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Temperament Factor Structure in Fragile X Syndrome: The Children's Behavior Questionnaire

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Abstract

Early patterns of temperament lay the foundation for a variety of developmental constructs such as self-regulation, psychopathology, and resilience. Children with fragile X syndrome (FXS) display unique patterns of temperament compared to age-matched clinical and non-clinical samples, and early patterns of temperament have been associated with later anxiety in this population. Despite these unique patterns in FXS and recent reports of atypical factor structure of temperament questionnaires in Williams Syndrome (Leyfer, John, Woodruff-Borden, & Mervis, 2012), no studies have examined the latent factor structure of temperament scales in FXS to ensure measurement validity in this sample. The present study used confirmatory factor analysis to examine the factor structure of a well-validated parent-reported temperament questionnaire, the *Children's Behavior Questionnaire* (Rothbart, Ahadi, Hershey, & Fisher, 2001), in a sample of 90 males with FXS ages 3-9 years. Our data produced a similar, but not identical, three-factor model that retained the original CBQ factors of negative affectivity, effortful control, and extraversion/surgency. In particular, our FXS sample demonstrated stronger factor loadings for fear and shyness than previously reported loadings in non-clinical samples, consistent with reports of poor social approach and elevated anxiety in this population. Although the original factor structure of the *Children's Behavior Questionnaire* is largely retained in children with FXS, differences in factor loading magnitudes may reflect phenotypic characteristics of the syndrome. These findings may inform future developmental and translational research efforts.

Keywords

temperament; fragile X syndrome; factor analysis

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1. Introduction

1.1 Statement of Problem

For decades, researchers have studied temperament as a means to investigate the biobehavioral processes underlying individual differences. Rothbart and Derryberry (1981) describe temperament as relatively stable individual differences in reactivity and self-regulation; processes influenced by genetics, experience and development. The psychosocial relationships of temperament to cognitive and behavioral outcomes are believed to be rooted in neurobiological development reflecting gene-brain-behavior relationships, particularly in prefrontal and limbic regions of the brain (see Whittle, Allen, Lubman & Yücel, 2006, for review). From this psychobiological perspective, the study of temperament involves examining and appreciating strengths and limitations of an individual's response to the environment. Moderate variability in temperament patterns is expected across individuals and reflects complex interactions of biological, environmental, and experiential factors that result in a good or poor “fit” in terms of the match between temperament traits and environmental demands. Extreme patterns of temperament often reflect maladaptive reactivity or regulatory abilities and have been linked to a host of pathological outcomes including conduct problems, hyperactivity, anxiety disorders and withdrawal (Rothbart, Posner, & Hershey, 1995; Rothbart & Bates, 2006). Thus, the study of temperament “allows for a view of the tremendous diversity and individual integrity of functioning existing even from the earliest months of life” (Rothbart & Derryberry, 1981, p. 39).

Rothbart and colleagues (2001) describe fifteen clusters of temperament characteristics (Table 1) that may be measured over time using developmentally-specific versions of parent-rated temperament measures. These measures differentiate infant, toddler and early childhood as distinct developmental stages in which temperament characteristics vary in terms of their emergence and the quality of behaviors that vary over time. For example, negative affect and surgency are present in early infancy; however, infants present reactive affiliation and orienting characteristics that mature into self-regulatory effortful control during toddlerhood (Putnam, Ellis & Rothbart, 2001).

