Does Age and Audience Make the Heart Beat Faster? A Study Into Embarrassment and Pride

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Layman's abstract

Embarrassment and pride are less examined than other emotions, like joy or sadness. Moreover, even less is known about physiological changes that may occur during these emotions—leading to the question: what happens inside the body when a person is embarrassed or proud? It is known that pride and embarrassment develop throughout childhood, and these emotions are bound to (imagined) people around us. Therefore, this study investigated whether there are differences in heart rate changes across ages during feelings of pride and embarrassment. Also, whether a small audience influences heart rate changes. It was expected to find a gradual increase in heart rate acceleration across age for both emotions, where adults have greater heart rate acceleration than children. Additionally, the presence of an audience would lead to more heart rate acceleration compared to being alone in a room when embarrassed or proud. This study investigated 176 individuals of three different age groups: 3.5-5-year-olds, 8-10-year-olds, and adults. All participants performed a singing and a puzzle task to make them feel embarrassed and proud—half of them in the presence of a small audience, the others alone in a room. Results showed a gradual increase in heart rate acceleration across the three age groups during embarrassment. We found no differences between the age groups during pride. Additionally, participants showed no differences in heart rate changes between the groups with an audience compared to the ones without an audience. This result has been found for pride as for embarrassment. Together, the results suggest different physiological development patterns for pride and embarrassment. In addition, it shows that a small audience does not influence the heart rate at different ages when someone feels embarrassed or proud. Future research could focus on other ways to raise embarrassment and pride to increase the intensity. Additionally, studies could include negative or positive evaluations, other physiological measures, or take different cultures into account.

Keywords: self-consciousness emotions, pride, embarrassment, heart rate, development, audience

Abstract

Despite the substantial impact of embarrassment and pride on social relations and situations, little is known about the physiological response accompanying these emotions. Both emotions have an interpersonal character and have a peculiar developmental pattern across childhood. This makes it interesting to investigate the impact of the social context in which they occur and whether there are differences across ages. Therefore, this study aims to identify whether there is a difference in heart rate reactivity across ages during the elicitation of embarrassment and pride. Additionally, we examined whether heart rate reactivity is affected by an audience in the immediate environment. It was expected to find a gradual increase in HR acceleration across ages for embarrassment and pride. Additionally, an audience condition would lead to significantly more HR acceleration than a solitary condition for both emotions. We investigated 176 individuals in three different age groups: 3.5-5-year-olds, 8-10-year-olds, and adults. All participants performed a singing and a puzzle task to elicit embarrassment and pride and were divided into an audience and solitary condition during measurement. Results showed a gradual increase in heart rate acceleration across the three age groups during the elicitation of embarrassment. During the elicitation of pride, we found no differences in heart rate reactivity between the three age groups. In addition, we found no differences in heart rate reactivity between the audience and the solitary condition for embarrassment and pride. The results suggest different physiological development patterns for pride and embarrassment. In addition, it shows that a small audience does not influence the heart rate at different ages. Future research could focus on different types of audiences, emotion elicitors, and the influence of different cultures on a wider range of physiological reactivity.

Keywords: self-consciousness emotions, pride, embarrassment, heart rate, development, audience

Does Age and Audience Make the Heart Beat Faster? A Study Into Embarrassment and Pride

Humans experience emotions that arise in a variety of situations. They play an important role throughout a human's life because they can enrich moments with pleasant or unpleasant attributions, such as winning a competition that made you feel very proud of or being in the centre of attention that made you feel embarrassed. Showing these emotions in social interactions can lead to positive interpersonal outcomes. For example, embarrassment can serve as a remedy for social violations (Keltner & Buswell, 1997) and pride increases prosocial behaviour (Tracy & Robins, 2004a). However, there can also be negative interpersonal consequences. Embarrassment could lead to avoiding situations or people in future similar events (Froming et al., 1990; Krishna et al., 2015), and showing pride in an interpersonal setting can lead to negatively evaluated by others or increase envious feelings (Lange & Crusius, 215; Schall et al, 2016). To understand these behaviours that embarrassment and pride cause it is important to understand how people experience and express these emotions from facial to body expressions to physiological changes that accompany them. Except, little is known about the physiological changes that accompany pride and embarrassment across the lifespan (Kreibig, 2010). Meanwhile, physiological measurements are important to understand age-related changes and differences in response to situational challenges (Sacrey, 2021).

For centuries, theorists have been interested in emotions, but still, there is much debate about the definition. Some researchers tend to agree about diagnostic features that indicate an emotion is occurring. These features are evaluation, physiological changes, expressions, subjective experience, and the disposition to engage in mental and physical actions (Scarantino, 2016). Nevertheless, here, are many questions too. Do these features together define an emotion? Are they causes and effects of each other? Are other features

also involved? Because of this unclarity emotions are often described in terms of meaning, functions, processes or motivations around these features (Lang, 1994; Scarantino, 2016).

One influential theory inspired by the idea that emotions are motivations is the basic emotion theory (Lang, 1994). The basic emotion theory characterizes the diagnostic features in terms of evolutionary adaptations. It explains that humans have biological basic mechanisms for emotions by which they solve domain-specific evolutionary problems. This means that in recurring situations emotions drive us to more focused solutions each time to reach our relevant goals (Ekman & Cordaro, 2011). Which emotions are precisely classified as basic emotions, is still in debate. Tracy & Randless (2011, p. 398) reviewed several classification models and considered the criteria used for classification. They concluded that there is an agreement on the criteria that "a basic emotion should be discrete, have a fixed set of neural and bodily expressed components, and a fixed feeling or motivational component that has been selected for through longstanding interactions with ecologically valid stimuli''. These criteria correspond closely with components Izard (2007) cites, as he explains six basic emotions as natural kinds: interest, joy, sadness, fear, anger, and disgust. As natural kinds they have unique common properties and capacities to motivate and regulate cognition and action. They possess prototypical facial expressions that can be seen as universal, and are accompanied by arousal (Ekman, 1992; James, 1884). Moreover, through the simple cognitive nature, infants already show affective responses that can be categorised as basic emotions (Izard, 2007).

Self-consciousness emotions

In contrast to basic emotions, there are emotions arising later through cognitive development that transform the emotional life of a child. Lewis (1995) categorizes these emotions as self-conscious emotions. These emotions are rooted in social relations that relate to the sense of the self and the reactions of others or imagined others (Lewis, 1995). He

describes three core foundations for a person's ability to experience self-conscious emotions that develop around the end of the second year of life; a sense of self-awareness, the ability to recognize an external standard, and the ability to adapt and recognize that standard. The growing sense of the conceptual self and understanding of the mind coincides with an increase in understanding and processing complex information about social relations (Lewis, 2016). This provides a basis for effective evaluation of actions and establishes connections between someone's own behaviour and the emotional reactions of others (Thompson et al., 2006).

