An Examination of Temperament and Attachment among a Twin Sample

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Abstract

Temperament has often been cited as the foundation of personality development across childhood. Since temperament is a crucial component of childhood development, temperament has also been assessed with other outcomes, such as attachment. Findings pertaining to the relations between attachment and temperament have been mixed. These results may stem from current temperament scales measuring temperament behavior too stringently. Three studies were conducted to examine alternate factor structures of temperament, to explore genetic and environmental variances of temperament, and to investigate associations between temperament and attachment. In Study 1, exploratory factor analyses were performed to comprise alternative smaller and broader temperament scales. In Study 2, intraclass correlations were observed of the original temperament scale and the two new temperament scales for comparison of temperament behavior amongst MZ and same-sex DZ twin pairs. In Study 3, the original temperament scale and the two new temperament scales were assessed across secure and insecure attachment status in MZ and same-sex DZ twin pairs. Study 1 showed that the original nine temperament trait scale can be comprised into three or four factors, while Study 2 confirmed that a smaller set of temperament scales may measure temperament more successfully in MZ twins. However, DZ twins still showed lower correlations among all three scales. In Study 3, attachment status did not significantly differ when compared across all three temperament scales in MZ and DZ twins.

Keywords: temperament, attachment, childhood, exploratory factor analyses, intraclass correlations, comparison of mean outcomes

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Childhood Temperament

Childhood temperament has long been considered the foundation of personality development, in which, these personality traits are established in adolescence and then remain stable into adulthood (Thomas et al., 1970; Cohen, 2008). Understanding temperament in the early years may be important for detecting positive developments, such as learning style or the ability to produce self-regulating capacities, and negative developments, such as predicting internalizing disorders in middle childhood or personality disorders in adulthood (Rothbart & Ahadi, 1994; Cohen, 2008). Although the literature supports that temperament predicts behaviors and disorders, identifying the specific characteristics of temperament have proven to be challenging for the scientific community (Cohen, 2008). Decades of debates related to the definition of temperament have led to scholars defining temperament in differing ways, which has made it challenging for scholars to solidify one specific definition of temperament (Cohen, 2008). However, through the unification of one cohesive definition of temperament, temperament traits can be more easily analyzed and provide stronger measurement of traits.

Unified Definition of Temperament

In 1987, Goldsmith et al. convened a roundtable discussion of temperament amongst leading experts; Mary Rothbart, Alexander Thomas and Stella Chess, Arnold Buss, and Robert Plomin. During the discussion, leading experts narrowed down past proposed definitions of temperament into a final definition (Goldsmith et al., 1987). These experts recommended the final definition for temperament to be an individual's disposition to express certain behaviors. In relation to the development of temperament, these experts stated that temperament is largely

influenced by biological factors early in life; however, environmental factors become more impactful for temperament during later child development (Goldsmith et al., 1987). This final definition decided by leading experts addressed foundational questions about temperament, as well as provided insights into initial theories of temperamental characteristics. Subsequent temperament research across the following 25 years has been strongly informed by this early definition of temperament (Shiner et al., 2012).

Development of Alexander Thomas and Stella Chess's (1970) Nine Temperament Traits

Researchers Alexander Thomas and Stella Chess (1970) advanced the definition suggested by Goldsmith and colleagues by proposing distinct clusters of behaviors that comprise an individual's temperament. In a sample of 85 families and 141 children, Thomas and Chess administered structured interviews to the infants' parents to examine their behavior in designated situations. These interviews were first conducted when the infants were two months old and were conducted again at regular intervals. Psychological testing was also administered to the participants to detect behavioral disturbances. These interviews, as well as the psychological testing, were then cross-referenced with a staff observer's report of the child participant to create a comprehensive outline of their behaviors. Findings showed that the behaviors of the children could then be categorized into nine, distinct clusters that included activity level, rhythmicity, distractibility, approach or withdrawal, adaptability, attention and persistence, intensity of reaction, threshold of responsiveness, and quality of mood. Since the establishment of Thomas and Chess's nine traits of temperament, these scales have been utilized in numerous follow-up studies to better capture and understand temperament in children.

Criticism of Thomas and Chess's (1970) Nine Temperament Traits

Although the development of the nine traits has furthered the field of temperamental research, the theory has still been met with some criticism. Critics of the nine temperament traits theory have questioned whether the temperament traits are truly comprised of distinct clusters, as scientists suggest that the clusters may not accurately describe their reported temperamental constructs (Super et al., 2008). In contrast, supporters of this theory have proposed that the individual clusters are not as critical, but rather that the items suggested to capture these clusters are necessary for understanding temperamental information. The commonality across both viewpoints supports that the individual items proposed by Thomas and Chess (1970) to capture temperament are needed to examine an individual's temperament, but that the nine unique clusters may be too expansive.

Development of the Behavioral Style Questionnaire (BSQ)

Given that research has demonstrated that the elements of the theory proposed by Thomas and Chess (1970) have been beneficial for measuring temperamental information in infancy and early childhood, the creation of empirically tested temperament scales was thus crucial. McDevitt and Carey (1977) put forth the Carey Temperament scales, inspired by the nine traits of temperament, that begins in infancy and continues into young adulthood. This combination of temperament tests includes the Behavioral Style Questionnaire (BSQ), formerly known as the McDevitt Temperament Scale. The BSQ, for children between the ages of 3- and 7-years old, has drawn particular attention from the temperament field for its ability to capture behaviors associated with temperamental traits that have begun to stabilize in early childhood (McDevitt et al., 1977). The BSQ has demonstrated a high test-retest reliability, an acceptable internal consistency, analyses that support an accurate capturing of the Thomas and Chess (1970)

temperamental traits, and a high external validity (McDevitt et al., 1977). These measures were also designed to capture similar constructs across test versions (Matheny, A. P., 1987). Analyses of the BSQ support that the BSQ is a strong measure of Thomas and Chess's (1970) theory, as well as of pertinent temperamental traits in the early childhood years.

Factor Analyses of the BSQ

To address the critique that Thomas and Chess's (1970) nine traits are too expansive to measure unique temperament clusters, Scholom et al. (1979) attempted to replicate the nine original temperament traits first established in the New York Longitudinal Study (NYLS). The Carey Infant Temperament Survey (CITS), a version of the BSQ for infants, was completed by 132 families of 77 boys and 55 girls between the ages of three and four years old. A factor analysis with a principal axis solution and varimax rotation of the CITS showed that there were only three unique factors within the scale. The first factor included approach, adaptability, mood, and threshold. The second factor had activity, intensity, and distractibility. The third and final factor consisted of regularity and persistence. While Scholom et al. (1979) were among the first to demonstrate that a three or four factor solution more precisely depicted the structure of temperament as opposed to the original nine trait scale, subsequent studies that included similar scales to the BSQ in factor analyses also contributed to these smaller factor findings.

Another study, conducted by Sanson et al. (1987), supported Scholom et al.'s (1979) findings in similarly conducted research utilizing factor analyses of the Revised Infant Temperament Questionnaire (RITQ). The RITQ, a Carey and McDevitt temperament scale, like the BSQ for infants, was administered to mothers of 2,443 infants between four to eight months of age. An item-level factor analysis with an orthogonal solution of the RITQ suggested that the nine traits of temperament do not measure nine distinct factors. Rather, the nine traits could be

comprised into three factors. While exploratory factor analyses of the BSQ were limited, factor analyses of similar Carey and McDevitt temperament scales in Scholom et al. (1979) and Sanson et al. (1987) support that a set of fewer and broader temperament traits would likely provide a unique and more pure set of temperament trait scales. Review of the findings from Scholom et al. and Sanson et al., it seems likely that creating a set of three or four factors from the same temperament items in the current study would be most beneficial to describing childhood temperament.

Twin Analyses of Temperament

In addition to the mixed findings on the appropriate factor structure for childhood temperament, questions also remain about the genetic and environmental contributions to these traits. To address these questions of genetic and environmental variance, twin populations have often been selected. Twin studies have been beneficial for providing informative interpretations on the genetic and environmental variations that occur in a phenotypic trait (Boomsma et al., 2002). For example, through comparisons of MZ and DZ twin resemblances, genetic variance can be interpreted when MZ twins show a stronger resemblance than DZ twins. In parallel, shared environmental variances and unique environmental variances can also be concluded from twins who have been raised in the same family household. Through comparison analyses of MZ and DZ twins who were raised in the same household, it is possible to infer genetic and environmental variances in a temperamental trait. Given that twin studies often contain longitudinal data, twin research provides the appropriate methodology for exploration of the genetic and environmental contributions to temperament.

