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Trajectories of behavioral avoidance in real time: Associations with temperament and physiological dysregulation in preschoolers

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ABSTRACT

Although excessive avoidance has been implicated in mental health problems and socioemotional difficulties, relatively little is known about dynamic changes of avoidance behaviors. We used a latent class growth analysis to examine the temporal course of avoidance behaviors in real time and determined whether the derived classes were distinguishable on temperament and physiological markers of regulation and reactivity (N = 153; M_{age} = 4.20 years). A three-class solution was found and identified a low, medium, and high increasing avoidance group. The high and increasing avoidance group had the highest physiological reactivity (cortisol reactivity) and shyness, and the lowest physiological regulation (i.e., respiratory sinus arrythmia suppression). High and increasing avoidance may therefore be associated with temperamental and physiological indices of risk implicated in maladjustment and highlight the value of data-driven, group-based approaches for examining dynamic patterns of behavior.

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Introduction

Children may engage in relatively high levels of avoidance for different reasons. For example, temperamental dispositions such as high negative emotionality, high shyness, or low approach and high avoidance may facilitate high levels of avoidance (Carver & White, 1994; Rothbart, Ahadi, Hershey, & Fisher, 2001). It is also possible that the sensitivity of a children's nervous system and parental modeling contribute to children's engagement in avoidance behaviors (Fox, Henderson, Marshall,

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Nichols, & Ghera, 2005). In short, avoidance behavioral tendencies likely result from a combination factors.

Regardless of the origin or motivation for these behaviors, avoidance can be problematic for a number of reasons. First, if children display high levels of avoidance in social situations, they may fail to develop social competencies, further excluding them from peer groups (Fantuzzo, Sekino, & Cohen, 2004; Rubin, Coplan, & Bowker, 2009). Second, children who consistently engage in avoidance as a primary strategy may fail to learn important lessons about their arousal, potentially perpetuating more avoidance in future situations. For example, we know from the anxiety literature that consistent exposure to a high-arousal situation provides individuals with important information about a) their ability to tolerate distress, and b) the temporary nature of high levels of arousal (Bouchard, Mendlowitz, Coles, & Franklin, 2004). Finally, pathological levels of avoidance are implicated to some degree in nearly every mood and anxiety disorder in adulthood (American Psychiatric Association, 2013). As such, children who engage in high levels of avoidance may be at relatively higher risk for developing psychological problems later on in life.

There is a large body of literature on temperamental factors that are theoretically implicated in avoidance-related behaviors (see Schmidt & Schulkin, 1999, for a review). One such temperamental characteristic is shyness. Shyness is characterized by an anxious preoccupation with the self in response to real or imaged social situations (Cheek & Melchior, 1990). Although shyness is a ubiquitous phenomenon that over 90% of the population experiences at some point in their lives (Zimbardo, 1977), a smaller percentage of individuals (i.e., 10–15%) have been identified as temperamentally shy (e.g., Kagan, 1994). Temperamental shyness is characterized by stable social inhibition and avoidance in social situations observed across time and context (see Schmidt & Schulkin, 1999).

Temperamental shyness has been positively associated with avoidance-related internalizing difficulties (Findlay, Coplan, & Bowker, 2009) and avoidance-related psychophysiological measures, including greater relative right frontal brain activity (Poole, Santesso, Van Lieshout, & Schmidt, 2019; Schmidt, 1999), higher and more stable heart rate at rest (Kagan, Reznick, & Snidman, 1988; Poole & Schmidt, 2018; Schmidt & Fox, 1994) and higher basal cortisol levels (Kagan et al., 1988; Schmidt et al., 1997; Schmidt, Santesso, Schulkin, & Segalowitz, 2007; Tang, Beaton, Schulkin, Hall, & Schmidt, 2014) in children and adults.

Behaviorally, children identified as shy have been found to make fewer initiations to start conversations, and speak less in social situations (e.g., Asendorpf & Meier, 1993; Coplan, Arbeau, & Armer, 2008; Crozier & Perkins, 2002; Evans, 2001). Despite the presumed role of avoidance-related behaviors in maintaining shyness in social contexts, there are relatively few studies to date that have examined directly the links among avoidance behavior, temperament, and physiology in children.

In addition to shyness, temperamental and physiological indices of reactivity and regulation may also contribute to children's engagement in avoidance-related behaviors. Following Rothbart's reactivity-regulation temperamental model, negative emotionality refers to the speed and intensity with which negative emotions are felt and displayed, whereas effortful control refers to processes that enable the modulation of reactivity in order to support goal directed behavior (Posner & Rothbart, 2000; Rothbart & Bates, 2006). If children are experiencing strong negative emotions when in social situations, and these strong emotions are largely unregulated, they may be more likely to withdraw.

