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Temperament Similarities and Differences: A Comparison of Factor Structures from the Behavioral Style Questionnaire in Children with and Without Autism Spectrum Disorder

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Abstract

The majority of studies of temperament in children with autism spectrum disorder (ASD) use scales normed on typical populations. The present study examined a widely used measure of temperament, the Behavioral Style Questionnaire (McDevitt and Carey in Behavioral Styles Questionnaire, Behavioral-Developmental Initiatives Scottsdale, AZ, 1975) to determine whether it contains the temperament traits theorized by its creators. Neither confirmatory nor exploratory factor analysis, using a sample of children with ASD and a population comparison group, identified the theorized nine temperament factors; many items did not strongly load on any of the original factors. A 10 factor solution best described the ASD data and a 9 factor solution best described the typical group's data. There were substantial similarities in the 9 factor solutions, but groups differed from one another enough to question construct similarity for several factors. These results highlight that more basic psychometric research is needed to better understand the BSQ in children with ASD.

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Author Contributions BB, EJM, SAR contributed to study concept. BB, CL performed statistical analysis. All authors participated in the study design and methods, conceived the statistical review and interpretation, contributed to manuscript preparation and/or review.

Conflict of interest The authors declare they have no conflict of interest.

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed Consent Informed consent was obtained from all individual participants included in the study.

Keywords

Autism; Temperament; Factor structure; Developmental disabilities

Autism spectrum disorder (ASD) is characterized by a number of well described core features including atypical sociability, impairments in nonverbal communication skills, repetitive behaviors, and unusual sensory responses (American Psychiatric Association 2013). Additional behavior patterns have also been studied in children with ASD. Temperament, for instance, is thought to consist of several biologically-mediated patterns of behavior (Buss and Plomin 1975, 2014; Pisula et al. 2015; Rothbart et al. 2000) that are present in early infancy and affect how children respond to their environment (Kagan et al. 1994; Rothbart 2007; Thomas and Chess 1977; Zentner and Bates 2008).

Temperament of children with ASD has been measured using a number of different measures (Barger et al. 2014, 2016; Rothbart 2007). A recent review showed that the Behavioral Style Questionnaire (BSQ, McDevitt and Carey 1975) is the most widely used measure on young children with ASD (Barger et al. 2014). The BSQ is based on Thomas and Chess's (1977) temperament model (T&C), which emphasizes a constellation of behavioral tendencies reflecting children's responses to environmental stimuli in terms of nine traits: *activity, approach, adaptability, distractibility, rhythmicity, intensity, persistence, mood*, and *threshold*. The BSQ is composed of 100 rated items wherein higher scores indicate greater levels of temperament problems. *Activity* refers to how much energy and movement a child regularly expresses, with high score indicating over activity. *Approach* refers to a child's initial response to his/her environment, with higher scores indicating withdrawal. *Adaptability* refers to children's responses to changes in their environment, with higher scores indicating maladaptive behaviors. *Distractibility* refers to a child's tendency to have attention diverted by outside distractions, with higher scores indicating greater distractibility. *Intensity* refers to amount of energy expressed during emotional responses, with higher scores indicating more intensity. *Persistence* refers to a child's capacity to stay focused on tasks, with higher scores indicating lower persistence. *Rhythmicity* refers to the regular cycles of a child's biological rhythms, with higher scores indicating arrhythmia. *Threshold* refers to how responsive a child is to minor changes in his/her environment, with higher scores indicating low responsivity.

A number of studies have found associations between BSQ temperament and developmental outcomes. For example, Kasari and Sigman (1997) found that parents perceived children with ASD as more difficult than children with Down syndrome or typical children and that temperamental difficultness had an association with parent social engagement in children with ASD, but not in the comparison groups. Other studies have shown that children with ASD have scores that differ from published norms on a number of scales (Bailey et al. 2000; Hepburn and Stone 2006) Furthermore, Chuang et al. (2012) and Brock et al. (2012) also reported differences between ASD and typical children on several BSQ dimensions. Chuang et al. (2012) also reported that difficult temperament in ASD is associated with greater sensory processing dysfunction compared to typical children. Brock et al. (2012) reported negative associations between *adaptability, reactivity*, and *distractibility*, positive

associations with *withdrawal* and negative *mood* with a measure of sensory sensitivity. To date, studies indicate that BSQ scales differentiate children with ASD from typical children and statistically correlate with associated sensory measures.

There is evidence that the BSQ may function differently in those with ASD compared to typically developing individuals. First, recent research indicates that some temperament factors, while moderately correlated in typical children, are uncorrelated, or weakly correlated in children with ASD (Barger 2013). Studies that report internal reliability of temperament measures have found that some scales display poor internal reliability in samples of children with ASD (Barger 2013; Hepburn and Stone 2006). This indicates that the items on some scales display weak covariance with other scale items compared to the covariance patterns in typical children; this potentially reflects differences in factor structures for children with ASD and comparison groups.

