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Psychometrics vs neurochemistry: A controversy around mobility-like scales of temperament

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ABSTRACT

There is a disagreement between the factor-analytic (FA) approach in differential psychology and findings in neuroscience in identifying mobility-like temperament traits (i.e. speed of integration of actions that include plasticity, tempo, impulsivity). Due to their entanglement with "energetic" traits, mobility-like traits never emerge as independent dimensions in FA models of temperament and personality. This paper points out that there are, however, well-documented neurochemical biomarkers of these traits, which are distinct from biomarkers of "energetic" traits. To highlight this controversy, this paper reports the results from three studies conducted on English-Canadian, Russian, and Portuguese-Brazilian samples. The studies confirmed the correspondence between similar scales of two models developed independently in two distinct branches of the Pavlovian tradition. In all three samples and two inventories, there were strong positive correlations between mobility-like and endurance-like scales. By psychometric standards, these scales should be viewed as parts of one dimension, but this would be contrary to the evidence from neuroscience pointing to their different biomarkers. Moreover, our examination of PTS and STQ-77 temperament profiles associated with polymathy demonstrated the benefits of mobility-like traits. The disagreement between psychometric and neurochemical perspectives shows the limitations of relying on FA in deriving models of differential psychology.

1. Introduction: the controversy around mobility-like scales of temperament

The concept of temperament refers to neurochemically-based individual differences in behavioural regulation, which are present both in pre-cultural individuals (animals, infants) and adult humans (Rusalov, 1989; Strelau, 1998). There are multiple temperament and personality models, all using diverse components that often overlap between models (see Trofimova, 2016 for review). Many models were derived using linear correlational statistics, such as factor analysis (FA)and structural equation modeling, inheriting the limitations of linear correlations (see Trofimova et al., 2018 for review). Part of the reliance on FA in differential psychology could be explained by the psychometric requirement that the scales of a test be independent. This requirement for scale independence, however, often goes against psychobiological phenomena, where nonlinear, feedback, reciprocal and contingent relationships abound. An example of a disagreement between psychometric principles and the neuroscience of bio-behavioural traits can be seen in the group of traits related to the speed of integration of actions (mobility, plasticity-rigidity, tempo). Integration is understood here as a choice and sequencing of behavioural alternatives when multiple alternatives in actions are present.

Mobility, as a property of the nervous system and as a temperament trait, was first identified within the experimental psychophysiology tradition started by Ivan Pavlov in the 1920–30s. This tradition later evolved into two branches, one in Poland, under the supervision of Jan Strelau (Strelau, 1998; Strelau et al., 1999; Strelau & Zawadzki, 1993), and another in Russia, under the supervision of Teplov, Nebylitzyn and Rusalov (Rusalov, 1989, 2018; Rusalov & Trofimova, 2007). Pavlov's model was also analyzed and further developed by Gray in the UK (Gray, 1991) and by Trofimova in Canada (Rusalov and Trofimova, 2007; Trofimova, 2010a,b, 2016, 2021a; Trofimova and Sulis, 2010, 2011; Trofimova and Robbins, 2016; Trofimova and Gaykalova, 2021). Despite the differences in structure and content of the models coming out of these schools, the presence of mobility, plasticity, flexibility, tempo and perseveration scales was a distinct "signature" feature in the temperament models offered by Strelau, Rusalov and Trofimova.

Mobility is defined here as the ease (speed) of integration of actions,

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including the integration needed in the switching between different tasks and actions. There are several mobility-like temperament traits that reflect aspects of behavioural regulation differing by their degree of automaticity. The speed of integration of actions in changing complex, probabilistic situations is known as *plasticity-rigidity,* whereas the speed of automatic integration of operations within well-learned (defined) actions is known as *tempo* (see Trofimova, 2016 for review). Pavlovian Temperament Survey (PTS, Strelau et al., 1999) has three scales: Strength of Excitation (PTS-E), Strength of Inhibition (PTS—I) and Mobility (PTS-M). Rusalov and Trofimova's model of the compact version of the Structure of Temperament Questionnaire (STQ-77) has 12 scales and includes several mobility-like traits (Rusalov & Trofimova, 2007; Trofimova, 2010a, 2010b; Trofimova & Sulis, 2010, 2011) (see Fig. 1). Similar to the Strelau-Zawadzki model (Strelau & Zawadzki, 1993), the STQ-77 differentiates between aspects of mobility related to different levels of automaticity of behaviour (i.e. plasticity/perseverance and tempo/briskness). The STQ-77 is structured as a 3 × 4 matrix, in line with Luria's theory of three major brain regulatory systems (orientation, integration and energetic maintenance). It uses the activity-specific approach developed by Rusalov (Rusalov, 1989, 2018) that distinguishes between physical, social and mental aspects of behaviour. Importantly, the STQ-77 follows the structure of the neurochemical model, Functional Ensemble of Temperament (FET), that summarized the currently known contributions of neurotransmitter systems to bio-behavioural individual differences (Trofimova, 2016, 2018, 2019, 2021a,b; Trofimova & Robbins, 2016).

Despite the century-long history of mobility-like traits in differential psychology, the majority of temperament and personality models don't include any of them. The main reason for this void is that many models rely on the results of FA, which, in turn, uses matrices of linear correlations. Linear correlations are used even in hierarchical and nonlinear types of FA. Mobility-like traits consistently show significant linear correlations with the "energetic" traits (Strength of Excitation; Strelau et al., 1999), Ergonicity (Rusalov & Trofimova, 2007; Trofimova, 2010a) or Endurance (Trofimova, 2010b; Trofimova & Sulis, 2011). Due to this correlation, mobility-like traits do not emerge as independent dimensions in FA studies but instead are collapsed into a factor describing energetic capacities. Since FA is used to derive most uncorrelated dimensions, FA-based models of bio-behavioural traits never identify them. Interestingly, some models that are derived from parental observations and not from the factor analysis, for example, Thomas and Chess (1977) and their followers Windle and Lerner (1986), included a flexibility-rigidity dimension.

The aim of this paper is to highlight the contradiction between psychometric and neurochemical findings in relation to mobility-like traits. First, we report the results of Study 1 and Study 2, conducted in three cultural samples that illustrate the entanglement of mobility-related and endurance-related traits of temperament. To address the issue of differential diagnostic capacities of the models, the study used the inventories representing two different branches of the Pavlovian tradition that included mobility-like traits.