In contrast to earlier work that focused on the individual temperament subscales, recent research has examined the latent structure and interrelationship among these temperament subscales in greater detail. Several factor analytic studies of typically developing children using temperament measures have consistently yielded a three-factor structure consisting of negative affectivity, surgency (also termed “extraversion”), and effortful control (Rothbart, Ahadi, & Evans, 2000). These factors are generally stable over time. Negative affect reflects negative emotional reactivity and includes constructs such as fear, approach, soothability, sadness, anger, discomfort, and motor activity (Putnam, Rothbart, & Gartstein, 2008). Surgency characterizes a child's desire for warmth and closeness with others and is reflected in both positive affective responsiveness to stimulation and novelty and speed of response and level of gross motor activity (Rothbart, 2007). Effortful control includes the capacity to focus and maintain short attention, control or inhibit impulses, and to derive pleasure from low-intensity stimuli (Kochanska, Murray, & Harlan, 2000). These factors have been increasingly conceptualized as interrelating risk and protective factors for psychosocial development (e.g. Fox, Russo, Bowles, & Dutton, 2001; Rothbart, 2007; Putnam, Rothbart & Gartstein, 2008).

1.2. Temperament in Clinical Populations

In light of the well-established relationship between temperament and psychosocial outcomes in typically developing children, a growing body of work has begun examining the relationship between temperament and atypical development in clinical pediatric

samples. Children with Williams syndrome, a neurodevelopmental disorder caused by the deletion of ~25 genes on chromosome 7q11.23 (Klein-Tasman & Mervis, 2003, Tomc, Williamson, & Pauli, 1990). In the only published study to investigate the factor structure of temperament in neurodevelopmental disorders that we are aware of, Leyfer and colleagues (2012) reported a four-factor model of temperament that differentiated children with Williams syndrome from typically developing norms. The four-factor solution for Williams syndrome included constructs from both infant and early childhood stages, potentially reflecting the delayed developmental changes observed in Williams (Ovsanna, John, Woodruff-Border, & Mervis, 2012). Interestingly, the authors also identified differential associations between specific temperament factors and diagnoses of anxiety and attention deficit hyperactivity disorder in this sample.

1.3. Fragile X Syndrome

In addition to this work in Williams syndrome, several studies have examined atypical patterns of temperament in young children with fragile X syndrome. Fragile X syndrome (FXS) is the most common inherited form of intellectual disability and is caused by an unstable expansion of the CGG repeat sequence at Xq27.3 (>200 CGG repeats). This expansion reduces *FMR1* protein production, which dysregulates messenger RNA translation and impairs brain function (Bassell & Warren, 2008). Fragile X syndrome affects approximately 1:4000 males and 1:6000 females (Kaufmann & Moser, 2000), with females often experiencing less severe symptoms. Because the molecular mechanisms of FXS are well characterized, FXS is a robust model for investigating the interplay of genes, environment, behavior, and neurobiology. The cognitive and behavioral phenotype often includes hyperactivity, gaze aversion, social withdrawal and anxiety, impulsivity, aggression, stereotypic behaviors, and autism (Hall, Burns, Lightbody, & Reiss, 2008; Roberts et al., 2009; Woodcock et al., 2009). The majority of persons with FXS also meet criteria for comorbid conditions including anxiety (86%, Cordeiro et al., 2011) and attention deficit hyperactivity disorder (90%, Hagerman & Hagerman, 2002).

A number of studies have compared temperament in FXS and other clinical and non-clinical groups using experimental, physiological and parent-reported dimensions of temperament. This work indicates children with FXS are rated as more active; as well as less adaptable, intense, sad, angry, persistent, and approachable compared to typically developing peers (Hatton et al., 1999; Shanahan et al., 2008). Temperament profiles have also been used to differentiate boys with FXS from same-age peers with autism (Bailey et al., 2000) and developmental delay (Kau et al., 2000). These phenotypic differences are likely rooted in well-documented neurobiological self-regulation deficits associated with FXS (e.g. Hall et al., 2009; Heilman et al., 2011), supported by evidence that parent-reported temperament is associated with physiological arousal in young boys with FXS (Roberts et al., 2006). Commensurate with this association between neurobiology and temperament, as well as with the well-documented association between temperament and psychopathology in nonclinical samples (e.g. Fox, et al, 2001), temperament ratings have been associated with autism symptoms (Shanahan et al., 2008) and anxiety (Tonnsen, Malone, Hatton & Roberts, 2013) in young males with FXS.

