

ORIGINAL ARTICLE

# *The structure of child temperament as measured by the Polish versions of the Children's Behavior Questionnaire and the Temperament in Middle Childhood Questionnaire: insight from the network psychometrics approach*

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## BACKGROUND

The model proposed by Rothbart is one of the most frequently used models to describe children's temperament. However, the structure of temperamental traits in children is not unambiguous. We examine this structure in children from 3 to 10 years of age using two different measures in a less often studied cultural context (i.e., central Europe), and using a recently developed and still less common approach to study the internal structure of scales (i.e., network psychometrics).

## PARTICIPANTS AND PROCEDURE

This paper examines the structure of temperamental dimensions in children using two different measures – the Children's Behavior Questionnaire (CBQ) and the Temperament in Middle Childhood Questionnaire (TMCQ) – in two studies conducted on children aged 4-7 years ( $N = 178$ ; CBQ) and aged 7-10 years ( $N = 189$ ; TMCQ). We verified the structural validity of these measures with a bootstrapped exploratory graph analysis, which represents the network psychometric approach.

## RESULTS

Network psychometric analysis supported differentiation of three factors of temperamental traits in both groups of children. In addition, the construct validity of these instruments was supported through correlations of the temperament factors measured by the CBQ and the TMCQ with Emotionality, Activity, Sociability, and Shyness scales measured with the EAS Temperament Survey; and through confirmation of expected gender differences in the CBQ and TMCQ factors.

## CONCLUSIONS

Our findings support a three-factor solution of temperamental traits in children representing Negative Affectivity, Effortful Control, and Surgency.

## KEY WORDS

temperament; structure; network analysis; middle childhood

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## BACKGROUND

The model proposed by Rothbart (2011; Rothbart & Derryberry, 1981) is one of the most frequently used models to describe children's temperament (cf. Mervielde & De Pauw, 2012; Strelau, 2018). Results of numerous studies have distinguished three general factors (Surgency, Negative Affectivity and Effortful Control) that characterize the overarching structure of multiple narrowly defined temperament components (e.g., Klein & Linhares, 2010; see also Strelau, 2018). Since this three-factor structure was derived from factor analyses on a set of temperamental dimensions rather than being proposed based on theoretical considerations (Putnam & Rothbart, 2006; Rothbart, 2011; Rothbart et al., 2001), its confirmation in other cultural contexts, using different methods of assessment, is needed. This is especially important given the fact that some studies have revealed factor structure that is inconsistent with the three-factor model (González-Peña et al., 2015; Kotelnikova et al., 2016; Leyfer et al., 2012). Therefore, to contribute to the existing literature, in the current paper we examine the structure of the temperamental traits in children from 3 to 10 years of age using two different measures – the Children's Behavior Questionnaire (CBQ) and the Temperament in Middle Childhood Questionnaire (TMCQ) – in a less often studied cultural context (i.e., central Europe), and using a recently developed and still less common approach to study the internal structure of scales (i.e., network psychometrics). We additionally explored the construct validity of new adaptations of these instruments, via investigations of gender differences and relations with previously developed temperament scales.

## STRUCTURE OF TEMPERAMENT IN CHILDHOOD

Rothbart (1981, 2011; Rothbart & Bates, 2006; Rothbart & Derryberry, 1981) defined temperament as constitutionally based individual differences in reactivity and self-regulation in the domains of affect, activity, and attention. Reactivity is understood as responsiveness to change that occurs in the external and internal environment, while self-regulation involves processes (i.e., effortful control, orienting) that modulate the reactivity of the individual (Rothbart & Bates, 2006). Moving beyond these general concepts, Rothbart and colleagues have developed questionnaires to measure fine-grained aspects of temperament in subsequent developmental periods<sup>1</sup>. Across these instruments designed for various age groups, factor analyses have been conducted on the narrowly defined dimensions of temperament to capture the whole temperament domain as determined by reactivity and self-regulation. Although Rothbart emphasized the importance

of considering developmental differences in temperament aspects at various developmental periods (Putnam et al., 2001), factor analyses of the various instruments have frequently resulted in three general components: Surgency/Extraversion, Negative Affectivity, and Effortful Control (Putnam & Rothbart, 2006; Rothbart, 2011; Rothbart et al., 2001). The first two factors are frequently interpreted as combining aspects of temperament attributed to reactivity, while the latter factor is conceived as largely reflecting self-regulation (cf. Mervielde & De Pauw, 2012).

In the current study, we focused on the temperament structure in children from 3 to 10 years old. Table 1 presents the dimensions of temperament assessed in the Rothbart's measures developed for use with children aged 3-7 years and 7-10 years (Putnam & Rothbart, 2006; Rothbart et al., 2001; Simonds, 2006).

Rothbart's initial exploration of temperament structure was carried out on the fifteen scale scores of the Children's Behavior Questionnaire (CBQ), designed for use with 3- to 7-year-olds. Factor analyses of data collected in China, Japan and the US resulted in the aforementioned three factors (Ahadi et al., 1993; Kochanska et al., 1994; Rothbart et al., 2001). Surgency refers to positive emotions, higher levels of activity, and a rapid approach to anticipated rewards (Rothbart, 2011). Surgent children are very interested in new things and active in social interaction with peers. The second temperamental factor, Negative Affectivity, represents a general disposition to experience negative emotions: sadness, fear, anger, irritability, and discomfort (Rothbart, 2011). The last temperamental factor, Effortful Control, refers to the ability to voluntarily manage attention and inhibit or activate behavior as needed to adapt to the environment, especially when the child does not particularly want to do so, and also reflects tendencies to enjoy low-intensity activities (Rothbart, 2011). The three-factor structure formed the basis for development of an abbreviated version of the CBQ, with confirmatory factor analyses supporting the three factors (Putnam & Rothbart, 2006). This measure, the Very Short Form of the CBQ (CBQ-VSF), was used in the current study.