These developments ensure distinct self-consciousness emotions arise at different ages in childhood. Lewis (2016) divides the development of self-consciousness emotions into two developmental stages. He states that first, the so-called 'self-consciousness exposed emotions' arise, followed by the 'self-conscious evaluative emotions'. The first set of emotions seems to be directly connected to the emergence of mental representation of the self, and include embarrassment, jealousy, and empathy. For the second set of emotions, knowledge of standards, rules, and goals within the family and culture are required to develop ideas of responsibility for the child's own thoughts and actions. These self-conscious evaluative emotions include pride, guilt, shame, and hubris. This developmental path is enabled by extensive cognitive and social development and leads to a greater understanding of the self-conscious emotions across the years (Lewis, 1995).

Embarrassment

As stated by Lewis (2016), embarrassment is a first emergence of self-consciousness emotions, and can be defined as "an acute state of clustered, awkward, abashed chagrin that follows events that increase the threat of unwanted evaluations from real or imagined audiences'' (Miller, 1991, p. 129). Embarrassment can be elicited through several situations, like failures of privacy regulation, teasing, or being the object of attention (e.g. being

congratulate, or through someone else's predicament) (Crozier, 1998; Keltner & Anderson, 2000). It can be recognized by a rapid sequential chain of reactions of gaze aversion, attempts at smile control, smiling, and avoidant head movement (Keltner, 1995). Furthermore, a person who is embarrassed can have feelings of awkwardness, and sometimes start to blush, withdraw, or apologize (Keltner & Anderson, 2000). Expressing embarrassment can lead to emotions and behaviours in others that help remedy social violations and, therefore to the reconciliation of social relations (Keltner & Buswell, 1997). Therefore, it can serve as an appeasement function. However, embarrassment is often described as a negative emotion because it is frequently characterized by a temporary loss of self-esteem (Bastin et al, 2016; Fleming, 2012). Self-esteem is again tied to a better psychological well-being. A temporary loss often has negative consequences, like less well-being and a higher reactivity to stressful events (Creswell et al., 2005).

Empirical research shows that children from the age of 2 can already show expressions of embarrassment (Rochat, 2003). However, the understanding of embarrassment at this age is subject to discussion. Some theorists state that children do not learn complex emotional concepts until six or seven (Bennet & Gillingham, 1991; Harris, 1989). The understanding of embarrassment in young children goes along with the growth of self-understanding and understanding of the world around them which increases with age (Bennett, 1989). Bennet states that early in the development of embarrassment, children attribute this emotion to the self through the lack of well-developed social perspective-taking skills. Additionally, he distinguishes between primitive and mature stages of embarrassment. First, primitive embarrassment develops which is caused by others' overt reactions about the self. Secondly, mature embarrassment evolves resulting from others' assumed evaluations of the self. He found evidence that there is a shift from the first to the second stage by the age of 10 (Bennet, 1989). Researchers seem to concur that the understanding of embarrassment

increases through cognitive development. This means that a greater experience of embarrassment may lead to greater emotional understanding and expression and vice versa with age (Harris, 1989). This is in line with the findings of Buss, mentioning that there is an increase in expressing embarrassment between 3 and 12 years old (Buss et al., 1979).

Pride

Pride develops after embarrassment and can be classified as a self-conscious evaluative emotion (Lewis, 2016). Pride involves the maintenance of good feelings about oneself and often linked to the concept of positive self-worth (Griffin, 1995). Moreover, pride is characterized by appraisals of personal achievement, and by some theorists also by the dissimilarity from vulnerable others, promoting a desire to distance oneself from weak others (Oveis et al., 2010). It can be elicited by passing a test, learning something new, or at a younger age, performing something on one's own. Feelings of control and personal responsibility about these positive outcomes are critical for the experience of pride (Isenberg, 1980). Pride can be recognized by ''a small smile, with the head tilted slightly back, fully visible expanded posture (i.e., upper body), and either arm raised or hands on hips'' (Tracy & Robins, 2004a, p. 196). Feelings of pride can reinforce prosocial behaviour, such as interpersonal reciprocity, social justice, altruism, and caregiving (Michie, 2009; Tracy & Robins, 2004a). It increases behaviour directed towards helping another person and promotes social acceptance. However, pride can sometimes be suppressed through the fear of social costs arising through possible negative evaluations of others (Kalokerinos, 2014).

In contrast to embarrassment, there is less discussion about the developmental pattern of pride. Though, it is important to consider that less research has been focused on pride. Researchers indicate that children from approximately 2,5 years old show expressions of pride after succeeding a (new) task, like building a tower or completing a puzzle (Lewis et al., 1992; Stipek, 1992). Besides, children can recognize pride expressions by the age of 4

(Tracy et al., 2005). Children's conceptual knowledge of pride relies further on the development during middle to late childhood, which spans the ages between 6 till 11 years (Ruble & Frey, 1991). During this period there is a change of identifying personal control of the outcome of situations. Thompson (1989) showed in a study that children of 7 still often attribute success of tasks to external causes rather than internal factors. This means that, for example, they are more likely to link their success to luck than effort. After the age of 7 there is an increase in acknowledgment of personal control and that the self is responsible for an event. This is, as earlier stated, an important characteristic of feeling pride (Isenberg, 1980). Further, the development maintains an enhancement in perceived self-efficacy in controlling pride expressions between 10-11 and 16-17 years old (Web et al., 2016).

Heart Rate

It was established early in the history of emotion research that emotions are accompanied by physiological changes, like a change in heart rate (Cacioppo, 2000; James, 1884). Heart rate (HR) describes the frequency of the cardiac cycle and is estimated as ''the number of R-wave events (heartbeats) per unit time on the electrocardiogram (ECG)'' (Barbieri et al., 2005, p. 424). Through circumstances, like emotion-eliciting situations or stimuli there is cardiac reactivity resulting in HR changes. This cardiac reactivity is bidirectional and can be described as an acceleration or deceleration in HR. The autonomic nervous system (ANS) regulates HR reactivity in the short term to cope with everyday situations (Kreibig, 2010). The ANS includes the parasympathetic nervous system (PNS) and the sympathetic nervous system (SNS). The PNS ensures deceleration of the HR and is activated when the body is at rest and keeps the regulation balanced. The sympathetic nervous system (SNS) ensures acceleration of the HR and is activated during physiological stress and emotional response (McCorry, 2007). An emotional provoking situation can elicit an emotional response, leading to a change in the activation of different systems of the ANS,

which then results in a change in HR (Kreibig, 2010).

There is still debate about whether there is a specific pattern of activation in the ANS during different emotions. Taking a functional approach to autonomic emotion responding, it is reasoned that emotions are linked to different goals. Emotions need a differentiated range of autonomic activity to prepare the body to serve these different goals (Stemmler, 2004). Therefore, if one emotion has a different goal than another, it could be accompanied by a differential response in HR. However, some researchers state that there is only emotion valence HR differentiation, which means that positive vs. negative emotions can be differentiated (Taylor, 1991). Others suggest HR differentiation is based on emotional systems, where approach-related emotions (happiness, anger) contrasts withdrawal-related emotions (sadness, fear) (Cacioppo et al,. 2000). There is also a trend of research supporting the notion of autonomic specificity for basic emotions (Ekman et al., 1983; Stemmler, 2004). Whereas the discussion continues, empirical research shows HR changes during many emotions (James, 1884; Kreibig, 2010).

