An investigation into differences between the structure of temperament and the structure of personality

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This article analyzes the differences between an activity-specific temperament model and the Big Five personality model using the Structure of Temperament Questionnaire–Compact (STQ-77). The STQ-77 has 3 emotionality scales and 9 scales assessing 3 dynamic aspects (arousal, lability, and sensory sensitivity) in 3 areas of activity (physical, verbal–social, and mental). The results of administration of the Russian STQ-77, NEO-FFI, and SSS-V to 174 Russian participants showed how components of temperament can represent the traits described in the Big Five model. The confirmatory factor analysis of the English STQ-77 and the results of a study involving a prolonged word classification task with 221 Canadian participants showed the benefits of the activity-specific approach, separating temperament traits in three areas of activity. Such specificity of temperament traits differentiates them from personality traits.

Personality assessment methods analyze the product of interactions between the social and biological factors underlying individual differences. However, the concept of personality should not be viewed as completely covering the concepts of individuality or of the person, even though these concepts overlap. The concept of personality refers to a product of socialization, such as social skills, attitudes, self-perception, and relationships to other people, and the concept of individuality includes not only personality but also abilities, limitations, and other biologically based properties of a person. Allport, who initiated the lexical approach (so popular nowadays in personality theory), pointed to the confusion between personality and the factors underlying personality. He noted that "tests for physique, for intelligence, or for temperament are not tests of personality. . . . If, then, personality is the object of inquiry, traits of personality should not be confused with qualities or quantities of intelligence, physique, or temperament" (Allport, 1927, p. 284).

Another topic of confusion is the nature of the relationship between temperament and personality. Researchers in personality theory and developmental psychology tend to assign a leading role to personality as the main edifice of adult and socialized individuality and a submissive role to temperament as the foundation of this edifice, which plays a role only during the

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initial stage of construction (i.e., in childhood). Continuing the building analogy, one should not forget that there are plumbing and electrical systems, which run from the foundation. If something goes wrong with these systems, or (as in the case of the Tower of Pisa) there are problems with the underground support of the foundation, the functioning of the whole structure is affected. There is an overwhelming body of evidence that a person's social behavior changes with biological factors, such as pain, intoxication, chemical imbalances, or even time of the day, with all the social settings remaining intact.

It would be more realistic to treat social and biological factors, personality and temperament, as equal parties, having a continual interaction and mutual adjustment to one another. Such interaction is more noticeable in childhood because of the larger and faster changes in both the biological and social characteristics of individuality, but it does not end with adulthood. For example, people with a high tempo in physical activity or an ability to sustain intense physical activity become athletes not because of their socialization but because of their actual physical abilities. The same mechanisms (i.e., the impact of the biologically based abilities) make the same person withdraw from athletic activities in later life when these abilities change. Another example is the decrease in extroversion and sociability with age (Labouvie-Vief, Diehl, Tarnowski, & Shen, 2000; Mortimer, Finch, & Kumka, 1982; Yang, McCrae, & Costa, 1998; Zonderman, Siegler, Barefoot, Williams, & Costa, 1993), accompanied by such biological factors as an age-related decrease in energy level and an increase in emotionality. The best opinion on this topic comes from Gray (2004), who said, "consciousness comes too late," meaning that a person often acts first then thinks and assesses her or his own actions from a social perspective afterwards.

Sometimes there is a need in practice to focus primarily on either social factors (e.g., cultural expectations, acculturation factors, values, and opinions) or biological factors and not on the product of their interaction. Consistent individual differences in behavior, which are based on the physiology of the body, were noted 25 centuries ago by Hippocrates and Galen as temperament. Unlike the concept of personality (which includes the content aspects of behavior, e.g., values, goals, attitudes, and a history of relationships), the concept of temperament refers mostly to the dynamic properties of behavior, independent of content elements. "Emotionality" and "activity" (or "energy," or "strength of nervous system," i.e., the ability to stay active on a task) are two dimensions used by Kant (1798/1974), Stern (1900; cited in Lamiell, 2003), Heymans (1929), and Pavlov (1941) to derive the Galen–Hippocrates four temperaments. Cholerics were noted to be reactive and energetic, sanguines were balanced in reaction and energetic, phlegmatics were balanced and weak, and melancholics were reactive and weak. Later, the neuropsychological correlates of these two basic dimensions of temperament were found: The neuroendocrine functioning of the limbic system was linked to emotionality, and projections from the ascending reticular activation system were linked to the level of activation and arousal. Therefore, it is not surprising that the same two dimensions—emotionality (perceived as neuroticism) and arousal level (perceived as extroversion)—are always found in all personality models based on a lexical approach and factor analysis.

The oldest experimental tradition for studying the components of temperament belongs to the 100-year-old Pavlovian school of psychophysiological studies of the properties of nervous systems and to the worldwide tradition of the study of human abilities. Dozens of researchers supervised by Pavlov, Teplov, Nebylitsyn, and Rusalov throughout the 20th century conducted experiments with animals and with human participants in various modalities, using variable scheduling and difficulty of tasks, administration of caffeine, provision of tasks with deterministic and probabilistic conditions, measurement of absolute thresholds, evoked potentials, and electroencephalography. These researchers came up with the following findings, in addition to the description of the two basic dimensions of temperament (Gray, 1964; Nebylitsyn, 1972; Pavlov, 1941; Teplov & Nebylitsyn, 1963; Rusalov, 1979):

> Excitation and inhibition processes are regulated by different neurophysiological systems, and the relationships between these two systems (their balance) are not the same for all people, leading to consistent individual differences. This idea was further developed by Gray in his reinforcement sensitivity theory. Elucidating the relationships between various brain structures,

Gray (1982) explained Hippocrates' four classical temperaments in terms of the relationship between the Behavioral Approach System (BAS) and the Behavioral Inhibition System (BIS). Impulsivity was explained by the dominance of the BAS over the BIS, and neuroticism was attributed to the dominance of the BIS over the weaker BAS. This approach was later adapted by numerous approach–withdrawal models of temperament.

