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Cloninger's Psychobiological Model of Personality and Strelau's Regulative Theory of Temperament – analysis of their associations in a Polish sample

The present study explores the relationship between Cloninger scales and Strelau's Regulative Theory of Temperament (RTT) traits. Cloninger's psychobiological model identifies four dimensions of temperament (Novelty seeking, Harm Avoidance, Reward Dependence and Persistence) and three dimensions of character (Self-Directedness, Cooperativeness and Self-Transcendence). RTT proposes the traits of Briskness, Perseveration, Sensory Sensitivity, Emotional Reactivity, Endurance and Activity as the basic dimensions underlying individual differences. The relationships between the dimensions of Cloninger's Temperament and Character and Strelau's Regulative Theory of Temperament are investigated in a sample of 282 participants. Data analysis demonstrated some significant correlations between the two models. The strongest associations were found between the dimension of Harm Avoidance from Cloninger's concept and Strelau's RTT traits (positive correlations from $r = .73$ for Emotional Reactivity to $r = .48$ for Perseveration, and negative correlations from $r = -.57$ for Endurance to $r = -.51$ for Briskness). However, there is not enough evidence to suggest that the two models offer an alternative way of explaining individual differences. According to RTT, temperamental traits are expressed in formal characteristics of behavior (energetic and temporal) and every kind of behavior (irrespective of its content) can be described in the same formal categories. In the Psychobiological Model of Personality the traits are characterized rather by the content or goals of behavior. In this model, in addition to underlining the biological variation of heritable traits, the social, cultural and phenotypical levels of behavior are reflected.

Keywords: personality, temperament, TCI, FCB-TI

Introduction

Given the psychobiological basis of both Cloninger's personality model and Strelau's Regulative Theory of Temperament, it is relevant to investigate the extent to which the two overlap.

Cloninger (1994a, 1994b, 1997; also Cloninger, Svrakic, & Przybeck, 1993) proposed a psychobiological theory including four dimensions of temperament and three dimensions of character. Assumed to be independently heritable, the temperamental dimensions manifest themselves early in development. There are four such dimensions proposed by Cloninger: Novelty Seeking (NS – characterized by impulsive, exploratory, or sensation-seeking behavior), Harm Avoidance (HA – inhibition of behavior in response to signals of punishment and frustration when behavior is not rewarded), Reward Dependence (RD – maintaining behavior in response to cues of social reward) and Persistence (P – maintaining behavior despite

frustration, fatigue, and intermittent reinforcement). Three of the four temperament factors are hypothetically linked to a neurotransmitter system (Cloninger, 1986, 1987a): NS to low basal dopaminergic activity, HA to high serotonergic activity, and RD to low basal noradrenergic activity (Stallings, Hewitt, Cloninger, Heath, & Eaves, 1996). The four temperaments can also be seen to correspond to the four basic emotions of anger (Novelty Seeking), fear (Harm Avoidance), love (Reward Dependence), and tenacity (Persistence) (see Cloninger, Przybeck, Svrakic, & Wetzel, 1994, p. 16.) It is also known from clinical studies that the temperamental dimensions distinguish certain subtypes of personality disorders that are associated with specific configurations of temperamental facets (Cloninger, 2004, p. 41).

In contrast, character can be defined in terms of individual differences in concept-based goals and values. Three dimensions of character may be subject to modification as an individual identifies the self. According

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to Gillespie and others (Gillespie et al., 2003, p. 1932) "These dimensions were based on a synthesis of information about social and cognitive development and descriptions of personality development in humanistic and transpersonal psychology". They are defined as (Cloninger et al., 1994): Self-Directedness (SD – an extent to which an individual is responsible, reliable, resourceful, goal-oriented, and self-confident; conceptually related to Rotter's locus of control construct), Cooperativeness (C – an extent to which individuals conceive of themselves as integral parts of human society and humanity as such; it accounts for traits characterizing the interpersonal circumplex) and Self-Transcendence (ST – an extent to which individuals conceive of themselves as integral parts of the universe as a whole; refers to experiencing spiritual ideas). The psychobiology of these character dimensions is being actively investigated (see: Cloninger, 2004, p. 44-49).

Temperament and character may also be conceptualized as two types of memory and learning: procedural and propositional. Temperament (the sensational core of personality) contains procedural memory which is regulated by the cortico-striato-limbic system. Character (the conceptual core of personality) is related to propositional memory which includes high cognitive functions like symbolization and abstraction. These two basic memory and learning systems may be differentiated functionally (Cloninger et al., 1993).

The character in Cloninger's conception is thus rather independent of the temperamental structure. According to Cloninger (2004, p. 44), "Temperament provides a useful account of individual differences in the process of selective attention and emotional salience, but does not stand alone as a description of human personality or consciousness". Thus the need for the character perspective.

The seven-factor model of temperament and character devised and advocated by Cloninger and his colleagues (e.g., Cloninger et al., 1994) is assessed by the Temperament and Character Inventory (TCI).