Embarrassment

Several studies show that HR reactivity accompanies embarrassment. Research by Tangney et al. (1996) found a typically accompanying set of physiological reactions, including blushing and increased HR. Gerlach et al. (2003) examined subjects' HR during an embarrassment-eliciting task. The task involved subjects watching a previously made videotape of themselves singing. The results show that during the experience of embarrassment, the HR increased, supporting the idea of heightened sympathetic activation of the ANS. In contrast, Harris (2001) found that HR returned to baseline levels during the second minute when eliciting embarrassment in a similar two-minute embarrassment task. This could mean that embarrassment entails both the activation of the SNS and the PNS. The findings of an increased HR during embarrassment are supported by valanced emotions

research, which states that the SNS is active in the body during negative feelings, leading to an increase in HR (Kreibig, 2010).

Pride

Cardiovascular physiology during pride comprises a less strong reaction of the ANS, resulting in lower cardiac reactivity during pride compared to embarrassment (Fourie et al., 2011; Stellar et al., 2015). Stellar et al. (2015) investigated physiological changes associated with the experience of compassion. They included a stimulus that evoked compassion, but also a stimulus that elicited pride and a neutral stimulus. Results show that the HR did not differ sufficiently between the pride and neutral stimulus. Fourie et al. (2011) who examined the cardiovascular physiology of pride found similar results. In their research, they assigned female participants into three different conditions, guilt, pride and a neutral condition. The participants performed a social interaction task that elicited the emotion linked to their assigned condition. The participants in the pride condition showed a slight acceleration in HR but this did not significantly differ from the neutral condition. Nevertheless, Herrald & Tomaka, (2002) showed in their study a modest HR acceleration during pride elicitation. They compared cardiovascular reactivity during pride with the reactivity during two negative emotions, anger and shame, and a neutral stimulus. Results indicated lower cardiovascular arousal accompanying pride compared to anger and shame but higher HR reactivity relative to the neutral stimulus. In contrast, research of Gruber et al. (2008) found a small deceleration in HR during pride eliciting tasks. This finding is in line with research on positive feelings, which shows an activation of the PNS during positive emotions, leading to a decrease in HR (Kreibig, 2010). After all, it seems that HR reactivity during pride is small and results in research are contrary to the direction of the HR changes.

Audience

Self-consciousness emotions are elicited by the physical social environment. As stated earlier they are often seen as inherently social (Hart & Matsuba, 2007), and rooted in social relations that relate to the sense of the self and the reactions of others or imagined others. The physical presence of an audience increases the chance of being negatively socially evaluated or judged in a particular situation (Dickerson & Kemeny, 2004). Therefore, the presence of an audience could affect self-consciousness emotions. Already in the second year of life, the presence of an audience causes changes in behaviour through the feelings of being evaluated (Botto & Rochat, 2019; Holodynski, 2004). For example, a 4-year-old tends to comply with the opinion of the majority in public, but not in private (Haun & Tomasello, 2011). In adults an audience affects many daily life activities, like shopping behaviour (Griskevicius et al., 2010; Krishna et al., 2015), and avoiding certain situations or people (Froming et al., 1990; Krishna et al., 2015) which are often accompanied by the emotions pride and embarrassment. An audience not only influences behaviour but also affects physiological arousal. When performing a stressful task, an audience condition produces significantly stronger cortisol response and a heightened HR compared to a no audience condition (Taylor et al., 2010). An emotion-eliciting situation could be seen as stressful where the feelings of evaluation through an audience affect the HR of a person.

Embarrassment

Already in the definition of embarrassment, the importance of evaluations of others or imagined others emerges (Miller, 1991). However, the differences between situations or conditions with or without an audience are not clear and still under-investigated. Previously, it was thought that an audience was necessary for embarrassment, though later it emerged that people could also feel embarrassed in a private setting (Krishna et al., 2015). Studies focusing on physiological measurements show that people felt more embarrassed performing

in front of an audience and participants showed a greater increase in HR (Miller & Fahey, 1991). Shearn et al. (1992) investigated participants who watched themselves sing a song on a recorded video of themselves in the presence of an audience. Cheek and ear coloration, and cheek temperature increased significantly during the embarrassing video compared to the fearful video. Furthermore, the intensity of the cheek coloration increased as the size of the audience extended from one to four. Later research by Krishna et al. (2015) investigated participants who responded to item questions meant to capture the physiology of embarrassment from an in-public vs. in-private context. The questionnaire contained two physiological measures; "I would feel my face turning red" and "I would feel the blood rushing through my body" (Krishna et al., 2015, p. 480). Results showed that the audience condition was more strongly characterized by physiological reactions than the solitary condition. Bosch et al. (2009) examined HR during an embarrassment task. There were three conditions; no audience (control), 1-audience condition, and 4-audience condition. Results show that in each condition with a larger audience, there is significantly more embarrassment experienced and HR accelerated per condition.

Pride

As for embarrassment, researchers emphasize the importance of an audience for the emotion pride (Lewis, 2016; Van Osch et al., 2016; Van Osch et al., 2019). Still, even less is known of the influence of an audience on the experience, expression or physiological arousal that may accompany pride. A study by Van Osch et al. (2016) shows that the expression of pride can depend on culture, and whether someone belongs to the in-group or out-group. Another study by Van Osch et al. (2019) investigated whether pride expressions of individuals depended on the relevance of the audience. They found a small, but significant results. When the observer was irrelevant to the participant less pride was expressed by participants compared to the when the audience was relevant. It seems that individuals

selectively moderate pride expressions. They inhibit, or suppress, their pride expressions depending on an audience. This is an emotion regulation technique and could have effect on physiological reactivity when feeling proud. However, suppressing emotions does not have strong or consistent impact on physiological reactivity (Gross, 1998; Gross & Levenson, 1997). An audience can therefore have an effect on the expression of pride, and regulating emotion could have an effect on physiology. No studies yet show a direct relationship between audience and pride and the HR changes induced.

The present work

It is clear that embarrassment and pride follow a developmental path and that an important social aspect is embedded in these emotions. Despite this, little to no research has been done into HR reactivity during embarrassment and pride, how this can differ with age and the influence of an audience. Nevertheless, it is valuable to investigate this topic. Learning more about the developmental course and the effect of audiences could inform interventions which are especially focused on moral, social, and affective well-being for children with temperament or interpersonal emotional issues. It is important to know whether this interpersonal element is part of the physiological experience at different ages to understand better embarrassment’s and pride's ensuing function and behaviours.

Therefore, the aim of this study is to identify whether there is a difference in HR reactivity expressed in BPM across age during the elicitation of embarrassment and pride. Additionally, we will examine whether changes in HR are influenced by the presence of a small audience. For this reason, the following research questions will be investigated: Is there a difference in HR reactivity between three age groups (3,5–5 yo; 8–10 yo; adults) during the elicitation of embarrassment and pride? Secondly, is there a difference in HR reactivity when a person experiences these emotions alone versus in the presence of a small audience?

