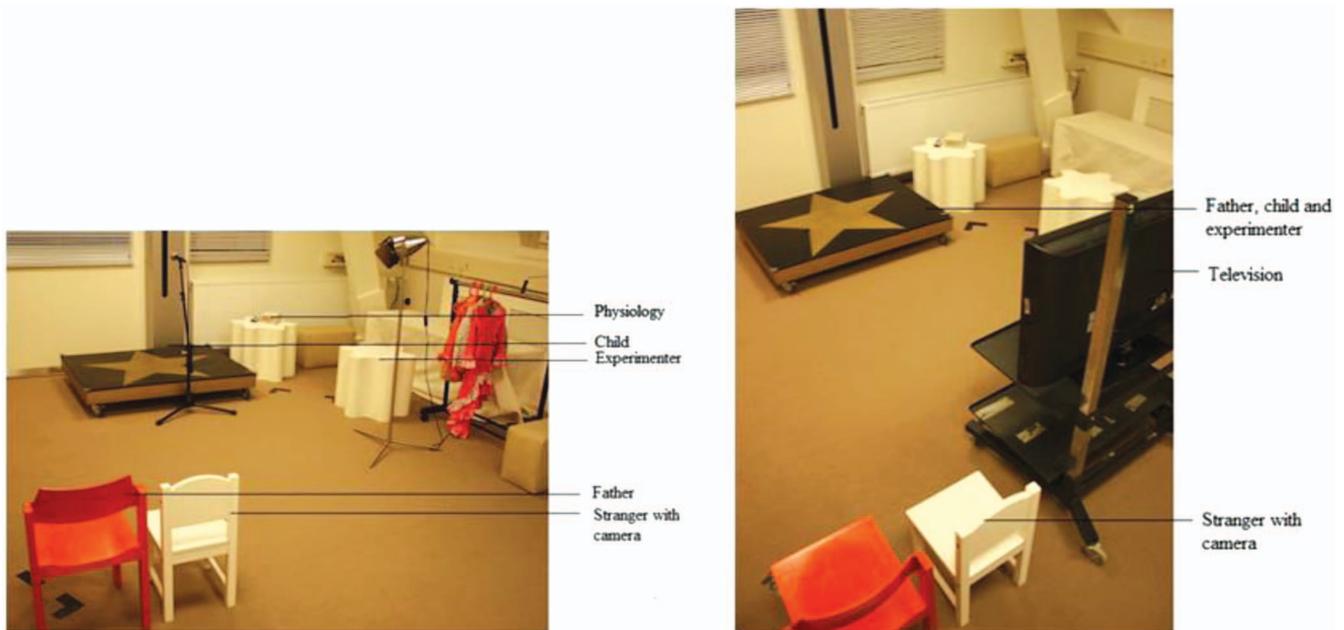


Figure 1. Setting of the tasks: the social performance (left) and the watching-back task (right). See the online article for the color version of this figure.

of shyness. The video observations ($n = 96$ for the performance task and $n = 64$ for the watching-back task) were coded offline with Observer XT 11.5 event-logging software (Noldus, Trienes, Hendriksen, Jansen, & Jansen, 2000). Two target behaviors were obtained combining coded behaviors: positive and negative expressions of shyness. Positive shy expressions were coded as the number of positive facial expressions in which a gaze and/or head aversion occurred within 0–2 s prior to the apex of the smile. Negative shy expressions were coded as the number of negative facial expressions in which a gaze and/or head aversion occurred during the duration of the negative facial expression in a temporal episode of 2 s (Colonnesi et al., 2014). To control for individual differences in the task length, the number of shy expressions was calculated as a number per first 30 s of the tasks. If a child performed for less than 30 s ($n = 10$), a corrected number of shy expressions was calculated based on the duration of the performance (number of shy expressions corrected for the duration of the task).