Second, most T&C temperament measures, such as the BSQ, were developed in the 1960s and 1970s prior to many of the statistical and methodological advances in factor analysis seen since the 1980s (Anastasi 1992). Moreover there is research that indicates T&C's original 9 factor conceptualization of temperament in typically developing populations is not found in T&C measures (Martin et al. 1994). The bulk of this work indicates that a smaller number of more complex factors best represents the factor structure of T&C measures in typically developing populations. However, no studies have investigated the factor structure of measures of temperament in ASD.

Given these findings, the assumption that temperament characteristics can be measured across different groups of children using a single instrument such as the BSQs, may not be valid. Therefore, we aimed to (1) examine whether the factor structure of temperament, as measured with the BSQ in children with ASD is functionally similar to the factor structure in children in the general population, (2) if the factor structure for children with ASD and population comparisons deviates from the 9 factor structure expected by the BSQ's developers, and (3) determine which factors are common across children with ASD and children in the general population.

Method

Participants

Data for this analysis come from the first round of data from the Study to Explore Early Development (SEED) collected from 2003 to 2006 (Schendel et al. 2012). Seed is the largest case-control study to date of the risk factors associated with ASD. Children 30.0–68.9 months old were asked to enroll in the study; of those who enrolled 707 had a confirmed ASD and 1223 were classified as POP (population comparison group). Of the POP children 52 were evaluated for ASD but did not meet SEED criteria for ASD (see Wiggins et al. 2015 for details). For children included in these analyses, 649 families of children with ASD completed the BSQ (91.8%) and 866 families of children classified as POP completed the BSQ (67.5%). Participating families came from catchment areas in California, Colorado, Georgia, Maryland, North Carolina, and Pennsylvania. Children with ASD were recruited from a variety of clinical and educational sources depending on the site. Children with

known ASD as well as broader developmental delays were recruited to ensure that both previously diagnosed and undiagnosed children were included. Typically developing children were recruited from a random sample of birth records. Spanish-speaking families were seen in California and Colorado only. Note that SEED also included a mixed Developmental Disabilities control group although this group was not included in this analysis. See Schendel et al. (2012) for complete details about this study, including eligibility, recruitment, case ascertainment, and study procedures.

Data Collection and Group Classification

Data collection procedures were standardized across all sites and included phone interviews, questionnaires, in-person interviews and clinical observation to determine the final classification of the child. See Wiggins and colleagues (2015) for complete details on the classification algorithms of all study participants. Parents of children in this analysis completed the BSQ prior to participating in clinical assessments. A final classification of either ASD or POP was given to those children who completed a core battery of measures.

Measures

Social Communication Questionnaire (SCQ; Rutter et al. 2003). All children received an ASD screening with the SCQ. The SCQ is a 40 item ASD caregiver report screener that predicts children's scores on ASD assessments, such as the ADI-R, and is appropriate for both verbal and non-verbal children; item 1, which is not counted in the score, queries parents on their children's verbal abilities and was used in our analyses to categorize children as verbal or non-verbal.

Mullen Scales of Early Learning (MSEL; Mullen 1995). The MSEL measures development in children from birth to 68 months via four scales: visual reception, fine motor, receptive language, and expressive language. MSEL includes an Early Learning Composite (ELC) standard score indicating children's relative level of development. In the present study an ELC below 70 is used to mark developmental delay. The item "says first word" was combined with SCQ item 1 to categorize children as verbal or non-verbal.

Behavioral Style Questionnaire (BSQ; McDevitt and Carey 1975), was used to measure child temperament. It is a parent report measure of T&C's 9 temperament traits: *activity, approach, adaptability, distractibility, intensity, mood, persistence, threshold*, and *rhythmicity* (Thomas and Chess 1977).

Analysis

The authors first used exploratory factor analysis (EFA) to analyze the factor structure of temperament for ASD and POP groups, reasoning that no one had yet firmly established the BSQ factor structure in the POP group or in children with ASD (Martin et al. 1994). Thus, to determine similarities and differences between the factor structures of children with ASD and POP, authors conducted separate 100 item EFAs on the BSQ for each group. Inspection of polychoric matrices indicated high collinearity between two BSQ items (items 54 and 67) and item 54 was omitted. Authors used the R minimum residual routine (minres), employing weighted Ordinary Least Square Squares analysis (R Core Team 2014).

Ordinary Least Square Squares is preferable to the more common maximum likelihood (ML) approach because: (a) non-normal individual level data are found in both groups, (b) neither group achieved multivariate normality, and (c) BSQ items are ordinal level (ML requires interval or ratio). As suggested by Norris and Lecavalier (2010), authors chose the following three methods to identify the number of factors for each group: (a) scree plot breaks, (b) Kaiser's criterion (i.e., Eigen ≥ 1), and (c) parallel analysis. Past temperament research on typical populations led authors to suspect non-independent factors, thus an oblique rotation was selected to allow items to cross-load across factors. Item communalities loading at 0.40 and above were selected as adequate for inclusion on a factor; items ≥ 0.32 (i.e., 0.32–1.0) were allowed to cross-load; loadings from 0.32 to 0.39 are considered weak and 0.40 or greater substantial. Authors performed all correlations and EFA in R using the 'psych' package (Revelle 2015).