Firstly, it is hypothesized that with an increasing age, embarrassment and pride are

accompanied with a greater HR acceleration. This results in the pattern that the HR increases from young children (3,5-5yo), to older children (8-10yo), and will be the highest in adults. This hypothesis is based on theories suggesting that the development of the self and increasing social and cognitive function across age underlies the development of these self-conscious emotions (Bennett, 1989; Harris, 1989; Ruble & Frey, 1991). Additionally, on findings where embarrassment and pride were accompanied by an acceleration in HR (Fourie et al., 2011; Gerlach et al., 2003; Herrald & Tomaka, 2002; Tangney et al., 1996). A better understanding could lead to a more intense emotion experience which may be in line with more arousal resulting in a higher HR acceleration across age (Thompson, 1994).

Secondly, it is expected that embarrassment and pride will be accompanied by a higher HR reactivity in the audience condition compared to the solitary condition. Participants in the audience condition will show greater acceleration in HR. This expectation is based on the previous studies showing that an audience leads to an increased sense of embarrassment and increased HR (Miller & Fahey, 1991; Krishna et al., 2015; Shearn et al., 1992). Additionally, that individuals suppress feelings of pride more in the presence of others which could lead to activation of the SNS (Gross, 1998; Reissland, & Harris, 1991).

Finally, it is hypothesized that there will be an interaction effect between age and audience for embarrassment and pride. With regard to embarrassment, it is expected that audience has the greatest effect on adults, followed by the 8-10yo children, and the smallest for the 3.5-5yo children. This hypothesis is based on findings that 5-year-old children were not embarrassed in the presence of a passive audience, whereas children between the age of 8 – 10 were (Bennett & Gillingham, 1991). Besides, through development and understanding of embarrassment, the effect of an audience will be the greatest for adults (Bennett, 1989). For pride, it is expected that the effect of audience will be greatest in 8-10yo children, followed by the 3,5-5yo children, and the smallest for adults. This is expected because of the

increasing understanding of pride and the environment across childhood. Additionally, on research that suggest an audience is more important for the experience of pride in children till the age of 11 because of the need for external recognition of their accomplishment (Seidner et al., 1988). Therefore the adult group is expected to have the smallest reactivity in HR taken audience into account, compared to the younger age groups.

To investigate the hypotheses, participants will be compared by looking at the outcome variable HR in beats per minute (BPM) measured during the elicitation of embarrassment and pride. Three age groups are included; 3.5-5-year olds, 8-10-year olds and adults and will be compared to explore the possible HR changes that accompany the development pattern. To identify audience effects, the group will be randomly divided into two conditions: the audience and the solitary condition. This thesis is part of larger research project where more psychological measures (e.g. skin conductance and cheek temperature) and facial expressions are investigated. In the method section, only the parts relevant to the research question above will be detailed.

Method

Participants

In total 176 participants engaged in the whole experiment, 89 males and 87 females. There were 54 young children between the 3,5-5 years old (M_{age} = 4.15, SD = 0.53), 49 older children between the 8-10 years old (M_{age} = 8.94, SD = 0.61), and 73 adults (M_{age} = 23.39, SD = 4.89). 50% of the participants were allocated to the audience group (N = 89) and 50% to the solitary group (N = 87). Exclusion criteria were vision problems and current treatment or medication use for a psychological disorder. The data of six participants was declared invalid because the participant requested to stop before the end of the experiment. Therefore, they were excluded from the analysis. Participants were recruited through social media, e.g., Facebook, the University of Leiden, and reaching out to elementary schools and child care

facilities. All adult participants were offered 7.50 euros for their participation and, if necessary, reimbursement of travel expenses, children were offered a small toy and a "Young Scientists" certificate. Students of the University of Leiden could receive research credits for their participation. Before recruiting the participants, ethical approval was obtained from the Ethical Committee of Leiden University. Before the experiment, the participant signed the informed consent. If the participant was underaged the parent or guardian signed the form. It was explained that there were three phases in the experiment and the duration of the experiment took approximately 45 minutes.

Design

In order to answer the research questions, a quantitative experimental lab study is performed to test the effects of age and audience on HR during the elicitation of embarrassment and pride. Age and audience serve as the between-subjects categorical variables. Age included three participant groups: young children (3.5-5yo), older children (8-10yo), and adults. Besides audience entailed two conditions per participant group; audience vs. solitary. Here, a participant was alone in the solitary condition, and in the presence of the two researchers in the audience condition, during the measurement. This together led to a 3 x 2 research design for pride and embarrassment with the dependent variable HR reactivity.

Apparatus

The mental rotation task is presented with Psychopy v3.0 (Pierce et al., 2019) software on a Dell OptiPlex 3060 computer connected to a Dell OptiPlex 3060 monitor. The participant's responses to the program were entered using a keyboard connected to the computer which was located in front of the participant. The mental rotation task, as the social performance task was recorded with a Sony Handycam HDR-CX240, which was fixed on a tripod. The camera recorded sound and vision.

The edited video which was shown during the measurement was played on another

Dell OptiPlex 3060 computer connected to a Dell OptiPlex 3060 monitor. To present the video on the computer the software E-Prime v3.0 was used. During the video, HR was measured using three Ag/Cl disposable isotonic electrodes (BIOPAC) connected to a BIOPAC MP150 with the ECG100C (ECG) module. One electrode was placed under the right collarbone, one on the left on the bottom rib, and one on the right just below the ribs (Meekel, 2020). To acquire, store and retrieve this data Acqknowledge v5.0 software (Goleta, 2008) was used. HR data was analysed and processed with the PhysioData Toolbox (Sjak-Shie, 2019).

Procedure

Phase 1 – Pride-Inducing Task

First, the participant performed a mental rotation task. This task is consistent with another study that found that completing a puzzle elicits pride (Williams, 2009). The task was age-appropriate in terms of difficulty, and therefore different for the age groups. During this task, the camera was focused on the back of the participant performing the task. The camera recorded video and sound.

The mental rotation task for the youngest age group (3.5-5yo) was a physical puzzle with false-positive feedback and lasted about 4 minutes. Participants used colored puzzle pieces to recreate a particular shape that the researcher showed them (see Appendix A). The participant sat at a low table facing the researcher were he performed the task. After showing the figure, the child had to complete the puzzle as quickly as possible by placing the correct puzzle pieces in the correct place in the image. For each puzzle, only the necessary pieces were presented to the participant. They were told that they had a maximum of 20 seconds to complete a puzzle and the time used was noted to calculate their overall performance. The first round was a practice round after additional explanations were given if needed. After this, the task began. In each round, the researcher pretended to set the timer to give the impression

that the task was actually timed, but did not let the timer ever sound such that the participant always finished the puzzle 'within' the time limit. The researcher pretended to note the performance time between the puzzles, but no feedback was given. There were four puzzles in total, excluding the practice round. After the fourth puzzle, the child received false positive-feedback, even if the puzzle was not done correctly. The researcher told the child: "You scored better than all the other children! Also, you were faster than all the other children! Very well done!".

The pride task for older children (8-10yo) and adults involved a mental rotation task on the computer. This entailed the participants sitting on a chair in front of the computer screen and performing a series of mental rotation exercises (10 puzzles for the children, 22 puzzles for the adults). In each exercise, one image of a monkey (8-10yo) or a three-dimensional block formation (adults) was displayed below a horizontal black line on the screen (see Appendix A). At the same time, two rotated images of the same monkey or three-dimensional block formation were displayed above the horizontal line. One of these two rotated images was also mirrored and therefore not identical to the image below the line. By pressing a key on the keyboard participants needed to choose as quickly as possible the identical image. The participants were told that the computer would calculate their score based on their time response and accuracy compared with the score of participants who completed the task previously. First, there was a practice round, where the participant was informed that he or she had endless time to answer. No feedback was given between the exercises. After the last exercise, the children (8-10yo) heard they scored “better and faster than everyone their age”, and the adults heard that they “scored better than 87% and faster than 85% of their age”.