Although this empirically obtained solution has been replicated in several age groups and across several cultures (e.g., Cozzi et al., 2013; Gartstein et al., 2005; Gartstein & Rothbart, 2003; Montirosso et al., 2011; Roberts et al., 2014; Sleddens et al., 2011), some studies have revealed alternative structures. Based on the results of an item-level exploratory factor analysis, Kotelnikova et al. (2016) identified 15 scales loading on four or five higher-order factors. Both the lower-order and broad factors differed somewhat from those identified by Rothbart, and slightly different structures were found for 3-year-olds and children aged 5 or 6. Among the older children, the first higher-order factor in Kotelnikova et al. (2016)

**Table 1**

*Description of dimensions within three factors of temperament (children aged 3-7 and 7-10 years)*

Dimension	Definition
Surgency	
Impulsivity (S1)	Speed of response initiation
Shyness (S2)	Inhibited or slow approach
Activity Level (S3)	Gross motor activity and movement
High-Intensity Pleasure (S4)	Pleasure related to stimuli of high intensity, novelty, or complexity
Approach/Positive Anticipation <sup>^</sup>	Excitement related to the anticipation of pleasurable activities
Smiling and Laughter <sup>^</sup>	Positive affect when stimulus is altered
Assertiveness/Dominance (Ass) <sup>*</sup>	Tendency to speak without hesitation and to gain and maintain control of social situations
Negative Affectivity	
Anger/Frustration (N1)	Negative affect related to interruption of current task
Sadness (N2)	Lowered state of mood related to disappointment or loss
Soothability (N3)	Recovery rate from distress, excitement, and arousal
Fear (N4)	Negative affect related to the anticipation of pain, distress, or threat
Discomfort (N5)	Negative affect related to sensory stimulation
Effortful Control	
Inhibitory Control (EC1)	Ability to restrain inappropriate actions or responses
Low-Intensity Pleasure (EC2)	Pleasure related to stimuli of low intensity, novelty, or complexity
Attentional Focusing (EC3)	Ability to sustain attention on an object or a task
Perceptual Sensitivity (EC4)	Ability to detect low intensity stimuli in the environment
Affiliation (Aff) <sup>*</sup>	The desire for warmth and closeness with others, independent of shyness or extraversion
Fantasy/Openness (Fan) <sup>*</sup>	Active imagination, aesthetic sensitivity, intellectual curiosity
Activation Control (Act) <sup>*</sup>	Ability to initiate action despite difficulties

*Note.* <sup>\*</sup>Dimension distinguished only in children 7-10 years old and assigned to the factors based on findings in the current study. <sup>^</sup>Smiling and Laughter and Approach/Positive Anticipation occasionally (Rothbart et al., 2001) loaded on factors other than Surgency (Smiling and Laughter on Effortful Control, Approach/Positive Anticipation on Negative Affectivity).

was similar to Negative Affectivity. The second factor reflected playfulness affectivity, as it contained Adventurous and Quiet Play. The third factor consisted of a combination of Smiling/Laughter and Approach/Positive Anticipation, and the fourth was largely defined by Soothability/Falling Reactivity. In a Spanish sample, González-Peña et al. (2015) reported an exploratory factor analysis of the CBQ scales, which revealed a four-factor solution including three broad dimensions (Negative Affectivity, Effortful Control, and Extraversion with two facets: Extraversion-Activation, and Extraversion-Inhibition). In research conducted in children with Williams syndrome (Leyfer et al., 2012), four factors were also identified, but

only two corresponded to Rothbart’s factors (Putnam & Rothbart, 2006; Rothbart, 2011; Rothbart et al., 2001), i.e. Effortful Control and Surgency, while the other two were blends of other dimensions.

For use with older children – aged 7-10 years – Simonds (2006) developed the Temperament in Middle Childhood Questionnaire (TMCQ). The TMCQ contains scales for all constructs measured with the CBQ, which are supplemented with four additional scales (Assertiveness/Dominance, Affiliation, Activation Control and Fantasy/Openness) that reflect the expanding intellectual capabilities and environmental demands placed on older children. The structure of temperament traits as measured by the current

version of the TMCQ has been seldomly reported. While examining the psychometric properties of an earlier version of the TMCQ, Simonds (2006) described four-factor solutions, with the factors labeled Negative Affectivity, Effortful Control, Surgency, and Sociability. In contrast, the typical three-factor structure (Surgency, Negative Affectivity, Effortful Control) has been obtained in research conducted in Sweden (Nystrom & Bengtsson, 2017). Using bottom-up item-based analyses, Kotelnikova et al. (2017) reported a three-factor solution deviating from the structure identified by Simonds (2006) and Nystrom and Bengtsson (2017), comprising factors of Impulsivity/Negative Affectivity, Negative Affectivity, and a third factor combining facets of Fantasy/Openness, Assertiveness/Dominance, and Affiliation.

## CURRENT STUDY

Different analytical approaches have revealed various solutions regarding the structure of temperament in children. The aim of the current study was to expand on this literature through application of network analyses, which has not previously been employed with temperament data. Although several studies have investigated the structure of the CBQ, examination in a novel culture with differing analytical tools provides converging or contrary evidence regarding the robustness of the three-factor model. Network analysis, described in detail in the Method section, holds certain advantages for this type of effort, as this inductive approach does not require researchers to decide upon the number of factors, nor does it require a factor rotation technique. In analyses of both data using the CBQ-VSF in 3- to 7-year-olds and the TMCQ in 7- to 10-year-olds, we expected to find a three-factor structure similar to Rothbart's original structure (Putnam & Rothbart, 2006; Rothbart, 2011; Rothbart et al., 2001) composed of Surgency, Negative Affectivity, and Effortful Control. Because our study is also the first to examine the structure of temperament dimensions measured by the Polish adaptation of the CBQ-VSF and the TMCQ, we also tested the basic psychometrics of these measures.