Negative emotionality and effortful control (i.e., self-regulation) have been identified as key components of temperament during the preschool period (Rothbart & Bates, 2006). There is some empirical evidence suggesting that effortful control and negative emotionality temperamentally may influence children's engagement in avoidance behaviors. For example, 4-month old infants selected for negative reactivity (low levels of motor reactivity and emotional reactivity) displayed significantly more behavioral avoidance during fear-inducing episodes at 9 months when compared to infants selected for positive reactivity (Hane, Fox, Henderson, & Marshall, 2008). In school settings, some researchers have also suggested that children with relatively high levels of effortful control may be more effective at building and maintaining positive social relationships with those around them, and therefore may be engaging in relatively higher levels of social engagement (Eisenberg, Valiente, & Eggum, 2010).

Reactivity and regulation also have been identified on a physiological level. Respiratory sinus arrythmia (RSA) refers to the variability in the heart that occurs during respiration (Porges, 2007). Polyva-

gal Theory suggests that RSA reflects self-regulatory capacity by providing us with information about the body's capacity for flexibly responding to environmental challenges through parasympathetic influences on the heart (Porges, 2007). Although high levels of baseline RSA have been used as an indicator of dispositional self-regulation (e.g., Geisler, Kubiak, Siewert, & Weber, 2013; Stifter, Fox, & Porges, 1989), RSA suppression during environmental challenges may be a more appropriate measure of in-the-moment, context-specific self-regulatory capacity than other measures, because it reflects the bodies regulatory response to specific environmental challenges (Beauchaine, 2001; Porges, 2007). RSA suppression has been positively associated with sociability (Fox, 1989) and bold, approach-related behaviors in the presence of a stranger (Brooker & Buss, 2010) in childhood. Taken together, these studies suggest that decreases in RSA from baseline to a demanding task may support greater social engagement.

While RSA suppression may be a physiological index of regulation, changes in cortisol can provide us with an index of physiological reactivity. When encountering environmental stressors, the hypothalamic–pituitary–adrenal (HPA) axis is activated, and the hormone cortisol is secreted as the end product of this process (McEwen, 2000). Individual differences in cortisol levels have been linked to children's behavior. For example, baseline cortisol levels have been negatively associated with social withdrawal in children (Granger et al., 1998) and positively associated with fear and distress in infants (Gunnar, Mangelsdorf, Larson, & Hertsgaard, 1989). Another study found that 4-year old children who displayed extreme levels of wariness in quartets were characterized by higher salivary morning cortisol than children who displayed relatively less wariness (Schmidt et al., 1997). Importantly, wariness in this study was operationalized in part as hovering and unoccupied behaviors, both of which can be categorized as avoidance-related behaviors (Schmidt et al., 1997). These mixed results may be in part due to a focus on baseline levels of cortisol, rather than examining cortisol reactivity in response to a stressor, which may serve as a better indicator of children's physiological negative emotionality.

In addition to the paucity of research characterizing children's avoidance, another limitation in the extant literature is traditionally treating avoidance as a static variable. In order to operationalize avoidance, individuals typically create a composite score from questionnaires or create a mean or sum score from different observed behaviors (e.g., Brooker et al., 2013; Dyson, Olino, Durbin, Goldsmith, & Klein, 2012; Hane et al., 2008). While this approach has advantages as it provides a single summary score of behavior across time, one limitation of this approach is that it may not fully take into account the temporal course of avoidance, because composite and mean scores do not provide us with information about how avoidance behaviors presumably manifest over time. Further, mean and composite scores also obscure indivdiual variability. One potential solution to this problem is to use statistical methods that allow us to capture the temporal course of dynamic behaviors such as avoidance. In the present study, we examined this very issue by examining the temporal course of individual differences in avoidance behaviors in real time.

The goals of the present study were two-fold. First, given the paucity of research examining variability in avoidance over time, we examined the temporal course of avoidance in the context of social threat by using latent-class growth curve analysis in a sample of typically developing preschoolers. Second, given the importance of avoidance in children's socioemotional development, we examined if these derived classes of avoidance were distinguishable on temperamental (i.e., shyness, negative emotionality, and effortful control) and physiological (i.e., regulation and reactivity) factors theoretically implicated in avoidance-related behaviors.

Method

Participants

Participants were 153 preschoolers (n_{female} = 76, M_{age} = 4.20 years, SD_{age} = 0.77 years) and their mothers (M_{age} = 35.88 years, SD_{age} = 5.01 years). The participants were primarily White (80.3%) and had a mean family income of $60,000 to 76,000 ($SD$ = $20,850) in Canadian dollars. The mothers and children were recruited from the Child Database at McMaster University. This database contains

the names and contact information of parents of healthy, full-term newborn infants recruited from hospitals across the greater Hamilton metropolitan area who consented to participate in future infant and child studies conducted at McMaster University.