To determine whether ELC, age, race, or gender were related to the factors, the weighted average factor scores were calculated for each individual. Pearson correlations with factors were calculated to determine the influence of ELC, SCQ, and age; t-tests were conducted to determine the influence of developmental ability, maternal education (≤ high school vs. > high school), and gender. Analysis of Variance (ANOVAs) with follow up Bonferroni corrections were conducted to determine the influence of race (White, Black, Other).

To determine if ASD status related to identified factors, authors created scale scores summing only items with factor loadings greater than 0.40 in *both* groups. Wilcoxon Rank Sum tests were then conducted comparing ASD and POP groups.

Results

Participants

Table 1 contains demographic data for both groups. Children were similar in age, but differed in proportion of children who were female (ASD = 18%; POP = 46%, $p < 0.01$), proportion of children who were non-verbal (ASD = 24%; POP = 1%, $p < 0.01$), proportion of non-White population (ASD = 38%; POP = 25%, $p < 0.01$), proportion with maternal education more than high school (ASD = 93%; POP = 97%, $p < 0.01$), and proportion of children with developmental delays (ASD = 62%; POP = 3%, $p < 0.01$).

BSQ Internal Consistency

As seen in Table 2, BSQ *activity, adaptability, approach, distractibility, intensity*, and *mood* scales had adequate or better reliability in both groups.

Factor Analyses

To better understand the meaning of each of the factors derived here, we developed titles that describe the primary construct captured by the items that loaded on each factor (positive and negative loadings were allowed). This process was conducted by three authors (BB, EM and SR) in an iterative process. The text of each item that loaded on a factor was scanned. The constructs underlying each item were distilled (e.g., item 9 asks about the child enjoying games with running and jumping and is suggestive of high *activity*). Each author developed

a title individually before discussing meaning as a group. Then, disagreements about meaning of the factors were discussed and final descriptive titles agreed upon by consensus as described below. There were no major disagreements. However, several factors included items that appeared to capture more than one construct.

Scree, Kaiser, and PA plots were used to determine the number of factors to choose (Norris and Lecavalier 2010). Originally, to be considered a factor authors required that at least four items loaded at 0.40 or higher; however, our final solution included a factor in the ASD group for which we relaxed this standard. For ASD and POP 10 and 9 factor solutions were chosen respectively (36% of variance in the POP group; 38% for ASD). Nine similar factors emerged across both groups, though item loadings were not entirely identical: *Maladaptability* [ASD Factor 1 (5% variance explained]; POP factor 2 [5% variance)], *Environmental Sensitivity* [ASD Factor 2 (4% variance); POP factor 4 (4% variance)], *Quiet Persistence* [ASD Factor 3 (4% variance); POP factor 6 (4% variance)], *Social Inattention* [ASD Factor 5 (4% variance); POP factor 1 (6% variance)], *Social Approach* [ASD Factor 6 (4% variance); POP factor 5 (4% variance)], *Activity* [ASD Factor 7 (4% variance); POP factor (5% variance)], *Crying* [ASD Factor 8 (4% variance); POP factor 3 (4% variance)], *Rhythmicity* [ASD Factor 9 (4% variance); POP factor 7 (3% variance)], and *Food Openness* [ASD Factor 10 (4% variance); POP factor 9 (3% variance)]. Additionally, a unique ASD factor was identified and labeled *Negative Social Interactions* [ASD Factor 4 (4% variance)]. Table 3 shows factor loadings above 0.32 for each group organized according to the ASD group's factor loadings with unique ASD Factor 4 placed in the last column. A list of BSQ items with brief item stems can be seen in Table 4.

ASD and POP children shared a number of different factors with mostly similar items. Some factors closely resembled the BSQ factors. For example, in both groups *Maladaptability* primarily included items from the BSQ *adaptability* scale, with weak loadings from the BSQ *approach* items indicating children's willingness to try new/different things and their ability to flexibly deal with new situations. Similarly, *Activity* blended BSQ *activity* items with weak loadings from *mood* and *intensity* items (POP only), though three BSQ *activity* items related to running and fidgeting loaded strongly on *Activity* for the ASD group, but strongly on *Social Inattention* for the POP group. Other scales did not resemble BSQ original factors. For example, *Quiet Persistence* blended BSQ *persistence, activity, adaptability*, and *threshold (*POP only*)* items indicating children's willingness/interest to engage in focused activities (e.g., will read a book for hours) and/or learning resulting from focused activity; *Crying* blended BSQ *intensity, mood*, and *threshold* items indicating children's tendency to cry or get upset across situations. Details of item-factor relationships are found in Table 3 and item stem-factors relationships in Table 4. When interpreting scores greater levels of *Maladaptability, Social Inattention, Activity*, and *Crying* indicate more problematic behaviors; higher *Social Approach, Environmental Sensitivity, Quiet Persistence, Rhythmicity* and *Food Openness* indicate more positive behaviors.

Unique ASD Factor

The ASD group displayed a unique factor (last column Table 3) called *Negative Social Interactions*. This factor included strong loadings from BSQ *mood, intensity, persistence,*

distractibility, and *rhythmicity* items, as well as weak loadings from *threshold* and *adaptability* items. Items for this factor blend children's tendency to complain or respond negatively to social interactions, with higher scores indicating more negative behaviors.