Phase 2 – Embarrassment-Inducing Task

Immediately after, the participant performed a social performance task, which was the

same for all age groups. For this task, the participant was instructed to stand on a marked dot in front of a camera and sing a song for one minute. This could be one or multiple songs. Meanwhile, they were recorded with a video camera, where the participant could be completely seen on the video. Past research has shown that being instructed to sing a song and view back their performance of themselves successfully induces embarrassment (Gerlach et al., 2003). If the child did not want to sing a song without the parent then the parent was allowed to stand next to the child for support.

Phase 3 – Viewing phase

Hereafter, the researcher trimmed the stimulus videos in another room. The video included both recordings of the tasks and twice a neutral stimulus. The neutral stimulus entailed a video of calm swimming fish without sound. Every stimulus had a duration of 1 minute, such that the total video had a duration of 4 minutes. The first and third minute included both the neutral stimulus that served as the baseline and the recovery interval for the next emotional stimulus. The second and fourth minute included recordings of the social performance task and the mental rotation task, in counterbalanced order.

After the video was prepared, the participant was asked to sit down in front of the stimulus screen. Then, the electrodes were attached to the body. The ECG was tested to make sure the electrodes were connected properly to obtain a valid measurement. Participants were instructed to stay seated and to look at the stimulus screen. Based on the condition, the researcher left the room (solitary condition) or stayed in the room where a second researcher was also present (audience condition). In the audience condition, the participant was told that the researchers both remained in the room and were going to watch the activity in his or her body that appeared on another screen. Both researchers sat on chairs approximately 2 meters from the participant avoiding interaction with the participant or each other. In the solitary condition, only the participant was in the experiment room. The parent left the room

regardless of the condition. Then the video started, and the HR measurement took place. After the video, the measurement was done. The electrodes were removed from the body, and the experiment was finished. Last of all, the participant was debriefed and informed about the content and goals of the study.

Data Analysis

The raw HR data was processed with the software PhysioData Toolbox (Sjak-Shie, 2019). First, the data was visually inspected to ensure the toolbox properly identified heartbeats and corrections were made when necessary to eliminate abnormal deviations. The toolbox transformed the raw data into means of HR per 60-second time segment. This resulted in 4 HR means (in BPM) per participant (baseline, recovery, pride, embarrassment). The baseline and recovery measurement where used for baseline correction to reduce the effect of drifts. HR reactivity entailed the relative change between the HR mean during the baseline/recovery period and the HR mean from subsequent emotional stimulus given. Two Two-Way ANOVA'S were conducted using statistical software analysis JASP 0.16.2.0. The data was checked for assumptions of normality, homogeneity of variance, and independence. Eta-squared is reported as a measure of effect size.

Results

Only participants who completed all phases of the study were included in the analysis. Through missing data of 6 participants, the analysis was conducted with 176 participants. Then, the dataset was explored to check the assumptions. The assumptions of normality were violated by looking at the Shapiro's Wilk tests (W_{pride} = .923, p < .001, W_{emb} = .985, p = .050). However, the Shapiro's Wilk test is considered over-sensitive in large groups and the ANOVA is quite robust against violations when group sizes are larger than 15 (Allen et al., 2014). Additionally, the Q-Q plots indicated that the assumption of normality was not extremely violated for embarrassment and pride. Therefore, normality was assumed.

The assumption of homogeneity of variance was met considering Levene's test statistics for embarrassment, $F(5, 170) = 1.880$, $p = .100$, and pride $F(5, 170) = 2.117$, $p = .066$. The observations were independent of each other, which means the assumption of independence was also supported. Last, two extreme scores were identified. Therefore, the following analyses were conducted with and without the extreme scores. Removing the extreme scores did not lead to statistically different outcomes. For this reason, it was decided to preserve the extreme scores and present the results with these included. Two 2 x 3 ANOVA's were performed to investigate the effect of age and audience on HR reactivity during pride and embarrassment.

Embarrassment

The ANOVA showed a significant main effect for age, $F(2, 170) = 3.247$, $p = .041$, $\eta 2 = 0.04$. A Tukey post hoc revealed a significant difference ($p = .032$) between the adults and young children (3,5-5yo) of 2.39 %, where the HR in the young children relatively decelerated by 0.93 % ($M = -0.93$, $SD = 4.40$), and the HR in the adults relatively accelerated by 1.48 % ($M = 1.48$, $SD = 6.13$). Besides, the older children group showed a relative acceleration in HR of 0.35 % ($M = 0.35$ $SD = 4.50$), but did not significantly differ from the young children ($p = .449$) or the adult group ($p = .466$). Figure 1 shows the results of the main effect of age on HR reactivity.

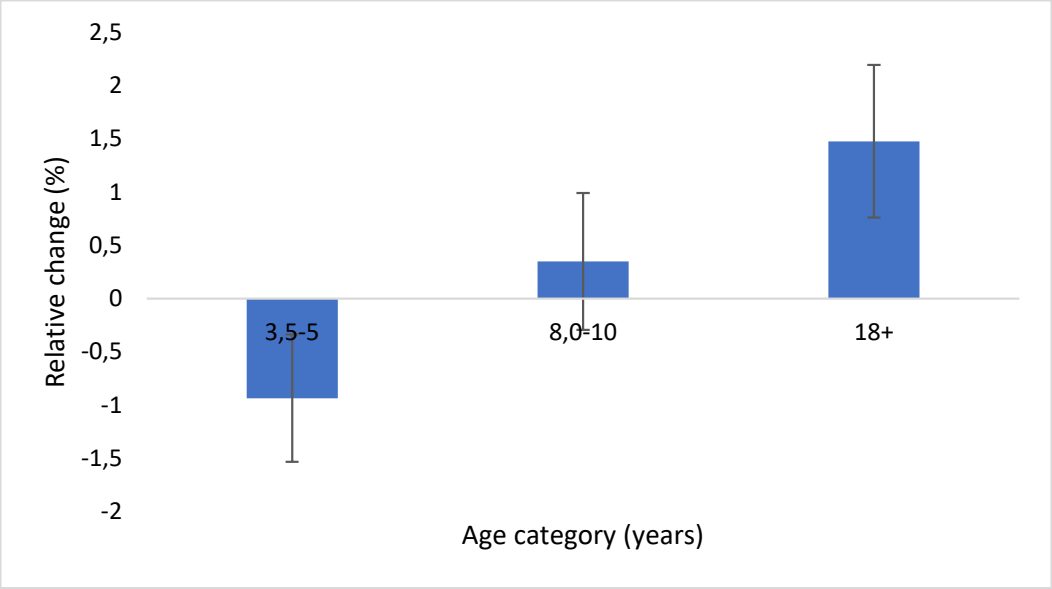

Figure 1. The mean HR change during the elicitation of embarrassment divided by age condition. The error bars represent standard error with 95% confidence intervals.