To date, these studies of temperament in FXS have primarily examined temperament at the subscale level and generally assumed that parent-report scales developed in non-clinical samples can be similarly applied in FXS. However, FXS is associated with atypical patterns of cognitive and self-regulatory mechanisms that may alter the expression and interrelationships of temperament factors. Indeed, recent evidence indicates that the factor structure of temperament differs in children with Williams syndrome compared to that reported for typically developing children (Leyfer et al., 2012). In light of these findings, the

present study seeks to clarify whether the latent structure of temperament in FXS parallels the documented three-prong structure (negative affect, surgency, effortful control) present in non-clinical pediatric samples. Given findings of differentiation of children with FXS to typical controls and recent evidence on the differing factor structure in Williams syndrome, we hypothesized that the original factor structure of the *Child Behavior Questionnaire* in FXS would not be retained in our clinical sample.

2. Methods

2.1 Participants

Participants included 90 males with FXS from a series of longitudinal studies out of the University of North Carolina investigating the developmental trajectories of children with FXS. Participants for this study were selected between 3 and 9 years (36 and 118 months, $M=5.85$ years, $SD=1.47$ years) with data from one parent-rated temperament questionnaire. Eighty-four percent of the participants were White, 9% African American, 1% Hispanic, and 6% other. Each parent completed the Vineland Adaptive Behaviors Scales—Interview Edition, which is a standardized interview that measures personal and social skills that relate to daily functioning (Sparrow, Balla, & Cicchetti, 1984). Mean Adaptive Behavior Composite Score (VABS) was 53.34 ($SD=11.23$) with a range of 30 to 94.

All recruitment, consent, and assessment procedures were approved by the Institutional Review Board at the University of North Carolina at Chapel Hill. Participants were recruited through genetic clinics and developmental assessment centers. Families participated in two-day assessments during which measures of child behavioral and cognitive characteristics were collected. Families were given a small stipend and a report of their child's developmental status for their participation.

2.2 Measures

The Children's Behavior Questionnaire (CBQ; Rothbart, Ahadi, Hershey, & Fisher, 2001) measures reactivity and self-regulation in children ages 3 to 7 years old. The CBQ assesses 15 dimensions of temperament including activity level, anger/frustration, approach, attentional focusing, discomfort, falling reactivity/soothability, fear, high intensity pleasure, impulsivity, inhibitory control, low intensity pleasure, perceptual sensitivity, sadness, shyness, and smiling/laughter (see Table 2 for descriptions). The psychometric properties of the CBQ have been extensively evaluated and suggest strong convergent and discriminate validity, inter-rater reliability, and internal consistency of the temperament scales (Rothbart et al., 2001; Putnam, Rothbart, & Garstein, 2008). In the current study, mothers completed the CBQ at each assessment point by rating how often their children displayed behaviors on a scale of 1 (never) to 7 (always). Mothers were selected to complete the CBQ as the majority of mothers in this study were the primary caregiver. Thus, mothers were assumed to have better insight into behavioral ratings than a non-primary caregiver would.

3. Results

3.1 Data Analytic Procedures

The full data set contained 187 observations with 90 participants. On average, participants had two observation points at varying ages; however, some participants had only one ($N=24$), some had two ($N=41$), and some had three observations ($N=27$). The original data analysis plan was to analyze our full sample of participants ($N=187$) using a multilevel confirmatory factor analysis strategy described by Muthén and Satorra (1995). However, due to convergence problems—likely related to our sample size—we eliminated cases where participants had multiple observations and conducted a standard confirmatory factor

analysis. We eliminated cases by identifying participants who had more than one observation and randomly sampled a single observation from their set. Participants with a single time point were slightly older and could not be eliminated by random sampling; thus, the average age of participants in our reduced and final data set was higher ($t=3.86$, $p<.05$) than the age of participants in the full data set ($M=5.88$ years versus $M=5.13$ years respectively). The final data set resulted in 90 participants with a single observation.