Procedure

Children and their mothers participated in this study at the Child Emotion Laboratory at McMaster University. The child, mother, and one female experimenter began in a room together. While the child played with a puzzle, the experimenter explained the study procedures to the mother. After written parental consent and verbal child assent was obtained, the electrodes for RSA collection were affixed to the child. Importantly, the mobile RSA recording unit was placed in a backpack so that the child still retained full range of motion. The mother then left the room to complete a series of questionnaires, where she could view her child on a closed-circuit computer monitor. To obtain baseline RSA, the child was instructed to do his or her best to sit still while he or she quietly watched a 5 and a half-minute neutral movie clip (Perry et al., 2013), and RSA was also collected during the stranger approach task. The child was then exposed to a stranger approach task (3 minutes). To obtain a measure cortisol reactivity, salivary cortisol was collected within 10 minutes of the child entering the laboratory, and 15 minutes after the stranger approach task. Families were provided two small toys, a Junior Scientist certificate, and a 20-dollar gift card as compensation for their participation. All procedures were approved by the McMaster University Research Ethics Board.

Behavioral measure

Stranger approach task

This task was heavily adapted from the stranger approach episode from the preschool Laboratory Temperament Assessment Battery (Lab-TAB; Goldsmith, Reilly, Lemery, Longley, & Prescott, 1995). While the child was seated at a table, the experimenter told the child that she had to go get something from the other room, and that she would be right back. After 10 seconds, an unfamiliar research assistant wearing sunglasses and a hat entered the room and proceeded engage the child using a standardized script, getting closer and closer to the child with each utterance (see Goldsmith et al., 1995, for the full script). The unfamiliar research assistant then told the child "I came looking for a paper, was there a woman in here?", and left the room to go wait in the hall. The original experimenter then re-entered the room and gave the stranger a piece of paper in front of the child, and the episode ended.

Behavioral coding

Avoidance was coded during the stranger approach task. Avoidance was operationalized as the sum of children's gaze towards the stranger (reversed), bodily fear, and physical orientation towards the stranger (reversed). All individual behaviors were *z*-scored before they were summed. These behaviors were coded using the following scales in 5-second epochs. Children's gaze was coded as either full gaze aversion (0), child meeting the stranger's gaze, but only for a fleeting moment (less than one second; [1]), child meets stranger's gaze for less than 50% of the epoch, but more than a fleeting glance (2), and child meets stranger's gaze for more 50% or more of the epoch (3). This index was reverse scored, so greater scores indicated more avoidance. Bodily fear was operationalized as physical manifestations of fear, including fidgeting, freezing, tensing, and hiding behaviors, and was coded as either absent (0), present (1), or present and salient (2). Children's orientation towards the stranger was coded as either fully oriented away from the stranger (0), somewhat oriented towards the stranger (e.g., the child's head is orientated towards the stranger but their torso and legs are oriented away from the stranger; [1]), or full orientation towards the stranger (2). This index was reverse scored, so greater scores indicated more avoidance. Excellent inter-rater reliability was established on 10% of the videos for gaze (k = .99), bodily fear (k = .96), and orientation towards the stranger (k = .99). Together, the average reliability for the behaviors that made up avoidance was excellent (k = .98).

Psychophysiological measure

RSA data collection

Cardiac and respiratory data were collected using the MindWare Mobile Impedance Cardiograph, Model 50-2303-00, with a sampling rate of 500 Hz and 24-bit ADC digitization. Cardiac data were recorded from three electrodes affixed to the child's upper right back and lower left and right sides. The mobile cardiograph was then placed in a backpack that the child wore for the duration of the study. Respiration data were recorded from a respiratory strain gauge placed around the child's chest.

RSA data reduction and quantification

The cardiac and respiratory signals were reduced and analyzed using a commercial software package (MindWare HRV 3.1.1, MindWare Technologies, Ltd.), and edited by hand for spurious or missing beats according to recommendations of Berntson and Stowell (1998). Baseline RSA was estimated by averaging the mean RSA from five one-minute long segments while the child watched a neutral video clip. On-task RSA was computed from two one-minute long segments while the child experienced the stranger approach task (described below). RSA suppression was operationalized as baseline RSA minus on-task RSA during the stranger approach task. Because the focus of the study was preschool aged children, we used a respiratory frequency of 0.24 to 1.04 Hz, which is commonly used for young children (e.g., Porges et al., 2007).

Salivary cortisol data collection

In order to reduce the influence of confounding factors on cortisol levels, mothers were asked to not have their child eat or drink anything other than water 30 minutes prior to visiting the laboratory. Saliva was collected by having participants chew for one minute on a cotton swab, which was placed into a cryogenic tube.