Mobility of activity, and not just the energetic component of activity, is also a very consistent and biologically based trait. Mobility appears as plasticity of behavior (i.e., how easily the person can start or stop activity and how flexible and adaptive the person is to new circumstances or instructions). Since the neuropsychological work of Luria in the 1940s, mobility (plasticity) of behavior was linked to the functioning of the frontal cortex and confirmed by numerous clinical cases of brain damage. The important issue about mobility is that, since Pavlov's time, it has been found to have bifurcation (nonlinear) structure and therefore a nonindependent relationship to the energetic component of temperament. Pavlov classified nervous systems into weak and strong types and differentiated only the strong types by the mobility criterion, whereas the weak type was found in many studies to always have low mobility. As a result, mobility, as measured by the Pavlovian Temperament Survey (PTS), shows significant positive correlations with the Strength of Excitation scale of the PTS (Strelau, 1999) and with both the Ergonicity (power of arousal) and Lability (of the arousal) scales of the Structure of Temperament Questionnaire (STQ) administered by Strelau on Polish and German samples, by Ruch, Angleitner, and Strelau (1991) on a German sample, and by Trofimova (2009a, 2010b) based on a Canadian sample. Such interdependence of the mobility and energetic component of temperament implies that mobility should show up as an independent factor and hiding under the dimension of general arousal in factor analytic studies.

Lability (i.e., tempo of activity) was found to be a dynamic property of activity separate from flexibility and adaptivity. The concept of lability described the speed of automatic performance according to an existing program (or habit, or previously developed skill) and was differentiated from general mobility, or plasticity, needed for putting together a new program of an action under changed circumstances. Findings in neurophysiology linked lability, time keeping, rhythmicity, and tempo of activity to the basal ganglia, dentate nucleus of the lateral cerebellum, putamen, and thalamic projections to the sensorimotor cortex, superior temporal gyrus, and inferior frontal gyrus (Franz, Zelaznik, & Smith, 1992; Franz, Ivry, & Helmuth, 1996; Ivry & Keele, 1989; Harrington, Haaland, & Hermanowicz, 1998; O'Boyle, 1997; Rao et al., 1997).

Sensitivity is also a biologically based trait affecting the behavior of a person, and it is also nonindependent on the energetic component of activity. Teplov and Nebylitsyn (1963) measured absolute visual and auditory thresholds and the electrical sensitivity of the eye and found that "weak" participants had a higher sensitivity (i.e., lower threshold). Similar results were found by Eysenck's school (Stelmack & Michaud-Achorn, 1985; Revelle, 1973; Gange, Geen, & Harkins, 2007). This meant that sensitivity and endurance of activity were not independent properties of individuality, even though they had different neurophysiological representation.

Nebylitsyn (1976) and then Rusalov (1979, 1989) concluded that the components of temperament are activity-specific; for example, the energetic level or tempo of performance might be different for the same person in physical, social, or intellectual activities, and therefore aspects of the performance of these activities should be assessed and analyzed separately. These findings were in line with neuropsychological descriptions of the role of the sensorimotor cortex in the regulation of physical activity, the role of the left temporal cortex in verbal behavior, and the role of the frontal cortex in intellectual activity. It would be simplistic to assign performance in social, physical, and intellectual activities to exact anatomic structures of the brain, given that any activity is performed by an ensemble of structures. However, it is reasonable to suggest that membership in these ensembles changes with a change in the object of activity and that at least for physical, verbal–social, and mental activities, the consistent dynamic aspects of these activities (e.g., energetic level and tempo) are regulated by different neurophysiological systems. Hebb (1980, p. 64) pointed out that

the arousal system consists of 28 separate pairs of nuclei, which make possible many different patterns of activity, all with the same purpose of activating the cortex but with different properties otherwise.

Based on his experiments, Rusalov (1979) proposed the Structure of Temperament theory and developed his STQ. The Extended version of the STQ has 12 (4 × 3) scales consisting of 12 items each, which analyze four temperamental traits: Ergonicity (determined by endurance of activity), Plasticity, Tempo of activity, and Emotionality in three areas of activity: social, physical, and intellectual (Rusalov, 1989, 1997; Rusalov & Trofimova, 2007).[1] A factor analysis conducted on the data from 1,937 participants showed that scales grouped consistently into four factors, organized around the type of activity (physical or motor, social, intellectual) and emotionality. Studies of the English version of the STQ (STQ-E) using American, Australian, and Canadian samples demonstrated that its scales have an activity-specific factor structure similar to that of the Russian language version and that it has good reliability and internal consistency (Bishop, Jacks, & Tandy, 1993; Bishop & Hertenstein, 2004; Dumenci, 1995, 1996 [using initial STQ]; Rusalov, 1997; Stough, Brebner, & Cooper, 1991; Rusalov & Trofimova, 2007; Trofimova, 2010a). Chinese (STQ-C), Urdu (STQ-U), and Polish (STQ-P) Extended versions of the STQ, administered among corresponding populations, demonstrated robust factor structures similar to those of the original version (Trofimova, 2010a).