Mplus version 5.0 was used to conduct the confirmatory factor analysis. Full information maximum likelihood was used as the estimator for all models. Model fit was evaluated by Chi-Squared (χ^2), Comparative Fit Index (CFI), Root Mean Square Error of Approximation (RMSEA), and the Standardized Root Mean Square Residual (SRMR). Because of our small sample, rejection of the good fit null hypothesis of the χ^2 suggests substantial misfit in the model. In the current study, the power to detect RMSEA values of .08 or more (indicating poor fit) was found to be .82 based on formulas provided by Schoemann, Preacher, and Coffman (2010).

3.2 Results

To confirm the factor structure of the CBQ we used Rothbart and colleagues (2001) final model for 4 and 5 year olds. This factor structure was chosen because the modal age in our sample was 5 years old. All loadings constrained to zero in this sample were constrained to zero for our initial model. Factor variances were constrained to 1 and all indicators were allowed to freely vary. Our sample fit the Rothbart et al. (2001) factor structure for 4 and 5 year olds poorly, $\chi^2(70, N=90)=115.00$, $p>.01$, CFI=.90, RMSEA=.09 (95% CI between .056 and .11), $p<.05$, SRMR=.07. Model parameters and residual variances were examined to evaluate potential causes of misfit. This examination revealed that the residual variance of the scale Impulsivity was negative, -.04 but not significant, $p=.51$. Because this value was small and non-significant the model was reevaluated with the variance of the impulsivity scale constrained to zero. This model also resulted in poor fit.

Based on the information obtained in the previous model, we constructed a second model (hereafter referred to as model 2), which was identical to the first with the exception that the impulsivity scale was removed. Model 2 demonstrated adequate fit, $\chi^2(48, N=90)=73.23$, $p=.09$, CFI=.96, RMSEA=.054 (95% CI between .00 and .090), $p=.41$, SRMR=.05.

Despite model 2 demonstrating adequate fit, several paths in the model were near zero. Upon examination of the final Rothbart et al. (2001) CFA models for 6 and 7 year olds and the factor analysis for the 3 year olds, several of the paths that were near zero in our model were inconsistent across the original models. Paths that were both near zero in the second model of this study and inconsistent across the original Rothbart et al. (2001) model were constrained to zero for a final model (Model 3). This final model demonstrated good fit, $\chi^2(66, n=90)=76.36$, $p=.17$, CFI=.97, RMSEA=.042 (95% CI between .00 and .08), $p=.61$, SRMR=.05. The factor loadings for the final model are presented in Table 3, with paths that were constrained to zero are represented with loading values of .00. Table 4 includes factor loading differences between the original Rothbart et al. (2001) factor loadings and the factor loadings derived from our sample of males with FXS.

4. Discussion

Temperament research offers a model for understanding individual differences in human behavior by recognizing the interplay between heritable biologically-based traits and the environment over time. As such, studying temperament offers us the opportunity to examine contributions at the neural and genetic level, as well as at the psychological level (Posner & Rothbart, 2007). Temperament research has documented the important role that individual

differences play in child development, with application to the child's developing personality and predicting both adaptive and maladaptive outcomes. One of the primary contributions of this work has been an increased understanding of the emergence and stability of problem behaviors and psychopathology across the lifespan. For example, children high in effortful control encounter fewer problems in development, with effortful control presenting as a protective factor against the presence of externalizing problems (Lengua, 2003; review by Muris & Ollendick, 2005). Likewise, elevated negative affectivity and atypical orienting are associated with increased risk for the development of anxiety disorders (Fox, Russo, Bowles, & Dutton, 2001).

Given elevated problem behaviors associated with boys with FXS, temperament is a useful model to examine the behavioral profiles of this population and allows characterization of multiple dimensions of behavior that are both adaptive and maladaptive. This model offers an alternative to exclusively focusing on problem behavior, a common practice with many other behavior rating scales. The aim of the present study is to contribute to our understanding of temperament in FXS by examining whether the latent structure in our sample of males with FXS is similar to previous reports of both typically developing and clinical samples. We used the CBQ, which represents a theoretically driven approach of temperament that recognizes the constitutional basis and important roles of attention and affect regulation as core foundations to temperament.