Salivary cortisol assay determinations and quantification

All saliva samples were stored at 80℃ prior to assaying. Salivary cortisol was quantified using a competitive Enzyme Immunoassay kit (Salimetrics, LLC State College, PA). The intra-assay coefficient of variation is 3.50%, the inter-assay coefficient of variation is 5.08%, and the sensitivity is 0.08 nanomoles per litre (nmol/L). Cortisol reactivity was operationalized as the sample collected after the stranger approach task minus the baseline sample.

Parental questionnaires

Children's temperament

Children's temperament was parent-reported using the Children's Behavior Questionnaire (CBQ; Rothbart, Ahadi, & Hershey, 1994). The CBQ is a parent-rated questionnaire evaluating 3- to 8-year-old children's temperament. Mothers were asked how often their children engaged in a behavior over the past few weeks on a scale of 1 (never) to 7 (always), and the scale score was computed using the average of the number of items. Of particular interest to the present study were measures of shyness (e.g., "Is sometimes shy even around people s/he has known a long time"; a = .89), effortful control (e.g., "Can wait before entering into new activities if s/he is asked to"; a = .88), and negative emotionality (e.g., "Is quite upset by a little cut or bruise" a = .82).

Demographics

A demographics questionnaire was also completed by mothers, which included questions about ethnicity, marital status, and household income.

Data loss

Of these 153 participants, 15 were missing RSA due to equipment failure or refusal to put or keep on the electrodes, 16 were missing cortisol data due to refusal to provide a sample, or insufficient saliva in the provided sample to assay the sample, and 1 was missing questionnaire data due to

experimenter error. The children with missing data did not differ from the children with complete data based on sex (X^2 [1, N = 151] = 1.78, p = .14), income level (F[1, 147] = 0.14, p = .71) or age (F [1, 150] = 0.66, p = .42), but they did differ in shyness, such that the children with missing data (M = 4.51, SE = .32) had higher shyness (F[1, 149] = 8.67, p = .004) compared to children with complete data (M = 3.51, SE = .11).

Data analyses

First, we attempted to derive trajectories of children's behavioral avoidance across four 30-second epochs during stranger approach task using latent class growth curve analysis in Mplus Version 8 (Muthen & Muthen, 2000). Latent class growth curve analysis aim to find the smallest number of classes that captures most variance in terms of the patterns of the variable being examined. We considered various criteria to determine the optimal number of latent classes of avoidance (Muthen & Muthen, 2000), including the Bayesian information criterion (BIC), Akaike information criterion (AIC), Sample Size Adjusted BIC (SSA-BIC), the adjusted Lo-Mendell Rubin Likelihood Ration Test (LMR-LRT), the bootstrap likelihood ratio test (BLRT), and entropy. Finally, we evaluated the theoretical meaningfulness of the trajectory classes (Muthen & Muthen, 2000).

Second, we used a series of one-way analysis of covariance (ANCOVA) tests to assess whether avoidance class membership distinguished individuals on temperament (i.e., shyness, effortful control, negative emotionality), physiological regulation (i.e., RSA suppression during the stranger approach task), and physiological reactivity (i.e., cortisol reactivity to the stranger approach task) controlling for children's age and sex in all analyses, baseline RSA in the RSA analyses, and baseline cortisol and time of first sample collected in the cortisol analysis.

Results

Descriptive statistics

Means, standard deviations, ranges, and intercorrelations are presented for all study variables in Table 1.

Derivation of trajectories of avoidance during social threat

A three-class solution was selected due to the best model fit and conceptually distinct trajectories. The three-class solution (Fig. 1) included the following trajectories: a *low and increasing avoidance group* (66.67%; n = 102), a *medium and increasing avoidance group* (22.22%; n = 34), and a *high and steeply increasing avoidance group* (11.11%; n = 17). It was not surprising that all three groups were increasing in avoidance, given the increasing proximity of the stranger to the child during the stranger approach episode (Goldsmith et al., 1999). Both the 2- and 4-class solutions were deemed less appropriate due to worse fit indices (Muthen & Muthen, 2000). Table 2 shows the fit indices for the 1, 2, 3, and 4-class solutions.

Association between avoidance trajectories and children's temperament

The results of the ANCOVA revealed that there was a significant main effect of avoidance group membership on children's shyness (F[1, 146] = 4.75, p = .01, η^2 = .06), but not children's effortful control (F[1, 146] = 2.21, p = .31, η^2 = .02) and negative emotionality (F[1, 146] = 1.18, p = .41, η^2 = .01). Children who belonged to the high and steeply increasing in avoidance group (M = 4.40, SE = .30) were rated as shyer than children who belonged to the medium (M = 3.77, SE = .22) and low (M = 3.43, SE = .12) avoidance groups.