Moreover, in Study 2, we explore the benefits of separating the mobility-like and endurance-like dimensions of temperament by examining the temperament profiles of polymathy (cognitive flexibility). Polymathy relates to a drive and ability of acquiring and implementing learning in multiple domains (Araki, 2018; Araki & Berg, 2021). Neuroscience consistently links superb learning abilities, cognitive flexibility and attention to detail to the functions of the frontal cortex (Goldberg, 2009), and polymaths are known for their ease of integration of new skills and knowledge (Araki, 2018; Araki & Berg, 2021; Araki & Cotellessa, 2020). The FET points to a leading role of dopaminergic systems in mobility-like traits (Plasticity, Tempo, Impulsivity) (Trofimova, 2016, 2021a, b; Trofimova & Robbins, 2016). Since plasticity (flexibility) in learning is one of the key features of polymathy, we hypothesized that these traits will be high in polymaths. Moreover, high information processing in polymaths would be associated with high scores in sustained attention (Intellectual Endurance) and Probabilistic Processing. In Study 2, therefore, we hypothesized that mobility-like traits in both inventories developed within Pavlov's tradition (i.e. PTS and STQ-77) will be positively associated with polymathy abilities. Study 2 also examined possible entanglement between mobility-like scales of the PTS and STQ-77 with the "energetic scale" (Extraversion) of Eysenck Personality Questionnaire.

Finally, in the Discussion section, we compare our results to neurochemical findings regarding mobility, and analyze the validity of relying on correlations in deriving the structure of temperament.

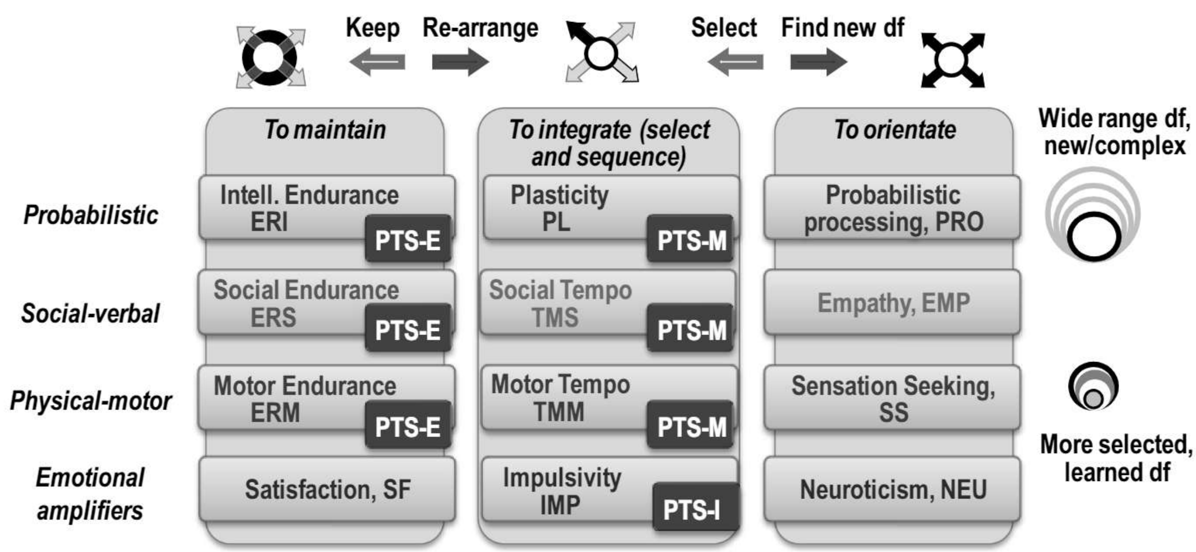

Fig. 1. The structure of the Functional Ensemble of Temperament framework (FET) that is used by the Structure of Temperament Questionnaire-Compact (STQ-77). *Note.* The 12 temperament traits of the STQ-77 reflect functional aspects of construction of behaviour (***bold italic***) out of multiple degrees of freedom (***df***) and capacities. The contingent relations between functional aspects make the traits to be interdependent, in contrast to psychometric requirements for tests. Dark small rectangular shapes show a correspondence between the STQ-77 and Pavlovian Temperament Survey (PTS) scales. PTS-E – Strength of Excitation; PTS-I – Strength of Inhibition; PTS-M – Mobility scale. Green shallow arrows indicate the action of mu- and delta-opioid receptors inducing the "approval bias" in chosen df; solid red arrows indicate the action of kappa-opioid receptors inducing the change and/or search for new df, as per FET model. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

The *hypotheses of Study 1* were:

H1. This hypothesis refers to the correlations between the similar scales of the PTS and STQ-77. In all three samples, there are significant positive correlations between:

1A. The PTS Mobility scale and the STQ-77 scales related to the speed of integration of actions (Plasticity, Motor Tempo and Social Tempo);

1B. The Strength of Excitation scale of the PTS and Physical Endurance and Social Endurance scales of the STQ-77.

1C. The Strength of Inhibition scale of the PTS and the STQ-77 Intellectual Endurance scale(and a significant negative correlation with the STQ-77 Impulsivity scale).

H2. This hypothesis refers to the correlations between the scales measuring mobility-like and endurance-like aspects of behaviour within each test (i.e. within the PTS and within the STQ-77). In all three samples, there are significant positive correlations between:

2A. The PTS Mobility scale and the PTS-E;

2B. The STQ-77 Motor Tempo and Motor Endurance scales;

2C. The STQ-77 Social Tempo and Social Endurance scales;

2D. The STQ-77 Plasticity and Intellectual Endurance scales;

The *hypotheses of Study 2* included H1 and H2 hypotheses. Additionally, it investigated the association of mobility-like traits with polymathy, and, therefore, had an additional hypothesis:

H3. This hypothesis relates to differential contributions of endurance-like and integration-like aspects of behaviour in polymathy. The hypothesis suggests that polymathy has significant positive correlations with the PTS Mobility scale and the STQ-77 Plasticity, Intellectual Endurance and Probabilistic Processing scales. In contrast with Endurance-like aspects of behaviour, polymathy does not have positive correlations with the PTS Strength of Excitation scale or the STQ-77 Physical Endurance scale.

2. Method

2.1. Study 1

2.1.1. Samples, Study 1 (author's identifiers by University have been removed)

Canadian subsample: N = 703, M/F = 220/483, aged 18–50 years, *Mean age* = 21.48, *SD* = 7.12, including psychology students of Author 1 University, Canada (68% of the sample) and volunteers (32% of the sample). Volunteers were invited during the teaching of psychology courses in this University from students who did not need credit, and from their relatives, and also from healthy visitors to Psychological Services, a private practice. The volunteers were motivated by offering to them their personal results on several psychological tests. This study was approved by the Ethics Committee of this University.

Russian subsample: N = 158, M/F = 54/104, aged 18–49 years, *Mean age* = 25.37, *SD* = 10.11,including law students of the Russian University (78% of the sample) and volunteers (22%). Volunteers were invited during the teaching of psychology courses in this University and another teaching Institute from students who did not need a credit, and from their relatives. Volunteers were motivated by offering to them their personal results on several psychological tests. The study was approved by the Ethics Committee of this University.