Twin Analyses Utilizing the BSQ

A dataset that is often selected for twin analyses is the longitudinal Louisville Twin Study (LTS), the largest twin study on child development (Davis et al., 2019). Due to the extensive data collected from numerous family members and the reporting of twins by both parents and staff observers, the study contains vast information on the physical, cognitive, and temperamental development of twins. Matheny Jr., former director of LTS from the 1960s to 1980s, initiated temperament research of twins by using the BSQ as reported by the mother (Matheny Jr., 1987; Davis et al., 2019). In this study, temperament data was collected through observations of vignettes conducted in the laboratory and the BSQ for 22 MZ twins and 23 DZ twins who were 36- and 48-months of age. Intraclass correlations were performed for scores of the twins from the laboratory observation, as well as scores obtained for the twins through the BSQ. Correlations for MZ twins from the laboratory observations were .64 at 36- months and .52 at 48- months, while correlations for DZ twins were .36 and .11 respectively. Analyses of the BSQ supported correlations for MZ twins that were higher at .74 at 36- months and .70 at 48- months of age. Comparatively, researchers found lower correlations for DZ twins of -0.16 at 36-months of age and 0.06 at 48-months of age. Findings from Matheny Jr.'s (1983) study are critical, given that the intraclass correlations were only significant for temperament traits that were reported for MZ twins by parents. Of note, correlations of the DZ twins fall far short of the correlations expected of DZ twins when compared to MZ twins. This does suggest that some amount of genetic variance likely also impacts temperament. These results contribute to the literature by supporting the hypothesis that items of the BSQ sufficiently portray temperament traits, but caution may be needed when observing parent reported outcomes of DZ twins.

Matheny Jr.'s (1989) continued pursuit of temperamental research in twins helped maintain his earlier findings of MZ twins displaying more similar temperament traits than DZ twins. In a follow-up study, Matheny Jr. again observed twin pairs; specifically whether MZ twins displayed more similar temperament traits than DZ twins, and whether these similarities in traits holds across age and situation. The Toddler Temperament Scale, a scale like the BSQ, was administered to the mothers of 33 MZ twins and 32 DZ twins who were 12-, 18-, 24-, and 30-months of age. Behaviors associated with temperament traits were also assessed through laboratory vignettes and questionnaires performed during mental testing of the twins. In line with Matheny's (1983) earlier results, only the MZ twins displayed significant outcomes of temperament on the parent-reported measure while DZ twins continued to show much lower correlations than would be expected. MZ twins showed much higher intraclass correlations of .67, .83, .15 and .48 at 12-, 18-, 24-, and 30-months of age than DZ twins who showed correlations of -.21, -.07, -.16, and -.18 at the same ages. Additional findings from the study demonstrated that MZ and DZ twins in the same pair will show similar changes in temperament across ages and across environments. Matheny Jr. also found that when twins showed age-related changes in temperament, the changes in temperament were seen more strongly in MZ twins. Taken together, these outcomes further establish that the use of parent-reported measures, like the Carey and McDevitt Temperament Scales, in twin studies, provide insight into the genetic and environmental variances that contribute to temperament.

Twin Analyses to Detect Genetic and Environmental Variances

Goldsmith, a leading expert and another contributor to the final definition of temperament, built upon Matheny Jr.'s findings by conducting his own temperament research to observe genetic and environmental variances. Goldsmith et al. (1997) examined lesser studied

temperamental traits, such as positive affect and emotion regulation, by investigating the environmental variance of positive and additive genetic variance of emotion regulation. In Goldsmith et al.'s (1997) study, caregivers were requested to complete the Toddler Behavior Assessment Questionnaire (TBAQ) and the Children's Behavior Questionnaire (CBQ) for 184 toddler twins and 119 preschool-aged twins. In contrast to the findings from both of Matheny's (1983) previous studies, intraclass correlations conducted on both temperament scales demonstrated that DZ twins had correlations that were larger than zero. Intraclass correlations for the TBAQ ranged between 0.50 to 0.81 for MZ twins, while DZ twins had correlations ranging between 0.33 to 0.61 for same-sex DZ twins and 0.17 to 0.66 for opposite-sex DZ twins. Findings from the CBQ were similar, in that, correlations for MZ twins ranged between 0.14 to 0.76, while correlations for same-sex DZ twins ranged between -0.30 to 0.55 and -0.37 to 0.55 for opposite-sex DZ twins. In addition to intraclass correlation analyses, an ACE model of the TBAQ also supported shared environmental variance of positive affectivity. Altogether, these findings counter previous research that has suggested that genetic variance contributes more heavily to temperament. An explanation for the higher DZ correlations of the two temperament measures may arise from item-format or differences in content across commonly used temperament questionnaires. Thus, while these studies do not replicate one another's findings in totality, it is clear from the three studies that contributors of genetic and environmental variances of temperament can be detected in twin studies.

John Bowlby and Mary Ainsworth's Attachment Theory

The bond that develops during the initial caregiver-infant relationship is one factor that is believed to heavily influence the temperament and relationships that an infant displays and subsequently experiences across their childhood (Ainsworth, 1979). John Bowlby and Mary

Ainsworth first developed attachment theory to define the possible classifications of the bonded relationship demonstrated by the mother and infant (Bretherton, 1992). Bowlby first proposed the foundations of attachment theory through three seminal papers on separation anxiety, despair, and difficulties in attachment to the caregiver. Bowlby's foundational points were then used to inform Ainsworth's future work that proposed three distinct attachment styles. Attachment styles are often observed through an experiment known as the Strange Situation.

Mary Ainsworth's (1978) The Strange Situation

The Strange Situation, first developed by Mary Ainsworth (1978), was created to assign attachment status to infants based on the unique behaviors displayed in mother-infant pair interactions (Belsky et al., 1987). In the original Strange Situation to inform attachment status, scientists observed the infant's exploration of the environment when playing alone, the infant's reaction to a stranger, and the infant's response to the mother upon returning (Belsky et al., 1987; Van Rosmalen et al., 2015). The infant's response to the mother upon the mother's return was deemed to be particularly informative for assignment of attachment status. For example, infants who were comforted by the presence of their mother and reacted positively to the return of their mother were designated a secure attachment status (Belsky et al., 1987). Through observation of the infant's behaviors in eight, three-minute episodes, infants were categorized into the three established categories: avoidant attachment, secure attachment, and ambivalent attachment (Pierrehumbert et al., 2000). As Ainsworth suggested, attachment status at an early age likely provides insight into children's future behaviors. For instance, children once characterized as securely attached are believed to have positive development outcomes, while children classified as avoidant or ambivalent attachments are believed to have future behavioral problems and low self-esteem (Pierrehumbert et al., 2000). The Strange Situation has been revolutionary in

providing researchers with insight into these attachment classifications and has often been used in experiments assessing attachment's association with temperament.

Attachment's Relation to Temperament

Although attachment status in infancy is believed to be associated with behaviors of temperament in later childhood, past research focusing on these relations have been mixed. Initial research from Belsky and Rovine (1987) addressed this question of whether there are temperamental differences between attachment status assigned in infancy. To assess this question, researchers utilized the Strange Situation to determine attachment assignments in infancy and the Infant Characteristics Questionnaire (ICQ) to observe fussiness, adaptability, and mood temperament scales. 184 infants who were 3 months of age had the ICQ completed by their mother and the Strange Situation completed with their mother and their father at 12- and 13- months of age. ANOVA analyses performed on the temperament measure suggested that temperament did not differ as a function of attachment status across the three attachment groups (Belsky, J. & Rovine, M., 1987). This is unsurprising, given that temperament is believed to become more stable as the child grows older. It is possible that having a set of nine unstable temperament traits at a young age may add confusion to the relations between attachment and temperament.

While Belsky and Rovine (1987) did not detect relations between infant attachment status and infant temperament, it seems likely that relations between infant attachment status and early childhood temperament could be detected once temperament stabilizes. Findings from a longitudinal study support this hypothesis by demonstrating that there are relations between attachment and temperament in 5 months to 3 years of age (Vaughn et al., 1992). Vaughn et al. (1992) observed attachment and temperament traits in six separate samples of infants, with

sample sizes ranging from the smallest group of 19 boys and 16 girls in sample 1, to the largest sample of 179 boys in sample six. The Carey Infant Temperament Questionnaire-Revised, the Bates ICQ, the Carey Toddler Temperament Scale, and the Rothbart Child Behavior Questionnaire, as completed by the mother, were all utilized to measure temperament for the age of the appropriate sample. The Attachment Behavior Q-Sort, as completed by the observer, was selected for detection of attachment across all sample sizes. Correlation analyses were conducted on four temperament components that were observed through principal-component analyses. Notable findings from Vaughn et al. (1992) included that secure attachment in all six samples showed a negative correlation with negative reactivity, and that secure attachment developed a stronger, positive association with temperament as the child grows older. The findings from Vaughn et al. (1992) maintain that the strength and direction of the interaction between attachment and temperament becomes clearer as children grow older and a smaller set of temperament traits become more broadly defined.

Researchers have continued to build upon Vaughn et al.'s (1992) findings in the literature by further demonstrating that relations between attachment and temperament can be detected when fewer and broader traits are selected for an older age of participants. Remondi et al. (2022) observed this result when analyzing the impact of technology addiction of insecurely attached young adults on persistence and self-esteem. 277 18- to 30-year-old young adults were asked to complete two self-report measures including the Experiences in Close Relationships-12 that assessed attachment status and the Temperament Character Inventory-Revised that assessed temperament. Zero-order correlations were observed for all psychosocial and contextual variables within the study. Of note, correlations between anxious attachment and persistence were -0.29 and avoidant attachment and persistence were -0.21. When taken together, these

findings demonstrated that the strength and the direction of the relations between attachment and temperament can be detected when select early childhood to young adulthood temperament traits are observed in association with attachment status. In line with Vaughn et al.'s (1992) results, it is feasible to believe that the associations with attachment will increase once a select, broader set of temperament traits are detected.