Our findings support a three-factor solution representing negative affectivity, effortful control, and extraversion/surgency, similar to the structure reported in typically developing children (Rothbart et al., 2001). We may compare factor analytic findings in terms of both location and magnitude of subscale loadings. In terms of location, our results are in agreement with the Rothbart model, with all scales not constrained to zero loading on the same factors and representing the same positive or negative valence. There were 8 scales constrained to zero in the FXS model that loaded on the Rothbart model. Of these 8 scales, 4 represented low loadings of .20 or lower. However, 4 scales represented moderate loadings, with low intensity pleasure producing the highest loading of .44 on the surgency/extraversion factor for the Rothbart model. Thus, the factor model from this study of males with FXS was highly similar, but not identical, to that of typically developing children. These findings contradicted our hypothesized dissimilar structure based on recent findings of a different temperament factor structure in Williams syndrome (Leyfer et al., 2012) and evidence of divergent profiles in FXS compared to non-clinical controls at the subscale level (Hatton et al., 1999; Shanahan et al., 2008).

The factor models across the FXS and typical groups are less consistent with regard to magnitude. Negative affect loadings are highly similar across both groups, whereas effortful control and extraversion/surgency are inconsistent to varying degrees. The primary differences in effortful control are the loading magnitudes for low intensity pleasure and smiling/laughter. Increased smiling/laughter and an elevated response to low intensity pleasure load positively on the effortful control factor across both groups; however, this relationship is weaker in the FXS group. Given that these two scales are similar in nature, our results may reflect that young males with FXS do not self-regulate in response to low intensity positive stimuli or express positive affect through facial expression to the extent observed in typical samples. This difference could reflect a decreased ability to detect positive events or a blunted response to positive events. However, the magnitude of the contribution of low intensity pleasure and smiling to the negative affectivity factor is similar to that of typically developing children, suggesting these response patterns are isolated to effortful control. Of note, the reduced contribution of smiling/laughter to the effortful control factor in Williams syndrome (.13, Leyfer et al., 2012) is remarkably similar to what we report in FXS (.21) versus typically developing children (.76). Thus, positive affective

expression may be a less salient trait in relation to self-regulation for children with neurodevelopmental disorders which distinguishes them from typically developing children.

Fear appears to more strongly contribute to both the negative affectivity and extraversion/surgency factors (.69 and -.61 respectively) in FXS compared to typically developing children (.47 and -.14 respectively). Fear loaded strongly on two of the factors in our FXS group compared to loading strongly on only 1 factor for the typically developing and only 1 for those with Williams syndrome (Leyfer et al., 2012). Shyness also reflected a stronger contribution in the FXS sample across both the extraversion/surgency and negative affectivity factors (.70 and .45 respectively) compared to the typically developing children (-.31 and .26 respectively), albeit more so for the extraversion/surgency factor. Shyness loaded strongly on 1 factor in the FXS sample, which differed in the typical and Williams samples that reflected more moderate loadings at most. These patterns suggest that fear and shyness may be signature temperament traits for FXS that differentiates them from typicals and other neurodevelopmental disorders like Williams syndrome. This interpretation is consistent with several recent findings in the FXS literature. First, males with FXS experience high rates of social withdrawal and anxiety (Cordeiro et al., 2013) and demonstrate poorer eye contact and increased facial and bodily fear in boys with FXS in response to social approach compared to typical controls (Roberts et al., 2007). Children with FXS have also demonstrated atypical physiological signatures of behavioral fear during a stranger approach paradigm (Tonnsen et al., in press), indicating potential biobehavioral dysregulation that may emerge early in life. Consistent with this possibility, early components of elevated negative affect, including fear and sadness, are associated with later parent-reported anxiety in FXS (Tonnsen et al., 2013).