The observations were coded by five independent master's students and one doctoral student after extensive training. Three observers coded the performance task, and three observers coded the watching-back task. Interrater reliability was calculated for 18 observations (20%) of the performance task and for 18 observations (27%) of the watching-back task. Cohen's kappa corrected for kappa max (Bakeman, Deckner, & Quera, 2005) was $\kappa = .89$ for the performance task and $\kappa = .95$ for the watching-back task.

During the watching-back task, 29 children expressed one positive shy expression, and one child expressed the same expression three times; only two children expressed one negative shy expression. Because of the lack of variance in the children's expressions of shyness during the watching-back situation, this task was not included in the analyses.

Children's Levels of Social Anxiety Reported by Parents

Both parents completed the Social Anxiety subscale of the Dutch version of the revised Preschool Anxiety Scale (PAS-R; Edwards, Rapee, Kennedy, & Spence, 2010) to measure children's social anxiety levels. The subscale has good construct validity and internal consistency (Edwards et al., 2010). In this study, Cronbach's alpha was .87. Mothers' and fathers' ratings of their child's social anxiety were correlated, $r = .46$, $p < .001$, and averaged into a composite score.

Data Analyses

Percentage increases from baseline (120 s) to performance (the first 30 s) in blood pulse volume (AC reactivity) and blood volume (DC reactivity) were computed because the absolute values of photoplethysmographic output are influenced by individual differences in skin characteristics, such as closeness and density of blood vessels (Drummond et al., 2007). Additionally, percentage increases from baseline to performance in cheek temperature (temperature reactivity) indicated in degrees Celsius were computed. Three physiological indices of blushing were not correlated (see Table 1) and were analyzed separately.

Detected outliers (± 3 standard deviations) were Winsorized by modifying their values to the closest observed values (Wilcox, 2005). Pearson's product-moment correlations were performed to analyze the associations between physiological blushing, expressions of shyness, and social anxiety. Three multiple regressions were performed to test for moderation effects of shy expressions on the relationship between blushing (AC reactivity, DC reactivity, and temperature reactivity) and social anxiety level. In all regres-

Table 1
Descriptive Statistics and Correlations for Blushing Measures and Expressions of Shyness During the Performance and Social Anxiety

	<i>n</i>	<i>M (SD)</i>	2	3	4	5	6
1. AC reactivity	63	1.44 (41.36)	-.06	.22 [†]	.29*	-.18	.19
2. DC reactivity	47	2.13 (9.89)	—	.03	.08	.15	-.10
3. Temperature reactivity	67	-.02 (2.37)	—	—	.00	.18	.18
4. Expressions of positive shyness	96	1.09 (1.39)	—	—	—	-.32**	-.21*
5. Expressions of negative shyness	96	1.11 (1.96)	—	—	—	—	.36**
6. Social anxiety level	103	2.09 (.68)					

Note. AC = alternating current; DC = direct current; AC reactivity = blood volume pulse percentage increase from baseline to the task; DC reactivity = blood volume percentage increase from baseline to the task.

[†] $p < .100$. * $p < .050$. ** $p < .010$.

sion models, bias-corrected bootstrap 95% confidence intervals (CIs) were calculated for the coefficients of the investigated effects with 5,000 replications using the Process macro for SPSS (Hayes, 2012) to overcome a concern regarding the limited sample size. The significant interactions were probed by estimating the conditional effect of blushing on social anxiety at values of the shy expressions that represent *low*, *moderate*, and *high* values (1 standard deviation below the mean, the mean, and 1 standard deviation above the mean, respectively; Hayes, 2012).

Results

Preliminary Analysis

One hundred and two children took part in the social performance task, and eight children refused to take part in the task. Seven children had missing data on the social anxiety questionnaire. Children who refused to take part in the social performance task did not significantly differ in levels of social anxiety from children who carried out the social performance task, $t_{(101)} = 0.85$, $p = .395$, $d = 0.31$, 95% CI [-0.41, 1.04]. Children who had missing data on blushing or shyness measures due to the equipment failure in the performance ($n = 26$) or because they did not want to have electrodes attached ($n = 14$) did not significantly differ in their level of social anxiety from the children who did have data on the blushing and shyness measures, $t_{(79)} = 1.65$, $p = .103$, $d = 0.39$, 95% CI [-0.86, 0.06] and $t_{(67)} = 0.99$, $p = .325$, $d = 0.30$, 95% CI [-0.89, 0.29], respectively.