Attachment's Relation to Temperament in Twins

While much research has focused on attachment and temperament in singletons, twins have also begun to contribute to the conversation of attachment and temperament. O'Connor and Croft (2001) observed the relations between attachment and temperament in a sample of 125 preschool-aged, same-sex twin pairs from both the metropolitan and rural areas of England. Attachment was determined through the Strange Situation, as completed by twins and their mothers, while temperament was observed through the Emotionality-Activity-Sociability (EAS) Scale, as reported by parents and observers. Univariate, behavioral genetic modeling was selected to measure additive genetic variance, shared environment, and unique environment contributions. O'Connor and Croft (2001) concluded that a main effect was not detected for parent- or observer-reported temperament on attachment. An explanation for this outcome may stem from the intricate nature of the relations between attachment and temperament, which may be challenging to measure at times (O'Connor and Croft, 2001). Given that a lack of crucial findings emerged in both Belsky and Rovine (1987) and O'Connor and Croft's (2001) review of temperament on attachment, it seems possible to detect relations, measurements of attachment at an earlier age are required, before then performing measurements of temperament.

Bokhorst et al. (2003) similarly conducted a study with a twin population to observe the genetic and environmental factors of attachment and temperament. 76 infant twin pairs from the Leiden Twin Study and 62 infant, same-sex twin pairs from the London Twin Study were selected. Attachment was assessed through mothers and twins' participation in the Strange Situation, while temperament was assessed through the Infant Behavior Questionnaire (IBQ) and the ICQ. Temperamental reactivity was the specific trait that was selected for analyses with attachment. ANOVAs conducted on temperamental reactivity with four unique attachment statues did not differ for either child within a twin-pair. Although Bokhorst et al.'s results contribute to the non-significant associations between attachment status and temperament, these findings appear to be particular to that methodological design. Given that these previous studies observed measures of temperament prior to measures of attachment, it seems likely that studies emphasizing attachment measurement prior to measurement of a small, broad set of temperament traits will likely produce stronger associations. The detection of the relation between earlier attachment measurement to later measured smaller and selective temperament traits will be instrumental for understanding future positive and negative behavioral outcomes.

The Present Study

Based on previous, mixed findings, the present study aims to provide transparency on the relation between attachment and temperament. Prior to reviewing attachment's relation to temperament, the aim of the current study will also be to establish whether a novel set of three or four temperament traits are better indicators of temperament behavior that could contribute to a better understanding of attachment and temperament outcomes. We expect that analyses pertaining to attachment status and the new temperament traits will show that there is a difference in temperament traits for securely attached twins when compared to insecurely

attached twins. Our hypotheses are as follows. 1) We predict that a smaller, broader set of three or four temperament trait scales will be more effective for measuring temperament behaviors as compared to the original nine temperament traits scale. 2) We hypothesize that MZ and DZ twins will show more similarity in temperament behavior on the new temperament scales as compared to the original nine temperament trait scale. 3) We expect that securely attached twins will show differences on the new temperament trait scales when compared to the insecurely attached twins. These findings will work in contrast to our analyses for the original nine temperament trait scale that we believe will produce no differences between attachment status and temperament. Taken together, we predict that a new scale of temperament traits will provide a clearer picture on temperament behavior in early childhood. Given that the new scales will hold more accurate depictions of temperament traits in early childhood, it is expected that these scales will further current knowledge on associations of attachment and temperament and understanding of the behavior that is captured by temperament in the early childhood years.

Study 1: Exploratory Factor Analyses of the Items and the Scales of the BSQ

This study was developed to test the two hypotheses that the items of the BSQ and the scales of the BSQ can each be reduced into a smaller set of three or four factors.

Method

Participants

1,822 individuals, originally in twin pairs, from the Louisville Twin Study (LTS) participated in Study 1. Subjects for LTS were recruited from the Louisville, KY region (Finkel et al., 2022). Individuals for this study were drawn from a pool of socioeconomically and ethnically diverse backgrounds. For the purposes of this study, the sample includes only those

who had the Behavioral Style Questionnaire, as completed by the mother, and were between the ages of 3- and 7 years old.

Measures

Behavioral Style Questionnaire (BSQ)

To assess temperament in the individuals from the original twin pairs, the Behavioral Style Questionnaire (BSQ) was utilized. The BSQ, a 100-item measure, was completed by mothers for their twin pairs at 36 months-, 48 months-, 60-months-, 72 months-, and 84 months of age (Karrass, J. et al., 2006). The measure was designed to include both high and low expressions of a temperament trait (high scores indicate more difficulty in the trait), as well as questions pertaining to a child's behavior in a specific setting (McDevitt, S.C. & Carey, W.B., 1978). The items on the Behavioral Style Questionnaire are scored on a Likert Scale ranging from 1 (Almost Never) to 6 (Almost Always). Each of the nine traits is then summed, directionally based on the specific behavior, for a total score of the corresponding questions (McDevitt, S.C. & Carey, W.B., 1978). The BSQ has demonstrated a test-retest reliability ranging from 0.67 to 0.94 across all scales, and an acceptable total internal consistency of 0.84 (McDevitt, S.C., 1977; McDevitt, S.C. & Carey, W.B., 1978). The BSQ has also been standardized and normed for children of this age range (Dilalla et al., 2004).

Statistical Analyses

Exploratory factor analyses (EFA) were conducted in Mplus Version 8.1 statistical software to develop alternative factor structures for the 50 items and the nine scales of the BSQ (Muthén & Muthén, 2017). *M-Plus* was selected due to its' ability to take the dichotomous nature of the items into account. Determination of the appropriate number of factors was

detected through the scree plot test and model fit (Gorsuch, 1983). In line with exploratory factor analyses in the literature, model fit was determined through the Comparative Fit Index (CFI), the Tucker-Lewis Index (TLI), and the Root Mean Square Error of Approximation (RMSEA). Model fit was deemed to be adequate if the CFI and the TLI were in the range of .90 or higher (Evans, D.E. & Rothbart, M.K., 2009). Relatedly, an RMSEA of .08 or lower was also thought to be of good model fit (Browne, M.W. et al., 1993). To ease with factor interpretation, the geomin oblique rotation was selected. To assist with interpretability, items were then assessed for low communality. Loadings of less than .3 or -.3 onto any factor were removed. The oblique rotation was included due to the expectation that the factors will correlate. All criteria were applied to the EFA of the item-level BSQ, as well as the EFA of the scale-level BSQ.

Results

Item-Level Exploratory Factor Analysis of the BSQ

Results of the items and the item loadings for each factor are shown in Table 1. Examination of the scree plot suggested that the 50 items could be condensed into four factors for the best possible solution (Figure 1). Model fit was deemed adequate to good, given that the CFI and TFI were above 0.7, and RMSEA was below 0.08. This new four factor model accounted for 21% of the total variance. Factor 1 explained 7.35% of the variance, while 6.25% of the variance was explained by Factor 2. The remaining Factor 3 and Factor 4 had 4.68% and 2.60% of the variance explained respectively. Factor 1 had high loadings on items such as, “The child is outgoing with strangers,” “The child smiles and laughs when he/she meets new visitors at home”, and “The child approaches children his/her age that he/she doesn’t know”. We interpreted this factor as Extraverted-Openness. Factor 2 encompassed high loadings of items

such as, “The child will avoid misbehavior if punished firmly once or twice,” and “The child sits quietly while waiting.” This factor was understood to be Disciplined. Factor 3, interpreted as Emotional Reactivity, incorporated high loadings of “The child reacts strongly (cries or complains) to a disappointment or failure,” and “The child cries or whines when frustrated.” Factor 4 included high loadings of “The child is sensitive to noises (telephone, doorbell) and looks up right away” and “The child looks up from playing when the telephone rings.” Factor 4 was understood as Sensitivity to Stimuli.

Summary-Level Exploratory Factor Analysis of the BSQ

Table 2 reports the three identified factors for the summary-level EFA. According to the scree plot criterion, a three-factor solution is ideal (Figure 2). Similar to the item-level BSQ EFA, this model suggests adequate to good model fit. The CFI for this model was above 0.9, and the TLI was above 0.7. However, RMSEA was above .10. The three-factor model accounted for 5% of the total variance. Factor 1 summary loadings consisted of Activity, Persistence, and a negative loading of Approach. When taken together, these summary level scales suggest that Factor 1 is composed of behaviors related to activity level and determination. Factor 2 summary loadings consist of the scores from the summary scales of Adaptability and Mood. When examining the behaviors related to these summary scales, we understand this new factor to pertain to emotional openness. Lastly, Factor 3 holds the summary scores from the scales of Threshold, Distractibility, and Intensity. An overview of the behaviors from these scales demonstrates that this new factor conveys behaviors associated with sensitivity in attention.

Study 2: Twin Analyses

The goal of study 2 was to detect, through twin analyses, if MZ twin pairs displayed stronger resemblances of temperament as compared to same-sex DZ twin pairs. It was also hypothesized that MZ and same-sex DZ twin pairs would have higher correlations on the new factor models as compared to Thomas and Chess's (1970) temperament traits scale. To observe these hypotheses, we conducted intraclass correlations of twin pairs who had completed versions of the BSQ at ages 36-, 48-, 60-, 72-, and 84-months of age to also observe longitudinal co-twin similarities of temperament.