All participants were debriefed and signed an informed consent form before testing.

2.1.2. Measures in Study 1

Participants of both samples completed the following inventories:

Compact Structure of Temperament Questionnaire, English (STQ-77E) in Canadian sample (Rusalov & Trofimova, 2007; Trofimova, 2010b; Trofimova & Sulis, 2011), and Russian (STQ—77Ru) in Russian sample (Rusalov & Trofimova, 2007, 2011). The STQ-77 has 77 statements, assigned to 12 temperamental scales (6 items each), and the validity scale (5 items). Responses are recorded in a Likert scale format: “strongly disagree” (1), “disagree” (2), “agree” (3), “strongly agree” (4) (Rusalov & Trofimova, 2007). The 12 temperament scales of the STQ-77 are organized in line with the neurochemical model FET in four groups as following:

- Endurance group, the scales of Motor-physical (ERM), Social-communicative (ERS) and Intellectual-mental Endurance (ERI): the ability of an individual to sustain prolonged physical, social-verbal, or mental activity, respectively;
- Speed of integration group, the scales of Motor (TMM, for example “*I quickly move into high gear in doing physical work*”) and Social-verbal Tempo (TMS, for example, “*I can easily handle rapid conversations*”) (preferred speed of familiar physical or verbal activity) and the Plasticity scale (PL, for example, “*I don't see a big deal if people ask me to redo something differently, and more than once*”) that assesses the ability to adapt quickly to changes in situations, to change the sequence of action, and to shift between different tasks;
- Sensitivity group, assessing how much behaviour of an individual is oriented primarily to risks or physical pleasures (the Sensation Seeking scale, SS), to other people's states (Empathy scale, EMP), or to probabilistic processing of causes and consequences of events (Sensitivity to Probabilities scale, PRO, for example, “*I like philosophy and science*”);
- Emotionality group, that includes: Self-confidence scale (SLF) measuring the tendency to be optimistic and confident (sometimes overly optimistic) in one's own performance, to ignore other people's warnings and criticism; Impulsivity scale (IMP) as emotional reactivity, a poor ability to control immediate impulses for actions; Neuroticism scale (NEU), measuring low tolerance of uncertainty and novelty, negativity bias in expectations of outcomes in own activity.

Strelau's Pavlovian Temperament Survey, English version (PTS) in Canadian sample (Strelau et al., 1999), and Russian version in Russian sample (Bodalev et al., 2001). All versions of the PTS in this study have 66 statements assigned to three scales (22 items each): Strength of Excitation (PTS-E), Strength of Inhibition (PTS—I) and Mobility scale (PTS-M). Responses are recorded in a Likert scale format: “strongly disagree” (1), “disagree” (2), “agree” (3), “strongly agree” (4).

The reliability coefficients for STQ-77 and PTS scales calculated from the data of this study are listed in Table 2.

2.2. Study 2

2.2.1. Sample, Study 2, author's identifiers by University have been removed)

Brazilian subsample: N = 155, M/F = 97/58, aged 17–43 years, *Mean age* = 24.61, *SD* = 7.37, including 102 undergraduate students enrolled at the entrepreneurship program in a University in Brazil, who received course credit in a general management course. We also recruited 53 professionals who volunteered for this study. This study was approved by the Ethics Committee of this University. All participants were debriefed and signed the informed consent form before testing.

2.2.2. Measures in study 2

As noted, participants completed the same inventories as in Study 1 plus the following inventories:

Portuguese version of the PTS (Guzzo et al., 2003) and the *Portuguese version of the STQ-77* (STQ—77Pt) (Araki & Trofimova, 2021; Trofimova, Araki, 2021a, 2021b). Moreover, the following inventories were used in this study:

Eysenck's Personality Questionnaire (EPQ-R), Portuguese version (Almiro et al., 2016) was used in the Brazilian sample. The EPQ has three scales: Psychoticism (EPQ-P), Extraversion (EPQ-E) and Neuroticism (EPQ-N), and a validity (Lie) scale, each having 12 items.

Responses are recorded in a Likert scale format: "strongly disagree" (1), "disagree" (2), "agree" (3), "strongly agree" (4). This paper also compares the results from the Brazilian sample to published results of EPQ-STQ relations in Russian sample (Rusalov, 1989).

Polymathy Orientation Scale (POS), Portuguese version was used on the Brazilian sample. POS measures polymathy tendencies and has four scales: P—D - Depth of learning interests (items like "*I enjoy spending hours investigating and delving into a subject*"); P—B - Breadth of learning (items like "*I often look for knowledge well outside my main area of study/specialization*"), P—I – Integrational abilities (items like "*It's easier and more exciting for me to have a lot of original ideas than to implement/execute existing ideas*", eight items per scale, and the POS – the Total score scale. Responses are recorded in a Likert scale format: "strongly disagree" (1), "disagree" (2), "agree" (3), "strongly agree" (4).

The reliability coefficients for STQ-77 and PTS scales calculated from the data of this study are listed in Tables 2 and 3.

Statistical processing included the calculations of the descriptive scale statistics (means, SD, confidence intervals), reliability coefficients (Cronbach's alphas) and correlations among all measures. Also, OLS regression analysis was performed for PTS and STQ-77 scales.

3. Results

Table 1 shows the descriptive statistics for the STQ-77 and PTS scales and the reliability coefficients measured by the Cronbach alphas (α) from both studies. All alpha values were in the acceptable range (0.70–0.83), with the exception of the STQ-PRO scale in the Russian subsample. Table 2 shows significant (at $p < .01$) correlations between the PTS and STQ-77scales in both studies, Table 3 shows the significant (at $p < .01$) correlations between the STQ-77, PTS, EPQ and POS scales in Study 2, and Table 4 the results of regression analysis for PTS-STQ-77 scales from both studies.

Concerning the relations between the corresponding scales of two inventories (PTS and STQ-77) (H1), there were high positive correlations between the PTS-Mobility scale and the STQ-77 scales related to the speed of integration of actions (Plasticity, Motor Tempo, and Social Tempo) in all three cultural samples (Table 2). Moreover, PTS-Mobility also had a high positive association with Social Endurance (sociability), Sensation Seeking and Dispositional Satisfaction scales of the STQ-77 and a negative correlation with STQ-77 Neuroticism in all three samples (Table 2). The PTS-Mobility scale also had significant positive correlations with the EPQ Extraversion and Psychoticism scales in Brazilian sample (Table 3).

The PTS Strength of Excitation scale had significant positive correlations with the STQ-77 Motor Endurance, Tempo, Social Endurance and Tempo, and Satisfaction scales in Canadian and Russian samples but not in the Brazilian sample. There were, however, significant positive correlations between the PTS-E and the STQ-77 scales of Plasticity and Intellectual Endurance, and negative correlations between PTS-E and STQ-77 Impulsivity and Neuroticism in Brazilian and Canadian samples but not in the Russian sample (Table 2). The PTS-E scale also had a significant positive correlation with the EPQ Psychoticism scale and a negative one – with the EPQ Neuroticism scale in Brazilian sample (Table 3).