Preliminary analyses, conducted to explore possible sex differences on all study variables, revealed no significant differences in boys and girls on any of the variables ($p > .05$). Therefore, sex was not included in the following analyses. Table 1 reports descriptive statistics and two-tailed correlations for children's blushing measures, positive and negative expressions of shyness during the performance task, and social anxiety.

Higher AC reactivity was significantly related to the higher number of positive shy expressions. Blushing measures were not related to each other, except for the association between AC and temperature reactivity, which showed a trend toward a positive correlation. Positive expressions of shyness were negatively related, and negative shy expressions were positively related to the level of social anxiety.

Blushing and Social Anxiety: Moderation by Positive and Negative Expressions of Shyness

Three multiple linear regression analyses were performed to evaluate the moderation effect of positive and negative shy expressions on the relationship between blushing (AC, DC, and temperature reactivity) and children's social anxiety levels. AC reactivity, positive and negative expressions of shyness, and the interactions between AC reactivity and positive shy expressions and AC reactivity and negative shy expressions explained 36% of the variance in children's social anxiety, $R^2 = .36$, $F_{(5,45)} = 5.11$, $p < .001$. As shown in Table 2, the interactions between AC reactivity and positive shy expressions and AC reactivity and negative shy expressions were significant. As shown in Figure 2a, higher AC reactivity was related to more social anxiety for children who showed moderate and low numbers of positive expressions of shyness, $\beta = .38$, bootstrapped 95% CI [0.09, 0.68], $t = 2.66$, $p = .011$ and $\beta = .53$, bootstrapped 95% CI [0.14, 0.91], $t = 2.77$, $p = .008$, respectively. However, for children who expressed positive shy behaviors more often, AC reactivity was not associated with social anxiety, $\beta = .22$, bootstrapped 95% CI [-0.06, 0.49], $t = 1.56$, $p = .126$. Regarding the interaction between AC reactivity and negative shy expressions, higher AC reactivity was associated with higher levels of social anxiety in children with a low number of negative shy expressions, $\beta = .32$, bootstrapped 95% CI [0.04, 0.60], $t = 2.29$, $p = .027$, and a trend toward this association was found for children with a moderate number of negative shy expressions, $\beta = .23$, bootstrapped 95% CI [-0.03, 0.49], $t = 1.81$, $p = .077$. However, in children who displayed a high number of negative shy expressions, AC reactivity was not related to social anxiety, $\beta = .04$, bootstrapped 95% CI [-0.40, 0.47], $t = 0.17$, $p = .867$ (Figure 2b). As shown in the figure, this group of children displayed the highest levels of social anxiety, no matter their blushing.

The model with DC reactivity, positive and negative shy expressions, and the interactions of DC reactivity and positive shy expressions and DC and negative shy expressions was not significant, $R^2 = .22$, $F_{(5,29)} = 1.62$, $p = .186$. The model with temperature reactivity and its interactions with positive and negative shy expressions as predictors explained a significant amount of variance, $R^2 = .23$, $F_{(5,49)} = 2.95$, $p = .021$. There was a trend of a higher number of negative shy expressions predicting a higher level of social anxiety. The interaction between temperature and