Method

Participants

Participants included 116 MZ twin pairs and 81 same-sex DZ twin pairs from LTS. Demographics of the subjects resembled demographics of the participants in Study 1. The MZ and DZ twin pairs were recruited from the same socioeconomically and ethnically diverse background. Only twin pairs who had the BSQ, as reported by the mother, between the ages of 3- and 7- years old were included in this sample.

Measures

Behavioral Style Questionnaire (BSQ)

As was described in Study 1, the BSQ was similarly selected for Study 2.

Statistical Analyses

Intraclass correlations were calculated for MZ and same-sex DZ co-twins who had completed versions of the BSQ. Correlations were observed using Mplus Version 8.1 Statistical

software (Muthén & Muthén, 2017). Analyses allowed for observation of co-twin resemblances of each trait from the three scales at the five time points. Positive intraclass correlations suggested resemblance amongst the twin pairs, while a near zero or zero correlation demonstrated little to no resemblance (Gagne, J.R. et al., 2013).

Results

Thomas and Chess's (1970) Original Nine Traits Scale

Table 3 reflects the intraclass correlations for Thomas and Chess's (1970) original nine traits scale for both MZ and same-sex DZ twin pairs. Across all ages and all scales, intraclass correlations of the parent-reported measure showed a pattern where many of the DZ twin correlations were less than one-half of MZ twin correlations. Specifically, on the Activity scale and the Approach scale, MZ twins demonstrated moderate to strong correlations, while DZ twins were near zero. This finding is in line with previously conducted intraclass correlations of the BSQ in LTS twins where MZ twins showed moderate to strong correlations as compared to DZ twins who reported low correlations (Matheny Jr., 1987). However, of note on the Intensity scale and the Distractibility scale, DZ twins showed higher correlations that reflected at least one-half of the correlations that were captured for MZ twins. While DZ twin correlations were higher on these two scales, no specific pattern emerged across ages or across scales.

Item-Level Four Factor Temperament Scale

Intraclass correlations of the item-level four factor temperament scale established in the earlier reported EFA are shown in Table 4. Intraclass correlations of Factor 1, Extraverted Openness, and Factor 2, Disciplined, demonstrated similar findings to that of the intraclass correlations for Thomas and Chess's (1970) scale. Like Thomas and Chess's scale, DZ twin

correlations were mostly near zero, while MZ twin correlations were moderate to strong. As was seen in the intraclass correlations of Thomas and Chess's scale, DZ twins reported higher correlations that were at least one-half of the correlations seen by MZ twin pairs on the two scales, Emotional Reactivity, Factor 3, and Sensitivity to Stimuli, Factor 4. Of note, across all four factors and all ages, MZ twin correlations were much higher as compared to the MZ twin correlations reported for Thomas and Chess's scale.

Summary-Level Three Factor Temperament Scale

The intraclass correlations of the summary-level three factor temperament scale demonstrated in an earlier EFA are reported in Table 5. In contrast to the intraclass correlations for DZ twins on Thomas and Chess's (1970) scale and the Item-Level Four Factor Temperament Scale, a pattern emerges of low to moderate correlations for DZ twins across all factors and at each age. Although correlations for DZ twins are higher, these intraclass correlations still fall short of one-half of the correlations reported for MZ twins on Factor 1, Active Determination, and Factor 2, Emotional Determination. Like the findings reported for DZ twin correlations on two of the subscales of Thomas and Chess's scale, and two of the Item-Level Four Factor Temperament Scale, intraclass correlations for DZ twins are one-half of those shown for MZ twins on Factor 3, Sensitivity to Attention. As was seen for intraclass correlations of MZ twins on the Item-Level Four Factor Temperament scale, many of the intraclass correlations are strong across all factors and all ages.

Study 3: Relations Between Temperament Scales and Attachment

To detect relations between attachment status and temperament, Study 3 was designed to capture mean differences between securely attached MZ and same-sex DZ twins and insecurely

attached MZ and same-sex DZ twins on the temperament scales included on Thomas and Chess's (1970) original nine temperament trait scale, the Item-Level Four Factor Temperament Trait Scale, and the Summary-Level Three Factor Temperament Trait Scale. Within- pair comparisons were made for both MZ and same-sex DZ twins across the five time points of 36-, 48-, 60-, 72-, and 84- months of age.

Method

Participants

Thirty-two MZ twin pairs and 27 same-sex DZ twin pairs participated from LTS. Subjects' demographics were similar to the demographics of the participants in both Study 1 and Study 2. Both MZ and DZ twin pairs were recruited from the same socioeconomically and ethnically diverse background. Twin pairs were only included in the sample if the twin pairs had completed the Modified Strange Situation at 24- months and had the BSQ, as reported by the mother, between the ages of 3- and 7- years old.

Measures

Behavioral Style Questionnaire (BSQ)

The BSQ described in Study 1 and Study 2 was also selected for Study 3.

The Modified Strange Situation

A modified Strange Situation, specific to the LTS study, was designed to measure the attachment status of twins at 24-months of age. This modified version incorporates the same tenets of the original Strange Situation with three exceptions (Finkel, D. & Matheny, A.P., 2000). The first exception is that the twin pairs remain together in the room during the first

separation and reunion episodes. The second exception is that, when separated, the twins are involved in play vignettes with a stranger. The third and final change in this modified version of the Strange Situation is that the length of the modified Strange Situation is much longer (around 90 minutes) than the design of the original Strange Situation (that is closer to 20 minutes).

Statistical Analyses

We compared mean outcomes of the BSQ scores from Thomas and Chess's (1970) original nine scales, the Item-Level Four Factor Temperament Trait Scale, and the Summary-Level Three Factor Temperament Trait Scale, across securely and insecurely attached twins. Before comparing mean outcomes of these scales, a dummy attachment variable was added to the dataset in *R Version 4.2.0* (Venables, W.N. & Smith, D.M., 2009). The dummy attachment variable that was added to the dataset in *R* was set to have Secure attachment account for "1", and Insecure attachment account for "0". After finalizing the dataset in *R*, mean outcome comparisons were conducted by each scale and age for within- MZ and same-sex DZ twin pairs of secure and insecure attachment status in Mplus Version 8.1 (Muthén & Muthén, 2017). Models were run separately for MZ and same-sex DZ twin pairs.

Results

Thomas and Chess's (1970) Nine Original Temperament Traits

Findings were mixed for both MZ and DZ twins across all traits and all ages (Table 6). Securely attached MZ twins and securely attached DZ twins scored lower on the activity, adaptability, intensity, and mood scales at almost all ages. On the rhythmicity scale, securely attached MZ twins scored higher than insecurely attached MZ twins at 48-, 72-, and 84- months of age, while securely attached DZ twins continued to score lower across almost all ages.

Securely attached DZ twins scored higher at almost all time points on approach, persistence, distractibility, and threshold, while securely attached MZ twins scored higher and lower at the five time points on these four scales.

Item-Level Four Factor Temperament Scales

Although findings continued to be mixed for securely attached MZ and securely attached DZ twins, securely attached MZ twins scored mostly higher than insecurely attached MZ twins (Table 7). On the Extraverted Openness, Disciplined, and Sensitivity to Stimuli scales, securely attached MZ twins scored higher than insecurely attached MZ twins at all time points. Securely attached DZ twins scored higher on the Disciplined and the Sensitivity to Stimuli scale, but lower on the Extraverted Openness scale across all time points. On the Emotional Reactivity scale, both securely attached MZ and DZ twins scored lower than their insecurely attached co-twin at almost all time points.

Summary-Level Three Factor Temperament Scales

Both securely attached MZ and DZ twins scored lower than their insecurely attached co-twin at almost all time points on the Emotional Openness and Sensitivity to Attention scales (Table 8). On the Active Determination scale, securely attached MZ twins scored lower than their co-twin at 36- and 60- months of age while securely attached DZ twins scored lower than their co-twin at 48- and 72- months of age.

Discussion

Results of the present three studies showed that temperament can be clustered into a smaller and broader set of traits as opposed to Thomas and Chess's (1970) original nine temperament scales. While the smaller and broader scales were stronger measures of

temperament in the MZ twin pairs sample, the new temperament traits did not show greater associations to attachment as compared to the associations seen between Thomas and Chess's (1970) traits and attachment. Specifically, Study 1 examined factor models of the BSQ at the item and the scale level. Study 2 observed MZ and same-sex DZ twin correlations for both Thomas and Chess's (1970) original temperament trait scale and the scales derived from the new factor models detected in Study 1. Study 3 focused on mean score differences of temperament between securely attached and insecurely attached MZ and same-sex DZ twins. These mean differences were calculated using Thomas and Chess's (1970) nine temperament trait scale, as well as the new factor models of temperament investigated in Study 1, and the attachment statuses assigned in the Modified Strange Situation.