The Regulative Theory of Temperament (RTT) was developed by Strelau (1983, 1998, 2001). According to this theory "temperament refers to basic, relatively stable personality traits which apply to the formal aspects of reactions and behavior (energetic and temporal characteristics). These traits are present since early childhood and they occur in both humans and animals. Being primarily determined by inborn psychological mechanisms, temperament is subject to changes caused by maturation and by some environmental factors" (Strelau & Zawadzki, 1993, p. 317). An inventory which corresponds to the regulative theory of temperament is the *Formal Characteristic of Behavior – Temperament Inventory* (FCB-TI).

According to the RTT, temperamental dimensions are of biological origin and the underlying physiological

processes are related to the activity of both the central and vegetative nervous systems. It is assumed that every behavior, which may be described in terms of energetic and temporal attributes, is the result of an interaction between all above mentioned mechanisms. However, particular traits are not ascribed to specific mechanisms (Strelau, 1998; Strelau & Zawadzki, 1993). Temperamental traits manifest themselves in early childhood and constitute the basic traits of personality, in the sense that they are the most general characteristics of personality. The RTT encompasses possible changes in temperamental dimensions due to biologically determined life-span variations and individual – specific interactions with the environment.

Temperament refers to the formal aspects of behavior which are manifested in the energetic level (intensity of reactions) and temporal features (time characteristics of reactions). As far as temporal characteristics are concerned, two traits have been distinguished: briskness and perseveration. Four traits constitute the energetic level of behavior: sensory sensitivity, endurance, emotional reactivity, and activity (Strelau & Zawadzki, 1993).

Six temperamental traits postulated by the Regulative Theory of Temperament are briefly described below: Briskness (BR) is the tendency to react and to perform activities quickly, to shift easily from one behavior to another; Perseveration (PE) is the tendency to continue and to repeat behavior after the cessation of stimuli; Sensory Sensitivity (SS) is the ability to react to sensory stimuli of low stimulative value; Emotional Reactivity (RE) is the tendency to react intensively to emotion-inducing stimuli; Endurance (E) is the ability to react adequately in situations demanding long-lasting or highly stimulating activity; and Activity (AC) is the tendency to undertake behavior of high stimulation value (Strelau & Zawadzki, 1993, p. 317-318).

The RTT, similarly to the Cloninger's model, sees temperament as biologically defined and playing a primordial role in the development of personality. Since the theoretical principles of both the Psychobiological Model of Personality postulated by Cloninger and Strelau's Regulative Theory of Temperament traits bear some similarities, it is particularly interesting to compare these two models and analyze them within the concept of activation.

Hypotheses

Taking into consideration the principles of Cloninger's Psychobiological Model of Personality and Strelau's Regulative Theory of Temperament, the following relations were expected:

a) positive correlations between **Novelty Seeking** and Zawadzki and Strelau's concept of **Activity** (Zawadzki & Strelau, 1997, p. 62). The reason for this hypothesis was the assumption that in both models the activity level is viewed as a means of discharging or augmenting the central

nervous system's arousal level and can be considered the basic source of stimulation. According to Strelau (Strelau & Zawadzki, 1993, p. 315) "The more complex and difficult the activity, the higher the stimulation being generated. One of the most efficient generators of stimulation is the emotional connotation of activity (risk-taking, threatening actions, etc.)". This is quite similar to Cloninger's position, in which novelty seeking is the temperamental dimension defined in terms of individual differences in behavioral learning mechanisms, explaining responses to novelty and danger (Cloninger, 2004, p. 42-43);

b) negative correlations between **Harm Avoidance** and **Emotional Reactivity**, **Briskness**, **Perseveration** and **Activity** in Zawadzki and Strelau's conceptualization of temperament. The harm avoidance dimension of temperament is "the tendency to respond intensely to aversive stimuli and their conditioned signals, thereby facilitating learning to inhibit behavior in order to avoid punishment, novelty, and frustrative omission of expected rewards" (Cloninger, 1987b, p. 414). Briskness and perseveration are temporal characteristics of behavior and can be described as the tendency to react quickly and to continue and repeat behavior (Strelau & Zawadzki, 1993, p. 327). Harm Avoidance and Briskness (as well as Perseveration) can thus be treated as opposite tendencies of behavior;

c) positive correlations were expected between **Reward Dependence** (Cloninger's theory) and **Emotional Reactivity** defined by the Regulatory Theory of Temperament. Reward Dependence is associated with the formation of conditioned signals of reward. According to Cloninger (Cloninger et al., 1994, p. 23) individuals with high reward dependence are emotionally dependent, warmly sympathetic, sentimental, sensitive to social cues, persistent and eager to help others. This is also true for the psychological characteristic of people with high Emotional Reactivity;

d) as far as **Persistence** is concerned, positive correlations were assumed between this dimension and Endurance, Activity and Briskness. A negative relation was also expected between Perseveration and Emotional Reactivity defined within the domain of the Regulatory Theory of Temperament.