The PTS Strength of Inhibition scale had a significant positive correlation with the STQ-77 Plasticity and a negative correlation with the STQ-77 Impulsivity scale across all three samples. The PTS-I also had a positive correlation with the STQ scales of Intellectual Endurance in Brazilian and Canadian samples and with the Probabilistic Processing scale of the STQ-77 in Brazilian and Russian samples (Table 2). The PTS-I in the Brazilian sample also had a significant negative correlation with the Neuroticism scales of both STQ-77 (Table 2) and EPQ (Table 3).

The EPQ Extraversion scale in the Brazilian sample had a significant positive correlation with the STQ-77 scales of Social Endurance, Social Tempo, Plasticity, Satisfaction and Impulsivity and negative correlations with the Probabilistic Processing scale (Table 2), as well as with the PTS-I scale (Table 3).

In regards to H2 (i.e. relations between the mobility-like and endurance-like scales within the used tests), there are strong (at $p < .001$) positive correlations between the STQ-77 Motor Tempo and Motor Endurance scales; between Social Tempo and Social Endurance scales; between Plasticity and Intellectual Endurance scales, and also (negative correlation) between the STQ-77 Impulsivity and PTS-Inhibition scales (Table 5, Table 6). This pattern is observed in all three samples and in both studies. There are also positive correlations of PTS-Excitation with the STQ-77 Motor Tempo, Social Tempo, and PTS-Mobility scales in Canadian and Russian samples, and with the STQ-77 Plasticity scale in Canadian and Brazilian samples. The PTS Mobility scale also has high positive correlations with the STQ Social Endurance scale in all three samples (Table 5 and 6).

In terms of the third hypothesis (Study 2), the POS-Total, Breadth and Integration scales in the Brazilian sample have significant positive correlations with the PTS Mobility scale, and the Integration scale also correlated positively with the STQ-77 Plasticity scale, confirming the integrative features of polymathy. POS Depth, Breadth and Total scales have significant positive correlations with the STQ-77 Probabilistic

Table 1
Means, Standard Deviations (SD) and standardized alpha Cronbach coefficients (α) for the STQ-77 scales from three studies.

	Canada	$N = 703$		Russia	$N = 158$		Brazil	$N = 155$	
	Mean	*SD*	α	Mean	*SD*	α	Mean	*SD*	α
PTS-E	57.44	7.14	0.79	56.41	8.44	0.71	40.97	8.27	0.81
PTS-I	58.66	6.56	0.66	56.43	7.86	0.68	51.72	8.12	0.78
PTS-M	57.09	6.73	0.72	56.34	7.90	0.65	51.85	8.55	0.83
ERM	15.60	4.35	0.81	15.92	4.42	0.83	15.39	3.23	0.72
TMM	15.40	3.82	0.71	16.00	3.83	0.72	15.66	3.18	0.71
SS	16.63	3.00	0.72	16.08	3.33	0.70	16.54	3.42	0.75
ERS	18.49	3.58	0.76	17.74	3.61	0.74	17.40	3.54	0.72
TMS	16.71	3.54	0.70	16.66	3.55	0.71	16.45	3.30	0.75
EMP	15.81	3.48	0.70	16.61	3.48	0.70	15.12	3.36	0.75
ERI	14.50	3.51	0.71	15.41	3.70	0.70	16.45	3.14	0.71
PL	15.04	3.06	0.70	15.32	3.13	0.71	14.92	3.05	0.70
PRO	15.83	3.26	0.70	16.24	3.20	0.67	18.12	3.20	0.70
SF	15.58	3.70	0.72	15.82	3.84	0.70	14.94	3.24	0.70
IMP	15.50	3.14	0.70	15.19	3.23	0.71	16.69	3.24	0.71
NEU	14.99	3.45	0.71	15.54	3.51	0.73	15.88	3.28	0.70

*Note.*Zeroes before the decimal point for alpha are omitted. Abbreviations for scales: Pavlovian Temperament Survey (PTS) scales: PTS-I – Strength of Inhibition; PTS-e – Strength of Excitation; PTS-M – Mobility. Structure of Temperament Questionnaire (STQ-77) scales: ERM/S/I – Motor/Social/Intellectual Endurance; TMM/S – Motor/Social Tempo; SS – Sensation Seeking; EMP – Empathy; PL – Plasticity; PRO – probabilistic processing; SF – dispositional Satisfaction; IMP – Impulsivity; NEU – Neuroticism.

Table 2
Significant (at p < .01) correlations between the Pavlovian Temperament Survey (PTS) and the Structure of Temperament Questionnaire (STQ-77) scales.

	Canada	N = 703		Russia	N = 158		Brazil	N = 155	
STQ77	PTS-E	PTS-I	PTS-M	PTS-E	PTS-I	PTS-M	PTS-E	PTS-I	PTS-M
ERM	0.36**		0.21**	0.34**					
TMM	0.40**		0.34**	0.24*		0.26**			0.24*
SS	0.64**		0.43**	0.38**		0.40**			0.28**
ERS	0.42**	−0.12*	0.45**	0.29**		0.37**			0.52**
TMS	0.33**	−0.20**	0.30**	0.30**		0.29**			0.43**
EMP	−0.17**	−0.12*							
ERI	0.26**	0.17**	0.14*				−0.38**	0.42**	
PL	0.32**	0.15**	0.36**		0.21*	0.29**	−0.38**	0.28**	0.56**
PRO	0.37**		0.31**		0.22*			0.28**	
SF	0.45**		0.28**	0.44**		0.26*			0.32**
IMP		−0.53**	0.13**		−0.36**		0.23*	−0.63**	
NEU	−0.21**		−0.32**			−0.23*	0.48**	−0.35**	−0.40**

Note. Abbreviations for PTS and STQ-77 scales are the same as in Table 1.
* $p < .01$.
** $p < .001$.

Table 3
Means, Standard Deviations (SD) and standardized alpha Cronbach coefficients (α) for the scales of the Eysenck Personality Inventory (EPQ) and Polymathy Orientation Scales (POS) scales and significant (at $p < .01$) correlations between these scales and other scales (Study 2).