Table 1
Pearson's correlations, mean, standard deviation (SD), and range for study measures.

Variables	1	2	3	4	5	6	7	8	9	10	Mean (SD)	Range
1. Total Observed Avoidance	–	.25**	.13	-.10	-.10	.003	-.14	.16	.09	.06	−11.03 (6.42)	−26.00 to 6.50
2. CBQ Shyness	–	–	-.01	.11	-.03	.01	-.05	-.05	.03	.14	3.46 (1.29)	1 to 6.67
3. CBQ Effortful Control	–	–	–	-.49**	-.05	-.19*	.20*	-.06	-.12	.03	4.53 (0.56)	3.01 to 6.50
4. CBQ Negative Emotionality	–	–	–	–	-.04	.10	-.20*	.10	.11	-.06	3.67 (0.72)	2.07 to 6.54
5. Baseline RSA	–	–	–	–	–	.75**	.37**	.06	.11	-.07	5.83 (1.28)	2.89 to 9.56
6. RSA during SA	–	–	–	–	–	–	-.33**	.03	.09	-.02	6.06 (1.26)	3.08 to 9.52
7. RSA Regulation (RSA suppression) during SA	–	–	–	–	–	–	–	.04	.04	-.07	−0.23 (0.91)	−4.18 to 2.45
8. Baseline Salivary Cortisol	–	–	–	–	–	–	–	–	.29**	-.59**	1.09 (1.03)	.01 to 5.85
9. Salivary Cortisol following SA	–	–	–	–	–	–	–	–	–	.63**	0.99 (1.11)	.02 to 7.27
10. Salivary Cortisol Reactivity to SA	–	–	–	–	–	–	–	–	–	–	−0.10 (1.01)	−2.97 to 3.27

Note. RSA = respiratory sinus arrythmia, SA = stranger approach task *$p < .05$; **$p < .01$.

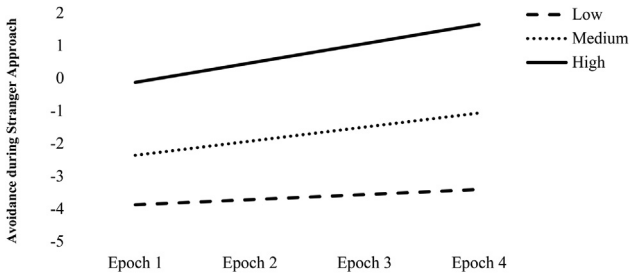

Fig. 1. Derived latent classes of behavioral avoidance coded in 30 second epochs during stranger approach task.

Table 2
Fit statistics for latent growth curve analysis models.

	AIC	BIC	Adjusted BIC	Entropy	LMR-LRT	BLRT	Smallest *N*
Class 1	2438.83	2456.01	2438.022	–	–	–	–
Class 2	2145.42	2172.70	2144.21	.92	.01	<.001	33
Class 3	**2047.82**	**2084.18**	**2084.18**	**.89**	**.003**	**<.001**	**17**
Class 4	1992.94	2038.40	1990.92	.88	.19	<.001	14

Note. Smaller values of AIC and BIC and larger values of entropy indicate better model fit. Adjusted BIC accounts for sample size. Significant LMR-LRT and PBLR p-values indicate that *N* number of classes has better fit than *N*-1 number of classes. The bolded model represents the chosen model. AIC = Akaike information criterion; BIC = Bayesian information criteria; LMR-LRT = Lo-Mendell–Rubin likelihood ratio test; BLRT = bootstrap likelihood ratio test.

Association between avoidance trajectories and children's physiological regulation and reactivity

RSA suppression

The results of the ANCOVA revealed that there was a significant main effect of avoidance group membership on children's physiological regulation, as indexed by RSA suppression (F[1, 129] = 3.89, p = .02, η^2 = .06; Fig. 2), controlling for baseline RSA. Children who belonged to the high avoidance (M = -0.79, SE = .23) displayed less physiological regulation (i.e., lower RSA suppression) than children who belonged to the medium (M = -.03, SE = .17) and low (M = -.20, SE = .09) avoidance groups.

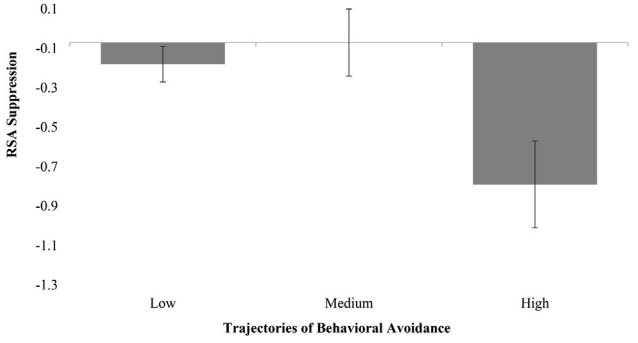

Fig. 2. Relation between avoidance class and children's RSA suppression during the stranger approach task. *Note.* RSA = Respiratory sinus arrythmia.