The compact version of the STQ (STQ-77) consists of 6 out of 12 items taken from each scale of the Extended STQ (Rusalov & Trofimova, 2007). In the STQ-77, the initial items of the STQ's Emotionality scales were regrouped into the STQ-77 scales of Empathy, Self-Confidence, and Neuroticism, based on several factor analytic studies of the STQ that consistently showed that the three former Emotionality scales (Motor Emotionality, Social Emotionality, and Intellectual Emotionality) were not as activity specific as the Ergonicity, Plasticity, and Tempo scales and basically constituted one factor (Bishop et al., 1993; Bishop & Hertenstein, 2004; Dumenci, 1996; Rusalov, 2004; Stough et al., 1991; Rusalov & Trofimova, 2007; Trofimova, 2010a; Trofimova & Sulis, 2010; Watkins, Mortazavi, & Trofimova, 2000). The original STQ scale of Intellectual Plasticity was renamed Sensitivity to Probabilities. The STQ-77 also upgraded Rusalov's original model of temperament by including the scales of Impulsivity, Sensitivity to Sensations, and Empathy. The last two new scales were included according to Luria's (1996) neuropsychological description of a so-called sensory-informational block of brain structures controlling the tuning of attention to certain types of stimuli and information. The discovery of mirror neurons supported the hypothesis of the biological origin of empathy as a sensitivity to people's intentions and feelings, the trait described by Rogers in the mid-1970s (Rogers, 1975). A person's attraction to activities of physical danger or risk taking, described by Zuckerman (1979) as sensation seeking, was linked to a deficiency in dopamine regulation. Thus empathy and sensation seeking were considered biologically based components of individuality.

In summary, the STQ-77 describes the structure of temperament as having four dimensions related to emotionality and to three dynamic aspects of activity—arousal (energetic aspect), lability, and sensory preferences—all applied to intellectual, communicative, and physical areas of activity Emotionality is presented in this model as a limbic-driven amplifier of arousal, lability, and the sensory orientation aspects of activity (Table 1). In contrast to the Big Five model of personality, this model includes not only aspects of social activities but also consistent characteristics of behavior related to physical and mental activities. Also in contrast to the Big Five, the STQ-77 was derived not from factor analysis but from experimental and psychophysiological studies of biologically based individual differences. The 12 components of temperament, which the STQ-77 measures, are not all independent, as the background theory and research of the STQ assumes nonlinear, feedback, and causal relationships between the psychophysiological mechanisms underlying these dynamic aspects of behavior. Because of the complex nature of the relationships between the components of the STQ-77 model, we could expect that in a factor analysis these 12 components would collapse in structure to a smaller number of components. We could expect a unification of the "medium 12" into a "Big 4 or 5," similar to the traditional four-factor activity-specific structure of the STQ (showing factors of Motor Ac-

tivity, Social–Verbal Activity, Intellectual Activity, and Emotionality). Such a structure reflects a stronger independence of biologically based abilities related to the three types of activities and an interdependence of the dynamic aspects of activity (such as endurance, lability, and sensitivity).

The inclusion of temperament components related to several types of activity (and not just to social activity) into the analysis of the correspondence between temperament and personality traits expands our understanding of the structure of individuality. For example, Eysenck pointed out the similarity between the temperament traits of extroversion and neuroticism in his model and the same traits in the Big Five model of personality. Several studies showed high positive correlations between the Neuroticism scale of the Big Five and of the EPQ with the Emotionality scales of the STQ, between the Extraversion of the EPQ and Social Ergonicity, Social Plasticity, and Tempo scales of the STQ (Brebner & Stough, 1993; Dumenci, 1995; Rusalov, 1989). In this study we wanted to explore the detailed relationships between personality traits in the Big Five model and the components of temperament as presented in the STQ-77 model. The 12 components of the STQ-77 model have been shown to have different neurophysiological and neurotransmitter correspondences, but nonlinear, feedback, and causal relationships between these components reveal the limited power of factor analysis in picking up the structure of consistent individual differences. Therefore, in addition to factor analysis, a review of correlations between the scales of these two questionnaires could provide information about these relationships. We suggest that temperament traits might contribute to personality traits in a spectrum manner rather than a one-to-one correspondence, that is, that a personality trait could result from the integration of several biologically based temperament traits.

The present study was designed to examine these suggestions. The goals of the present study were as follows:

To investigate the factor structure of the STQ-77 and its relationships with other models of temperament and personality; the hypothesis was that the STQ-77 has an activity-specific factor structure (i.e., the scales are grouped by the type of activity, not by the dynamic aspect of activity), and the factor structure of temperament models can be seen in the factor structure of personality models as multiple temperament components underlying a personality trait.

To analyze how the activity-specific scales of the STQ-77E can reflect the ability to carry out a prolonged and repetitive verbal and intellectual activity. The underlying hypothesis was that the time needed for a person to complete such a task would show stronger correlations with the dynamic aspects of verbal–social activity than with the aspects of physical or intellectual activity, and therefore the temperamental traits (i.e., dynamic aspects of activity) are activity specific (unlike personality traits).

To investigate the relationships between the STQ-77R scales (especially the scales of Sensitivity to Sensations, Impulsivity, Sensitivity to Probabilities, and Empathy) and the NEO-FFI and Sensation Seeking Scales (SSS-V). The hypothesis was that these four new scales of the STQ-77R would positively correlate (correspondingly) with the General scale of SSS-V, the Disinhibition scale of the SSS-V, and the Openness to Experience and Agreeableness scales of the NEO-FFI. The positive correlation of Social Ergonicity and Tempo of STQ-R with NEO-FFI's Extraversion scale and the correlation between the Neuroticism scales of STQ-R and NEO-FFI were also the part of this hypothesis.

TABLE 1. The STQ-77 structure and its temperament scales

	Energetic aspect	Lability	Sensitivity to
Mental activity	Intellectual Ergonicity (ERI)	Plasticity (PL)	Probabilities (PRO)
Physical activity	Motor Ergonicity (ERM)	Motor Tempo (TMM)	Sensations (SS)
Social–verbal activity	Social Ergonicity (ERS)	Social Tempo (TMS)	Others, Empathy (EMP)
Emotionality	Self-Confidence (SLF)	Impulsivity (IMP)	Neuroticism (NEU)

STUDY 1

METHOD

Participants

Participants were 226 Canadian citizens and residents (92 men and 134 women, aged 17–54 years, $M = 25.4$, $SD = 11.4$), volunteers from the Greater Toronto Area (30%) and psychology students of McMaster University (Hamilton, Ontario).