Confirmatory Factor Analysis

In response to a reviewer's suggestion, a confirmatory factor analysis (CFA) was conducted to test the original 9-Factor BSQ solution. The authors conducted a diagonally weighted least squared (preferred for ordinal data) CFAs on the ASD and POP groups using the *lavaan* R package (Rosseel 2012); fit indices for ASD and POP groups showed that the 9 factor solution fit poorly (ASD [$_{R-DWLS}X^2$ = 8850.18; CFI = 0.44; TLI = 0.42; RMSEA = 0.04; SRMR = 0.09]; POP [$_{R-DWLS}X^2$ = 9829.44; CFI = 0.56; TLI = 0.55; RMSEA = 0.04; SRMR = 0.08]) with patterns indicating item-factor misfit and factors with many weakly loading items (Heene et al. 2011). Although RMSEA indices indicated good fit, CFI and TLI scores were quite low, thus justifying a judgement of poor fit.

Correlates of Factor Scores

To assess correlates of factor scores, authors conducted bivariate analyses within each group (see Supplemental Tables 1 and 2 online). The ASD group displayed no gender differences on any temperament scores; POP males scored higher than females on *Maladjustment* and *Social Inattention* and lower on *Environmental Sensitivity, Quiet Persistence, Crying*, and *Food Openness*. Race differences were found in ASD only for *Maladaptability, Social Inattention, Crying*, and *Food Openness* and POP only for *Quiet Persistence*. Maternal Education was related to *Quiet Persistence* and *Crying* in ASD only and *Social Inattention* in POP only. ASD children with developmental delays had lower scores than ASD children without delays on *Environmental Sensitivity, Rhythmicity*, and *Negative Social Interactions* and greater scores on *Activity* and *Food Openness*. Nonverbal children with ASD had lower scores than verbal children with ASD on *Environmental Sensitivity, Quiet Persistence, Social Approach, Rhythmicity*, and *Negative Social Interactions*. The POP group had too few cases of developmental delay or non-verbal children to run accurate analyses.

In the ASD group, ELC scores positively correlated with *Quiet Persistence, Rhythmicity* and *Negative Social Interactions* and negatively with *Activity*; in the POP group, ELC scores correlated positively with *Quiet Persistence* and *Rhythmicity*. In the ASD group, SCQ scores correlated positively with *Maladaptability, Social Inattention* and *Crying* and negatively with *Environmental Sensitivity, Quiet Persistence, Social Approach, Rhythmicity, Food Openness*, and *Negative Social Interactions*; in the POP group SCQ scores correlated positively with *Maladaptability, Social Inattention* and *Crying* and negatively with *Environmental Sensitivity, Quiet Persistence, Social Approach, Rhythmicity*, and *Food Openness*. Age correlated positively with *Negative Social Interactions* in ASD only.

ASD and POP groups significantly differed on most scale scores comprised of shared items with loadings at 0.40 or greater (Table 5). The *Social Inattention* and *Social Approach* and scale score had negatively loading items requiring reverse scoring (see Table 3). ASD scored significantly higher on the *Maladaptive, Social Inattention*, and *Crying* scales and lower on

the *Environmental Sensitivity, Quiet Persistence, Social Approach, Rhythmicity*, and *Food Openness* scales.

Discussion

Similar to analyses of T&C factors in typical children (Martin et al. 1994), the originally hypothesized nine BSQ traits were not well-replicated in populations of children with ASD or typical children (POP), though some item-factor relationships did more closely resemble original intended factors than other. Specifically, both POP and ASD groups had factors that appeared closely aligned to BSQ constructs *adaptability* (*Maladaptability*), *activity* (*Activity*) and *rhythmicity* (*Rhythmicity*), and were comprised primarily by BSQ items intended to measure those factors. Alternatively, *Environmental Sensitivity, Quiet Persistence, Food Openness, Social Inattention, Social Approach* and *Crying* also were similar across group factors, but were comprised of disparate items from different BSQ scales. Additionally, the ASD group showed evidence for a single unique factor related to *Negative Social Interactions*. Although there were similarities in the factors of both groups, there were numerous differences between the BSQ factors and derived factors. For both groups, the majority of variance was left unexplained and 18 items did not load strongly on any factor for either group; 24 did not load for the POP group. This study indicates that the T&C factors differ enough between ASD and typical children to question common interpretations of sub-scales, and suggests the need for a critical investigation of the BSQ and other popular temperament measures.

Factor Structure

Several factors had clear correspondence with the original BSQ scales, however, at best clearly corresponding scales only included a small subset of original items (50% or less) common to ASD and POP groups, plus idiosyncratic item loadings from other BSQ scales unique to each group. *Maladaptability, Activity* and *Rhythmicity* represent the clearest domains similar to the original BSQ subscales; however, close inspection indicates that interpretation is not clear cut. For example, while ASD and POP groups have strong loadings on 4 BSQ *activity* items, three BSQ *activity* items (measuring fidgeting and/or running) loaded on our *Activity* factor in the ASD group, but with *Social Approach* in the POP. The ASD group's item loadings clearly indicate general agreement with the BSQ *activity* scale, but the POP does not; however, the POP group's loadings may reflect the fact that activity levels and sociability are strongly associated in typical populations (Zuckerman et al. 1993). For *Maladaptability*, both ASD and POP had strong loadings from 5 BSQ *adaptability* scale items, but weak single unique BSQ *approach* item loadings: "likes to go to new places" (ASD) and "trouble leaving mother on first day of school" (POP). These items may indicate how *Maladaptability* as a factor may relate to unique social outcomes in ASD and POP populations respectively. Four *Rhythmicity* items were common across ASD and POP, but ASD and POP had unique weak loadings from BSQ *rhythmicity* (falls asleep when put in bed [ASD]; wakes up at usual time [POP]) and *adaptability* items (ASD only), whereas POP also had a strong loading from a BSQ *intensity* item (outwardly expressive). Collectively, these data indicate that some theorized BSQ factors are reasonably identified, but that the original items may not capture the constructs optimally.