Salivary cortisol reactivity

The results of the ANCOVA revealed that there was a significant main effect of avoidance group membership on children's physiological reactivity, as indexed by cortisol reactivity

(F[1, 126] = 77.13, p < .001, η^2 = .38; Fig. 3). Children who belonged to the high and steeply increasing in avoidance group (M = .20, SE = .20) displayed greater physiological reactivity than children who belonged to the medium (M = -.18, SE = .14) and low (M = -.10, SE = .09) avoidance groups.

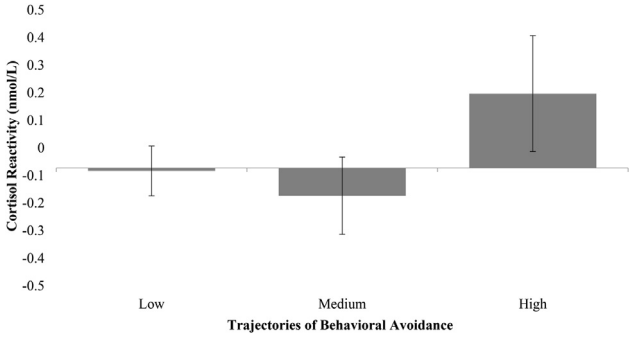

Fig. 3. Relation between avoidance class on children's cortisol reactivity during the stranger approach task. *Note.* nmol/L = nanomoles per litre.

Discussion

Using a sample of typically developing preschool aged children, we examined the temporal course of avoidance using a data driven approach, group-based approach, and whether the derived latent classes of avoidance were distinguishable on temperamental and physiological indices of reactivity and regulation theoretically and conceptually implicated in avoidance. We derived three classes of avoidance: a low and increasing in avoidance group, medium and increasing in avoidance group, and a high and steeply increasing in avoidance group. We found that these groups were distinguishable on maternal report of shyness, physiological regulation (RSA suppression), and physiological reactivity (cortisol reactivity), but not on maternal report of negative emotionally or effortful control. Specifically, we found that individuals in the high avoidance group had higher levels of shyness and physiological reactivity, and lower levels of physiological regulation.

Classes of avoidance were distinguishable on shyness, but not negative emotionality or negative reactivity. Children who fell in the high and increasing in avoidance group were rated as shyer by their mothers than the other groups. Avoidance has long been implicated in shyness, both theoretically and empirically (Schmidt & Schulkin, 1999). Even at definitional level, some have defined shyness in part as inhibition in social situations (Cheek & Buss, 1981). As previously highlighted, there is some behavioral evidence that suggests shyness is positively associated with avoidance in children. For example, shyness has been negatively associated with initiations to start conversations and speaking in social situations (e.g., Asendorpf & Meier, 1993, Coplan et al., 2008, Crozier & Perkins, 2002, Evans, 2001).

The present results extend on this earlier work by broadening the operationalization of avoidance to non-verbal manifestations. The results also further demonstrated that it may be useful to use non-static definitions of avoidance when considering the relation between avoidance and shyness, because the low and medium avoidance groups were indistinguishable on shyness. Moreover, it was specifically the high and steeply increasing avoidance group that exhibited the highest shyness.

Our analyses identified a relatively small subset of children who engaged in relatively high and steeply increasing levels of avoidance. These children had the highest levels of shyness and physiological reactivity, and the lowest levels of physiological regulation to the stranger task. It is possible that this subset reflects the small percentage (15%) of children who are temperamentally shy (Kagan, 1994). Temperamentally shy children have a specific pattern of behavioral and physiological responses to social stress, including greater relative right frontal EEG asymmetry (a neural index of avoidance-related motivations; Poole et al., 2019; Schmidt, 1999), higher and more stable heart rate

at rest (Kagan et al., 1988; Poole & Schmidt, 2018; Schmidt & Fox, 1994), and higher levels of morning basal salivary cortisol (Kagan et al., 1988; Schmidt et al., 1997; Schmidt, Santesso, Schulkin, & Segalowitz, 2007; Tang et al., 2014) and are also at relatively higher risk for poor emotional adjustment and mental health difficulties longitudinally (Rapee, Kennedy, Ingram, Edwards, & Sweeney, 2005; Rubin, Chen, McDougall, Bowker, & McKinnon, 1995; Tang et al., 2017). Future work will need to follow this small subset of children over time in order to determine whether these children will continue on in their trajectory of higher levels of observed physiological reactivity, dysregulation, and shyness, as well as to examine if these children develop mental health difficulties given their physiological and temperamental risk factors.