## PARTICIPANTS AND PROCEDURE

### PARTICIPANTS

We conducted two studies: the first used the Polish translation of the CBQ-VSF and the second used the Polish version of the TMCQ. In the first study, we collected data on 158 children (81 girls and 77 boys) from six Warsaw kindergartens. The age of children ranged from 46 to 84 months, with a mean of 63.41 and standard deviation of 8.78. Their parents were

aged from 23 to 52 years with a mean age of 36.48 ( $SD = 5.22$ ). Questionnaires were completed mostly by mothers (83.5%). In the second study, we collected data on 189 children (85 girls and 104 boys) from Warsaw primary schools. The children were 7-10-years old, with a mean age of 9.33 years ( $SD = 0.80$ ). The TMCQ was completed by parents, while the EAS Temperament Survey was completed either by parents ( $n = 66$ ) or teachers ( $n = 72$ ).

## MEASURES OF TEMPERAMENT

*Children's Behavior Questionnaire – Very Short Form* (CBQ-VSF). The CBQ-VSF contains items originally developed for the standard form of the CBQ (Rothbart et al., 2001), which consists of 195 items assessing 15 scales and three general factors. The CBQ-VSF was created specifically to capture the three broad factors of Surgency, Negative Affectivity, and Effortful Control (12 items per factor). Each scale contains two or three items from each narrow scale. For example, the very short Negative Affectivity scale contains two Frustration items, three Discomfort items, two Soothability items, three Sadness items, and two Fear items (Putnam & Rothbart, 2006). Two scales, Positive Anticipation and Smiling and Laughter, were inconsistent with respect to their primary loadings and often loaded highly on more than one scale; thus the CBQ-VSF includes no items representing these scales (Putnam & Rothbart, 2006). In the CBQ-VSF, parents are asked to rate their child on a 7-point scale ranging from 1 (*extremely untrue of your child*) to 7 (*extremely true of your child*). Parents are also provided with a *not applicable* response option when the child has not been observed in the described situation. In the subsequent analysis we used the mean scores.

*Temperament in Middle Childhood Questionnaire* (TMCQ). The TMCQ (Simonds, 2006) comprises 157 parent-report items, describing the child on a 5-point scale, ranging from 1 (*almost always untrue*) to 5 (*almost always true*), with *does not apply* as an additional option. Items represent 17 dimensions of temperament, of which 13 are the same as scales in the CBQ. Two scales (Approach/Positive Anticipation and Smiling and Laughter) were removed, while four others (Activation Control, Assertiveness/Dominance, Fantasy/Openness, and Affiliation) were added to the TMCQ (Rothbart et al., 2001; Simonds, 2006). In the subsequent analysis we used the mean scores.

### BASIC PSYCHOMETRICS OF CBQ-VSF AND TMCQ

Because this was the first study using the Polish versions of the CBQ-VSF and the TMCQ, we present their basic psychometrics. Table 2 presents descriptive statistics and Cronbach's  $\alpha$  of both questionnaires.

**Table 2**

*Descriptive statistics and reliability estimates of the CBQ-VSF (N = 158) and TMCQ scales (N = 189)*

Scale	M (SD)	Skewness	Kurtosis	α
Study 1 (CBQ)				
Surgency	4.55 (0.96)	-0.52	0.17	.80
Negative Affectivity	4.28 (0.81)	-0.12	-0.47	.68
Effortful Control	5.43 (0.75)	-0.20	-0.47	.73
Study 2 (TMCQ)				
Factors				
Surgency	3.35 (0.41)	0.01	-0.38	.87
Negative Affectivity	2.66 (0.61)	0.07	-0.39	.89
Effortful Control	3.60 (0.51)	-0.13	-0.21	.87
Scales				
Impulsivity	2.81 (0.66)	0.51	0.03	.75
Shyness	2.33 (0.98)	0.40	-0.38	.75
NO Shyness	3.67 (0.98)	-0.40	-0.38	.75
Activity Level	3.94 (0.87)	-0.78	-0.30	.86
High-Intensity Pleasure	3.20 (0.70)	0.22	-0.54	.73
Anger	3.10 (0.87)	0.16	-0.54	.76
Sadness	2.68 (0.65)	0.22	-0.34	.66
Soothability	3.52 (0.69)	-0.30	-0.42	.58
NO Soothability (reduced)	2.48 (0.77)	0.25	-0.58	.64
Fear	2.53 (0.80)	0.43	-0.12	.69
Discomfort	2.48 (0.72)	0.45	-0.32	.70
Inhibitory Control	3.25 (0.72)	0.17	-0.45	.65
Low-Intensity Pleasure	3.59 (0.73)	-0.18	-0.53	.69
Attention Focusing	3.62 (0.95)	-0.60	-0.31	.82
Perceptual Sensitivity	3.63 (0.71)	-0.21	-0.23	.79
Affiliation	4.01 (0.61)	-0.71	0.48	.72
Assertiveness/Dominance	3.16 (0.64)	0.01	-0.14	.65
Fantasy/Openness	3.83 (0.72)	-0.56	-0.15	.72
Activation Control	3.24 (0.53)	0.10	-0.50	.56
Activation Control (reduced)	3.30 (0.61)	0.04	-0.25	.63

*Note.* CBQ-VSF – Children’s Behavior Questionnaire – Very Short Form; TMCQ – Temperament in Middle Childhood Questionnaire.

All of the scales in the CBQ-VSF demonstrated acceptable internal consistency, with the lowest estimates for Negative Affectivity. Internal consistencies for most of the TMCQ scales were satisfactory. The Soothability and Activation Control scales, however, did not exhibit the expected levels of reliability. Two items were deleted from the Activation Control scale,

and one item was deleted from the Soothability scale because these items significantly reduced the scales’ reliability. In subsequent analyses, reversed scales (called NO Shyness and NO Soothability) were used because the anticipated factors include the opposition of shyness and soothability (e.g., Soothability typically loads negatively on Negative Affectivity).