Table 2
Blushing and Shy Expressions as Predictors of Social Anxiety

Model	Parameter	β	95% CI	t	p
AC reactivity and expressions of shyness predicting social anxiety	AC reactivity	.39	[.11, .67]	2.77	.008
	Positive expressions of shyness	-.11	[-.35, .13]	-.93	.355
	Negative expressions of shyness	.26	[-.11, .62]	1.40	.169
	AC Reactivity \times Positive Expressions of Shyness	-.27	[-.45, -.09]	-3.10	.003
	AC Reactivity \times Negative Expressions of Shyness	-.46	[-.88, -.04]	-2.22	.032
$R^2 = .36, F_{(5,45)} = 5.11, p < .001$					
DC reactivity and expressions of shyness predicting social anxiety	DC reactivity	-.18	[-.64, .27]	-.83	.416
	Positive expressions of shyness	-.03	[-.40, .35]	-.14	.890
	Negative expressions of shyness	.46	[-.04, .96]	1.87	.072
	DC Reactivity \times Positive Expressions of Shyness	.77	[.02, 1.53]	2.10	.045
	DC Reactivity \times Negative Expressions of Shyness	.71	[-.22, 1.64]	1.56	.129
$R^2 = .22, F_{(5,29)} = 1.62, p = .186$					
Temperature reactivity and expressions of shyness predicting social anxiety	Temperature reactivity	.25	[-.14, .64]	1.30	.200
	Positive expressions of shyness	-.15	[-.41, .10]	-1.20	.236
	Negative expressions of shyness	.28	[-.01, .57]	1.97	.055
	Temperature Reactivity \times Positive Expressions of Shyness	-.40	[-.86, .06]	-1.73	.091
	Temperature Reactivity \times Negative Expressions of Shyness	-.02	[-.55, .52]	-.06	.952
$R^2 = .23, F_{(5,49)} = 2.95, p = .021$					

Note. CI = confidence interval; AC = alternating current; DC = direct current.

positive expressions of shyness also showed a trend toward predicting social anxiety. As shown in Figure 3, higher temperature reactivity was significantly associated with more social anxiety only in children who had a low number of positive shy expressions, $\beta = .66$, bootstrapped 95% CI [0.16, 1.16], $t = 2.63$, $p = .011$, but not in the children who expressed positive shyness moderately and often, $\beta = .28$, bootstrapped 95% CI [-0.11, 0.67], $t = 1.44$, $p = .155$ and $\beta = -.17$, bootstrapped 95% CI [-0.75, 0.40], $t = -0.61$, $p = .547$, respectively.

Because of the limited sample size in the study, we did not test the three-way interaction between positive and negative shy expressions and blushing on social anxiety. However, a further exploration of the combined effect of positive and negative shy expressions on the association between blushing and social anxiety was performed by forming groups of children based on their scores on positive and negative expressions of shyness (see Figure 1a in the online supplemental materials). Group 1 consisted of children who displayed a high number of positive (1 standard deviation