Despite these associations between negative affect and biological and behavioral features in FXS, children with Williams syndrome are also characterized by high anxiety, and fear did not show the same magnitude of contribution to temperament factors as seen in the FXS group. Although speculative, this difference may reflect that although children with Williams syndrome and FXS often meet criteria for specific phobia, several other types of anxiety disorders are common in FXS, including social phobia, generalized anxiety disorder, obsessive compulsive disorder, and selective mutism (Cordeiro et al., 2013). These findings support the usefulness of employing temperament to refine behavioral phenotypes, a strategy that may be particularly useful in cross-group comparison studies.

The temperament factor structure we report in FXS differs from the four factor model reported in Williams syndrome (Leyfer et al., 2012), although several methodological differences may contribute to these outcomes. First, the Williams syndrome sample was more than twice the size of our sample and included only children aged 5 years and older with an average age of 7.28 years (range of 5 to 10 years) compared to an average age of 5.85 (range of 3 to 9 years) in our FXS sample. Also, the children with Williams syndrome were higher functioning with a mean IQ of 75 compared to the mean adaptive behavior score of 54 in our FXS sample. Finally, the Williams syndrome study employed exploratory factor analyses rather than confirmatory factor analyses as used in our current study.

4.1 Limitations

Our sample size of 90 warrants some concern as it drops below several rules of thumb in the latent variable modeling literature (e.g. $N > 200$; Kline, 2011; Loehlin, 2004), and approaches the limits of some recommendations based on Monte Carlo studies. As such, we believe that the results of the factor analysis must be tempered by the limitations present in conducting research with any low incidence sample, such as individuals with FXS. The primary concerns with such a small sample are the accuracy of parameter estimates, the power to reject the null hypothesis of good fit, convergence issues, and/or improper solutions (e.g.

negative residual variance estimates). A related limitation is the plausibility of measurement invariance across age, which was present in the original Rothbart et al. (2001) study. Because of the already limited sample-size, we could not test a multiple group CFA to empirically examine age-related differences and this is a limitation of our study. Covariance estimates across age bands 3-5 and 6-9 are available in Technical Appendix A.

However, samples of this size may be appropriate under certain circumstances, particularly for evaluating misfit, which is a primary concern in this study. Loehlin (2004) provides a review of the Monte Carlo literature and suggests that if the distributions of indicators approach multivariate normality “sample sizes of 100 were sufficient to yield reasonably accurate model rejection, although larger samples, say 200 or more, were often required for accurate parameter estimates and standard errors” (pg.59). In the current study, primary emphasis will be placed on measures of fit, with a healthy skepticism of the accuracy of parameter estimates.

4.2 Implications and Future Directions

Findings from our study suggest that the temperament factor structure in boys with FXS is quite similar to that of typically developing children (Rothbart et al., 2001) and different from that reported in children with Williams syndrome (Leyfer et al., 2012). Specific scales, however, load differently onto the factors. Compared to loadings derived from nonclinical samples, fear and shyness load more strongly and low intensity pleasure and smiling/laughter load less strongly to factors in our FXS sample. The magnitude of the scale loading only differed between FXS and Williams syndrome in terms of fear and shyness, suggesting temperament studies across neurodevelopmental disorders may be fruitful to identify gene-brain-behavior relationships in identified syndromes such as FXS and Williams syndrome. Such studies would yield several important outcomes: (1) refining the behavioral phenotype in these syndromes, and (2) increasing our understanding of the contribution of genetic factors in these syndromes, and (3) informing our understanding of typical development by characterizing atypical development. As such, temperament studies in neurodevelopmental disorders could facilitate translational efforts to monitor the developmental presentation of symptoms and inform best practices for treatment and intervention.