N = 153	EPQ-P	EPQ-E	EPQ-N	P-D	P-B	P-I	POS
Means	23.97	33.52	31.48	15.56	17.23	16.63	16.47
SD	3.87	6.67	6.89	3.16	2.80	2.59	1.86
alpha	0.56	0.89	0.86	0.66	0.72	0.68	0.74
TMM		0.21*					
SS	0.37**	0.37**				0.36*	
ERS		0.71**				0.50**	0.32*
TMS		0.38**					
EMP			0.29**				
ERI			−0.30**	0.44**			0.36*
PL		0.21*	−0.33**			0.38*	
PRO		−0.26*		0.48**	0.35**		0.41**
SF		0.23*	−0.33**				
IMP		0.33**	0.57**				
NEU	−0.30**		0.47**			−0.43**	
PTS-E	0.28**		−0.38**				
PTS-I		−0.23*	−0.55**				
PTS-M	0.24*	0.60**			0.34**	0.52**	0.37*
EPQ-E						0.39**	
P-D					0.46**	0.41**	0.77**
P-B				0.46**		0.60**	0.83**
P-I				0.41**	0.60**		0.83**

Abbreviations for PTS and STQ-77 scales are the same as in Table 1. EPQ-P – Psychoticism; EPQ-E – Extraversion; EPQ-N – Neuroticism; P—D - Depth orientation, P—B - Breadth orientation, P—I - Integration orientation, POS- Total. Zeroes before the decimal point are omitted. The scales STQ-77 ERM, EPQ-P and EPQ-N didn't have significant correlations with EPQ-E or POS scales.
* $p < .01$.
** $p < .001$.

Processing scale, and POS Depth and Total scale also have significant positive correlations with the STQ-77 Intellectual Endurance scale, supporting the idea that polymaths have high learning abilities and sustained attention. The POS Integration scale has significant positive correlations with the STQ-77 Sensation Seeking and Social Endurance scales, as well as a significant negative correlation with Neuroticism.

Regression analysis using heteroscedasticity-consistent (robust) errors showed that, across three cultures, PTS-Mobility could be explained by endurance-like scales. The proportion of the variance explained ranged between 38 and 45%. Particularly, STQ Social Endurance and PTS Strength of Excitation were strong predictors of PTS Mobility. For instance, a 1-unit increase in the STQ Social Endurance score is associated with a 1.1-unit increase in PTS Mobility in the Brazilian sample, all else being equal. We also tested relationships between other endurance-like and mobility-like scales across different measures and cultures. PTS Strength of Inhibition was a significant negative predictor of STQ Impulsivity (all samples) and STQ Social tempo (Canadian and Russian samples). Finally, there were significant associations between Motor Tempo and Motor Endurance, as well as between Social Tempo and Social Endurance.

4. Discussion: comparing it to neurochemical perspective

Our investigation of the correspondence between two temperament inventories that included mobility-like scales and represented two branches of the Pavlovian tradition overall confirmed our first hypothesis. There are strong correlations between the scales measuring mobility and impulse control between the PTS and the STQ-77 in all three samples (hypotheses H1A and H1C). Hypothesis H1B was also supported in Canadian and Russian samples showing a strong correlation between PTS-E and Endurance-like scales of the STQ-77.

Overall, the second hypothesis was also confirmed: there are strong positive correlations between mobility-like scales (PTS-Mobility, STQ-Motor Tempo, Social Tempo, Plasticity, and Impulsivity) and endurance-like scales (PTS-Excitation, STQ-Motor Endurance, Social Endurance, Intellectual Endurance, EPQ-Extraversion). Moreover, there

Table 4
OLS Regressions with PTS scales as outcome variables and the STQ scales as predictors, controlling for sex and age.

	Canadian Sample			Russian Sample			Brazilian Sample		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Variables	PTS-E	PTS-I	PTS-M	PTS-E	PTS-I	PTS-M	PTS-E	PTS-I	PTS-M
ERM	−0.043	0.217	−0.143	0.208	−0.045	−0.113	0.412	0.392	−0.275
	(0.198)	(0.142)	(0.152)	(0.118)	(0.124)	(0.123)	(0.706)	(0.799)	(0.319)
TMM	0.295	0.324	0.151	0.188	0.075	**0.289***	−0.262	−0.190	0.454
	(0.229)	(0.141)	(0.163)	(0.084)	(0.078)	**(0.090)**	(0.358)	(0.383)	(0.189)
SS	−0.114	**−0.385***	0.090	**1.127***	−0.077	**0.447***	**1.151***	0.590	**0.619***
	(0.173)	**(0.132)**	(0.161)	**(0.100)**	(0.100)	**(0.101)**	**(0.387)**	(0.457)	**(0.202)**
ERS	−0.268	0.121	**0.680***	**0.327***	0.174	**0.568***	0.083	0.045	**0.471***
	(0.180)	(0.139)	**(0.133)**	**(0.076)**	(0.077)	**(0.074)**	(0.266)	(0.316)	**(0.148)**
TMS	0.145	−0.426	0.215	**0.267***	**−0.334***	0.090	0.405	−0.040	0.173
	(0.195)	(0.171)	(0.164)	**(0.071)**	**(0.077)**	(0.074)	(0.236)	(0.265)	(0.148)
EMP	0.334	−0.005	0.150	**−0.207***	−0.193	**0.407***	0.215	−0.000	0.273
	(0.178)	(0.133)	(0.130)	**(0.073)**	(0.078)	**(0.075)**	(0.214)	(0.263)	(0.167)
ERI	**0.500***	0.313	0.059	**0.345***	**0.224***	0.087	0.288	0.134	0.102
	(0.191)	(0.164)	(0.138)	**(0.081)**	**(0.080)**	(0.078)	(0.334)	(0.396)	(0.168)
PL	0.498	0.436	**0.985***	**0.209****	**0.292***	**0.497***	0.597	0.778	**0.556***
	(0.226)	(0.196)	**(0.156)**	**(0.082)**	**(0.088)**	**(0.086)**	(0.295)	(0.326)	**(0.185)**
PRO	0.037	0.184	0.133	**0.261***	−0.069	0.161	−0.361	−0.545	−0.122
	(0.150)	(0.140)	(0.133)	**(0.088)**	(0.089)	(0.079)	(0.385)	(0.462)	(0.214)
SF	0.062	0.198	0.336	−0.022	0.156	0.113	0.248	−0.077	0.095
	(0.156)	(0.162)	(0.144)	(0.152)	(0.148)	(0.158)	(0.664)	(0.736)	(0.326)
IMP	−0.106	**−1.105***	0.389	0.008	**−1.127***	0.019	0.713	−0.279	0.053
	(0.200)	**(0.167)**	(0.164)	(0.084)	**(0.076)**	(0.076)	(0.326)	(0.388)	(0.165)
NEU	**−0.853***	−0.126	−0.419	−0.038	0.063	**−0.703***	−0.519	−0.246	**−0.466***
	(0.189)	(0.151)	(0.163)	(0.076)	(0.086)	**(0.077)**	(0.296)	(0.342)	**(0.166)**
Constant	38.202*	58.252*	10.956	14.243*	70.370*	24.054*	12.591	49.211*	27.291*
	(9.881)	(7.173)	(8.204)	(2.796)	(3.401)	(3.138)	(9.265)	(11.385)	(6.469)
R-squared	0.373	0.550	0.615	0.559	0.348	0.454	0.344	0.108	0.485
Log-Lik.	−495.9	−459.0	−452.9	−2172	−2209	−2212	−523.8	−540.8	−412.4

Robust standard errors are indicated in parentheses. Zeroes before the decimal point are omitted.
Bold duplicates the significance marking, for visual facilitation of significant effects.
* $p < .01$.