Furthermore, no significant main effect was found for audience on HR reactivity, $F(1, 170) = 1.528$, $p = .218$, $\eta 2 = .009$. This indicates that the audience condition did not differ in reactivity compared to the solitary condition when eliciting embarrassment. Besides, no significant interaction effect was found for age and audience, $F(2, 170) = .130$, $p = .879$, $\eta 2 = .001$. Figure 2 shows the results divided by all separate conditions for embarrassment. Overall, the results show that there is greater acceleration in HR for adults compared to young children and no difference in HR reactivity between the audience versus the solitary condition during the elicitation of embarrassment.

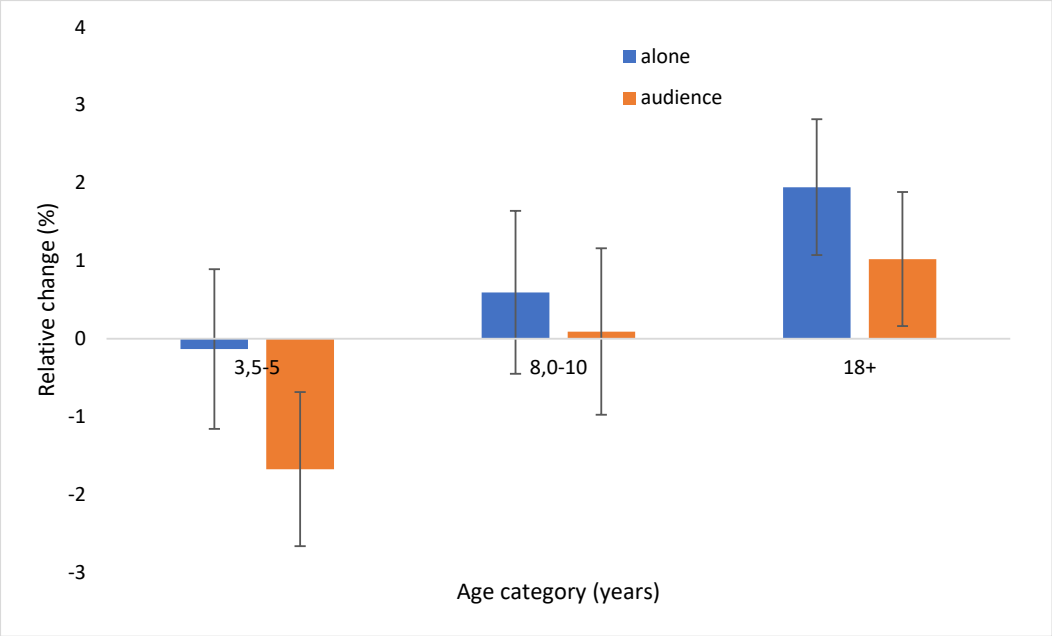

Figure 2. The mean HR change during the elicitation of embarrassment divided by age and audience condition. The error bars represent standard error with 95% confidence intervals.

The ANOVA showed no significant main effect of age, $F(2, 170) = .358$, $p = .700$, $\eta 2 = .004$, nor a main effect of audience on HR reactivity during pride, $F(1, 170) = .405$, $p = 0.525$, $\eta 2 = .002$. Meaning no significant differences in HR reactivity between the different age and audience groups. Furthermore, no significant interaction effect was found for age and audience $F(2, 170) = .943$, $p = .391$, $\eta 2 = .011$. Meaning that age or audience did not influence the effect of the other independent variable on HR reactivity. Figure 3 shows the results divided by all separate conditions for pride. Overall, results show that there are no differences in HR reactivity between the three age groups, nor between the audience conditions during the elicitation of pride.

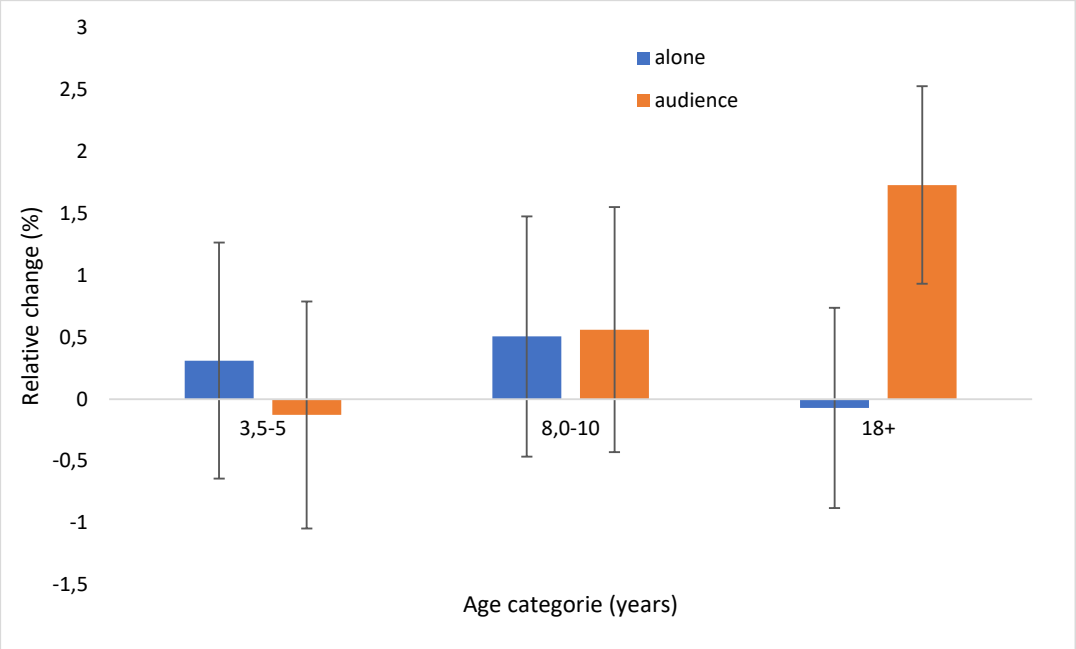

Figure 3. The mean HR change during the elicitation of pride divided by age and audience condition. The error bars represent standard error with 95% confidence intervals.

Discussion

This study investigated whether age affects HR reactivity during the elicitation of embarrassment and pride. Additionally, we examined if a small audience influences HR reactivity. Firstly, the expectation was that with increasing age, embarrassment and pride accompany a greater HR acceleration. The HR acceleration increases from young children (3,5-5yo) to older children (8-10yo) and will be the highest in adults. Results show a gradual increase in HR acceleration across the three age groups during the elicitation of embarrassment. Therefore, the hypothesis of age effect on embarrassment is supported. However, we found no difference in HR reactivity between the three age groups during the elicitation of pride. Hence, the hypothesis of age effect on pride is not supported.

Secondly, we expected that embarrassment and pride would be accompanied by a higher acceleration in HR in the audience condition compared to the solitary condition. The results showed no difference in HR reactivity of participants in the audience compared to

solitary conditions during both emotions. Therefore, the hypotheses of audience effect on HR during the elicitation of embarrassment and pride are not supported.