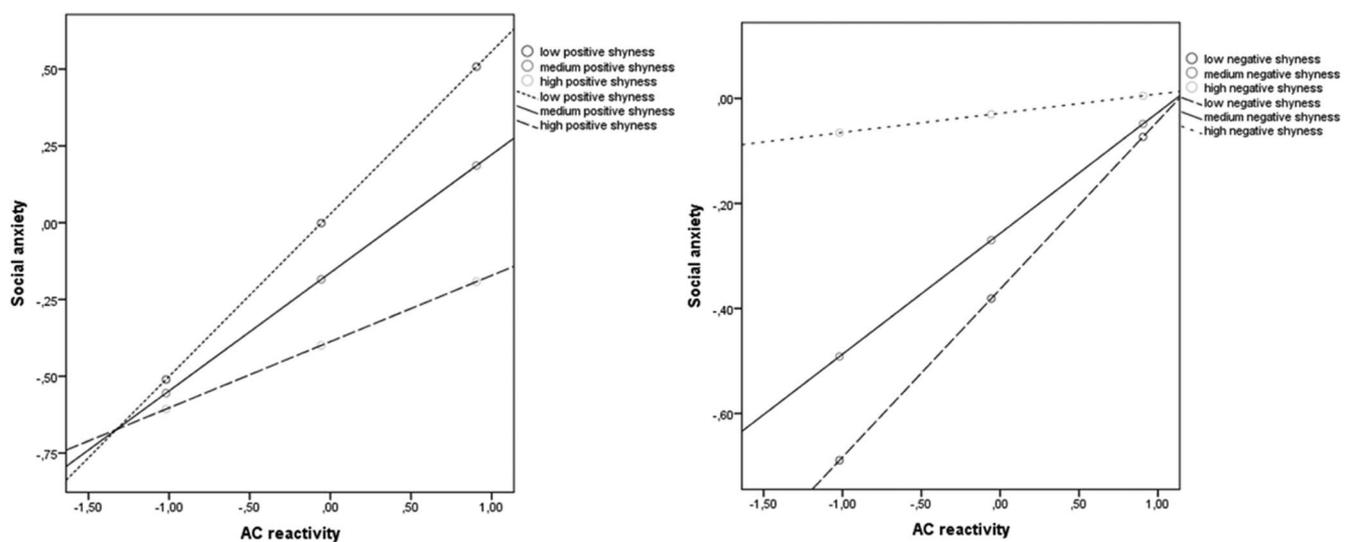


Figure 2. The moderating effect of positive (a) and negative (b) expressions of shyness on the relation between alternating current (AC) reactivity and social anxiety.

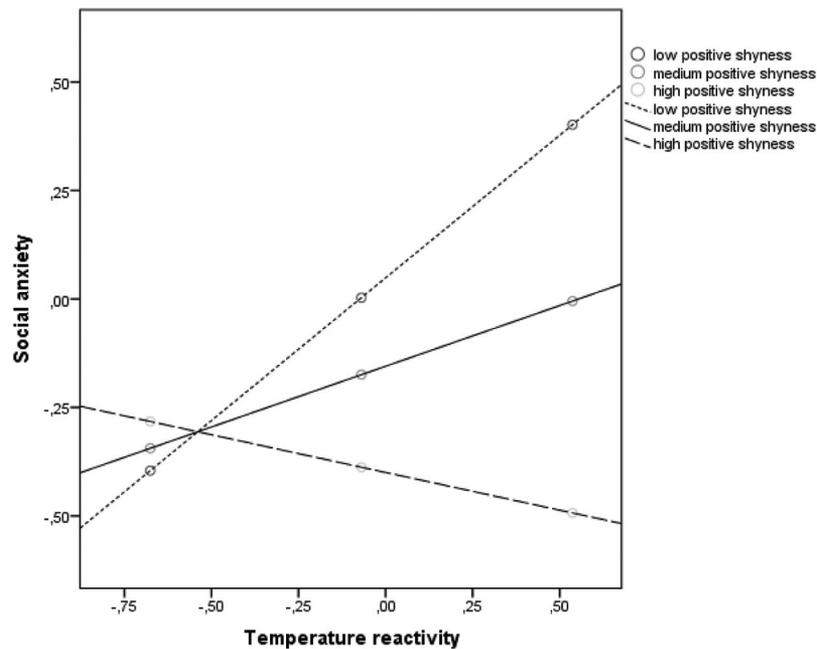


Figure 3. The moderating effect of positive expressions of shyness on the relation between temperature reactivity and social anxiety.

above the mean) and a low number of negative (below the mean) shy expressions ($n = 11$); Group 2 consisted of children who displayed a high number of negative (1 standard deviation above the mean) and a low number of positive (below the mean) shy expressions ($n = 5$); and Group 3 consisted of children with a low number of positive and a low number of negative (mean ± 1 standard deviation) shy expressions ($n = 35$). There were no children who scored high (1 standard deviation above the mean) on both positive and negative shy expressions.