Study 1 found that both the item-level data and the summary-level data of the BSQ held alternative factor structures of a four-factor scale and a three-factor scale of temperament, respectively. These data supported our hypothesis that the original nine temperament trait scale was much too large to effectively measure behaviors that were associated with temperament. Similarly, by reducing the original nine temperament trait scale to a four-factor scale or a three-factor scale, there was a reduction in cross-loadings. This reduction suggests that the new broader and smaller scales of temperament hold purer information of behaviors tied to a specific temperament trait. These results also align with the literature that has suggested that the original nine temperament trait scales be broadened down to three or four factors (Sanson et al., 1987). Of note, while factor analyses have been conducted at the summary-level of the BSQ, fewer factor analyses have focused on the item-level of the BSQ. Thus, the new item-level four factor temperament scale and the new three factor summary scale contribute to the literature a new set of scales that more effectively measure temperament.

Study 2 examined intraclass correlations conducted for the original nine temperament trait scale that showed multiple violations of the classical twin model across the ages for the individual traits. Violations occurred when DZ twins were less than half as similar as MZ twins. These findings further contribute to the literature that has suggested that DZ twins often score much lower on parent reports than the one-half similarity to MZ twins that is expected of DZ twins (Saudino, K.J., 2005). Given that there were violations on seven of Thomas and Chess's (1970) nine temperament scales, these findings suggest that these intraclass correlations may have been inhibited in strength by the large number of factors that capture similar behaviors across the individual scales.

While improvement in correlations was seen on the item-level four factor temperament scale and the summary-level three factor temperament scale, DZ twin correlations still failed to obtain at least one-half of the correlations exhibited by MZ twins, both on two factors of the four-factor model and two factors on the three-factor model. While MZ twins became stronger in their correlations on the new temperament scales, DZ twins only improved so much. In fact, violations were noted on the new four-factor temperament scale at every age for Factor 1 (Extraverted-Openness) and every age for Factor 2 (Disciplined). Violations were also noted on the summary-level three factor model, with all five ages of Factor 1 (Active Determination) and Factor 2 (Emotional Determination) showing violations. The new factor models were expected to capture broader and more distinct temperament traits as compared to the nine-factor model that showed overlap of certain behaviors of temperament across each scale. Therefore, we believed that the MZ and DZ correlations would increase on the new factor models of temperament. Thus, these findings were unexpected for the DZ twins. Given that the behaviors became more distinct on the new factors, it is possible that the parent-reporting of dissimilarity in DZ twins became

more apparent. Past literature has suggested that some parents may report their DZ twins as similarly as they would a non-twin sibling, and this finding appears to be the case here (Saudino, 2005). Although DZ twin correlations showed more dissimilarity in measurement of temperament, the stronger MZ twin correlations suggest that the new temperament scales are still effective measures of behaviors associated with temperament at a young age. These findings are essential given that the early preschool years are when temperament changes occur before stabilization. This suggests that the two new temperament scales measured temperament behavior well and will likely contribute to additional findings of behavioral outcomes.

In Study 3, the mean outcomes from each of the three temperament scales showed few to no significant differences in associations between secure or insecure attachment status and temperament trait at each age. These findings are contrary to our hypothesis that attachment status with the new temperament scales would show significant predictors of secure versus insecure attachment status. These results also contradict former research that has found associations between a four-factor model of temperament and attachment (Pierrehumbert et al., 2000). Perhaps the associations between attachment and temperament were not detected because attachment often seems to have strong associations with a specific behavior, such as compliance or cooperation, rather than many behaviors that comprise one individual temperament scale (Remondi et al., 2022). Results support the literature that suggests that associations of attachment status with temperament scales may not be as detectable as associations of attachment status with specific temperament behaviors.

Limitations and Future Directions

While this study provides novel and important findings within the fields of temperament and attachment, some limitations to our study should be considered in the interpretation of our findings. First, while the LTS sample population has often been selected for twin analyses, the majority of the sample population is comprised of Caucasian individuals. This suggests that generalizability of the findings from these new temperament factors in relation to attachment status may present challenges in extrapolating to diverse communities.

A second limitation is the delineation of attachment status. In Ainsworth's (1978) original Strange Situation, individual infants are often left alone in the room or are left alone in the room with a stranger. In the present, modified Strange Situation, the twin infants are left in the room together. When the twins are alone in the room together, the twins are involved in vignette roleplays that are not typically involved in the Strange Situation. The addition of these two procedures may have impacted how twins display their behaviors or how their behaviors are being interpreted. For example, securely attached individuals are sometimes deemed so if they are comfortable exploring the room on their own when their mother has left. These behaviors cannot be observed if the twin infants are participating in a vignette or are interacting with one another. By having both infants in the room at the same time, it seems to be difficult to parse apart what behaviors associated with attachment are specific to the infant versus what behaviors associated with attachment are due to the infants' interactions with their sibling. Lastly, the modified Strange Situation is a long examination for attachment status in infants. The original Strange Situation is much shorter in length and newborn infants are typically not expected to participate in interactions that span longer than an hour. It seems highly unlikely that even securely attached infants would display securely attached behavior for this length of time.

To begin addressing some of the above limitations, future directions for these findings may involve a new analysis of the temperament scales and attachment status with an original Strange Situation. It seems likely that by having both twins in the room that the interpretation of attachment status was affected, leading to inaccurate assignment of attachment status. Other measures, such as the Attachment Q-Sort, have also shown higher levels of detection for attachment status. It is possible that a measure such as this can find more distinctions in the temperament behaviors of various attachment statuses. Relatedly, a replication study in a more diverse sample size would be beneficial. Due to the construction of the LTS sample size, it would be challenging to suggest that these results would apply to a broader population. More comparisons of mean outcomes of attachment and temperament in a diverse sample will be needed to make this distinction and clarify if these results have a larger applicability.

References

Ainsworth, M. D. S. (1978). The bowlby-ainsworth attachment theory. *Behavioral and brain sciences*, *1*(3), 436-438.

Ainsworth, M. S. (1979). Infant–mother attachment. *American psychologist*, *34*(10), 932.

Belsky, J., & Rovine, M. (1987). Temperament and attachment security in the strange situation: An empirical rapprochement. *Child development*, 787-795.

Bokhorst, C. L., Bakermans-kranenburg, M. J., Pasco Fearon, R. M., Van Ijzendoorn, M. H., Fonagy, P., & Schuengel, C. (2003). The importance of shared environment in mother–infant attachment security: A behavioral genetic study. *Child development*, *74*(6), 1769-1782.

Boomsma, D., Busjahn, A., & Peltonen, L. (2002). Classical twin studies and beyond. *Nature reviews genetics*, *3*(11), 872-882.

Bretherton, I. (1992). The origins of attachment theory: John Bowlby and Mary Ainsworth. *Developmental psychology*, *28*(5), 759.

Browne, M. W., Cudeck, R., Bollen, K. A., & Long, J. S. (1993). Testing structural equation models.

Cohen, P. (2008). Child development and personality disorder. *Psychiatric Clinics of North America*, *31*(3), 477-493.

Davis, D. W., Turkheimer, E., Finkel, D., Beam, C., & Ryan, L. (2019). The Louisville twin study: past, present and future. *Twin Research and Human Genetics*, *22*(6), 735-740.

DiLalla, L. F., Marcus, J. L., & Wright-Phillips, M. V. (2004). Longitudinal effects of preschool behavioral styles on early adolescent school performance. *Journal of School Psychology*, *42*(5), 385-401.

Evans, D. E., & Rothbart, M. K. (2009). A two-factor model of temperament. *Personality and individual differences*, *47*(6), 565-570.

Finkel, D., & Matheny, A. P. (2000). Genetic and environmental influences on a measure of infant attachment security. *Twin Research and Human Genetics*, *3*(4), 242-250.

Finkel, D., Davis, D. W., Giangrande, E. J., Womack, S., Turkheimer, E., & Beam, C. (2022). Socioeconomic status impacts genetic influences on the longitudinal dynamic relationship between temperament and general cognitive ability in childhood: The Louisville Twin Study. *Child development*, *93*(2), e135-e148.

Gagne, J. R., Spann, C. A., & Prater, J. C. (2013). Parent depression symptoms and child temperament outcomes: A family study approach. *Journal of Applied Biobehavioral Research*, *18*(4), 175-197.

Goldsmith, H. H., Buss, A. H., Plomin, R., Rothbart, M. K., Thomas, A., Chess, S., ... & McCall, R. B. (1987). Roundtable: What is temperament? Four approaches. *Child development*, 505-529.

Goldsmith, H. H., Buss, K. A., & Lemery, K. S. (1997). Toddler and childhood temperament: expanded content, stronger genetic evidence, new evidence for the importance of environment. *Developmental psychology*, *33*(6), 891.

Gorsuch RL. *Factor analysis.* 2. Hillsdale, NJ: Erlbaum; 1983

Karrass, J., Walden, T. A., Conture, E. G., Graham, C. G., Arnold, H. S., Hartfield, K. N., & Schwenk, K. A. (2006). Relation of emotional reactivity and regulation to childhood stuttering. *Journal of communication disorders*, *39*(6), 402-423.

Matheny, A. P. (1987). Developmental research of twin's temperament. *Acta geneticae medicae et gemellologiae: twin research*, *36*(2), 135-143.

Matheny Jr, A. P. (1989). Children's behavioral inhibition over age and across situations: Genetic similarity for α trait during change. *Journal of Personality*, *57*(2), 215-235.