Procedure

In 2006 each participant completed the Compact English STQ (STQ-77E; Rusalov & Trofimova, 2007), and 221 participants (91 men and 130 women, aged 17–54 years, $M = 25.18$, $SD = 11.3$) completed the semantic task: Subjects were asked to estimate 25 abstract concepts (words) on 60 7-point bipolar scales (e.g., "warm–cold," "soft–hard," "interesting–uninteresting"). Each word was presented on a computer monitor along with each of the scales. Participants were instructed to work as fast as possible, and their time on this task was recorded. The computer program Expan detected whether a participant was giving random or inconsistent answers. All participants received debriefing and signed an informed consent form before testing and participation in the study. University students received a practicum credit for their participation.

STUDY 2

METHOD

Participants

Participants were 174 Russian citizens (63 men and 111 women, aged 17–55 years, $M = 24.8$, $SD = 9.9$), volunteers from the Moscow community (15%) and students of the Moscow Social University Department of Law, who took part in this study in 1994–1997.

Procedure

All participants were debriefed and signed an informed consent form before testing and participation in the study. University students received a practicum credit for their participation. Each participant completed the Compact Russian STQ (STQ-77R; Rusalov & Trofimova, 2007); the Five-Factor Inventory (NEO-FFI; Costa & McCrae, 1992, adapted to Russian (Kudryashev, 1992), with reliability coefficients varying in several samples between .53 and .75), which is the 60-item abbreviated version of the NEO PI-R; and the Sensation Seeking Scales (SSS-V). SSS-V includes subscales of Thrill and Adventure Seeking (TAS), Experience Seeking (ES), Disinhibition (DIS), and Boredom Susceptibility (BS). The General subscale is the largest scale (20 items), which examines the person's attraction to risky and sensation-seeking activities, and the Disinhibition subscale (18 items) assesses a person's desire to exhibit uninhibited or unrestrained behaviors, including risk taking, heavy drinking, drug use, or having a variety of sexual partners (Zuckerman, 1994; adapted to Russian by Egorova and Piankova, 1992), with reliability coefficients .70 and higher).

Each STQ-77 version had 77 statements, assigned to 12 temperamental scales (6 items each), and the validity scale (5 items, addressing social desirability bias). The protocols that had values of 15–20 on the validity scale were considered invalid because the respondents were likely to demonstrate a positive impression bias in their responses. The answers have a 4-point Likert scale format: 1 (*strongly disagree*), 2 (*disagree*), 3 (*agree*), 4 (*strongly agree*).

1–3: Scales of Motor, Social, and Intellectual Ergonicity (ERM, ERS, ERI)—the ability of an individual to sustain prolonged physical, social, or mental activity, respectively.

4–5: Scales of Motor and Social Tempo—preferred speed of manipulation with physical objects (TMM) and speed of speech and reading and of other verbal activities (TMS).

Sensitivity to Sensations (SS): sensitivity to basic physical sensations and pleasures, a tendency for sensation-seeking and risk-taking behavior.

Empathy (EMP): sensitivity to another person's state and expectations. The maximum value on this scale indicates psychosocial dependency.

Plasticity (PL): the ability to adapt quickly to changes in situation, to change the program of action, and to shift between different tasks.

Self-Confidence (SLF): a tendency to be optimistic and confident (sometimes overly optimistic) in one's performance, to ignore other people's warnings and criticism.

Sensitivity to Probabilities (PRO): the ability to develop adequate understanding and expectations of probable events, efficient extraction and

processing of new knowledge, classification, and learning abilities.

Impulsivity (IMP): lability of emotional reaction, poor ability to control immediate impulses for actions.

Neuroticism (NEU): the expectation of a negative outcome, low tolerance for uncertainty.

RESULTS AND DISCUSSION

1

Confirmatory factor analysis used the traditional four-factor STQ model, including two new STQ-77 scales of Sensitivity to Sensations and Impulsivity (4f-STQ-77), and a "4+1-STQ-77" model, which had a fifth factor of Sensation Seeking consisting of these two new scales, in addition to the traditional STQ four-factor model (Figure 1). The difference between 4f-STQ-77 and 4+1-STQ-77 models was only in assigning the parameters 11, 12, and 32: The 4f-STQ-77 model had the Sensitivity to Sensation scale as a part of the Emotionality factor and the Impulsivity scale as part of the Inhibitory–Intellectual Activity factor, and parameter 32 was the correlation between the Emotionality and Intellectual Activity factors. In order to reach the best fit, it made sense to have residuals of SS and IMP, SS and NEU scales correlated following the theory of Sensation Seeking (Zuckerman, 1994) and acknowledging the fact that risk-taking behavior described by the Sensitivity to Sensations scale is somewhat opposite to the cautious behavior described by the Neuroticism scale of the STQ-77. Both 4f-STQ-77 and 4+1f-STQ-77 models have these two residual correlations (parameters 29 and 30), and also correlations between Emotionality and Social Activity and between Social Activity and Motor Activity factors, as the correlations between these factors were elements of the previous exploratory and confirmatory factor analysis STQ models (Rusalov & Trofimova, 2007; Trofimova, 2010a). The STQ-77 model also understood Sensitivity to Sensation as a trait driven by mostly physical sensations and Empathy as a trait driven mostly by social stimuli, and so these two traits gave corresponding contributions to Motor Activity and Social Activity factors. As stated earlier, the Plasticity scale was compounded from the items describing all three types of activity (physical, communication, and mental) and so gave a contribution to all three Activity factors, without specified factor loadings (Figure 1).