Nonparametric tests were used because of the limited sample size in the three groups. A Kruskal–Wallis H test showed that the three groups of children did not differ in their blushing response (AC reactivity), $\chi^2(2) = 2.58, p = .275, d = 0.43, 95\% \text{ CI} [-0.10, 0.96]$, with a mean rank score of 36 for Group 1 (high positive and low negative shy expressions), 22.60 for Group 2 (low positive and high negative shy expressions), and 28.62 for Group 3 (low negative and low positive shy expressions). However, the three groups of children differed in their social anxiety levels, $\chi^2(2) = 6.78, p = .034, d = 0.58, 95\% \text{ CI} [0.14, 1.01]$, with a mean rank score of 38.30 for Group 1, 60.43 for Group 2, and 42.30 for Group 3. The Dunn–Bonferroni pairwise comparisons showed that children in Group 2 were marginally more socially anxious than children in Group 1 and Group 3, $t = -2.33, p = .059, d = 0.73, 95\% \text{ CI} [-0.02, 1.49]$ and $t = -2.39, p = .051, d = 0.59, 95\% \text{ CI} [-0.0003, 1.18]$, respectively. Children in Group 1 and Group 3 did not differ in their social anxiety scores, $t = -3.98, p = .588, d = 0.16, 95\% \text{ CI} [-0.41, 0.72]$. Furthermore, there was no significant correlation between blushing (AC reactivity) and social anxiety in Group 1 ($\rho = -.03, p = .936$) or in Group 2 ($\rho = -.10, p = .873$). However, a significant correlation between blushing and social anxiety was found in Group 3, $\rho = .42, p = .011$.

Discussion

The present study investigated blushing in young children and its relation to the expressions of shyness and social anxiety. The main results were (a) blushing was related to more positive shy expressions in the performance situation; (b) blushing was related to more social anxiety in children who expressed few positive shy behaviors, but not in children who expressed many positive shy expressions during the social performance; and (c) blushing was related to more social anxiety in children who displayed a low number of negative shy expressions. However, children who expressed many negative shy expressions during the social performance scored high on social anxiety, no matter their blushing.

Blushing indexed as the change in blood volume pulse (AC reactivity) was related to expressions of positive shyness but not to expressions of negative shyness. Both blushing and positive shy expressions are assumed to have an appeasement function in social situations in which an individual experiences competing motivational goals: to avoid the situation due to the heightened arousal and to engage in the situation and interact with the social environment. They serve to weaken other people's possible negative reactions (Castelfranchi & Poggi, 1990; Leary & Meadows, 1991) and to increase affiliative tendencies of other people (Colonnesi et al., 2014; Keltner & Buswell, 1997). Given their remedial role in social interactions, the expected association between blushing and positive shy expressions was confirmed in the present study. Conversely, negative expressions of shyness were not associated with a heightened blushing response. Shyness expressed in a negative way is assumed to mostly represent avoidance motivation. It is displayed through withdrawal, and it is assumed to be a nonadaptive social strategy because it does not allow a child to

engage in a social situation and learn to cope with interpersonal challenges (Colonnesi et al., 2014; Thompson & Calkins, 1996). Possibly, children who display negative shyness during a performance situation are primarily motivated to avoid the fearful social situation rather than to engage in it; experience negative rather than positive emotions; and thus do not display appeasement signs that signal the ambivalence of positive and negative affects, such as blushing.

Blushing measures were not directly correlated to social anxiety and to each other. Only a trend toward a positive correlation between AC and temperature reactivity was found. This result may be expected, as an increase in blood volume pulse should increase the peripheral temperature (Peper et al., 2007). Although some previous studies used DC and temperature measures simultaneously (e.g., Dijk et al., 2009; Shearn et al., 1990; Voncken & Bögels, 2009), no study employed AC and DC measures at the same time. One study reported on the moderate correlation between DC reactivity and temperature (e.g., Dijk et al., 2009). However, Shearn and colleagues (1990) found that DC reactivity was dissociated with temperature response during stimulation intended to evoke blushing, which is in line with our findings. DC reactivity was also not connected to AC reactivity. AC response is, unlike DC response, a fast-changing component of blood flow, which could explain null findings. It is likely that the DC response was delayed compared to the AC and temperature responses.