Rothbart (Rothbart et al., 2001; Rothbart & Derryberry, 1981) indicates conceptual relations between the extracted general dimensions of temperament and the dimensions postulated in the model proposed by Buss and Plomin (1984), who distinguished three basic temperament traits – Emotionality, Activity, and Sociability (EAS) – with an additional trait (Shyness) apparent only in childhood. Constructs of Activity Level and Sociability are part of the Surgency factor, whereas aspects such as Anger/Frustration and Fear are components of Negative Affectivity. Shyness in turn tends to load negatively on Surgency and positively on Negative Affectivity in factor analyses of the CBQ. These conceptual considerations allowed us to test the theoretical validity of the CBQ-VSF and the TMCQ, with expectations of the following relations between the three factors from Rothbart’s model (Rothbart, 2011; Rothbart et al., 2000, 2001) and the temperamental traits from the Buss and Plomin’s (1984) model: (1) Negative Affectivity with Emotionality (positive) and with Shyness (negative); (2) Surgency with Activity (positive), Sociability (positive), and Shyness (negative).

In order to test these expectations and provide support for the validity of the CBQ-VSF and TMCQ we used the EAS Temperament Survey (EAS). The EAS questionnaire was developed by Buss and Plomin (1984). The parent-report and teacher-report versions of the instrument developed for children between 3 and 11 years of age were employed in the current study. These versions contain 20 items, describing the child on a 5-point scale, ranging from 1 (*strongly disagree*) to 5 (*strongly agree*) grouped in

four scales – Emotionality, Activity, Sociability, and Shyness. All but one scale presented satisfactory internal consistency (Cronbach’s  $\alpha$  values ranged from .64 to .86). Only Sociability (parental ratings for younger children) obtained a low  $\alpha$  (.48), which is similar to other Polish studies (Oniszczenko, 2015).

Table 3 shows the correlation coefficients between temperament traits measured by the CBQ-VSF or TMCQ and the EAS. In the first study, all theoretically expected correlations were significant and in the expected directions: Surgency was positively associated with Activity and Sociability, and negatively associated with Shyness. Negative Affectivity was positively associated with Emotionality and Shyness. In the second study, all relations were in the expected directions, but they were not all significant (especially with the teacher as an informant). Surgency was positively associated with Activity and negatively associated with Shyness (parent report). Negative Affectivity was positively associated with Emotionality and Shyness (teacher report).

Previous research using Rothbart’s approach has examined gender differences. Else-Quest et al. (2006) used meta-analytical techniques to estimate gender differences in children, analyzing 35 dimensions and three factors of temperament in over 60 different studies. Their findings indicated that Effortful Control had a large gender difference with girls demonstrating a stronger ability to manage and regulate their attention and to inhibit their impulses and behaviors; girls were also better at perceiving, and expressed more enjoyment of low-intensity environmental stimuli than boys. Surgency showed

**Table 3**

*Correlations between temperament traits as measured by the CBQ-VSF/TMCQ and the EAS*

Study 1 – CBQ (N = 157)				
	EASp			
	Emotionality	Activity	Sociability	Shyness
Surgency	-.08	<u>.71**</u>	<u>.27**</u>	<u>-.69**</u>
Negative Affectivity	<u>.58**</u>	-.08	.02	.16*
Effortful Control	-.12	.09	.16*	-.08
Study 2 – TMCQ (N = 138)				
	EASp/t			
	Emotionality	Activity	Sociability	Shyness
Surgency	-.03/.08	<u>.68**</u> /.21	<u>.22</u> /.13	<u>-.31*</u> /.05
Negative Affectivity	<u>.55**</u> /.22	-.05/-.19	-.11/-.19	<u>.08</u> /.24*
Effortful Control	-.18/.14	<u>.37**</u> /.20	.05/-.19	-.25*/.17

*Note.* CBQ-VSF – Children’s Behavior Questionnaire – Very Short Form; TMCQ – Temperament in Middle Childhood Questionnaire; EAS – EAS Temperament Survey; p – parent, t – teacher; theoretically expected relations are underlined; \* $p < .05$ , \*\* $p < .01$ .

**Table 4**

*Gender differences in temperament traits*

Study 1 – CBQ-VSF			
Factor	Boys ( <i>n</i> = 77)	Girls ( <i>n</i> = 81)	<i>t</i> (156)
	<i>M</i> ( <i>SD</i> )	<i>M</i> ( <i>SD</i> )	
Surgency	4.70 (0.91)	4.40 (0.99)	-1.99
Negative Affectivity	4.28 (0.82)	4.28 (0.81)	0.02
Effortful Control	5.24 (0.78)	5.60 (0.69)	3.08**
Study 2 – TMCQ			
Factor	Boys ( <i>n</i> = 85)	Girls ( <i>n</i> = 104)	<i>t</i> (187)
	<i>M</i> ( <i>SD</i> )	<i>M</i> ( <i>SD</i> )	
Surgency	3.35 (0.40)	3.35 (0.41)	-0.05
Negative Affectivity	2.63 (0.59)	2.68 (0.62)	0.46
Effortful Control	3.50 (0.51)	3.69 (0.49)	2.61**

*Note.* CBQ-VSF – Children’s Behavior Questionnaire – Very Short Form; TMCQ – Temperament in Middle Childhood Questionnaire; \*\**p* < .01.

a difference favoring boys, in particular with boys scoring higher on Activity Level and High-Intensity Pleasure. Negative Affectivity showed no significant gender differences (only a small difference in Fear). We expected to replicate these findings.

Table 4 presents the gender differences obtained in both studies. In both studies, only the Effortful Control factor displayed significant gender differences. Consistent with our expectations, girls scored higher than boys.