It is also important to distinguish between temperamental shyness (i.e., the outcome variable), and avoidance during the stranger approach task (i.e., the predictor variable). Although temperamental shyness may make an individual more likely to engage in avoidance in the social context, the behavior is a consequence of temperament, rather than a component of temperament. Shyness is a broad construct encompassing cognitive (i.e., self-consciousness, embarrassment) and affective (i.e., anxious preoccupation, fear) experiences in social situations, and behavioral measures of avoidance in and of themselves may not fully capture the dynamic nature of shyness (Cheek & Melchior, 1990; Crozier, 1979; Zimbardo, Pilkonis, & Norwood, 1977). In support of this postulation, total observed avoidance in the present study was only moderately correlated with shyness, suggesting that avoidance and shyness are distinct, but related constructs.

It is interesting, and perhaps surprising, that classes of avoidance were not distinguishable on subjective measures of negative emotionality and effortful control. If negative emotionality represents the speed and intensity with which negative emotions are felt and displayed, and effortful control represents the ability to manage attentional resources and to inhibit a dominant response in favor of a subordinate response (Rothbart & Bates, 2006), one might expect that children in the high and increasing levels of avoidance group would be rated as the highest in negative emotionality and the lowest in effortful control.

It is possible that we did not find this pattern of results because of the social nature of the task used to elicit responses. Perhaps effortful control would be more effective in distinguishing classes of avoidance elicited in situations calling for more inhibitory control or recruiting more attentional resources (Rueda, Posner, & Rothbart, 2005). Further, emotion regulation, rather than general effortful control, may be a more important factor when considering the potential perceived threat associated with the stranger approach task, and some studies have indeed found indices of emotion regulation and effortful control are largely uncorrelated in children (e.g., Simonds, Kieras, Rueda, & Rothbart, 2007). It is also possible that these temperamental dimensions are simply not as important as shyness when examining correlates of avoidance. Together, the pattern of results suggests that, at least in this social context, shyness is a more important correlate of avoidance compared to negative emotionality and effortful control. Finally, it might be that physiological measures of reactivity and regulation are more sensitive to distinguishing among the latent classes of avoidance than maternal report measures of temperament.

Classes of avoidance were also distinguishable on physiological indices of regulation and reactivity implicated in the modulation of arousal and fear. We found that individuals in the high and increasing in avoidance class had the lowest levels of physiological regulation (RSA suppression), and the highest levels of physiological reactivity (cortisol reactivity). Some researchers have conceptualized RSA as a marker of the physiological response system's efficiency in responding to environmental challenges (Thayer & Lane, 2000), such that relatively higher levels of RSA suppression may index greater flexibility (Porges, Doussard-Roosevelt, Portales, & Greenspan, 1996, Friedman, 2007; Rottenberg, Salomon, Gross, & Gotlib, 2005). Cortisol reactivity, on the other hand, also has been conceptualized as a stress response to perceived threat, such that greater values may be indicative of greater perceived threat (Schulkin, Morgan, & Rosen, 2005). Although the activation of the HPA axis is a normal and adaptive response to environmental stressors, chronically high levels of cortisol have been associated with serious functional and structural neural changes, as well as cognitive deficits (e.g., Bremner, 1999, Cicchetti & Walker, 2001; Heffelfinger & Newcomer, 2001). Given this conceptualization, the relatively low levels of RSA suppression and high levels of cortisol reactivity exhibited by the

children in the high avoidance group may reflect the rigidity of the behavioral responses exhibited and high levels of perceived social stress experienced by these children during the stranger approach task.

Importantly, we controlled for baseline RSA and baseline salivary cortisol in the reported analyses, so our results are likely capturing individual differences in physiological response to the stranger approach task, rather than individual differences in resting physiology. Our results provide insight into some of the physiological responses that may support relatively high levels of avoidance. Although our study is cross-sectional in nature, our preliminary results suggest that relatively low levels of RSA suppression and relatively high levels of cortisol reactivity are important correlates of high avoidance in this social context during the preschool period.