Because the underlying mechanisms of AC- and DC-related blushing have not been clarified yet, we can only speculate about the absence of the relationship between these two responses. The result that AC and DC reactivity were not correlated to each other and that they were differentially associated with the expressions of shyness (AC reactivity was related to a higher number of positive shy expressions, and DC was not related to any shy expressions) could suggest that AC and DC reactivity underlie two different mechanisms in the blush response. It could be that these mechanisms are differently involved in different types of blushing—namely, AC more with the classic blush, which appears and disappears quickly, and DC more with the creeping blush, which spreads over a period of several minutes (Leary et al., 1992). AC reactivity was also differently associated with social anxiety than DC reactivity, which was not found to be related to social anxiety in any group of children in the present study. One can argue that DC reactivity is possibly more involved in a slowly occurring creeping blush and that the association between creeping blushing and social anxiety does not yet exist in early childhood. As creeping blushing is thought to occur in prolonged social exposure situations (Leary et al., 1992) that are not typical of an early age, it may be that this relationship develops later in life, only when children experience social exposure situations and find blushing distressing. Similarly to our findings, AC was found to be related to social anxiety and to increase from baseline to the social interaction and social performance task in adults (Drummond et al., 2007). However, DC was also found to increase from baseline to the watching-back task in adults (Mulken et al., 1999; Shearn et al., 1990). In the previous studies, the watching-back task (strong stressor) was conducted after the initial baseline, the introduction of the experimenters who were also seated in the room to watch back the participants' performance (mild stressor), and the second baseline. Thus, it is possible that creeping blushing also occurred in this situation in which the participants were exposed to

the experimenters and experienced a prolonged stressful situation. It may be that the two types of blushing are differently involved in different social situations (social interaction, social performance, and watching-back situation); it is also possible that they differ in children and adults. To investigate these hypotheses, research is needed on the physiological underpinnings of classic and creeping blush and their occurrence in different social situations, such as interaction versus performance situations, as well as on their developmental differences and their different relationships to social anxiety. For example, it would be interesting to investigate whether creeping blush has a later onset in development than classic blush and whether it is related more to performance anxiety than to interaction anxiety. Such research is particularly important given the discussion on the two types of social anxiety disorder (SAD): performance only and performance plus interaction anxiety (APA, 2013; Bögels et al., 2010).

Positive shy expressions were negatively associated with social anxiety, and negative shy expressions were positively associated with social anxiety. The finding that coy smiles are protective of social anxiety is in line with the previous findings of Colonnesi and colleagues (2014), who revealed that positive shy expressions are negatively related to social anxiety in the same sample of children when they were 2.5 years old, whereas negative shy expressions, which mostly represent fear, discomfort, and avoidance in socially threatening situations, are indicative of high social anxiety (Asendorpf, 1989; Kashdan et al., 2014; Rubin & Burgess, 2001). Although both positive and negative shy expressions are assumed to serve a regulative function in a socially challenging situation, only positive expressions of shyness seem to be a socially adaptive strategy to cope with this kind of situation because they help a child engage in the social situation, provoke positive feedback from other people, and give rise to positive social experiences (Thompson & Calkins, 1996). On the contrary, negative shy expressions seem to represent a less adaptive coping strategy that is associated with heightened worry in social situations and high levels of social anxiety (Eisenberg & Fabes, 1992).

With respect to the moderation analyses, blushing was related to more social anxiety only in children with few or no positive shy expressions. It is possible that children who blush and express few positive shy behaviors are not able to successfully cope with a challenging social situation because they do not use adaptive social strategies (such as positive shy expressions) in these situations (Colonnesi et al., 2014). Thus, they may experience these situations as distressing, possibly obtain negative experiences in social situations because of the lack of the strategies that increase affiliative behaviors of other people, consequently fear and avoid challenging social situations, and become socially anxious. On the contrary, children who blush in the situation in which they may be evaluated by others but also use positive shy expressions as a social strategy to appease others are more likely to evoke other people's affiliative behaviors toward them and receive positive feedback from their social environment; consequently, they are less likely to experience challenging social situations as threatening and are less likely to become socially anxious.