STATISTICAL ANALYSES TO TEST THE HYPOTHESIS ON THE STRUCTURE

We used an exploratory graph analysis (EGA; Golino & Epskamp, 2017) to test our hypothesis on the temperament structure measured by the CBQ-VSF and TMCQ. In brief, EGA is based on the Gaussian graphical network model (Lauritzen, 1996). EGA estimates the correlation matrix of the observed variables and then applies a graphical LASSO estimation to obtain the sparse inverse covariance matrix (Friedman et al., 2008). Using the walktrap algorithm, which delivers the correct number of communities regardless of network sizes (Yang et al., 2016), the number of factors is identified. Each element of the inverse covariance matrix represents a connection (i.e., *edge*) between two variables (i.e., *nodes*). Edges can be interpreted as partial correlation coefficients of two variables after conditioning of all other variables within a network. The width of the edge reflects how strongly nodes are related to one another. Within a network, nodes

which are similar to each other (i.e., are related one to another) are grouped within clusters. EGA identifies which of the partial correlations are similar, identifying the underlying number of factors. The results of EGA can also be bootstrapped (see Christensen & Golino, 2019) to evaluate the extent to which the factorial structure is stable (i.e., how often are simulations from a given model reproduced) and to evaluate the extent to which given nodes are stable (i.e., how often was a given node assigned to a given factor in simulations).

Our analyses were carried out in three steps. First, we used 100 bootstrapped simulations to determine the underlying number of factors. Given the novelty of this approach, we supplemented it with a more common parallel analysis (Horn, 1965). Second, we examined whether the hypothesized structure was reproduced in empirical data using a standard EGA. Finally, we compared the empirical results to the bootstrapped simulations, assessing the stability of the factor assignments. We have stored the R script as well as the knitted document on the OSF project site: <https://osf.io/hqzb7>.

RESULTS

STRUCTURE OF TEMPERAMENT IN CHILDREN 3-7 YEARS OLD (STUDY 1)

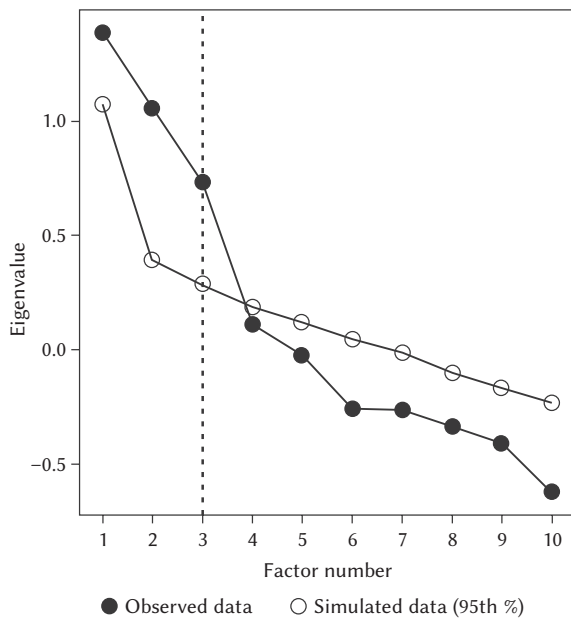
We introduced 13 parcels from the CBQ-VSF that represent the scales from the CBQ to the analysis. Three parcels were not related to others (Fear, Discomfort

and Perceptual Sensitivity), and were dropped from the subsequent analysis. A three-factor solution of the remaining parcels was replicated in 54% of simulations obtained in the bootEGA. A four-factor solution was replicated in 44% of simulations, whereas two factorial solutions appeared in 2% of simulations. The parallel analysis (Figure 1) suggested retaining three factors, providing further support for the most replicated, and theoretically expected solution. The three-factor structure was also retained on empirical data in EGA, as illustrated in Figure 2.

All of the parcels were allocated within the expected factors. One factor, representing Effortful Control, remained orthogonal to Negative Affectivity and Surgency, which in turn were only weakly related. These results mostly confirm the expected factorial structure of the measure. Finally, we assessed the extent to which the scales were replicated in corresponding factors across all simulations. The results of this stability analysis are presented in Table 5. All of the CBQ-VSF parcels primarily replicated in their corresponding factors. Factor 4 comprised minor

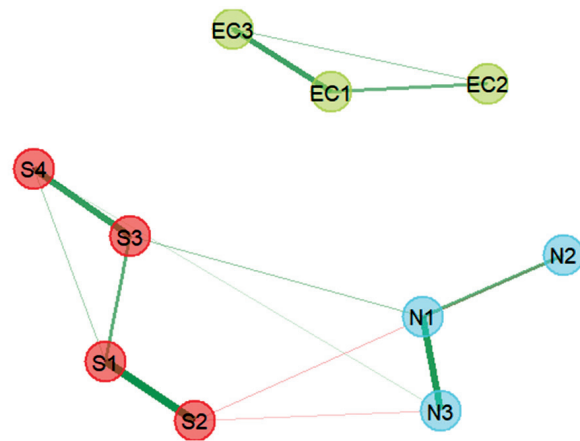
**Figure 1**

Results of the parallel analysis examining the CBQ-VSF



**Figure 2**

Results of the exploratory graph analysis of the CBQ-VSF. Red corresponds to Surgency; blue corresponds to Negative Affectivity; green corresponds to Effortful Control. Green lines represent a positive relation; red lines represent a negative relation. Abbreviations are explained in Table 1.



**Table 5**

Stability of membership of the CBQ-VSF scales for a given factor (percentage)

	Surgency	Negative Affectivity	Effortful Control	Factor 4
S1 Impulsivity	.93	.03		.04
S2 Shyness (reversed)	.91	.04		.04
S3 Activity Level	.50	.10		.40
S4 High-Intensity Pleasure	.51	.09		.40
N1 Anger	.01	.98		
N2 Sadness	.06	.87		.07
N3 Soothability (reversed)	.02	.97		.01
EC1 Inhibitory Control			1.00	
EC2 Low-Intensity Pleasure		.01	.98	
EC3 Attention Focusing			.99	

Note. CBQ-VSF – Children’s Behavior Questionnaire – Very Short Form.



replications of the parcels from the Surgency factor and negligible replications (i.e., all less than 4%) from other factors (i.e., Activity Level and High-Intensity Pleasure). Therefore, the hypothesized three-factorial structure seems to best represent the CBQ-VSF structure.