McDevitt, S. C. (1977). A longitudinal assessment of continuity and stability in temperamental characteristics from infancy to early childhood. Dissertation Abstracts International, 37.

McDevitt, S. C., & Carey, W. B. (1978). The measurement of temperament in 3–7 year old children. *Child Psychology & Psychiatry & Allied Disciplines*.

Muthén, B., & Muthén, L. (2017). Mplus. In *Handbook of item response theory* (pp. 507-518). Chapman and Hall/CRC.

O'Connor, T. G., & Croft, C. M. (2001). A twin study of attachment in preschool children. *Child development*, *72*(5), 1501-1511.

Pierrehumbert, B., Miljkovitch, R., Plancherel, B., Halfon, O., & Ansermet, F. (2000).

Attachment and temperament in early childhood; Implications for later behavior problems. *Infant and Child Development: An International Journal of Research and Practice*, *9*(1), 17-32.

Rothbart, M. K., & Ahadi, S. A. (1994). Temperament and the development of personality. *Journal of abnormal psychology*, *103*(1), 55.

Remondi, C., Compare, A., Tasca, G. A., Lo Coco, G., Chiozza, V., Favini, A., ... & Brugnera, A. (2022). The Effects of Attachment, Temperament, and Self-Esteem on Technology Addiction: A Mediation Model Among Young Adults. *Cyberpsychology, Behavior, and Social Networking*, *25*(4), 258-263.

Sanson, A., Prior, M., Garino, E., Oberklaid, F., & Sewell, J. (1987). The structure of infant temperament: Factor analysis of the Revised Infant Temperament Questionnaire. *Infant Behavior and Development*, *10*(1), 97-104.

Saudino, K. J. (2005). Behavioral genetics and child temperament. *Journal of developmental and behavioral pediatrics: JDBP*, *26*(3), 214.

Scholom, A., Zucker, R. A., & Stollak, G. E. (1979). Relating early child adjustment to infant and parent temperament. Journal of Abnormal Child Psychology, 7, 297-308. doi:10.1007/BF00916539

Shiner, R. L., Buss, K. A., McClowry, S. G., Putnam, S. P., Saudino, K. J., & Zentner, M. (2012). What is temperament now? Assessing progress in temperament research on the Twenty-Fifth Anniversary of Goldsmith et al.(). *Child Development Perspectives*, *6*(4), 436-444.

Super, C. M., Axia, G., Harkness, S., Welles-Nystrom, B., Zylicz, P. O., Parmar, P., ... & McGurk, H. (2008). Culture, temperament, and the "difficult child": A study in seven Western cultures. *International Journal of Developmental Science*, *2*(1-2), 136-157.

Thomas, A., Chess, S., & Birch, H. G. (1970). The origin of personality. *Scientific American*, *223*(2), 102-109.

Van Rosmalen, L., Van der Veer, R., & Van der Horst, F. (2015). Ainsworth's Strange Situation Procedure: The Origin of an instrument. Journal of the History of the Behavioral Sciences, 51(3), 261–284. https://doi.org/10.1002/jhbs.21729

Vaughn, B. E., Stevenson-Hinde, J., Waters, E., Kotsaftis, A., Lefever, G. B., Shouldice, A., ... & Belsky, J. (1992). Attachment security and temperament in infancy and early childhood: Some conceptual clarifications. *Developmental Psychology*, *28*(3), 463.

Venables, W. N., Smith, D. M., & R Development Core Team. (2009). An introduction to R.

Wilson, R. S., & Matheny, A. P. (1983). Assessment of temperament in infant twins. *Developmental Psychology*, *19*(2), 172.

Table 1

Results From an Exploratory Factor Analysis of the Item-Level Data from the Behavioral Style Questionnaire: Geomin Oblique Rotation

Behavioral Style Questionnaire Item	Factor Loadings			
	EO	**D**	**ER**	**SS**
Factor 1: Extraverted-Openness				
40. The child is outgoing with strangers	**.75**	-.24	-.04	-.10
38. The child smiles and laughs when he/she meets new visitors at home	**.73**	-.09	-.05	-.04
52. The child approaches children his/her age that he/she doesn't know	**.65**	-.25	.02	.01
33. The child moves about actively when he/she explores new places	**.54**	-.28	.03	.06
21. The child is willing to try new things	**.54**	-.05	-.23	.21
70. The child adjusts easily to changes in his/her routine	**.53**	.10	-.30	.11
55. The child is enthusiastic when he/she masters an activity and wants to show everyone	**.52**	.14	**.30**	.17
54. The child is outwardly expressive of his/her emotions	**.51**	.01	**.34**	.12
39. The child is easily excited by praise	**.47**	.06	.27	.16
18. The child enjoys games that involve running or jumping	**.43**	-.22	.04	.17
34. The child likes to go to new places rather than familiar ones	**.43**	-.14	.01	.09
37. The child learns new things at his/her level quickly and easily	**.42**	.27	.05	-.05
14. The child laughs or smiles while playing	**.42**	.10	.14	.02
19. The child is slow to adjust to changes in household rules	**.75**	-.24	-.04	-.10
77. The child needs encouragement before he/she will try new things	**-.39**	-.25	**.33**	-.01
59. The child holds back until sure of himself/herself	**-.45**	.11	.29	-.01
30. The child had trouble leaving the mother the first three days when he/she entered school	**-.47**	**.35**	.15	.12
17. The child needs a period of adjustment to get used to changes in school or at home	**-.47**	-.11	.21	.13
64. The child has difficulty getting used to new situations	**-.56**	.04	**.31**	.10
40. The child is outgoing with strangers	**-.65**	.01	.29	.04
Factor 2: Disciplined				
65. The child will avoid misbehavior if punished firmly once or twice	-.01	**.70**	-.14	.14
35. The child sits quietly while waiting	-.10	**.69**	-.08	-.06
53. The child plays quietly with his/her age that he/she doesn't know	.03	**.58**	.07	-.09
56. The child is sleepy at his/her bedtime	-.04	**.55**	.03	**.31**
32. The child falls asleep as soon as he/she is put to bed	-.04	**.51**	-.05	.22
22. The child sits calmly while watching TV or listening to music	.09	**.51**	.06	-.13

49. The child becomes engrossed in an interesting activity for one half hour or move	.25	**.49**	.14	-.22
12. The child can be coaxed out of a forbidden activity	.18	**.47**	-.10	.13
27. The child responds to mild disapproval by the parent (a frown or shake of the head)	.12	**.40**	.18	.13
36. The child spends over an hour reading a book or looking at the pictures	.09	**.37**	.02	-.27
15. The child moves slowly when working on a project or activity	-.12	**.34**	.14	-.07
44. The child practices an activity until he/she masters it	.27	**.34**	.07	-.12
45. The child easts about the same amount at supper from day to day	.27	**.32**	.04	.25
71. The child eats about the same amount at breakfast from day to day	.28	**.31**	.03	.24
67. The child prefers active outdoor play to quiet play inside	-.01	**.70**	-.14	.14
23. The child leaves or wants to leave the table during meals	-.10	**.69**	-.08	-.06
48. The child loses interest in a new toy or game the same day	.03	**.58**	.07	-.09
13. The child runs ahead when walking with the parent	-.04	**.55**	.03	.31
41. The child fidgets when he/she has to stay still	-.04	**.51**	-.05	.22
74. The child repeats behavior for which he/she has previously been punished	.05	**-.66**	.20	-.06
Factor 3: Emotional Reactivity				
62. The child reacts strongly (cries or complains) to a disappointment or failure	.04	-.02	**.65**	-.01
73. The child cries or whines when frustrated	.01	-.10	**.60**	.08
16. The child responds intensely to disapproval	.08	.06	**.57**	.04
50. The child cries intensely when hurt	.07	.06	**.53**	.07
29. The child shows strong reaction to things, both positive and negative	.23	.00	**.53**	.08
24. Changes in plans bother the child	-.26	-.03	**.50**	-.01
51. The child reacts strongly to kidding or lighthearted comments	-.01	.09	**.47**	-.05
10. The child is moody for more than a few minutes when corrected or disciplined	-.15	-.06	**.43**	-.05
43. The child is annoyed at interrupting play to comply with a parental request	.08	-.20	**.41**	-.09
47. The child complains when tired	.03	.15	**.35**	.19
63. The child accepts new foods within one or two tries	.01	-.10	**.60**	**.08**
76. The child is willing to try new foods	.08	.06	**.57**	**.04**
Factor 4: Sensitivity to Stimuli				
66. The child is sensitive to noises (telephone, doorbell) and looks up right away	-.06	-.07	.13	**.74**
75. The child looks up from playing when the telephone rings	-.04	-.12	.09	**.68**
60. The child looks up when someone walks past the doorway	-.04	-.04	.11	**.46**
57. The child stops an activity because something else catches his/her attention	-.02	-.26	.16	**.42**
46. Unusual noises (siren, thunder, etc.) interrupt the child's behavior	-.12	-.11	.25	**.35**

Table 2

Results From an Exploratory Factor Analysis of the Summary-Level Data of the Behavioral Style Questionnaire: Geomin Rotation