Table 5
Correlations between mobility-like scales (columns) and endurance-like scales (rows) at p < .001.

	STQ-77				PTS
	Motor Tempo	Social Tempo	Plasticity	Impulsivity	Mobility
STQ Motor	Endurance				
Can	0.60	0.21			0.21
Rus	0.63				
Brzl	0.57				
STQ Social	Endurance				
Can	0.29	0.49		0.26	0.45
Rus		0.46			0.37
Brzl		0.41			0.52
Intellectual	Endurance				
Can			0.23		
Rus			0.32	−0.20	
Brzl			0.19	−0.41	
PTS	Strength of	Excitation			
Can	0.40	0.33	0.32		0.53
Rus	0.24	0.30			0.61
Brzl			0.39		
PTS	Strength of	Inhibition			
Can		−0.20	0.15	−0.53	
Rus			0.21	−0.36	0.23
Brzl			0.29	−0.63	
EPQ	Extraversion				
Rus†	0.50	0.51	0.65	N/A	N/A
Brzl		0.38		0.33	

Note. (Can)adian sample, $N = 703$, (Rus)sian sample, $N = 158$, Brazilian (Brzl) sample, $N = 155$. † – results provided by Rusalov based on his study (Rusalov, 1989). N/A – not available.

are cross-instruments significant correlations between mobility-like and endurance-like scales: for example, between STQ-Motor Tempo or Plasticity and PTS-E in two samples. Psychometrically these inter-correlations between scales are not good news, but this paper specifically challenges the validity of our reliance on psychometric principles in investigations of the dimensions of temperament. Clearly, if factor analysis is used on our data, such strong correlations between mobility- and endurance-like traits would collapse them into "energetic" dimensions, and mobility-like traits would not be considered as consistent, stand-alone bio-behavioural individual differences. This pattern of inter-correlations is similar to those reported from Polish and German samples (Ruch et al., 1991; Strelau et al., 1999), Chinese, Russian (Trofimova, 2010a) and Canadian samples (Trofimova, 2010a, 2010b; Trofimova & Sulis, 2010, 2011).

In terms of the observed cross-cultural differences, it is important to note that these differences were related to associations that were not included in hypotheses, whereas all associations included in hypotheses 1 and 2 were confirmed in all three samples, with the exception of the relation between the PTS-E and endurance-like scales of the STQ-77. The most noticeable difference was the absence of significant (at $p < .001$) correlations between the PTS-E and STQ-77 scales of ERM and ERS in the Brazilian sample (part of H1), whereas these (positive) correlations were present in the Canadian and Russian samples. PTS-E also had significant (at $p < .001$) negative correlations with the STQ-77 ERI scale, and (positive) with the IMP and NEU scales in Brazilian samples. The name of the PTS-E scale in Portuguese version is "Excitability", unlike the "Excitation" name in English and Russian versions, indicative of a possible focus of PTS-*E*-Pt on impulse control and reactivity rather than on endurance aspects (as in English and Russian versions of the PTS-E). Other associations observed only in two cultures (for example, PTS-E and the STQ scales of TMM, TMS and SS in Canadian and Russian samples, or PTS-E and the STQ scales of PL, IMP, and NEU in Canadian

Table 6
OLS Regression with Mobility-like scales as outcome variables and the endurance-like scales as predictors, controlling for sex and age.

	(1)		(2)		(3)		(4)		(5)	
Variables	PTS-M	SE	TMM	SE	TMS	SE	PL	SE	IMP	SE
STQ Motor	Endurance									
Can	0.025	0.059	**0.432***	0.028	−0.061	0.028	0.008	0.027	−0.014	0.025
Rus	−0.028	0.122	**0.575***	0.060	−0.016	0.067	0.156	0.065	−0.148	0.060
Brzl	0.275	0.152	**0.541***	0.067	0.166	0.074	0.157	0.068	**0.036***	0.010
STQ Social	Endurance									
Can	**0.678***	0.073	**0.094***	0.035	**0.412***	0.035	−0.014	0.034	**0.140***	0.031
Rus	**0.486***	0.135	0.074	0.069	**0.381***	0.077	0.015	0.074	0.100	0.069
Brzl	**1.098***	0.138	0.038	0.060	**0.366***	0.068	0.145	0.062	0.020	0.009
Intellectual	Endurance									
Can	0.069	0.072	**−0.091***	0.034	0.107*	0.035	**0.115***	0.033	−0.046	0.030
Rus	0.031	0.142	−0.037	0.070	0.049	0.079	**0.285***	0.076	**−0.234***	0.071
Brzl	−0.064	0.183	**−0.152***	0.080	0.116	0.090	−0.057	0.082	−0.026	0.012
PTS	Strength of	Excitation								
Can	**0.378***	0.035	**0.095***	0.017	**0.071***	0.017	**0.110***	0.016	**0.042***	0.015
Rus	**0.557***	0.083	0.042	0.033	**0.123***	0.037	0.038	0.036	**0.199***	0.033
Brzl	**0.251***	0.070	0.048	0.031	0.066	0.034	**0.125***	0.031	−0.004	0.005
PTS	Strength of	Inhibition								
Can	**0.140***	0.034	−0.015	0.016	**−0.091***	0.016	**0.043***	0.016	**−0.229***	0.014
Rus	0.104	0.076	−0.027	0.032	**−0.095***	0.036	0.012	0.035	**−0.158***	0.033
Brzl	0.055	0.078	−0.004	0.034	−0.080	0.038	**0.094***	0.035	**−0.043***	0.005
R-sq, Can	0.380		0.417		0.305		0.139		0.339	
Rus	0.453		0.495		0.299		0.166		0.297	
Brzl	0.378		0.351		0.250		0.274		0.487	
L-L, Can	−2257		−1740		−1746		−1722		−1650	
Rus	−416.5		−341		−356.6		−351.4		−341.9	
Brzl	−489.8		−363		−380.1		−365.8		−72.23	

Note. Constant, sex and age results omitted for space. Can = Canadian sample; Rus = Russian; Brzl = Brazilian. SE = Robust standard errors. R-sq. = Coefficient of Determination. L-L = Log-likelihood.
Bold duplicates the significance marking, for visual facilitation of singificant effects.
* $p < .01$.

and Brazilian samples) can be interpreted as a result of the non-specificity of the PTS-E scale reflecting general arousal aspects of behaviour in English and Russian versions of the PTS-E but not in the Portuguese version of the PTS-E.