STRUCTURE OF TEMPERAMENT IN CHILDREN 7-10 YEARS OLD (STUDY 2)

We initially analyzed all 17 scales from the TMCQ. Shyness was not related to the other scales, and we excluded this scale from further analysis. Results of the bootstrapped EGA simulations performed on the remaining 16 scales suggested retaining a three-factor model in 68% of simulations from the bootEGA. Following that, a four-factor solution was replicated in 26% of simulations, while a two-factorial solution was replicated only in 6% of simulations. The results of the parallel analysis, presented in Figure 3, also support the distinction of three factors.

The results of the EGA on empirical data yielded a three-factorial structure (Figure 4), similar to the simulations and the parallel analysis. The stabilities of the TMCQ scales for given factors are presented in Table 6.

All scales, except for EC3 (Attention Focusing), replicated within the hypothesized factors in the majority of simulations. The fourth factor comprised few replications (i.e., less than 20%) of Surgency scales and minor replications from other factors; therefore,

it is difficult to interpret theoretically. Notably, EC3 (Attention Focusing) replicated 64% of the time in Surgency but only 31% in expected Effortful Control. Moreover, Surgency scales had minor cross-replications in Effortful Control, and some Effortful Control scales (i.e., EC1 Inhibitory Control, Affiliation, Fantasy/Openness, Activation Control) were replicated in the Surgency factor. Summarizing the above, our results support the three-factorial model of the TMCQ. However, all of the factors remained intercorrelated more than in the case of the CBQ-VSF.

DISCUSSION

In the current study, we focused on the structure of children’s temperament measured by the CBQ-VSF and the TMCQ using a network analysis on a Polish sample. However, because it was the first study with the Polish adaptations of these questionnaires we also tested the basic psychometrics of these scales.

The psychometric properties of the Polish versions of the CBQ-VSF and the TMCQ can be deemed as acceptable for initial scientific purposes. All scales of the CBQ-VSF demonstrated acceptable internal consistency, with Cronbach’s  $\alpha$  values greater than .60. In the TMCQ, all but two scales presented satisfactory internal consistency; however, removal of items from the Soothability and Activation Control scales enhanced their internal consistency. Moreover, the expected relations between the three factors in Rothbart’s model (Putnam & Rothbart, 2006; Rothbart,

Figure 3

Results of the parallel analysis examining the TMCQ

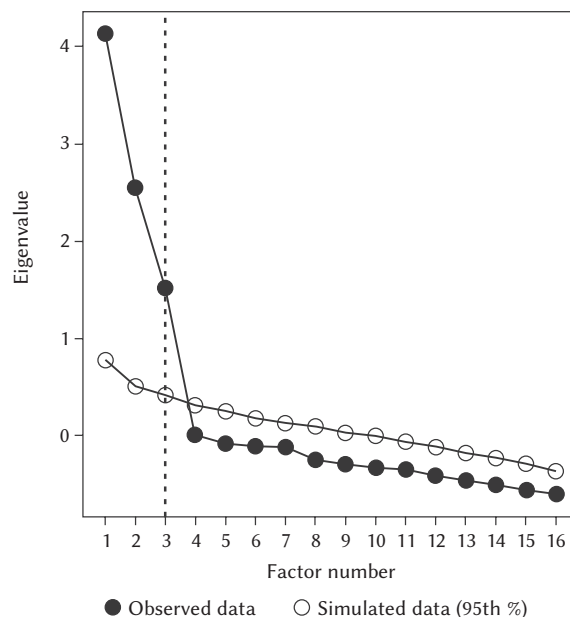
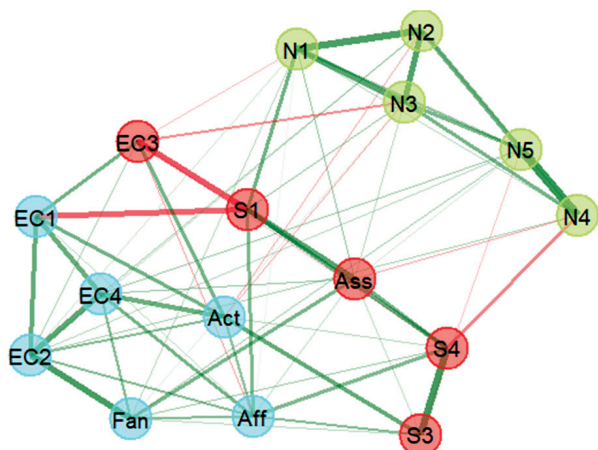


Figure 4

Results of the exploratory graph analysis of the TMCQ. Red corresponds to Surgency; green corresponds to Negative Affectivity; blue corresponds to Effortful Control. Green lines represent a positive relation; red lines represent a negative relation. Abbreviations are explained in Table 1.



**Table 6***Stability of membership of the TMCQ scales for a given factor (percentage)*

	Surgency	Effortful Control	Negative Affectivity	Factor 4
S1 Impulsivity	.80	.15		.05
S3 Activity Level	.55	.25		.19
S4 High-Intensity Pleasure	.66	.14		.19
N1 Anger			1.00	.05
N2 Sadness			1.00	.05
N3 Soothability (reversed)			1.00	.05
N4 Fear			.98	.01
N5 Discomfort			.98	.01
EC1 Inhibitory Control	.09	.87		.04
EC2 Low-Intensity Pleasure		1.00		
EC3 Attention Focusing	.64	.31		.06
EC4 Perceptual Sensitivity		1.00		
Assertiveness/Dominance	.80	.15		.05
Affiliation	.12	.79		.09
Fantasy/Openness	.05	.92		.03
Activation Control	.09	.87		.04

Note. TMCQ – Temperament in Middle Childhood Questionnaire.