Behavioral Style Questionnaire Summary	Factor Loadings		
	AD	**EO**	**SA**
Factor 1: Active Determination (AD)			
Activity	**.84**	.01	.02
Persistence	**.51**	.21	-.01
Approach	**-.38**	**.63**	-.00
Factor 2: Emotional Openness (EO)			
Adaptability	.08	**.86**	.01
Mood	-.00	**.66**	.23
Factor 3: Sensitivity in Attention (SA)			
Distractibility	.06	-.10	**.63**
Intensity	-.00	.20	**.45**
Threshold	-.26	.00	**.93**

Table 3

Intraclass Correlations on Thomas and Chess (1970) original temperament trait variables for monozygotic and dizygotic twins

Thomas and Chess (1970) Original Nine Temperament Trait Scale		Correlations by Age Months				
		36	**48**	**60**	**72**	**84**
Activity	MZ	.50	.37	.44	.43	.58
	DZ	**.03**	**.02**	**.10**	**.05**	**.10**
Rhythmicity	MZ	.78	.73	.85	.83	.83
	DZ	**.40**	**.13**	**.20**	**.17**	**.35**
Approach	MZ	.65	.78	.73	.73	.72
	DZ	**.05**	**.03**	**.04**	**.06**	**.01**
Adaptability	MZ	.76	.62	.77	.85	.63
	DZ	**.34**	**.40**	**.23**	**.32**	**.40**
Intensity	MZ	.74	.72	.61	.53	.41
	DZ	**.38**	**.52**	**.29**	**.46**	**.41**
Mood	MZ	.74	.71	.71	.55	.58
	DZ	**.54**	**.35**	**.30**	**.47**	**.48**
Persistence	MZ	.53	.53	.44	.50	.61
	DZ	**.36**	**.01**	**.13**	**.14**	**.13**
Distractibility	MZ	.76	.76	.75	.88	.82
	DZ	**.70**	**.40**	**.55**	**.38**	**.56**
Threshold	MZ	.68	.85	.71	.78	.67
	DZ	**.40**	**.39**	**.51**	**.51**	**.45**

Table 4

Intraclass Correlations of Item-Level Four Factor Temperament Traits Scale for monozygotic and dizygotic twins

Item-Level Four Factor Temperament Traits		Correlations by Age Months				
		36	**48**	**60**	**72**	**84**
Extraverted	MZ	.85	.79	.78	.74	.65
Openness (EO)	**DZ**	**.01**	**.15**	**.01**	**.02**	**.04**
Disciplined	MZ	.49	.58	.60	.62	.72
	DZ	**.05**	**.06**	**.08**	**.02**	**.21**
Emotional	MZ	.72	.65	.63	.74	.70
Reactivity (ER)	**DZ**	**.48**	**.48**	**.28**	**.41**	**.28**
Sensitivity	MZ	.62	.67	.65	.73	.72
To Stimuli (SS)	**DZ**	**.63**	**.28**	**.34**	**.30**	**.28**

Table 5

Intraclass Correlations of Summary-Level Three Factor Temperament Traits Scale for monozygotic and dizygotic twins

Summary-Level Three Factor Temperament Traits		Correlations by Age Months				
		36	**48**	**60**	**72**	**84**
Active	MZ	.54	.60	.62	.60	.59
Determination (AD)	**DZ**	**.08**	**.04**	**.11**	**.04**	**.05**
Emotional	MZ	.84	.79	.78	.80	.69
Determination (ED)	**DZ**	**.21**	**.20**	**.10**	**.21**	**.22**
Sensitivity	MZ	.79	.81	.72	.80	.74
To Attention (SA)	**DZ**	**.51**	**.57**	**.53**	**.47**	**.53**

Table 6

Estimates of means by attachment status and temperament of Thomas and Chess's (1970) original nine temperament trait scale for monozygotic and dizygotic twins

Model	**Secure MZ Twins** (***N = 32***)	**Secure DZ Twins** (***N = 27***)
Activity at 36 Months	**-.03 (.88)**	**-.05 (.82)**
Activity at 48 Months	**-.02 (.93)**	**-.04 (.87)**
Activity at 60 Months	**-.10 (.61)**	**.05 (.87)**
Activity at 72 Months	**.02 (.95)**	**-.01 (.96)**
Activity at 84 Months	**-.04 (.84)**	**-.05 (.96)**
Rhythmicity at 36 Months	-.00 (.99)	.04 (.82)
Rhythmicity at 48 Months	.21 (.38)	-.24 (.19)
Rhythmicity at 60 Months	-.30 (.25)	-.10 (.55)
Rhythmicity at 72 Months	.07 (.82)	-.05 (.81)
Rhythmicity at 84 Months	.05 (.81)	-.01 (.96)
Approach at 36 Months	**-.02 (.95)**	**-.08 (.76)**
Approach at 48 Months	**-.39 (.14)**	**.08 (.76)**
Approach at 60 Months	**-.20 (.36)**	**-.01 (.96)**
Approach at 72 Months	**.00 (.99)**	**.11 (.70)**
Approach at 84 Months	**-.43 (.06)**	**.04 (.86)**
Adaptability at 36 Months	-.26 (.21)	-.05 (.80)
Adaptability at 48 Months	-.18 (.30)	-.16 (.47)
Adaptability at 60 Months	-.38 (.07)	-.33 (.14)
Adaptability at 72 Months	-.22 (.35)	-.15 (.42)
Adaptability at 84 Months	-.32 (.23)	-.23 (.20)
Intensity at 36 Months	**-.17 (.45)**	**-.29 (.07)**
Intensity at 48 Months	**-.11 (.54)**	**-.21 (.31)**
Intensity at 60 Months	**-.10 (.59)**	**-.04 (.87)**
Intensity at 72 Months	**-.05 (.83)**	**-.09 (.65)**
Intensity at 84 Months	**-.34 (.08)**	**-.02 (.94)**
Mood at 36 Months	-.32 (.16)	-.13 (.43)
Mood at 48 Months	-.70 (.00)	-.00 (.99)
Mood at 60 Months	-.40 (.06)	-.27 (.05)
Mood at 72 Months	-.28 (.27)	-.30 (.06)
Mood at 84 Months	-.53 (.04)	.02 (.94)
Persistence at 36 Months	**-.03 (.90)**	**.11 (.64)**

Persistence at 48 Months	**.06 (.68)**	**.04 (.85)**
Persistence at 60 Months	**-.18 (.38)**	**.22 (.30)**
Persistence at 72 Months	**.24 (.18)**	**.06 (.77)**
Persistence at 84 Months	**.21 (.32)**	**.10 (.64)**
Distractibility at 36 Months	.35 (.16)	-.05 (.81)
Distractibility at 48 Months	.23 (.45)	.13 (.49)
Distractibility at 60 Months	-.09 (.78)	.11 (.56)
Distractibility at 72 Months	.89 (.01)	.17 (.22)
Distractibility at 84 Months	.31 (.34)	-.06 (.81)
Threshold at 36 Months	**.25 (.28)**	**-.16 (.39)**
Threshold at 48 Months	**-.15 (.53)**	**.12 (.38)**
Threshold at 60 Months	**.00 (.99)**	**-.23 (.11)**
Threshold at 72 Months	**.39 (.15)**	**.03 (.87)**
Threshold at 84 Months	**.12 (.62)**	**.05 (.74)**

**Note: p-values are in parentheses*

Table 7

Estimates of means by attachment status and temperament of Item-level Four Factor Temperament Trait Scale for monozygotic and dizygotic twins

Model	**Secure MZ Twins** (***N = 32***)	**Secure DZ Twins** (***N = 27***)
Extraverted Openness at 36 Months	**.07 (.74)**	**-.05 (.85)**
Extraverted Openness at 48 Months	**.33 (.04)**	**-.15 (.53)**
Extraverted Openness at 60 Months	**.26 (.10)**	**.05 (.80)**
Extraverted Openness at 72 Months	**.15 (.43)**	**-.10 (.67)**
Extraverted Openness at 84 Months	**.41 (.01)**	**-.06 (.79)**
Disciplined at 36 Months	.10 (.52)	.10 (.63)
Disciplined at 48 Months	.33 (.04)	.26 (.22)
Disciplined at 60 Months	.22 (.24)	.20 (.45)
Disciplined at 72 Months	.15 (.39)	.23 (.31)
Disciplined at 84 Months	.07 (.73)	.20 (.34)
Emotional Reactivity at 36 Months	**-.10 (.63)**	**-.35 (.01)**
Emotional Reactivity at 48 Months	**-.21 (.20)**	**-.12 (.52)**
Emotional Reactivity at 60 Months	**-.21 (.28)**	**-.29 (.17)**
Emotional Reactivity at 72 Months	**.03 (.90)**	**-.20 (.35)**
Emotional Reactivity at 84 Months	**-.44 (.05)**	**.09 (.69)**
Sensitivity to Stimuli at 36 Months	.20 (.43)	.03 (.89)
Sensitivity to Stimuli at 48 Months	.11 (.69)	.01 (.96)
Sensitivity to Stimuli at 60 Months	.18 (.58)	.09 (.73)
Sensitivity to Stimuli at 72 Months	.51 (.02)	.07 (.74)
Sensitivity to Stimuli at 84 Months	.17 (.43)	.07 (.81)