The analyses also revealed that blushing was related to social anxiety in children who expressed negative shyness infrequently, but not in children who expressed many negative shy expressions. Children with a high number of negative shy expressions were the most socially anxious children. Thus, it is possible that the asso-

ciation with blushing was not found because of the lack of variation in social anxiety in this group of children. This seems to suggest that a negative shy expression, which mostly reflects fear and discomfort, is a maladaptive avoidant strategy and a risk factor for social anxiety in young children. This is in line with previous literature about social inhibition (Asendorpf, 1989; Schwartz, Snidman, & Kagan, 1999) and social withdrawal (Rubin & Burgess, 2001; Rubin et al., 2009). Unlike children with a lot of positive shy expressions, these children do not proactively cope with the challenging social situation in an appropriate way and, as a consequence of this inability, may avoid future socially challenging situations (Colonnesi et al., 2014). Furthermore, children with this maladaptive strategy may elicit negative social outcomes; receive negative feedback from their environment (unlike children who use social approach behaviors, such as smiling; Taylor & Alden, 2011); and gain negative experiences, which in turn may lead to future avoidance of similar situations and heightened levels of social anxiety.

The exploratory analyses also revealed that children with a high or a low number of shy expressions did not differ in their blushing response. However, the extent to which blushing was related to social anxiety differed between these groups of children. Specifically, children who displayed a high number of positive shy expressions and a low number of negative shy expressions were not socially anxious, even when they feared other people's evaluations (and consequently blushed) in a challenging social situation, probably because they used adaptive social strategies to deal with the situation. On the other hand, children who displayed a high number of negative shy expressions and a low number of positive shy expressions scored high on social anxiety, regardless of their blushing. Finally, more blushing was found to be related to more social anxiety in the group of children with a low number of both positive and negative shy expressions. It seems that children who experience fear and blush but do not regulate their fear and arousal through the expressions of shy emotions in challenging social situations do not cope with these situations successfully. Thus, they experience challenging social situations as negative and become socially anxious. It is possible that the inability to regulate emotions that are displayed involuntarily (blush response) may lead to social anxiety already in early childhood and that blushing, when not regulated through shy expressions, may signal high social anxiety already in early childhood.

Because this was a correlational study, the directionality of the effects could not be determined. It can be hypothesized as well that high levels of social anxiety and expressions of shyness lead to blushing in a socially threatening situation. It is, for example, possible that socially anxious children have, already in early childhood, heightened self-focused attention (Bögels & Mansell, 2004); are more sensitive to interoceptive cues; and interpret them in a more catastrophic way (Domschke et al., 2010), which in turn enhances their physiological responses, such as blushing.

A limitation of the present study was the sample, which consisted of middle- to high-class mostly Caucasian families with a relatively high education level, which limited the generalizability of our findings to some extent. Second, the study had a single-age, nonexperimental design, which does not allow for any causal and prospective conclusions about effects of blushing on shyness and social anxiety, and vice versa. Therefore, a longitudinal study that would employ multiple measures of blushing, shyness, and social

anxiety in early and late childhood is needed to reveal the predictive role of blushing in social anxiety and vice versa, and experimental designs are needed to provide more insight into possible mechanisms through which blushing, shyness, and social anxiety influence and reinforce each other.

Conclusions

The present study provides evidence that children who blush but display many positive shy expressions are not socially anxious and suggests that positive expressions of shyness have a regulative and socially adaptive function in coping with undesired social attention and subsequent blushing. The study also shows that blushing, in combination with a low number of positive shy expressions, is related to heightened social anxiety and that negative shy expressions are associated with more social anxiety in young children. It seems that the inability to adaptively cope with socially fearful situations represented as avoidance and withdrawal in social situations is associated with heightened social anxiety in early childhood. This study represents novel research on blushing and its association with the expressions of shyness and social anxiety in young children. However, further research is needed to explore the directionality of the effects in the associations between blushing, shyness, and social anxiety.

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