Both the 4f-STQ-77 and the 4+1f-STQ-77 models with two correlated residuals produced the following fit to the data obtained in the Canadian sample: The root mean square error approximation was (respectively) .067 (confidence interval [CI] .047–.087) and .065 (.045–.085), and without correlated residuals it was .080 (.062–.099) and .073 (.054-.091). The standardized root mean square residual was .0532 for the 4f-STQ-77 and .0574 for the 4+1f-STQ-77 model with correlated residuals, and .0663 and .0599 without them. The ratio of χ^2 to degrees of freedom was 2.05 for the 4f-STQ-77 and 1.97 for the 4+1f-STQ-77 model with two correlated residuals, and 2.51 and 2.21 without correlated residuals. The Comparative Fit Index was .914 for the 4f-STQ-77 and .917 for the 4+1f-STQ-77 model with correlated residuals, but .868 and .894 without it, which might be explained by the impact of the kurtosis of the data. Exploratory factor analysis for the four-factor solution with normalized varimax rotation performed for the data from the Canadian sample explained 61% of variance, and the five-factor solution (obtained when the limit for the size of a factor eigenvalue was set to 0.9) explained 69% of variance.

In summary, confirmatory factor analysis using data from the Canadian sample showed a satisfactory fit for the traditional four-factor STQ activity-specific model grouping the scales to the factors of Motor, Social, and Intellectual activity and Emotionality (i.e., by the type of activity), which supported our hypothesis. The addition of two new scales, Sensitivity to Sensations and Impulsivity, whether inside this four-factor model or as a fifth, standalone factor of Sensation Seeking, did not compromise the traditional STQ model. The 4+1f-STQ-77 model can be interpreted as "Rusalov's Four plus a Sensation Seeking factor" (Figure 1). It was also consistent with the STQ-77 model seeing Sensitivity to Sensations as an orientation to physical stimulations, Empathy as an orientation to social stimulation, and Plasticity as an ability to integrate behavior that was universal across activities (Rusalov & Trofimova, 2007).

Cronbach's alpha for the scales of the English STQ-77 administered to the Canadian sample was in the range of .70–85. The same range was found for the scales of the Russian STQ-77 in the Russian sample

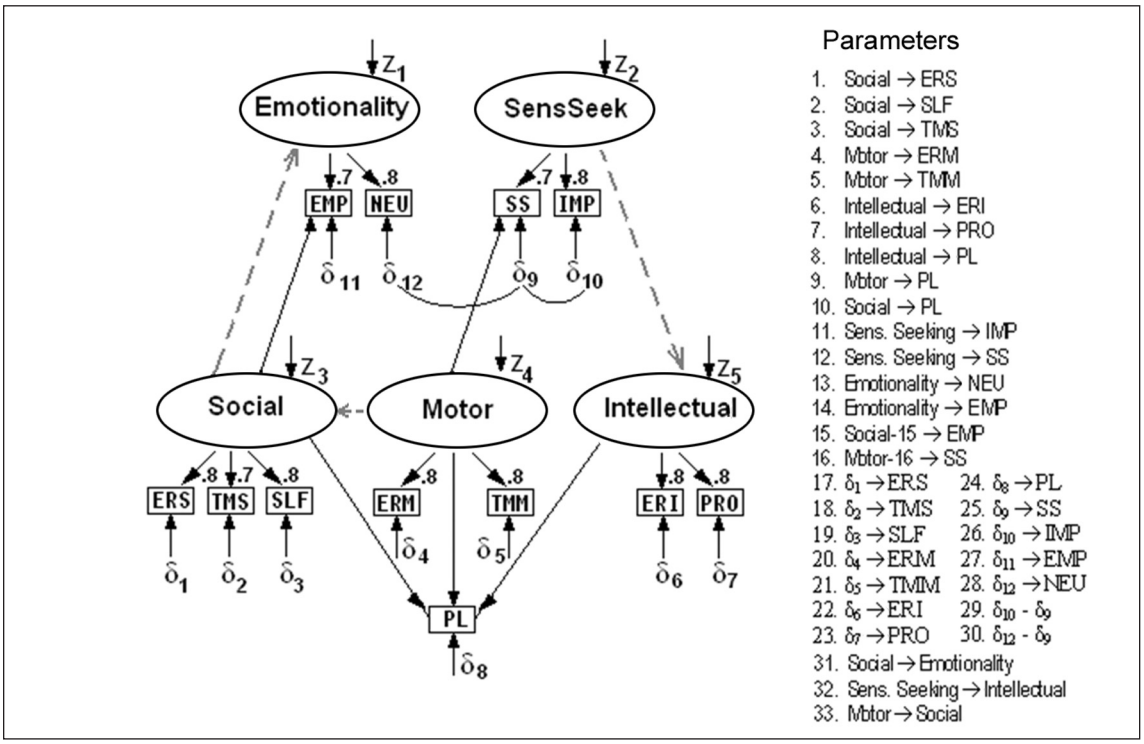

Figure 1. The "4+1f-STQ-77" model used in Comparative Fit Index for the Canadian sample (N = 226). The numbers above each scale label are factor loadings (regression weights)

except for the Plasticity scale, which had a .67 value for this coefficient. The Plasticity scale combined items from the Motor Plasticity, Social Plasticity, and Intellectual Plasticity scales of the Extended STQ, and this might affect the scale's consistency (Table 2). All scales had a normal distribution of scale scores. Mean scaled and adjusted mean scaled univariate kurtosis in the Canadian data were both equal to 0.018, and the relative multivariate kurtosis was 1.11.