These results expand knowledge about embarrassment and pride, especially during early and middle childhood, and contribute to developmental literature. It shows cardiac differences between age groups during embarrassment, which may indicate that the development of embarrassment is accompanied by an acceleration in HR increasing by age. Additionally, it shows that pride has no differences in HR reactivity across ages; despite behavioural and cognitive differences (Thompson, 1989; Web et al., 2016). Young children, older children, and adults have no differential HR reactivity when proud. Furthermore, it seems that a small audience does not lead to differentiate HR reactivity in contrast to a solitary condition. This is the opposite of what is often mentioned as important for these emotions in the literature (Lewis, 2016; Miller, 1991). Also, an audience has no other effect on HR reactivity in the young children, older children, and the adult group compared to no audience.

Age-related effects on embarrassment and pride.

There have been no previous studies on measuring HR reactivity during embarrassment that include different ages, from young children to adults. As a result, expectations were mainly based on cognitive and social development during childhood based on the ideas of Bennett (1989) and Harris (1989) and the idea that this would lead to more intense emotions and cardiac reactivity. Self-consciousness emotions are more than basic emotions bounded to cognitive events as elicitors. The more an individual is capable of experiencing a situation in their thoughts and understanding the social factors that play a role, the more the person feels embarrassed. As Lewis (1995, p.75) describes, "It is the way people think or what they think about that becomes the elicitor of pride". Cognitive and social development during childhood leads to a better understanding and differences in thoughts

about the embarrassment and associated feelings. A better understanding of embarrassment could also mean that the fear of (imagined) social evaluation and threat is growing. In contrast to children, adults have a more sophisticated understanding of social standards and understand that others' opinions may have lasting consequences, like rejection (Botto & Rochat, 2018). Therefore, it may be that the attention of others when a person feels socially threatened can be more intense for adults than for a child. Additionally, there is a relationship between social evaluative threat and HR (Woody et al., 2018). The HR is higher when a person feels greater social evaluative threat during negative affect. More research is necessary considering negative evaluation after embarrassing situations where children and adults are included to conclude whether this explains differences across ages.

Despite the developmental pattern of pride, differences in HR reactivity over age were not obtained. No previous research was conducted on HR in children during pride elicitation. Therefore, these results give a first impression of HR reactivity in childhood during the elicitation of pride. A possible explanation for this result may be related to pride's small, physiologic reactivity, which can be explained by looking at emotion valance. Embarrassment is often experienced as a negative emotion and pride as a positive emotion (Kreibig, 2010). There is negativity dominance when considering the valance of emotion (Rozin en Royman, 2001). This means that emotions with a negative valance are more powerful at eliciting related cognitive and perceptual responses than positive emotions. Negative information dominates the cognitive system because the purpose of negative emotions is often related to survival and can therefore be seen as more important than positive emotions (Baumeister, Bratslavsky, Finkeauer Vohs, 2001). Positive emotions, like happiness, are accompanied by less physiological arousal than negative emotions (Kreibig, 2010). This phenomenon is in line with earlier research showing little physiological response during pride (Fourie et al., 2011; Herrald & Tomaka, 2002; Steller et al., 2015). Because

there is probably low reactivity across all ages, there are also no significant differences in reactivity.

Furthermore, it appears that the intensity of emotion is highly related to the relevance of the stimuli to a person. When a person is exposed to a stimulus that is more relevant to the self, the individual shows greater emotional reactivity accompanied by greater physiological responses (Kunzmann & Grühn, 2005). An earlier explained study by Van Osch et al. (2019) also revealed that individuals' pride expressions depend on the audience's relevance. When the observer is irrelevant to the participant, participants express less pride than in the presence of a relevant audience. Moreover, it appears that the relevance of an emotional stimulus can be linked to particular ages. For young children, it is emphasized that they are motivated to get a better evaluation of close relationships, like their parents (Alessandri & Lewis, 1993; Larson et al., 1996). As children age, this changes, and they value the evaluation and opinions of their peers more (Larson & Richards, 1991). At a later age, knowledge-focused goals are more important (Carstensen et al., 1999). In our study, all participants got a mental rotation task, which in previous research proved to elicit pride (Williams, 2009). However, differences between ages might depend on the motivation and relevance of a situation or task that provokes pride.

Audience-related effects on embarrassment and pride.

Interestingly, we found no audience effects during embarrassment and pride elicitation, while an audience is noticed as an important contextual factor for both emotions (Lewis, 2016; Miller, 1991). The finding contradicts similar research by Gruenewald (2014) on shame. He investigated cognitive, emotional, and physiological responses to the performance of stressor tasks and the influence of social-self threat. Gruenewald (2014) considered HR to assess changes during stress arousal elicited by speech and mental arithmetic tasks. He found that greater social-evaluative threat, represented by an evaluative

audience compared to no audience, resulted in higher intensity of shame, decrements in social self-esteem, and higher HR reactivity. Shame can be differentiated from embarrassment; however, they are both self-conscious emotions, belong to the same family of moral emotions, and are negatively valence (Haidt, 2003). So, it may be that they have physiological similarities. Additionally, Tangey et al. (1996) found even greater increased HR during embarrassment in contrast to shame. One possible explanation for the contradicting findings of Gruenewald (2014) and this study may be that he unfriendly and negatively evaluated the participants. Whereas our study's audience was neutral, and the participants were not explicitly evaluated. Maybe more outstanding (negative) reaction or audience evaluations is necessary to elicit HR reactivity. This idea is supported by the research of Lewis & Ramsay (2002), who investigated cortisol response in 4-year-old children during the elicitation of embarrassment. They made a distinction between evaluative and exposure embarrassing situations. Evaluative embarrassment was elicited by negative evaluation of the self, and exposure embarrassment was elicited by being the object of attention, like dancing in front of someone else. They demonstrated a higher cortisol response in evaluative embarrassment compared to exposure embarrassment. This result could mean that with a higher degree of evaluation, more stress is generated because a person feels more socially threatened, leading to an acceleration in HR (Taylor et al., 2010). Another study that fits this idea is conducted by Bennet and Gillingham (1991), who showed that feelings of embarrassment could depend on the presence of an active vs. passive audience. The active audience drew negative attention to the participant, and the passive audience did not overtly respond to the participant's situation. Participants attributed embarrassment to the self when the audience was active, while with a passive audience, they did not.

The result found for pride, that is, no audience differences during pride can be supported by the research of Seidner (1988). In his research, children from the fifth year of

life often indicated that the outcomes of a task were mainly attributed to themselves. This self-attribution indicates that pride is less dependent on the positive evaluation of others than embarrassment on negative evaluation. Further, this idea is in line with the findings of Müller-Pinzler et al. (2015). They revealed that exposing one's performance to the audience increased self-reported experiences of embarrassment but did not affect experiences of pride. Their neurophysiological research also indicated that when participants' failure was exposed to the public, they felt more embarrassed and showed signs of sympathetic activation. This effect was not evident for pride when accomplishment was exposed to the public.