Several future directions may greatly enhance our current findings. First, we could further our understanding of the constitutional basis of temperament traits and how they may differ across specific syndromes by including biomarkers such as genetic factors and physiological functioning such as salivary cortisol, heart activity and brain imaging. Second, we could strengthen comparisons across developmental abilities by including multiple groups representing both typically developing and identified syndromes in a single report would. Third, studies should integrate laboratory or experimental behavioral measures of temperament with parental reports to inform our understanding of the ways in which the expression of temperament varies by context and rater. These future directions build on our present work characterizing the factor structure of temperament in males with FXS.

Acknowledgments

Removed for Blinding

Appendix A

Covariance Matrices

Ages 3 to 5														
	AL	SH	AN	AP	AF	DS	SO	FE	HP	IC	LP	SE	SD	SL
AL	0.610													
SH	0.096	1.540												
AN	0.180	-0.036	0.980											
AP	0.220	-0.057	0.494	0.780										
AF	-0.204	-0.262	0.004	0.087	0.606									
DS	0.096	0.279	0.261	0.117	-0.091	0.663								
SO	-0.274	-0.266	-0.453	-0.228	0.141	-0.261	0.739							
FE	-0.079	0.251	0.186	0.208	-0.002	0.201	-0.176	0.826						
HP	0.207	-0.353	0.098	0.153	0.112	-0.131	-0.067	-0.215	0.635					
IC	-0.246	-0.219	-0.033	0.144	0.321	-0.069	0.288	0.100	0.156	0.671				
LP	-0.190	-0.246	-0.014	0.029	0.179	-0.018	0.108	-0.060	0.062	0.187	0.366			
SE	-0.292	0.085	0.278	0.209	0.128	0.223	0.075	0.291	-0.101	0.301	0.086	0.959		
SD	0.092	0.017	0.578	0.416	0.044	0.188	-0.411	0.288	0.092	0.003	0.016	0.229	0.827	
SL	-0.018	-0.239	0.157	0.230	0.191	-0.013	0.034	-0.122	0.185	0.228	0.205	0.221	0.174	0.538

Ages 6 to 9														
	AL	SH	AN	AP	AF	DS	SO	FE	HP	IC	LP	SE	SD	SL
AL	0.733													
SH	-0.290	1.824												
AN	0.085	0.066	0.999											
AP	0.150	0.095	0.514	0.873										
AF	-0.166	0.080	0.280	0.174	0.753									
DS	-0.057	-0.078	0.531	0.461	0.328	1.020								
SO	-0.284	0.297	-0.197	-0.247	0.158	-0.155	0.781							
FE	-0.021	0.393	0.208	0.007	0.150	0.556	-0.029	1.094						
HP	0.160	-0.258	0.409	0.428	0.201	0.209	0.228	-0.163	0.648					
IC	-0.134	0.004	0.137	0.144	0.282	0.207	0.200	0.119	0.143	0.449				
LP	-0.236	0.044	0.181	0.213	0.307	0.299	0.052	0.013	0.088	0.133	0.609			
SE	0.054	0.103	0.432	0.672	0.291	0.585	-0.219	0.188	0.379	0.320	0.419	1.291		
SD	0.063	0.290	0.744	0.597	0.243	0.507	-0.197	0.278	0.465	0.281	0.230	0.743	1.066	
SL	0.072	-0.118	0.209	0.304	-0.034	0.198	-0.114	-0.049	0.164	0.000	0.248	0.458	0.190	0.460

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Abbreviations

CBQ	Children's Behavior Questionnaire
FXS	Fragile X syndrome
CFA	Confirmatory Factor Analysis

Highlights

- Distinct patterns of temperament in fragile X syndrome (FXS) are associated with clinical outcomes
- The factor structure the *Children's Behavior Questionnaire* is largely retained in children with FXS
- Different CBQ factor loadings in FXS may reflect syndrome-specific self-regulation, fear, and shyness.