As noted earlier (Trofimova et al., 2018), when linear statistical methods (like factor analysis) are used for data analysis, the entangled relations between biological systems of behavioural regulation will lead to strong linear correlations between variables associated with these systems. If variables reflect systems with contingent and feedback relations, the strong correlations between them will emerge regardless of the origin of the models (i.e. whether the models were derived from observations, previous factor analysis or were based on analytic summary of biomarkers, like the FET). In this sense, linear correlations (and hence factor analysis) will collapse the true dimensionality of behavioural regulation but will not reflect the underlying complexity.

The correlations received in our studies demonstrated the collapse in dimensionality of temperament. There is indeed functional entanglement between energetic, integration and orientational aspects of behavioural regulation, which were proven to have different neuroanatomic and neurochemical biomarkers (Trofimova, 2021a). For example, when an action could be performed but could be re-integrated, an individual changes the course of actions (as seen in plasticity). If this is not sufficient for situational demands, then the behavioural regulation intensifies orientation, to search for new degrees of freedom and expand behavioural alternatives (Fig. 1). New degrees of freedom are constantly selected by the integration block, and an action is performed based on learned and novel elements. The FET shares a functional constructivism approach that considers behaviour as a generative, constructive process of selection out of multiple degrees of freedom. All functional aspects of behavioural construction are, therefore, highly contingent on each other's status. However, each of these regulatory systems are unique, in terms of neurochemistry and neural networks. More specifically, the following neurochemical evidence supports the position that the endurance-like traits reflect very different aspects of behavioural regulation and should not be mixed up with integration (mobility-like) traits.

1) *Specificity of brain DA systems.* To mention briefly, there is consensus concerning the role of brain dopamine (DA) systems in behavioural plasticity and motor performance requiring timely integration of actions (Robbins, 2010; Seamans & Yang, 2004; Yin & Knowlton, 2006). Plasticity involves the simultaneous activation and suppression of several scripts of behaviour, the integration of a new program of actions and its sequencing. DA release is also associated with the process of attaching significance to stimuli (saliency) of both positive and negative emotional valence (Berridge, 2007; Salamone et al., 1997). In fact, contrary to the notion of DA as a "neurotransmitter of pleasure", appetitive stimuli enhance activity in the mesocortical DA system to a lesser degree and more transiently than do aversive stimuli (Robbins, 2010). DA release, therefore, alters priorities in perception, and this contributes to the final programming (integration of sequences and suppression of irrelevant elements) of actions and accompanies motivational processes. The capacity of DA release to affect the prioritization and sequencing of actions is also seen in its regulation of motor output, "motor readiness" during the preparation of behavioural responses by the striatum (Graybiel & Grafton, 2015; Graybiel & Matsushima, 2020; Robbins, 2010; Seamans & Yang, 2004; Yin & Knowlton, 2006). DA release, therefore, was linked to the prioritization and facilitation of selection of behavioural alternatives necessary for the *integration* of actions (whether perceptual-cognitive or motor). At the same time, not a single study linked DA to the regulation of endurance of behaviour.
2) *Specificity of brain 5-HT systems.* In contrast to mobility-like traits reflecting the speed of integration of actions, energetic traits are linked to different and more diffuse neurotransmitter systems: serotonin (5-HT) and neuropeptides for physical endurance, hormonal systems for social endurance and acetylcholine-GABA systems for intellectual endurance (sustained attention) (Trofimova, 2016,

2021a, b, Trofimova and Robbins, 2016). Also, in contrast to DA, 5-HT and neuropeptides are widely spread not only in the brain but also the body, regulating homeostatic maintenance and energetic aspects of behaviour, but were never implicated in the regulation of the speed of integration of behaviour (Azmitia, 2010).

3) *Specificity of the systems regulating probabilistic* versus *deterministic integration and endurance.* As noted above, the FET identified three types of endurance and four types of systems of behavioural integration (Fig. 1), each having its own neurochemical ensemble of regulation and acting differently for well-learned (deterministic) vs. novel/complex (probabilistic) tasks (Graybiel & Grafton, 2015; Graybiel & Matsushima, 2020; Yin & Knowlton, 2006). These ensembles have different neurochemical members and locations in the brain and also employ a diversity of receptors (Netter, 2021; Robbins, 2010; Trofimova, 2021a). Thus, a separation between plasticity and tempo is validated by the evidence linking plasticity to cortical serotonin-dopamine regulation whereas tempo (integration of well-learned actions) develops with the transition from cortex to ventral striatum and then to dorsal striatum, with more involvement of cholinergic interneurons and with higher support of hypothalamic neuropeptides (Graybiel & Grafton, 2015; Graybiel & Matsushima, 2020; Trofimova, 2021a; Yin & Knowlton, 2006).
4) *Interactions between DA and 5-HT (integration and endurance systems) does not mean that they should be viewed as one.* Regarding the relationships between Motor Endurance and Motor Tempo, 5-HTand DA systems support each other's release during the integration of behaviour (Adell et al., 2010; Di Pietro & Seamans, 2007), but this support is not always guaranteed and depends upon the availability of serotonin and dopamine (Netter, 2018; Walker et al., 2009). In the optimal case, serotonin facilitates DA release, and so this explains why they both were linked to flexibility of behaviour (Dalley et al., 2008; Walker et al., 2009). This process is complemented by a number of mediators, such as neuropeptides, GABA, glutamate, opioid receptors and some hormones (Netter, 2018). Serotonin imbalance can lead to different mobility patterns, depending on the location of this disbalance and the state of mediators. If there is cortical serotonin deficiency, then with overactive DA release in striatum, it can lead to OCD (Chamberlain et al., 2021; Denys et al., 2004), while with underactive DA in striatum it can give rise to impulsivity (Bari & Robbins, 2013; Dalley et al., 2008); if combined with low hypothalamic neuropeptides activity it can give rise to low tempo, while with optimal DA in striatum it can lead to rigidity (low plasticity) (Walker et al., 2009). Optimal serotonergic activity but deficient DA activity can also lead to rigidity, psycho-motor slowdown and impulsivity (Bari & Robbins, 2013; Dalley et al., 2008; Denys et al., 2004). We can think of multiple combinations when one of these systems is over- or under-performing, and others compensate for it, and this would give specific consistent behavioural patterns.