Several similar factors emerged across both groups blending multiple BSQ items. *Social Inattention, Social Approach* and *Crying* factors were the most similar across groups in their item loadings. These factors each resulted in 5 items with loadings greater than 0.40; each factor had at most a single unique weak loading item present in one group or another indicating that they were largely measuring similar constructs. On the other hand, despite a core set of strongly loading items, *Environmental Sensitivity, Quiet Persistence*, and *Food Openness* showed more variable unique cross-group loadings. For example, on *Environmental Sensitivity* while the ASD group had unique loadings from single BSQ *threshold* and *intensity* items; the same *threshold* item ("unusual noises [thunder, sirens] interrupt child's behavior") loaded on the *Maladaptability* factor in the POP group, indicating how behaviors may differentially co-vary across groups. Furthermore, on *Quiet Persistence* the ASD group had unique weak loadings from single *activity* (sits quietly when waiting), *persistence* (unwilling to leave uncompleted activity), and *intensity* (enthusiastic when masters activity) items, but in the POP group these items loaded on other factors. Similarly, *Food Openness* was comprised of three BSQ *approach* items, but the ASD group had a strong unique loading on a *threshold* item (notices change in food consistency) not seen in the POP. Collectively, these indicate that ASD and POP populations display similar item covariance structures suggestive of common underlying factors that are fundamentally distinct from BSQ suggested scales, but enough unique between group variance exists on several factors to warrant caution and further investigation.

Negative Social Interactions was a unique factor found in ASD blending BSQ *mood, intensity*, and *distractibility* items, and weak loadings from *adaptability, threshold* and *rhythmicity* items indicating verbal expression of dis/satisfaction across multiple scenarios (e.g., frowns when requested to do chores). Interestingly, most items did not load strongly on any factor in the POP group. This factor positively correlated with increased developmental functioning and negatively with autism symptomology indicating that negative social interactions increased with greater abilities and lower symptom expressions in children with ASD. This finding resonates with a recent meta-analysis showing that children with ASD have lower relationship quality with peers compared to typical children (Mendelson et al. 2016). Higher functioning children with ASD may have more opportunities to engage in social relationships than lower functioning children, yet challenges related to core ASD symptoms (e.g., low empathic capacity, reduced perspective taking) may increase conflict and misunderstandings between children with ASD and others (Mendelson et al. 2016). Future research should seek to better understand this unique factor in relation to core ASD traits.

Clinical Implications

These findings raise questions on our ability to interpret clinical and research results based on the original BSQ factor scores. For example, data indicate that *distractibility* and *threshold* scales have, respectively, strong and weak predictive relationships with hypo-responsiveness in children with ASD (Brock et al. 2012). Our analyses indicate that BSQ *distractibility* items load with other scale items primarily on the *Environmental Responsivity* and *Social Awareness* factors; *threshold* items do not clearly load on any factor and are spread across five factors, including two items with *Environmental Responsivity*. The strong

and weak predictive relationships with hypo-responsiveness may reflect shared variance from several *distractibility* items and two *threshold* items related to *Environmental Responsivity*. In addition, we found that the internal reliability of the persistence, rhythmicity, and threshold scales had unsatisfactory reliabilities in both groups ($a \leq 0.60$), indicating unstable reliabilities for clinical use (Cortina 1993). Similarly low reliability have also been reported by Hepburn and Stone (2006). These results suggest that clinicians and researchers should exercise caution in interpreting results based on traditional BSQ factors. Research is needed to verify our findings regarding the construct structure of the BSQ. Moreover it would be important to determine whether the problems we observed in the BSQ also characterize other temperament measures commonly used in ASD temperament research.

The gender differences of the typical children generally reflected differences reported in the temperament/personality literature (Else-Quest et al. 2006): POP group boys were higher than girls on *Maladaptive* and *Social Inattention* and lower on *Environmental Sensitivity, Quiet Persistence, Social Approach, Crying*, and *Food Openness*; Children with ASD did not display gender differences on any temperament factors. Interestingly, except for *Crying*, the *within* group differences of the male versus female POP group mirrored the same pattern of differences as *between* ASD versus POP (i.e., Children with ASD higher on *Maladaptive* and *Social Inattention*; lower on *Environmental Sensitivity, Quiet Persistence, Social Approach, Crying*, and *Food Openness*). Further investigations on the relation between these factors and gender would help refine our current understanding of the phenotypic presentation of ASD in females (Lai et al. 2015).