A series of runs of factor analysis performed for the data from the Russian and Canadian samples with the solution for two to six factors revealed structures that would match the models of temperament and personality proposed in the psychological literature (Figure 2). The two-factor solution came up with two factors, which conditionally could be named excitation and inhibition. Such a structure is similar to the Pavlovian approach to excitatory and inhibitory processes, developed after Pavlov in the work of Teplov, Nebilitsyn, Strelau, and Gray. Gray (1982) specifically described the BAS and the BIS as two regulatory systems of activity underlying temperament, which launched a series of approach–withdrawal models of temperament. The three-factor solution was similar to Rusalov's model of formal dynamic traits of activity, separating these traits in three different areas: physical, social, and intellectual. The four-factor solution was consistent with Rusalov's model of temperament, which, in addition to the aforementioned three areas of activity, included Emotionality as an aspect of temperament. The five-factor solution could be interpreted as "Rusalov's four plus a Sensation Seeking factor." The five- and six-factor solutions were obtained when the limit for the size of an eigenvalue of a factor was set to 0.7. The six-factor solution for both samples can be linked to the "Big Five" model with an additional Sensation Seeking factor. Summarizing this solution, one can see that there are patterns of the temperamental characteristics that can be viewed as an underlying basis of the personality traits described by the Big Five model: NEO-FFI Extraversion can be represented by the dynamic aspects of social–communicative activity, and the NEO-FFI Neuroticism, Agreeableness, and Openness to Experience scales are linked (respectively) to the Neuroticism, Empathy, and scales of Intellectual Activity of the STQ-77.

TABLE 2. Descriptive scale statistics for STQ-77R and STQ-E scales: Means with confidence intervals, standard deviations, and Cronbach's alpha coefficient

	Russian sample (N = 174)			Canadian sample (N = 221)		
STQ-77 scales	**Mean (CI)**	***SD***	**Alpha**	**Mean (CI)**	***SD***	**Alpha**
Motor Ergonicity	17.2 (16.5–17.9)	4.6	.80	15.2 (14.7–15.7)	4.0	.85
Motor Tempo	18.9 (18.3–19.6)	4.3	.77	15.3 (14.8–15.7)	3.0	.70
Sensitivity to Sensations	19.0 (18.6–19.4)	2.9	.85	15.9 (15.6–16.3)	3.3	.73
Social Ergonicity	18.7 (18.0–19.4)	4.5	.75	17.6 (17.1–18.0)	3.7	.80
Social Tempo	15.9 (15.2–16.6)	4.5	.72	16.3 (15.9–16.7)	3.1	.75
Empathy	16.2 (15.7–16.6)	3.0	.71	16.1 (15.8–16.5)	2.5	.70
Intellectual Ergonicity	16.0 (15.6–16.5)	3.0	.75	14.5 (14.1–14.9)	3.0	.71
Plasticity	17.5 (16.9–18.1)	4.0	.65	14.9 (14.7–15.2)	2.6	.71
Sensitivity to Probabilities	17.7 (17.2–18.2)	3.2	.70	15.8 (15.4–16.1)	2.8	.72
Self-Confidence	15.5 (15.0–15.9)	3.2	.72	15.9 (15.6–16.1)	2.7	.70
Impulsivity	17.0 (16.6–17.4)	2.7	.71	15.3 (15.0–15.6)	2.9	.74
Neuroticism	16.2 (15.6–16.8)	4.2	.70	15.1 (14.7–15.5)	2.8	.71

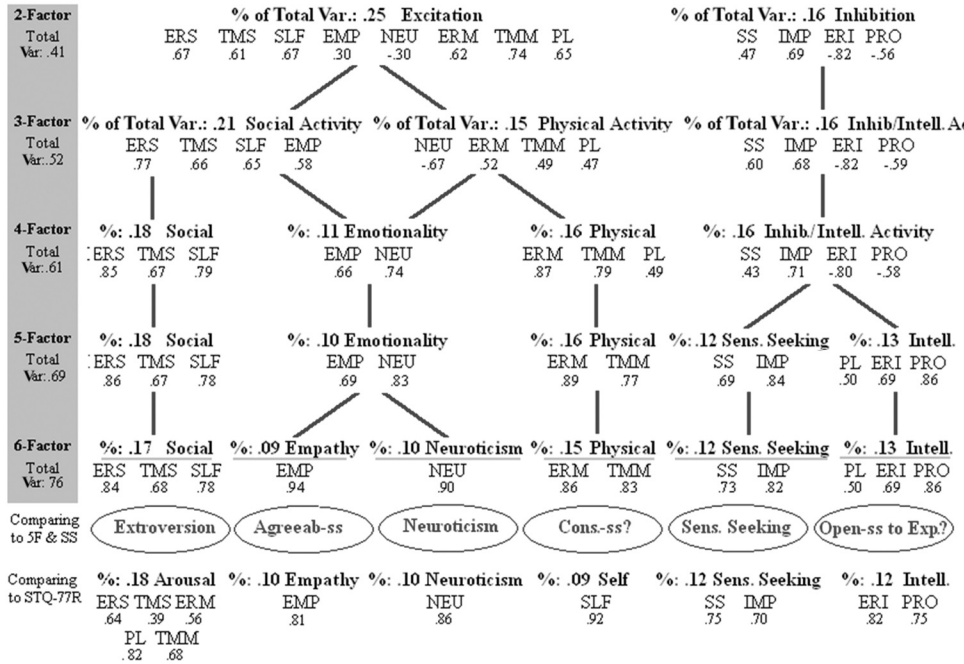

Figure 2. Factor solutions with 2–6 factors for the English version of the STQ (N = 221). Numbers under each scale are factor loadings. The last row represents a comparison with Five-Factor Personality model and an additional Sensation Seeking factor