Table 1

Participant Characteristics

Variable	N	M	SD	Min	Max
Age (months)	90	70.2	17.63	36.44	118.08
VABS *	90	53.34	11.23	30	94
Race					
White	76 (84.44%)				
African American	8 (8.89%)				
Hispanic	1 (1.11%)				
Other	5 (5.56%)				

* Note: Vineland Adaptive Behaviors Composite Scaled Score

Table 2

Description of 15 Dimensions of Temperament

Dimension	Definition	Min	Max	Mean	SD
Activity Level	Gross motor activity and movement.	3.38	7.00	5.45	0.82
Anger/Frustration	Negative affect related to interruption of current task.	2.42	7.00	4.29	1.00
Approach	Excitement related to the anticipation of pleasurable activities.	2.69	7.00	5.09	0.93
Attentional Focusing	Ability to sustain attention on an object or a task.	1.56	5.44	3.06	0.82
Discomfort	Negative affect related to sensory stimulation.	1.75	7.00	4.05	0.90
Soothability	Recovery rate from distress, excitement, and arousal.	1.92	6.00	4.25	0.88
Fear	Negative affect related to the anticipation of pain, distress, or threat.	1.75	6.08	3.52	0.99
High-intensity Pleasure	Pleasure related to stimuli of high intensity, novelty, or complexity.	2.15	7.00	4.50	0.81
Impulsivity	Speed of response initiation.	2.43	6.33	4.80	0.85
Inhibitory Control	Ability to restrain inappropriate actions or responses.	1.54	4.92	3.19	0.78
Low-intensity Pleasure	Pleasure related to stimuli of low intensity, novelty, or complexity.	3.23	6.85	5.13	0.70
Perceptual Sensitivity	Ability to detect low intensity stimuli in the environment.	2.08	6.42	4.19	0.99
Sadness	Lowered state of mood related to disappointment or loss	1.50	6.33	3.49	0.97
Shyness	Inhibited or slow approach.	1.45	6.92	4.27	1.29
Smiling/Laughter	Positive affect when stimulus is altered.	2.58	6.92	5.65	0.72

Table 3
Final confirmatory factor analysis with Impulsivity scale removed and near-zero paths
constrained to zero

Scale	Factor		
	1	2	3
	Negative Affectivity	Extraversion/Surgency	Effortful Control
Positive anticipation	0.52	0.25	0.00
High intensity pleasure	0.00	0.57	0.00
Smiling laughter	0.00	0.33	0.21
Activity level	0.00	0.47	-0.56
Shyness	0.45	-0.70	0.00
Discomfort	0.62	-0.28	0.00
Fear	0.69	-0.61	0.00
Anger/frustration	0.77	0.00	0.00
Sadness	0.78	0.00	0.00
Soothability	-0.55	0.00	0.45
Inhibitory control	0.00	0.00	0.55
Attentional focusing	0.00	0.00	0.51
Low intensity pleasure	0.00	0.00	0.40
Perceptual sensitivity	0.43	0.00	0.39

Table 4

Discrepancy between Confirmatory Factor Analysis (CFA) of Children's Behavior Questionnaire Scales in typically developing 4- and 5-year-olds (Rothbart et. al., 2001) and CFA of our sample of children with fragile X syndrome.

Scale	Factor		
	1 Negative Affectivity	2 Surgency/Extraversion	3 Effortful Control
Positive anticipation	0.06	-0.35	-0.35
High intensity pleasure	0.00	-0.19	-0.20
Smiling laughter	0.00	-0.41	-0.55
Activity level	-0.11	-0.3	-0.35
Impulsivity	n/a	n/a	n/a
Shyness	0.19	-0.39	0.00
Discomfort	0.09	-0.12	0.00
Fear	0.22	-0.47	0.00
Anger/frustration	0.02	-0.18	0.00
Sadness	0.07	0.00	0.00
Soothability	0.09	-0.1	0.11
Inhibitory control	0.26	0.00	-0.10
Attentional focusing	0.33	0.00	-0.01
Low intensity pleasure	0.00	-0.44	-0.53
Perceptual sensitivity	0.26	0.00	0.39

Note: Discrepancies are listed as FXS-Original models, with positive values indicating higher loadings in the FXS sample