2011; Rothbart et al., 2001) and the temperament traits in the Buss and Plomin's model (1984) were largely confirmed. Therefore, the theoretical validity of the Polish versions of the CBQ-VSF and the TMCQ appears sound. Finally, we examined gender differences in childhood temperament. Previous studies have noted significant gender differences (Else-Quest et al., 2006), with girls demonstrating higher levels of Effortful Control and boys higher levels of Surgency. Although we did not find any significant differences in Surgency, girls were rated higher than boys with regard to Effortful Control in both age groups. Else-Quest et al. (2006) noted that these abilities are considered to be a major developmental task in childhood. As girls tend to do better than boys at these tasks, this may suggest a male maturational lag that lasts through middle childhood. Prior to the current study, however, these differences have scarcely been documented in older children.

Our findings support a three-factor solution representing Negative Affectivity, Effortful Control, and Surgency, similar to the structure reported in original research (Kochanska et al., 1994; Putnam & Rothbart, 2006; Rothbart et al., 2001; Simonds, 2006). Previous studies using factor analysis gave inconclusive results regarding the number of higher-order factors. The effect was usually three (Ahadi et al., 1993; Kochanska

et al., 1994; Rothbart et al., 2001) or four (González-Peña et al., 2015; Kotelnikova et al., 2016; Leyfer et al., 2012) factors. We have made an attempt to answer the question about the number of factors using a different statistical method, network analysis. The results of this analysis indicated three factors corresponding to those described by Rothbart (2011; Rothbart et al., 2001). Therefore, they seem to confirm the three-factor structure of temperament in children. In analyses of the CBQ-VSF, all scales included in the analysis were allocated, consistently with our theoretical expectations. In the case of the TMCQ, scales were allocated within the expected factors, except Impulsivity, which was expected to be associated with Effortful Control, but instead fit better with Surgency. Thus applying a new method of analysis (psychometric network analysis) supported the three factor solution in the CBQ-VSF and TMCQ, and this result is even more important in light of some ambiguous results in the literature. Moreover, the new method produces new information about high instability of the fourth factor, which in turn supports the three-factor solution.

Our study is not without limitations. First, we had to exclude some scales from both the CBQ-VSF and the TMCQ because they were unrelated to others. According to the requirements of the network analysis they could not be included. Fear, Discomfort,

and Perceptual Sensitivity contain unique variance that renders them somewhat distinct from the three factors. In future research, the approach proposed by Kotelnikova et al. (2017) could be applied, with EGA conducted at the item rather than scale level. Moreover, interpretation of our findings is somewhat clouded by the involvement of both a new analytical method and new language adaptations of the questionnaires. Furthermore, our analyses were not based on the latent scores. In future research both mean and latent scores can be used and compared. Future research will benefit from the use of this analytical approach with other language versions of the questionnaires to more thoroughly understand the structure of childhood temperament.

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### ENDNOTE

1 All available questionnaires are listed at <https://research.bowdoin.edu/rothbart-temperament-questionnaires/>

### REFERENCES

- Ahadi, S. A., Rothbart, M. K., & Ye, R. M. (1993). Child temperament in the U.S. and China: Similarities and differences. *European Journal of Personality*, 7, 359–377. <https://doi.org/10.1002/per.2410070506>
- Buss, A. H., & Plomin, R. (1984). *Temperament: Early developing personality traits*. Erlbaum.
- Christensen, A. P., & Golino, H. F. (2019). *Estimating the stability of the number of factors via bootstrap exploratory graph analysis: a Monte Carlo simulation and tutorial*. <https://doi.org/10.31234/osf.io/9deay>
- Cozzi, P., Putnam, S. P., Ersilia, M., Gartstein, M. A., Aureli, T., & Montiroso, R. (2013). Cross-cultural differences in fine-grained aspects of toddler temperament: United States of America (U.S.) and Italy. *Infant Behavior and Development*, 36, 480–483. <https://doi.org/10.1016/j.infbeh.2013.03.014>
- Else-Quest, N. M., Hyde, J. S., Goldsmith, H. H., & Van Hulle, C. A. (2006). Gender differences in temperament: a meta-analysis. *Psychological Bulletin*, 132, 33–72. <https://doi.org/10.1037/0033-2909.132.1.33>
- Friedman, J., Hastie, T., & Tibshirani, R. (2008). Sparse inverse covariance estimation with the graphical lasso. *Biostatistics*, 9, 432–441. <https://doi.org/10.1093/biostatistics/kxm045>
- Gartstein, M. A., Knyazev, G. G., & Slobodskaya, H. R. (2005). Cross-cultural differences in the structure of infant temperament: United States of America (U.S.) and Russia. *Infant Behavior & Development*, 28, 54–61. <https://doi.org/10.1016/j.infbeh.2004.09.003>
- Gartstein, M. A., & Rothbart, M. K. (2003). Studying infant temperament via the Revised Infant Behavior Questionnaire. *Infant Behavior and Development*, 26, 64–86. [https://doi.org/10.1016/S0163-6383\(02\)00169-8](https://doi.org/10.1016/S0163-6383(02)00169-8)
- Golino, H. F., & Epskamp, S. (2017). Exploratory graph analysis: a new approach for estimating the number of dimensions in psychological research. *PLoS One*, 12, e0174035. <https://doi.org/10.1371/journal.pone.0174035>
- González-Peña, P., Paredes-Gázquez, J. D., Carrasco, M. A., & Holgado-Tello, F. P. (2015). Dimensionality of the temperament in Spanish children: negative affectivity, effortful control, and extraversion. *Journal of Behavioural Sciences*, 25, 1–19.
- Horn, J. L. (1965). A rationale and test for the number of factors in factor analysis. *Psychometrika*, 30, 179–185. <https://doi.org/10.1007/BF02289447>
- Klein, V. C., & Linhares, M. B. M. (2010). Temperament and child development: Systematic review of the literature. *Psicologia em Estudo*, 15, 821–829. <https://doi.org/10.1590/S1413-73722010000400018>
- Kochanska, G., DeVet, K., Goldman, M., Murray, K., & Putnam, S. P. (1994). Maternal reports of conscience development and temperament in young children. *Child Development*, 65, 852–868. <https://doi.org/10.2307/1131423>
- Kotelnikova, Y., Olino, T. M., Klein, D. N., Kryski, K. R., & Hayden, E. P. (2016). Higher- and lower-order factor analyses of the Children’s Behavior Questionnaire in early and middle childhood. *Psychological Assessment*, 28, 92–108. <https://doi.org/10.1037/pas0000153>
- Kotelnikova, Y., Olino, T. M., Klein, D. N., Mackrell, S. V. M., & Hayden, E. P. (2017). Higher and lower order factor analyses of the Temperament in Middle Childhood Questionnaire. *Psychological Assessment*, 24, 1050–1061. <https://doi.org/10.1177/1073191116639376>
- Lauritzen, S. L. (1996). *Graphical models*. Oxford University Press.
- Leyfer, O., John, A. E., Woodruff-Borden, J., & Merivis, C. B. (2012). Factor structure of the Children’s Behavior Questionnaire in children with Williams syndrome. *Journal Autism Dev Disorder*, 42, 2346–2353. <https://doi.org/10.1007/s10803-012-1482-3>
- Mervielde, I., & De Pauw, S. S. W. (2012). Models of child temperament. In M. Zentner & R. L. Shiner (Eds.), *Handbook of temperament* (pp. 21–40). The Guilford Press.
- Montiroso, R., Cozzi, P., Putnam, S. P., Gartstein, M. A., & Borgatti, R. (2011). Studying cross-cultural differences in temperament in the first year of life: United States of America and Italy. *In-*