2

The time of performance on the semantic task (which involved a prolonged evaluation of abstract concepts at a fast pace) had statistically significant (effect size $d = .78$) negative correlations with both scales of social–verbal activity, plus the Plasticity, Motor Tempo, and Sensitivity to Sensations scales of the STQ-77E (Table 3, rightmost column). Higher scores on these scales were associated with faster reading and faster estimation of abstract concepts. The high correlation (effect size $d > .50$) of the time on semantic task with the Plasticity and Self-Confidence scales of the STQ-77E can be explained by the role these traits play in fast decision making during the performance of this task. The medium effect size ($d = .41$) of the correlation between the time on the semantic task and the Motor Tempo scale shows that the ability of a person to work on a computer at a fast pace is one of the tempo-related characteristics of physical activity, which is measured by this scale. Overall, our second hypothesis was also supported, demonstrating the benefits of having scales separately assessing arousal in specific activities rather than one scale assessing activation in general without narrowing it to a specific type of activity (e.g., strength of excitation, activity, or extroversion). The study of gender and age differences in performing a similar semantic task and STQ scores in our other study also showed age-related dynamics in gender differences, which was possible to see only because our test of temperament assessed tempo of activity separately in verbal and physical areas. It appeared that women had higher scores on the Social Tempo scale and were faster in the semantic task, whereas men had higher scores on the Motor Ergonicity scale. Such gender differences became significantly smaller after age 24 (Trofimova, 2009b).

3.1

The correlations between applied measures are shown in Table 3. The new scales of the STQ-77R, the scales of Sensitivity to Sensations, Sensitivity to Probabilities, and Impulsivity had statistically significant positive correlations with all of Zuckerman's sensation-seeking scales. The general SSS-V scale and the subscales of TAS and BS had high correlations with both scales of physical (Motor) activity, with Social Ergonicity and Plasticity. At the same

TABLE 3. Correlations of STQ-77R with two sensation-seeking scales (SSS) and NEO-FFI scales (Russian sample), and correlations of STQ-77E with the time needed to complete the semantic task (Canadian sample)

	SSS ($N = 174$)		NEO-FFI ($N = 174$)					$N = 221$
STQ-77	**General**	**DIS**	**NEU**	**EXTR**	**OPN**	**AGR**	**CNS**	**TSem**
Motor Ergonicity	.26***	.11	–.24***	.17*	.16*	–.08	.35***	–.13
Motor Tempo	.26***	.30***	–.13	.38***	.17*	–.02	.22**	–.20**
Sensitivity to Sensations	.68***	.34***	–.05	.16*	.22**	.00	–.21**	–.06
Social Ergonicity	.33***	.52***	–.14	.46***	.16	–.06	.10	–.18**
Social Tempo	.07	.06	–.06	.16*	–.02	–.03	.13	–.36***
Empathy	.10	–.14	–.04	.11	.52***	.46***	.02	–.17*
Intellectual Ergonicity	.12	–.03	–.24***	.20**	.31***	–.09	.34***	–.17*
Plasticity	.19**	.23***	–.20***	.23***	.22**	.03	.22**	–.25***
Sensitivity to Probabilities	.27***	.11	.00	.14	.40***	.02	.07	–.12
Self-Confidence	–.14	–.17*	.03	–.14	.03	.20**	–.06	–.29***
Impulsivity	.33***	.37***	–.09	.52***	.25***	–.19*	.05	.09
Neuroticism	–.17*	–.13	.38***	.00	.09	.16*	–.05	.08

Note. *AGR = agreeableness; CNS = conscientiousness; DIS = disinhibition; EXTR = extroversion; NEU = neuroticism; OPN = openness to experience; TSem = time needed to complete the semantic task.*
*p < .05. **p < .01. ***p < .001.

time, the fact that Intellectual Ergonicity (ability to sustain prolonged or intense mental work) had low correlations with the SSS-V scales shows that arousal in the part of the nervous system dealing with physical activities is different from arousal (sustaining attention) in intellectual activities. The Disinhibition scale of the SSS-V correlated highly and positively with STQ Impulsivity, Social Ergonicity, and Plasticity but did not show significant correlation with the Motor Ergonicity scale. It suggests that the SSS-V Disinhibition scale measures mostly social aspects of impulsivity and disinhibition. The Empathy scale of the STQ-77R had a high positive correlation with the NEO-FFI scale of Agreeableness, and the two "sensitivity" scales of the STQ-77R, the scales of Sensitivity to Probabilities and Empathy (as sensitivity to others), had highest positive correlations with the NEO-FFI Openness to Experience scale. The Neuroticism scales of the STQ-77R and NEO-FFI had a statistically significant positive correlation, and the NEO-FFI Extraversion scale had significant positive correlations with the Ergonicity and Tempo in Motor, Social, and Intellectual activities and also with the Plasticity and Impulsivity scales of the STQ-77R. These results support our second hypothesis. The pattern of correlations on the Extraversion and Neuroticism scales of the NEO-FFI with the STQ was similar to that obtained by Dumenci (1995) in administration of the initial version of the STQ and NEO-PI in an American sample.