Limitations

Although these results are based upon a large and diverse sample, several limitations should be mentioned. First, our between group analyses should be interpreted with caution as we did not establish measurement invariance across groups. Future research should determine whether the common temperament constructs identified here display measurement invariance across groups so that researchers can make accurate inferences when comparing temperament factors between populations. Finally, this study was designed to explore the psychometric properties of the BSQ in research settings. Much more research on the applied implications of this research is needed.

Conclusion

Our results suggest there may be a core group of BSQ temperament constructs that are interpretable across children with ASD and non-ASD comparison populations. However, even though similar constructs were identified most of the BSQ's hypothesized scales were not supported. Additional work is needed to fully understand the temperament constructs measured by the BSQ, and how they perform in different subgroups of children. Until this occurs, research on temperament in ASD should be interpreted cautiously due to uncertainty concerning what constructs are actually measured by temperament scales like those on the BSQ.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1

Demographics by final classification

	ASD (n = 649) N (%)	POP (n = 866) N (%)	p-value
Gender			< 0.01
Male	534 (82)	470 (54)	
Verbal			< 0.01
Yes	493 (76)	859 (99)	
Maternal race			< 0.01
Black	126 (19)	101 (12)	
Other	85 (13)	78 (9)	
White	404 (62)	653 (75)	
Missing	34 (5)	34 (4)	
Maternal education			< 0.01
High school or less	35 (5)	22 (3)	
More than high school	605 (93)	836 (97)	
Missing	9 (1)	8 (1)	
Current income			< 0.01
<$10,000	45 (7)	44 (5)	
$10,000–$30,000	107 (16)	66 (8)	
$30,000–$50,000	73 (11)	91 (11)	
$50,000–$70,000	91 (14)	102 (12)	
$70,000–$90,000	82 (13)	120 (14)	
$90,000–$110,000	75 (12)	114 (13)	
>$110,000	152 (23)	298 (34)	
Developmental delay			< 0.01
Yes	403 (62)	25 (3)	
No	238 (37)	804 (93)	
Missing	8 (1)	37 (4)	
	Mean (SD)	Mean (SD)	
Child’s age	4.9 (0.6)	4.9 (0.6)	0.98

ASD Autism Spectrum Disorder, *POP* typically developing children

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Table 2

Internal reliabilities

T&C Scale	ASD alpha (95% CI)	POP alpha (95% CI)
Activity	0.68 (0.64–0.72)	0.68 (0.65–0.71)
Adaptability	0.76 (0.74–0.79)	0.81 (0.79–0.83)
Approach	0.73 (0.7–0.76)	0.78 (0.76–0.8)
Distractibility	0.76 (0.73–0.78)	0.69 (0.65–0.72)
Intensity	0.74 (0.7–0.76)	0.66 (0.63–0.69)
Mood	0.67 (0.64–0.71)	0.75 (0.72–0.77)
Persistence	0.60 (0.55–0.64)	0.57 (0.52–0.61)
Rhythmicity	0.59 (0.54–0.63)	0.59 (0.55–0.63)
Threshold	0.52 (0.47–0.58)	0.37 (0.31–0.43)

ASD Autism Spectrum Disorder, *POP* typically developing population children

Table 3

BSQ factor loadings for children with ASD and population comparison children (ASD/POP) Bolded items indicate item loadings ≥ 0.40

Item Num	T&C	Maladapt	Environ sensitive	Quiet persistence	Social inattention	Social approach	Activity	Crying	Rhythm	Food openness	Neg Soc
8	Ad	**0.77/0.78**									
15	Ad	**0.76/0.68**									
55	Ad	**0.65/0.53**									
10	Ad	**0.50/0.60**									
25	Ap	−0.37/−									
63	Ad	**−0.41**/−									
61	Ad	**−0.86/−0.64**									
21	Ap	−/0.36									
85	D		**0.75/0.65**								
77	D		**0.66/0.75**								
66	D		**0.64/0.71**								
57	T		**0.60/0.47**								
81	D		**0.54/0.58**		−0.32/−						
51	D		**0.52/0.57**								
37	T	**−/0.42**	**0.41/-**		0.34/-						
89	D		0.36/**0.47**								0.33
76	I		0.33/-								
79	T		**−0.48/−0.45**								
40	P			**0.62/0.57**							
35	P			**0.53/0.48**							
44	Ac			**0.50/0.43**							
28	Ad			**0.45**/0.35							
13	Ac			**0.45/0.45**							
27	P			**0.42/0.51**							
46	I			0.36/-		0.32/-			**−/0.40**		0.32
90	P			0.35/-							
26	Ac			0.35/-	−/−0.39						
83	P			0.34/**0.47**							