- ternational Journal of Behavioral Development*, 35, 27–37. <https://doi.org/10.1177/0165025410368944>
- Nystrom, B., & Bengtsson, H. (2017). A psychometric evaluation of the Temperament in Middle Childhood Questionnaire (TMCQ) in a Swedish sample. *Scandinavian Journal of Psychology*, 58, 477–484. <https://doi.org/10.1111/sjop.12393>
- Oniszczenko, W. (2015). *Kwestionariusz Temperamentu EAS Arnolda H. Bussa i Roberta Plomina. Wersje dla dorosłych i dla dzieci. Adaptacja polska* [Arnold H. Buss' and Robert Plomin's EAS Temperament Survey for adults and children. Polish adaptation]. Pracownia Testów Psychologicznych PTP.
- Putnam, S. P., Ellis, L. K., & Rothbart, M. K. (2001). The structure of temperament from infancy through adolescence. In A. Elias & A. Angleitner (Eds.), *Advances in research on temperament* (pp. 165–182). Pabst Science.
- Putnam, S. P., & Rothbart, M. K. (2006). Development of Short and Very Short forms of the Children's Behavior Questionnaire. *Journal of Personality Assessment*, 87, 102–112. [https://doi.org/10.1207/s15327752jpa8701\\_09](https://doi.org/10.1207/s15327752jpa8701_09)
- Roberts, J. E., Tonnsen, B. L., Robinson, M., McQuillin, S. D., & Hatton, D. D. (2014). Temperament factor structure in fragile X syndrome: The Children's Behavior Questionnaire. *Research in Developmental Disabilities*, 35, 563–571. <https://doi.org/10.1016/j.ridd.2013.11.024>
- Rothbart, M. K. (1981). Measurement of temperament in infancy. *Child Development*, 52, 569–578. <https://doi.org/10.2307/1129176>
- Rothbart, M. K. (2011). *Becoming who we are: Temperament and personality in development*. The Guilford Press.
- Rothbart, M. K., Ahadi, S. A., & Evans, D. E. (2000). Temperament and personality: Origins and outcomes. *Journal of Personality and Social Psychology*, 78, 122–135. <https://doi.org/10.1037/0022-3514.78.1.122>
- Rothbart, M. K., Ahadi, S. A., Hershey, K. L., & Fisher, P. (2001). Investigations of temperament at 3–7 years: The Children's Behavior Questionnaire. *Child Development*, 72, 1394–1408. <https://doi.org/10.1111/1467-8624.00355>
- Rothbart, M. K., & Bates, J. E. (2006). Temperament in children's development. In W. Damon, R. Lerner, & N. Eisenberg (Eds.), *Handbook of child psychology: Vol. 3. Social, emotional, and personality development* (pp. 99–166). Wiley.
- Rothbart, M. K., & Derryberry, D. (1981). Development of individual differences in temperament. In M. E. Lamb & A. L. Brown (Eds.), *Advances in developmental psychology* (Vol. 1, pp. 37–86). Erlbaum.
- Simonds, J. (2006). *The role of reward sensitivity and response: Execution in childhood extraversion* (Unpublished doctoral dissertation). University of Oregon.
- Sleddens, E. F., Kremers, S. P., Candel, M. J., De Vries, N. N., & Thijs, C. (2011). Validating the Children's Behavior Questionnaire in Dutch children: Psychometric properties and a cross-cultural comparison of factor structures. *Psychological Assessment*, 23, 417–426. <https://doi.org/10.1037/a0022111>
- Strelau, J. (2018). Temperament. In V. Zeigler-Hill & T. K. Shackelford (Eds.), *Encyclopedia of personality and individual differences*. Springer. [https://doi.org/10.1007/978-3-319-28099-8\\_446-1](https://doi.org/10.1007/978-3-319-28099-8_446-1)
- Yang, Z., Algesheimer, R., & Tessone, C. A. (2016). Comparative analysis of community detection algorithms on artificial networks. *Scientific Reports*, 6, 30750. <https://doi.org/10.1038/srep30750#>