3.2

The Neuroticism scale of the NEO-FFI had statistically significant negative correlations with the Motor and Intellectual Ergonicity scales of the STQ-77R, that is, participants with a weaker ability to sustain a prolonged or intense physical or mental activity had higher scores on the Neuroticism scale. This is consistent with the findings in Nebylitzyn's school in regard to relationships between sensitivity and endurance described earlier and with Gray's presentation of neuroticism as due to a BAS in the presence of a stronger BIS (Gray, 1982). It is also in line with the concept of psychoasthenia in clinical psychology; people with such a condition tend to report physical and mental tiredness, cannot sustain prolonged physical and mental work, and feel more insecure and anxious than others. This result demonstrates a nonindependence between energetic and sensitivity components of temperament and probably a bifurcation relationship between these components. Thus, using Gray's model we can argue, similarly to Pavlov, that people with a weaker BAS would be in a category of "withdrawn" people regardless of whether they have a stronger or weaker BIS (and so for this group BAS and BIS would show less independence). For people with a stronger BAS the cases with stronger or weaker BIS would bifurcate into two separate groups, so these two dimensions would be more visible. This type of results shows the benefits of considering multicomponent models, like the STQ-77, in which components have nonlinear relationships.

3.3

The highest correlation of the Extraversion scale was found with Social Ergonicity and Impulsivity (the effect sizes $d = 1.04$ and $d = 1.23$, respectively). This suggests that both impulsivity and the ability to sustain prolonged social–verbal activity underline such a personality trait of Extraversion, at least as measured by the NEO-FFI. This is in line with a large body of results reported be Revelle (Revelle, Humphreys, Simon, & Gilliland, 1980; Rocklin & Revelle, 1981; Fahrenberg, 1991), noting a significant component of Impulsivity in the trait of Extraversion.

3.4

The scale of Conscientiousness showed statistically significant positive correlations with the STQ-77R scales of Motor and Intellectual Ergonicity, Motor Tempo, and Plasticity. It suggested that the ability of a person to work hard and to move fast correlates with his or her compliant behavior. Interestingly, in our studies the STQ-77 scales of Motor Ergonicity, Tempo, and Self-Confidence showed significant correlations with the Achieving Tendency Scale, which measures the tendency for a higher aspiration level, and for the ability and attitude to work harder in order to achieve higher goals (Trofimova, 2010b). We suggest that "living by the rules" and having moral reasoning are easier for people who can actually meet the requirements of society and more difficult for people who cannot sustain prolonged physical work or cannot work and "shift gears" at a fast pace. It is in line with the hypothesis of "projection through capacities" proposed by Trofimova (1999), which suggests that a

person perceives and organizes his or her life based mostly on internal capacities rather than on external requirements and expectations. These results are an example of the feedback nature of the regulatory processes of nervous systems, which we describe here as components of temperament. Feedback processes are necessary aspects of most psychological phenomena, and interdependence caused by feedback processes limits the applicability of factor analysis, which searches for independent dimensions.

Another example of a feedback between performance and self-reflection was seen in the role of the self-confidence trait in determining the speed of performance on the semantic task: Participants with higher scores in Self-Confidence had a faster performance on the semantic task than participants with lower scores on this scale. The Self-Confidence scale measures a sense of entitlement and optimism about one's performance and might be a precursor of manic tendencies, which are linked in psychiatric and psychophysiological studies to imbalances between noradrenaline, adrenaline, cortisol, and serotonin. It is possible that self-confidence works as an amplifier of approach behavior and helps to speed up performance.

Conclusion

The STQ-77 model describes dynamic aspects of physical and mental activity, in addition to the components of social–verbal activity, commonly considered in personality models. The factor analytic solutions for our data using various numbers of factors showed that Pavlov's, Gray's, Rusalov's, and Big Five models are describing the same thing but on different analytic levels. From this point of view the differences between temperament and personality traits are in the specificity of temperament traits, and an activity-specific approach in temperament is complementary to personality assessment methods. The received solutions with three, four, and five factors correspond to the activity-specific types of abilities as relatively independent aspects of individuality. The differentiation between dynamic aspects of activity, such as endurance, lability, sensitivity, and emotionality, assessed separately in three types of activities requires special care in terms of the nonlinear, feedback, and causal relationships between these components of temperament. Such complex relationships, described in the psychological literature and in the results of our study, pose limitations on the use of factor analysis in the search for the structure of individuality.

The separation of the components of temperament according to the three types of activity revealed the benefits of analysis of a Big Five model in terms of the contributions of "medium 12" biologically based characteristics into the personality traits. The results of our semantic task study showed the benefits of such detailed analysis and of the activity-specific approach. The results also showed that the following temperament components measured by the STQ-77 could be linked to personality traits as measured by the NEO-FFI:

- Impulsivity, Social and Intellectual Ergonicity, and Motor Tempo can be linked to Extraversion.
- Neuroticism as a temperament component can be linked to Neuroticism as a personality trait.
- Empathy and Self-Confidence can be linked to Agreeableness.
- Sensitivity to Sensations, Impulsivity, and Sensitivity to Probabilities can be linked to Zuckerman's concept of Sensation Seeking.
- Empathy, Intellectual Ergonicity, and Sensitivity to Sensations can be linked to Openness to Experience.
- Motor and Intellectual Ergonicity, Plasticity, and Motor Tempo can be linked to the capacity of a person to obey social rules, which is described as the personality trait of Conscientiousness.
- Self-confidence might be a component affecting the speed of performance in verbal activities, along with Social Tempo.

Despite the solid theoretical background, the study had several limitations. First, the STQ-77 and the other tests used in this study were self-report measures and had limitations common for such measures. The STQ validity scale, which allowed one to screen for the high social desirability tendency and to select the invalid protocols, improved the validity of the results but did not completely eliminate the measurement errors expected for self-report measures. Second, despite the rich history of experimental and concurrent validation of the Extended version of the STQ, this study cannot be the basis for a final conclusion on the reported findings, as one study cannot possibly cover all aspects of a test measuring 12 temperamental traits. Future studies are needed to complement the study reported in this article.

NOTES

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1. The first version of STQ had eight scales: the same four temperament scales (Ergonicity, Plasticity, Tempo, and Emotionality) applied to the situations in social and physical activity. Each scale had 12 items (Rusalov, 1989).

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