Item Num	T&C	Maladapt	Environ sensitive	Quiet persistence	Social inattention	Social approach	Activity	Crying	Rhythm	Food openness	Neg Soc
22	T			−/0.37							
17	D				**0.55/0.56**						
71	P				**0.53/0.60**						
2	D				**0.50/0.49**						
65	Ad				**0.43/0.58**						
78	M				**0.41/0.59**						
87	Ac			−/−0.36	0.39/0.34						
34	M				0.37/**0.50**						
93	P			0.35/0.34	−0.37/−**0.48**						
72	M				−/0.36			−/0.33			
31	Ap					**0.72/0.82**					
29	M					**0.69/0.71**					
43	Ap					**0.45/0.59**					
30	I					0.33/0.36	−/0.34				
98	Ap					**−0.45/−0.62**					
86	Ap					**−0.74/−0.77**					
50	Ap					−/−0.34					
9	Ac						**0.60/0.67**				
58	Ac						**0.59/0.52**				
24	Ac						**0.54/0.40**				
70	Ac						**0.54/0.48**				
4	Ac				**−/0.41**		**0.41/-**				
14	Ac				**−/0.40**		0.34/-				
32	Ac				**−/0.55**		0.32/-				
5	M						−/0.34				
92	I						−/0.33				
82	I							**0.73/0.72**			
88	T							**0.69/0.67**			
41	I							**0.66/0.61**			
69	M							**0.54/0.52**			
64	M				0.37/0.35			**0.43/0.40**			

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Item Num	T&C	Maladapt	Environ sensitive	Quiet persistence	Social inattention	Social approach	Activity	Crying	Rhythm	Food openness	Neg Soc
62	R								**0.71/0.51**		
36	R								**0.65**/0.39		
49	R								**0.47**/0.34	−0.37	
47	R								**0.46/0.45**		
23	R								0.34/-		
56	Ad				−/− **0.42**				0.34/-		
3	Ad								−/0.34		
45	I								**−/0.40**		
84	R								−0.39		
67	Ap									**0.91/0.89**	
54	Ap									**0.87/0.91**	
12	Ap									0.36/0.37	
60	T									**−0.44**/−	
96	M										**0.69**
33	P										**0.68**
42	I										**0.61**
97	M				−/0.36						**0.49**
95	D		0.34/0.34								**0.43**
53	I							−/0.34			**0.41**
52	R										**0.41**
19	Ad										0.35
16	T										0.32

ASD Autism Spectrum Disorder, *Ac* Behavioral Style Questionnaire (BSQ) Activity scale, *Ad* BSQ Adaptability scale, *Ap* BSQ Approach scale, *D* BSQ Distractibility scale, *I* BSQ Intensity scale, *M* BSQ Mood scale, *Neg Soc* Negative Sociality, *P* BSQ Persistence scale, *Pop* typically developing population children, *R* BSQ Rhythmicity scale, *Rhythm* Rhythmicity factor, *T* BSQ Threshold scale, *T & C* Thomas and Chess BSQ measure

Table 4

BSQ items organized according to factor loadings

BSQ scale and item number		ASD	POP
Maladaptive items			
Ad8	[needs adjustment period to get used to changes]	X	X
Ad15	[is bothered by plan changes]	X	X
Ad55	[has] difficulty [with] new situations	X	X
Ad10	[adjusts slowly to household rule changes]	X	X
Ap25	Likes … new places [as opposed to familiar ones]	X	
Ad63	Take[s] setbacks in stride	X	
Ad61	Adjusts easily to [routine changes]	X	
Ap21	[when starting school had trouble leaving mother]		X
Environmental sensitivity items			
D85	Responds to [sounds/noises unrelated to … activity]	X	X
D77	Looks up when [hearing voices]	X	X
D66	Looks up [when the phone rings]	X	X
T57	Sensitive to noises [and looks up]	X	X
D81	Stops [activity and looks up when person enters room]	X	X
D51	Looks up when someone walks [by]	X	X
T37	[behavior interrupted by unexpected noises]	X	
D89	Interrupts an activity to [hear conversations]	X	X
I76	Rushes to [loudly] greet … parent	X	
T79	Ignores loud noises when reading	X	X
Quiet persistence			
P40	Becomes engrossed [in interesting activities]	X	X
P35	Practices [to mastery]	X	X
Ac44	Plays quietly with [toys/games]	X	X
Ad28	Learns new things [quickly/easily]	X	X
Ac13	Sits calmly…	X	X
P27	Spends over an hour [occupying self with quiet activities]	X	X
I46	Is enthusiastic when [mastering activity]	X	

BSQ scale and item number		ASD	POP
P90	Is unwilling [unwilling to leave uncompleted play activity]	X	
Ac26	Sits quietly [when] waiting	X	
P83	Watches [long tv programs uninterrupted]	X	X
T22	Picks up [nuances/subtleties explanations]		X
Social inattention			
D17	Does not acknowledge [when called if preoccupied]	X	X
P71	Attention drifts/lapses [while being instructed]	X	X
D2	Seems not to hear [when engaged]	X	X
Ad65	Repeats [previously punished] behavior	X	X
M78	Protests when [request is denied]	X	X
Ac87	Fidgets when [listening to story]	X	X
M34	Is annoyed [when play interrupted by request]	X	X
P93	Pays attention [while listening to explanation]	X	X
M72	[Easily angered by] playmates		X
Social approach			
Ap31	Outgoing with strangers	X	X
M29	Smiles/laughs when [meeting visitors]	X	X
Ap43	Approaches [unknown children]	X	X
I30	Excited by praise	X	X
Ap98	Hold back in [novel] situations	X	X
Ap86	Avoids new [people]	X	X
Ap50	Holds back until sure		X
Activity			
Ac9	Enjoys [running/jumping] games	X	X
Ac58	Prefers active outdoor play	X	X
Ac24	Moves actively when [exploring]	X	X
Ac70	Runs to [go places]	X	X
Ac4	Runs ahead	X	
Ac14	Leaves table [at mealtime]	X	
Ac32	Fidgets when [should be still]	X	
M5	[Laughs/smiles at play]		X