**Note: p-values are in parentheses*

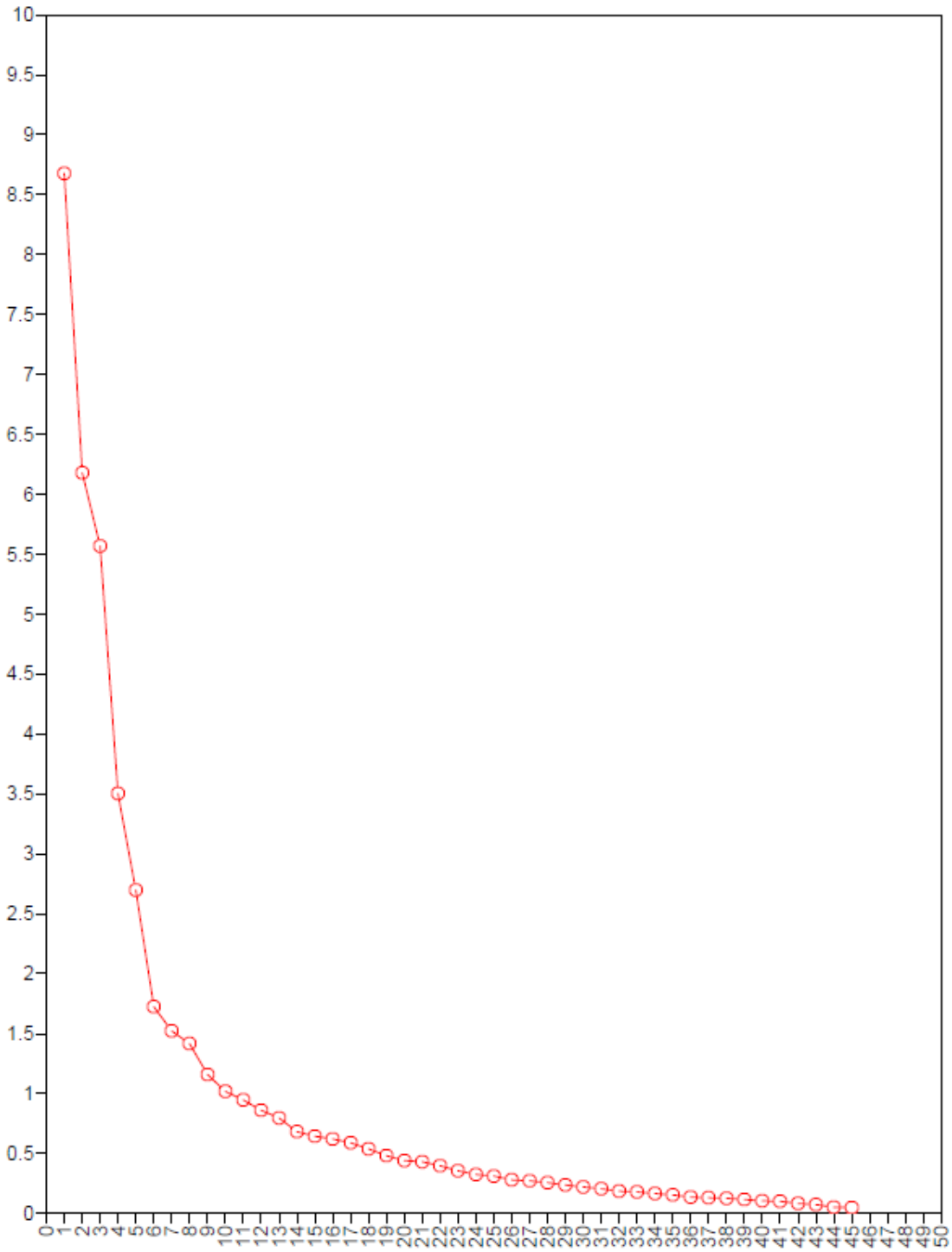
Table 8

Estimates of means by attachment status and temperament of Summary-level Three Factor Temperament Trait Scale for monozygotic and dizygotic twins

Model	**Secure MZ Twins** (***N = 32***)	**Secure DZ Twins** (***N = 27***)
Active Determination at 36 Months	**-.02 (.92)**	**.05 (.79)**
Active Determination at 48 Months	**.15 (.21)**	**-.02 (.88)**
Active Determination at 60 Months	**-.03 (.82)**	**.09 (.65)**
Active Determination at 72 Months	**.08 (.51)**	**-.02 (.88)**
Active Determination at 84 Months	**.19 (.20)**	**.01 (.95)**
Emotional Openness at 36 Months	-.20 (.24)	-.07 (.66)
Emotional Openness at 48 Months	-.42 (.01)	-.01 (.96)
Emotional Openness at 60 Months	-.33 (.04)	-.24 (.10)
Emotional Openness at 72 Months	-.16 (.42)	-.12 (.43)
Emotional Openness at 84 Months	-.44 (.02)	-.05 (.74)
Sensitivity to Attention at 36 Months	**.14 (.47)**	**-.16 (.27)**
Sensitivity to Attention at 48 Months	**-.01 (.97)**	**.01 (.96)**
Sensitivity to Attention at 60 Months	**-.06 (.76)**	**-.05 (.71)**
Sensitivity to Attention at 72 Months	**.40 (.04)**	**.04 (.77)**
Sensitivity to Attention at 84 Months	**-.04 (.82)**	**-.02 (.90)**

**Note: p-values are in parentheses*

Figure 1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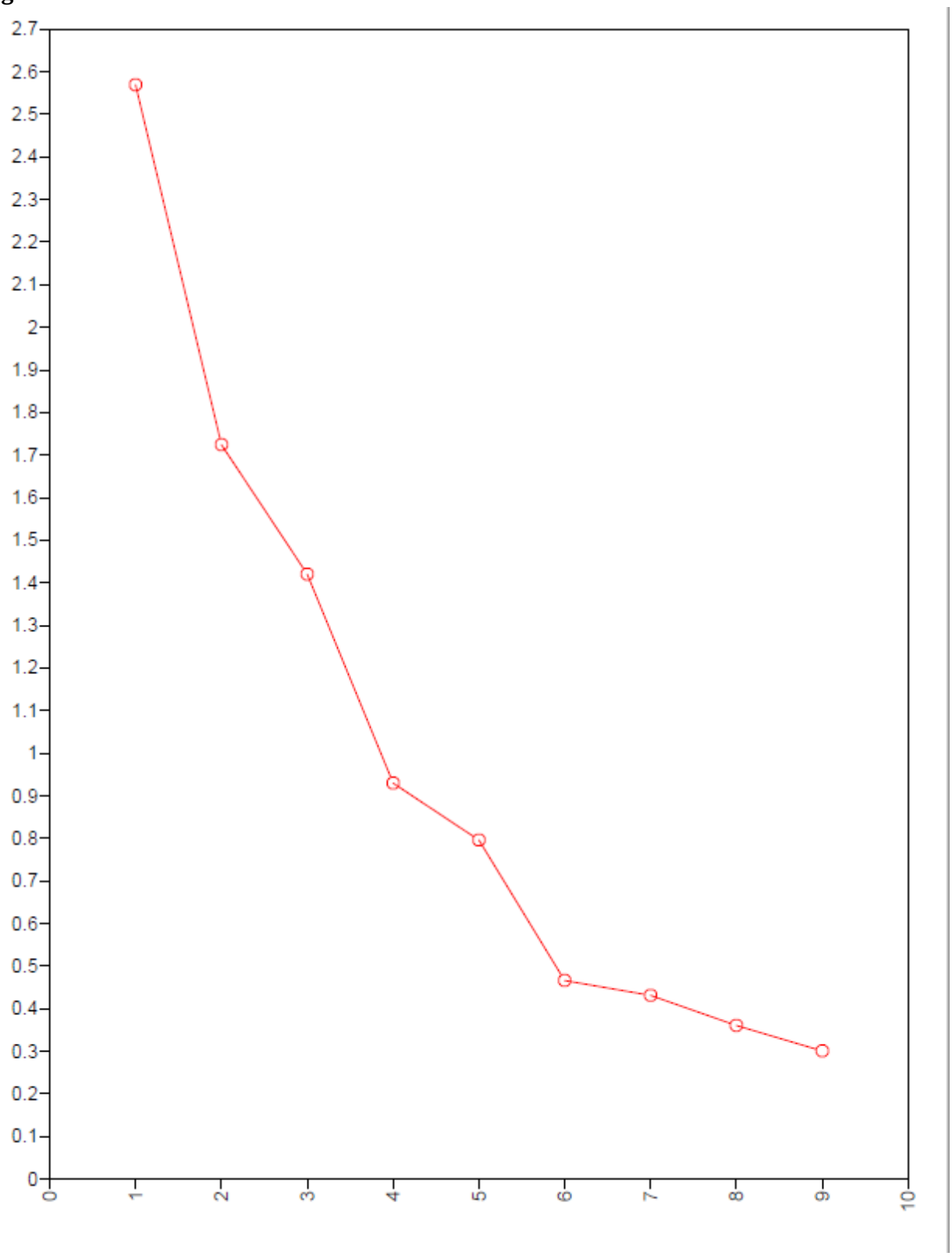
9
8.5
8
7.5
7
6.5
6
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50

Figure 2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2.6
2.5
2.4
2.3
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
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0.4
0.3
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1
2
3
4
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6
7
8
9
10