High and increasing levels of avoidance in our study were associated with temperamental and physiological indices of risk. Shyness has been negatively associated with social skills, and positively associated with peer and socioemotional difficulties (Coplan et al., 2008; Coplan, Bowker, & Cooper, 2003; Coplan, Prakash, O'Neil, & Armer, 2004). RSA suppression has been positively associated with performance on cognitive tasks (Böhm, Rötting, Schwenk, Grebe, & Mansmann, 2001; Van Roon, Mulder, Althaus, & Mulder, 2004), prosociality in some contexts (Obradović, Bush, Stamperdahl, Adler, & Boyce, 2010), and prospective behavioral warmth (Diamond & Cribbet, 2013). High levels of cortisol reactivity also have been linked to stress-reactivity and psychopathology (Burke, Davis, Otte, & Mohr, 2005; Quirin, Pruessner, & Kuhl, 2008; Steudte-Schmiedgen et al., 2017). Together, these results converge with the adult literature suggesting that high levels of avoidance may be associated with risk for maladjustment (e.g., Mowrer, 1960; Salters-Pedneault, Tull, & Roemer, 2004; Trew, 2011), and provide a preliminary justification of monitoring avoidance behaviors during the preschool period.

The present study was framed around temperamental and physiological indices of reactivity (i.e., negative emotionality and cortisol reactivity) and regulation (i.e., effortful control and RSA regulation), discriminating latent classes of avoidance trajectories. Given our conceptual framework, we expected that negative emotionality and cortisol reactivity as well as effortful control and RSA regulation would be positively correlated. Although this was the case for effortful control and RSA regulation, we failed to find a significant correlation between negative emotionality and cortisol reactivity. One potential explanation for these differences is that RSA regulation relative to baseline was collected "live" (i.e., during the stranger approach task), whereas the measure of cortisol reactivity relative to baseline was collected approximately 15 minutes after exposure to the stranger approach episode to capture peak cortisol reactivity. However, individuals vary in the time taken to reach peak cortisol reactivity between 5 to 30 minutes, and so there may be considerably more noise in measures of cortisol reactivity compared to RSA suppression (Del Giudice, Ellis, & Shirtclif, 2011). There is also less clarity around the relation between cortisol levels at least at baseline and broad measures of reactivity, as some studies have found positive relations (Granger et al., 1998), while others have found negative relations (Schmidt et al., 1997). Outside of methodological difficulties, it is also possible that RSA suppression is a better index of effortful control than cortisol reactivity is of negative emotionality.

Given the cross-sectional design of the present study, it is important to highlight that we could not address issues of directionality. It is very likely that the relations among avoidance, temperament, and physiological regulation and reactivity are bidirectional. In the clinical literature, for example, it has been suggested that engaging in high levels of avoidance may perpetuate anxiety, and high levels of anxiety may perpetuate avoidance (Manfro, Heldt, Cordioli, & Otto, 2008). It is possible that temperament and physiology function in the same way, such that high levels of shyness, for example, may perpetuate avoidance in social situations, and avoidance in social situations may perpetuate perceived shyness. Although we used avoidance classes as predictors, and temperament and physiology as outcomes, the focus of the present study was to identify factors that distinguish children who engage in different levels of avoidance in order to gather more information about avoidance. As a result, it is possible that temperament and physiology predict trajectories of avoidance.

Strengths, limitations, and future directions

There are several strengths of the present study. These include the measuring and coding of behavior from direct observations in real time, the inclusion of multiple psychophysiological measures, and

a unique data analytic approach to chart the growth of avoidance behavior within a cross-sectional design.

The results, however, should be considered with the following limitations in mind. First, children's temperament was maternally reported, so there may have been some reporting biases since these are subjective measures. However, the CBQ is a widely used, valid, and reliable index of children's temperament (Rothbart et al., 1994). Second, our sample was typically developing, relatively high functioning, primarily White and our mean household income was relatively high, so it is possible that our results may not be generalizable to children from more socioeconomically disadvantaged homes and ethnically diverse backgrounds. Finally, although we found that the high and increasing avoidance group was associated with temperamental and physiological indices implicated in risk for maladjustment, these results were cross-sectional, and so we cannot comment on the prospective correlates and consequences of different levels of avoidance downstream. In addition to attempting to replicate the results found in the present study, future research should examine the prospective consequences of different avoidance classes in the context of temperament, physiology, and socioemotional difficulties and psychopathology in a more ethnically and demographically diverse sample than the demographically homogenous sample used in the present study. Given the importance of examining dynamic changes in behavior and physiology, future studies should employ similar methods to identify the correlates of changes in RSA suppression over time in the social context.

Conclusions and implications

In the present study, we considered avoidance behavior coded from direct observations in real time, treating children's avoidance behavior as a dynamic, rather than static variable, which may provide us with a better understanding of the individual variability that exists within children's avoidance-related behaviors that is not completely possible when examining mean levels. Being classified as high and increasing in avoidance was associated with temperamental and physiological indices of risk implicated in maladjustment. This present study is an important first step to understanding the temporal course of avoidance behavior in real time, how avoidance manifests in a specific social context, and characterizing temperamental and physiological correlates of avoidance during the preschool period.

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