Higher endurance could, therefore, be accompanied (and so correlated) by either high mobility-plasticity or rigidity or impulsivity. In this context, the “energetic” system indeed supports the integration of behaviour, but their relations are not linear (i.e. the idea that “more energetic support, the higher integration” would be wrong). Interestingly, Ivan Pavlov and colleagues, based on their experiments studying temperament (types and properties of nervous systems) suggested that the four Hippocratic temperament types could be derived from three dimensions and not using classic independent Cartesian dimensions. Instead, Pavlov observed that only the “strong” (high endurance) type of nervous systems differentiates into rigid versus flexible types (Mobility dimension). Furthermore, only the highly mobile types bifurcate into non-balanced (impulsivity) and balanced (plasticity) types.

Moreover, only a small portion of serotonin receptors activates DA release (Azmitia, 2010), and this process is mutual: there are some areas where DA release activates 5-HT receptors, but DA release can be activated without 5-HT (Adell et al., 2010, Di Pietro & Seamans, 2007). Other than that, these neurotransmitter systems interact with a dozen other neurotransmitters and neuropeptides. Despite their mutual regulation, DA and 5-HT systems are occasional partners but do not constitute one biomarker for the “energetic” dimension of temperament.

5) *Activity-specific approach highlights differentiation between social and physical aspects of behaviour that was missing in animal studies in Pavlov's work.* In line with the activity-specific approach that differentiates between physical, social and probabilistic aspects of behavioural regulation, the received pattern of inter-correlations in our studies was divided between these three types of traits (Table 5). The division of temperament traits into arousal-driven and inhibition-driven processes might have some validity, but it overlooks those aspects of arousal specific to humans. While Pavlov, in his original experiments on dogs, could not observe social or intellectual types of activities, and, therefore, limited his theory to three traits observed in animals (i.e., the strength of excitation, mobility and balance), individual differences in social and mental aspects are clearly identifiable in humans. Our results illustrate the validity of the activity-specific approach of the FET model and suggest exploring this approach in differential psychology.

There are, therefore, neurochemical and neuro-anatomic biomarkers differentiating between several mobility-like traits, and also differentiating them from endurance-like traits. The FET framework suggests a multi-marker approach to neurochemical classification (i.e., that there is no single neurotransmitter that regulates any specific behavioural pattern (trait)) (Trofimova, 2016, 2021a, b; Trofimova and Gaykalova, 2021; Trofimova and Robbins, 2016). In the case of DA systems, they regulate integration aspects of behaviour in close collaboration with acetylcholine, neuropeptides, and delta-opioid systems in basal ganglia-cortical networks (Trofimova, 2021a, 2021b).

Our third hypothesis was confirmed, showing the benefits of the Mobility-like scales. Three Polymathy scales had a high positive association with the PTS Mobility scale, and the POS-Integration scale positively correlated with the STQ-77 Plasticity scale. This is consistent with the idea that high learning abilities in polymathy are based on their high cognitive flexibility and potency (Araki, 2018; Araki & Berg, 2021). The associations of Polymathy scales with STQ-77 Sensation Seeking, Intellectual Endurance and Probabilistic Processing scales are also in line with this view. The negative correlation of the POS-Integration scale with the STQ-77 Neuroticism scale is also in line with the predictions of the FET model related to emotionality (Trofimova, 2018). The FET points out to the evidence in neurochemistry that DA release (the key regulator of mobility-like traits) is activated by mu- and delta-opioid receptors that were linked to positive emotionality and a sense of security. As a result, polymaths have a dispositional sense of security and low neuroticism, that, perhaps, allows them to penetrate unknown disciplines and learn new knowledge without feeling intimidated (Araki & Cotellessa, 2020).

One of the great contributions of Jan Strelau to differential psychology was, that, despite a significant correlation between mobility-like and “energetic” traits, he and his colleagues did not cave in under the pressure of factor-analytic models of personality and kept mobility-like traits in their models (Strelau et al., 1999; Strelau & Zawadzki, 1993). Currently, neuroscience provides solid evidence for the validity of this position and points to the distinct neurochemical nature of mobility-like traits (see Trofimova, 2016, 2021a, b; Trofimova and Robbins, 2016 for reviews).

5. Conclusions

This paper highlights a disagreement between psychometric requirements (FA) in differential psychology and findings in neuroscience in identifying mobility-like temperament traits (i.e. speed of integration of actions that include plasticity, tempo and impulsivity). Mobility-like traits never emerge as independent dimensions in FA studies and in the majority of modern models of temperament/personality due to their entanglement with endurance-like traits. This paper points out that there are, however, well-documented neurochemical biomarkers of mobility-like traits, which are distinct from the biomarkers of "energetic" traits. To highlight this controversy, this paper reports results from three studies conducted on English-Canadian, Russian, and Portuguese-Brazilian samples. The studies confirmed the correspondence between corresponding scales of two models developed independently in two distinct branches of the Pavlovian tradition: Strelau Temperament Survey, PTS and Structure of Temperament Questionnaire, STQ-77. The unique feature of these inventories is that they both include mobility-like scales. The results confirmed strong positive correlations and regression between mobility-like and endurance-like scales in both the PTS and STQ-77,and also the Extraversion scale of the EPQ. If so, then, by psychometric standards, these scales should be viewed as parts of one dimension. Yet, the consensus in neuroscience shows clearly identifiable neurochemical biomarkers for each of these mobility-like and endurance-like traits, that speaks against a unification of these traits into one factor. This disagreement between psychometric and neurochemical perspectives shows the limitations of relying on factor analysis in deriving models of differential psychology. Moreover, our examination of PTS and STQ-77 temperament profiles associated with polymathy using Polymathy Orientation Scales demonstrated the benefits of mobility-like traits, as they were positively correlated with polymathy. These arguments highlight the contribution of Jan Strelau's work that considered mobility-like bio-behavioural traits as stand-alone dimensions of temperament.

The limitations of the reported Studies come from the self-report nature of the measures. To address these limitations, the STQ-77 has a validity scale screening for a social desirability bias. Furthermore, the purpose of the Studies was to verify the suspected strong correlations between mobility-like and endurance-like scales and to explain the entanglement and yet specificity of these scales by findings in neurochemistry. The aim of the paper was, then, not to have an in-depth experimental study, but to describe the methodological challenges in shaping our view on the structure of temperament. It should be noted that correlations between the scales of questionnaires and interactions between neurochemical biomarkers follow different regulatory factors. For this reason, models of biobehavioural individual differences should not start from self-reports tests and then followed by validation of the test's scales with biomarkers. Instead, the model should be based on findings in neuropsychology and, if possible, to be reflected in complementary testing methods.

CRediT authorship contribution statement

Irina Trofimova:

Designed the Study 1, partially designed the Study 2, conducted the Study 1 in Canadian and Russian samples, did data processing, preparation of the tables related to that study, Fig. 1, prepared and edited first and second drafts of the manuscript, prepared references.

Michael Espindola Araki

Partially designed the Study 2, conducted the Study 2 in Brazilian sample, did data processing, preparation of the tables related to that study, edited first and second drafts of the manuscript, prepared references.

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