Another possible explanation could be that the audience group, which consisted of 2 individuals, was too small to elicit enough emotional intensity to cause HR reactivity. Previous research presented that a 4-person audience can lead to significantly more physiological reactivity and stress during embarrassment compared to a 0-, 1- or 2-person audience (Bosch et al., 2009; Shearn et al., 1992). Also, Tangney et al. (1996) indicated that embarrassment is more likely to happen with a larger audience than with a smaller audience. Such studies that observe different audience sizes are still missing concerning pride. Because of the evaluative aspect of both emotions, it could be that this is also applicable to pride.

Limitations and further research

A limitation of this study is that it is not known to what extent embarrassment and pride were elicited. It is questionable if watching the video in the viewing phase elicited a sufficient intensity of embarrassment and pride. No self-report measures were considered that confirmed the reliability of the participants' subjective emotional experiences. Especially pride intensity can be questioned in certain cases. Participants heard a computer voice with positive feedback at the end of the mental rotation task. Some participants turned to the experimenter and expressed their doubt about the truthfulness of the feedback. This included participants from all three age groups. The researcher then verified the feedback to convince

the participant that the feedback was accurate. However, it could be that the participant did not believe it, which may have influenced the feelings of pride during the measurement in the third phase (Isenberg, 1980). A second limitation is that only one single parameter of ANS reactivity was measured. It is essential to consider more than HR to fully understand and analyse the physiological reactivity associated with emotions (Bauer, 1998). Further research may include additional physiological measurements to understand ANS reactivity comprehensively.

A strength of this study is that the baseline measurement was similarly designed to the stimulus measurement. This similarity is necessary to isolate ANS reactivity from peripheral triggers that cause physiological activation. ANS response can very easily be induced by simple motor activity or focus of attention (Dennis et al., 2012). In the present study, the motor activity and engagement were similar in the baseline and stimulus measurement, which excluded other peripheral influences that could have affected our results.

A direction for further research could be to adjust the audience's size or composition. It may be interesting to conduct a comparative study including a larger audience. It could clarify if a larger audience has a different impact on HR reactivity across age, as were found for adults (Bosch et al., 2009; Shearn et al., 1992), and discover whether a larger audience does have a certain impact on pride. Additionally, it may be interesting to consider the motivation and value of different age groups eliciting pride and embarrassment in research. Furthermore, a more overt (negative) evaluation of the participant is necessary to increase the intensity of embarrassment to see a difference in HR reactivity between a solitary and to research HR reactivity. Considering different conditions of evaluation could be valuable for parental and temperamental interventions due to knowledge about what evaluations do to a child's physiological state during embarrassment and pride.

Lastly, this study was conducted with people from a Western culture. What is seen as competent and how success is defined can depend significantly on culture (Reissland & Harris, 1991; Zhang & Cross, 2011). Various studies have shown that cultural differences affect feelings and expressions of pride and embarrassment (Hagan, 2021), especially between Western and East Asian societies. Within some Asian cultures, people show other responses to achievements and failures (lewis et al., 2010). These cultural differences may arise through the variation in audience valuation (Sznycer & Cohen, 2021). Therefore, it may be interesting to examine whether HR reactivity differences between cultures and whether this is affected by age.

Conclusion

This study is the first to examine the experience of pride and embarrassment across the lifespan focusing on HR reactivity. The results show interesting insights into HR reactivity across ages during the elicitation of pride and embarrassment and the effect of a small audience on this. In conclusion, this research found that there are age differences in HR reactivity during embarrassment, implying that HR acceleration increases across age. Concerning pride, there are no significant differences in HR reactivity across the lifespan. Additionally, HR reactivity during the elicitation of embarrassment and pride was not influenced by the presence of a small audience in the immediate environment. More research is needed to measure a greater variety of physiological responses to gain a deeper understanding of the experience and expression of pride and embarrassment in childhood. Secondly, more research could provide interesting insights into the influence of different audience sizes, composition, and active vs. passive audiences on HR in all ages. Most importantly, this research contributes to identifying a possible physiological developmental pattern. It made a solid start in revealing differences and similarities in HR reactivity concerning pride and embarrassment across ages.

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Appendix

Examples of the mental rotation task for all age groups

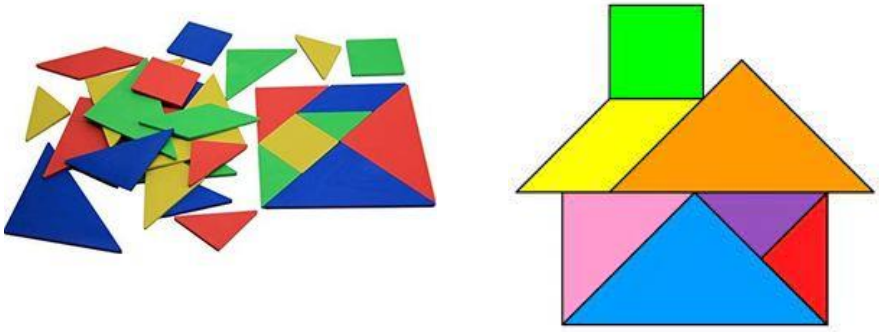

Figure A1. Example of the mental rotation task for 3,5-5 year-old children

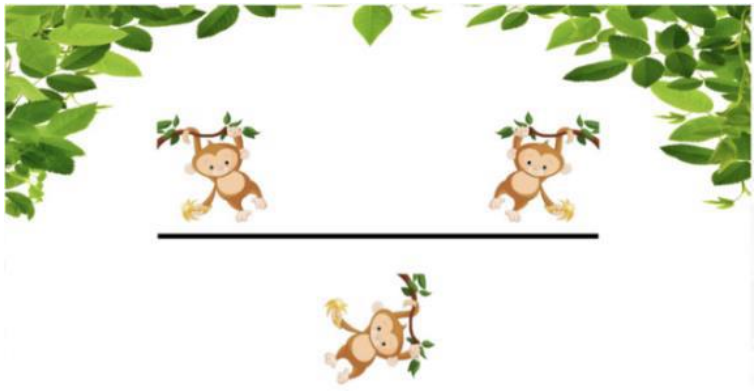

Figure A2. Example of the mental rotation task for 8-10 year-old children

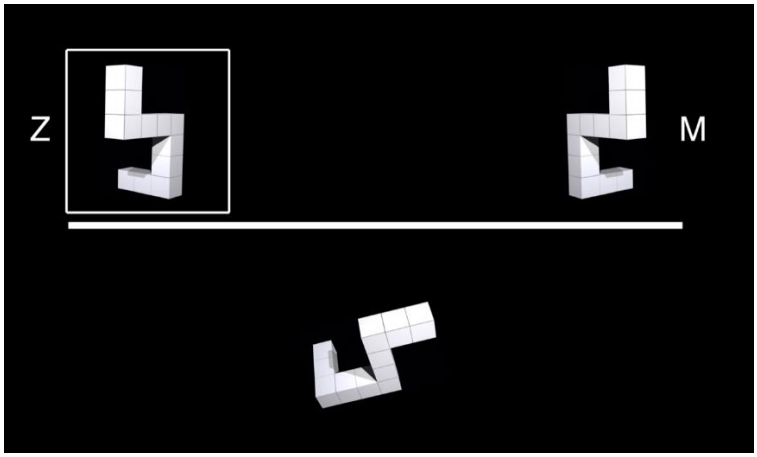

Figure A3. Example of mental rotation task for adults