BSQ scale and item number		ASD	POP
I92	Excited [by] new toy or game		X
Crying			
I82	Cries [a lot] when	X	X
T88	Upset/cries over minor [events]	X	X
I41	Cries intensely	X	X
M69	Cries/whines when [sick]	X	X
M64	[Cries/whines when frustrated]	X	X
Rhythm			
R62	[Daily eats same amount at breakfast]	X	X
R36	[Daily eats same amount at supper]	X	X
R49	Hungry at dinner	X	X
R47	Sleepy at [bed-time]	X	X
R23	Falls asleep [when put to bed]	X	
Ad56	… Avoids misbehavior [when punished]	X	
Ad3	Can be coaxed [out of behavior]		X
I45	[Emotionally expressive]		X
R84	[Wakes at usual time during weekends]		X
Food openness			
Ap67	[Tries new foods]	X	X
Ap54	[Readily] accepts new foods	X	X
Ap12	[Tries] new things	X	X
T60	Notices [differences/changes in food consistency]	X	
Negative social			
M96	Complains [about school/playmates]	X	
P33	[“Bored” with toys/games]	X	
I42	[Reactive to kidding]	X	
M97	Frowns when [parent requests chores]	X	
D95	… Leaves [meals to get doorbell/phone]	X	
I53	[Cries/complains when disappointed/fails]	X	
R52	Upset [when misses tv program]	X	
Ad19	[Quickly] settles arguments with playmates	X	

BSQ scale and item number		ASD	POP
T16	Notices minor changes in [dress/appearance]	X	
Items not loading on any factor			
T18	[Responsive to mild parental disapproval]		
M1	Moody [when corrected/disciplined]		
Ac6	Moves slowly when working…		
I17	Responds [to disapproval intensely]		
R11	Has bowel movements [with daily regularity]		
I20	[Has strong positive and negative reaction]		
M38	Complains when tired		
P39	[Quickly] loses interest in [new toy/game]		
D48	Stops [activities when attention is captured]		
T59	[Only likes ice cold drinks]		
Ap68	Needs encouragement [to try new things]		
P73	[Does not give up easily at difficulty tasks]		
T74	[Positive reactions to mild approval]		
R75	[Asks for food outside of meal/snack times]		
Ad80	[Dislikes previously likes foods]		
T91	[Can sleep in presence of nearby conversation]		
Ac94	[Difficult to understand due to pace of speech]		
I99	Laughs hard [at cartoons/comedy]		
M100	Somedays [is moody/cranky]		

Ac Behavioral Style Questionnaire (BSQ) Activity scale, *Ad* BSQ Adaptability scale, *Ap* BSQ Approach scale, *D* BSQ Distractibility scale, *I* BSQ Intensity scale, *M* BSQ Mood scale, *Neg Soc* Negative Sociality, *P* BSQ Persistence scale, *Pop* typically developing population children, *R* BSQ Rhythmicity scale, *Rhythm* Rhythmicity factor, *T* BSQ Threshold scale, *X* scales with loading ≥ 0.32

Table 5

Between group comparisons on BSQ scales items with loadings ≥ 0.40

Factors	Mean (SD)[a]		Median (range)[b]	
	ASD	POP	ASD	POP
Maladaptive[f]	15.69 (5.09)	10.26 (4,34)	16 (4–24)	10 (4–24)***
Environmental	25.02 (6.09)	28.15 (5.11)***	25 (9–42)	28 (9–42)
Sensitivity Quiet Persistence[f]	17.15 (4.84)	20.72 (4.01)	17 (5–29)	21 (8–30)***
Social Inattention	22.30 (4.58)	16.50 (4.79)***	23 (8–30)	16 (5–29)
Social Approach[d]	16.59 (3.46)	18.16 (2.66)	17 (6–28)	18(7–28)***
Activity	19.14 (3.67)	19.50 (2.96)[c]	20 (4–24)	20 (8–24)
Crying[f]	17.61 (5.57)	16.00 (5.09)	17 (5–30)	16 (5–30)***
Rhythmicity[f]	8.90 (2.38)	9.74 (1.82)	9 (2–12)	10 (4–12)***
Food Openness[e]	5.31 (3.10)	7.59 (2.97)	4 (2–12)	8 (2–12)***

ASD Autism Spectrum Disorder, *Pop* typically developing population children

* $p < 0.05$

** $p < 0.01$

*** $p < 0.001$

[a] Parametric scores analyzed with t-tests

[b] Non-parametric distributions analyzed with Wilcoxon Rank Sums

[c] ns

[d] Residuals non-normally distributed in ASD and POP

[e] Residuals non-normally distributed in ASD only

[f] Residuals non-normally distributed in POP only