Formulating any hypotheses regarding the relations between character dimensions defined by the Psychobiological Model of Personality and temperamental traits described by the Regulatory Theory of Temperament turned out to be more difficult. The character in the concept model being discussed is defined as the features of an individual that are formed during the formative period of his/her development and relate to an individual's perception of himself/herself (his or her goals and values). It can be argued that this dimension is the one in which the individual's former experiences play a crucial part and it

relates not as much to the formal aspects of behavior but rather to its content. Temperamental traits are considered to be biologically predefined and can be assumed to show particular relations with dimensions of similar biological background. However, it can be hypothesised that some dimensions of character may not emerge as distinct factors, and temperament and character facets overlapped with one another.

The aim of this part of the study was to determine the degree to which Cloninger's dimensions of character have been related to Strelau's temperamental characteristics. According to Angleitner and Spinath (2003, p. 121) the following relations were expected: positive correlations between Self-Directedness and Persistence, Cooperativeness and Briskness, and negative ones between Self-Directedness and Emotional Reactivity. If the hypothesized correlations were replicable, it would be proof of an overlap of temperament and character. If so, this may suggest that the empirical data does support the conceptual distinction between them (Herbs et al., 2000, Ando et al., 2004).

Participants

The research was carried out on a group of 282 participants (145 women – 51.4% and 137 men – 48.6%) aged 18 to 83 ($M = 32.6$; $SD = 14.2$ in the whole sample; $M = 32.3$ and $SD = 14.4$ in women, and $M = 32.8$ and $SD = 13.4$ in men). The proportions of young (aged 18 to 25) and aging people (aged 75 to 83) were similar (about 4% of the whole sample). The educational level was under 9 years for 11.7% of participants and above 15 years for 37.9%.

Two groups of the participants were invited to take part in a study: one consisted of 151 persons from the normative group, second of 131 persons from validation studies. They were all in good health and did not suffer from any mental disorders. All participants were instructed to complete the forms individually in a setting with no distractions. The questionnaire completion procedures took place at the Institute of Psychology of Adam Mickiewicz University and at the two Polish Medical Universities, in Szczecin and Poznan. The participation in the study was entirely voluntary.

Measures of temperament domains

The Polish translation of Cloninger's *Temperament and Character Inventory* (Hornowska, 2002) was used to assess the four dimensions of temperament and the three dimensions of character. This measure is a 226-item self-report questionnaire with a 2-point scale (yes or no). The temperament dimensions are as follows: Novelty Seeking (40 items) defined as the tendency to respond actively to novel stimuli (e.g. *I often try new things just for fun or thrills, even if most people think it is a waste of time*), Harm Avoidance (35 items) defined as a tendency for an

Table 1

Descriptive statistics (means, standard deviations) for the whole sample as well as gender groups of Cloninger's *Temperament and Character Inventory* (TCI) and Strelau's *Formal Characteristic of Behavior – Temperament Inventory* (FCB-TI) scales and t-test in the female and male groups.

Scales	Total sample N = 282		Women N = 145		Men N = 137		t test, probability
	M	SD	M	SD	M	SD	
TCI scales							
Novelty Seeking	20.72	5.85	20.43	5.71	21.03	5.99	ns
Harm Avoidance	15.09	6.43	17.01	6.46	13.06	5.76	t = 5.40, p<0.01
Reward Dependence	14.05	3.41	15.24	3.07	12.78	3.31	t = 6.49, p<0.01
Persistence	4.29	1.90	4.35	1.86	4.23	1.94	ns
Self-Directedness	28.30	7.24	29.10	7.64	27.47	6.72	ns
Cooperativeness	31.24	5.85	33.54	4.78	28.81	6.45	t = 6.98, p<0.01
Self-Transcendence	14.48	6.13	15.01	5.97	13.91	6.28	ns
FCB-TI scales							
Briskness	15.68	3.43	15.67	3.59	15.69	3.27	ns
Perseveration	11.98	4.13	12.32	4.54	11.62	3.62	ns
Sensory Sensitivity	14.76	2.96	14.87	2.30	14.65	2.91	ns
Emotional Reactivity	10.07	4.85	11.65	4.55	8.41	4.62	t = 5.94, p<0.01
Endurance	10.01	4.96	8.87	4.57	11.22	5.09	t = -4.08, p<0.01
Activity	9.74	4.68	8.85	4.56	10.67	4.64	t = -3.32, p<0.01

inhibitory response to signals of aversive stimuli (e.g. *I am usually confident that everything will go well, even in situations that worry most people*), Reward Dependence (24 items) defined as the tendency for a positive response to the signals of reward (e.g. *I like to please other people as much as I can*), and Persistence (8 items) defined as the ability to perpetuate the activity without the reward (e.g. *I usually push myself harder than most people do because I want to do well as I possibly can*). The three character dimensions are measured by the following scales: Self-Directedness (44 items) defined as the ability to adapt to different situations according to one's goal (e.g. *I have many bad habits that I wish I could break*), Cooperativeness (44 items) defined as the ability to interact with other people (e.g. *I have no patience with people who don't accept my view*), and Self-Transcendence (33 items) defined as the ability to identify with the whole world (e.g. *I am fascinated by the many things in life that cannot be scientifically explained*). The KR₂₀ coefficients for each score of the Polish TCI main dimensions were generally satisfactory, i.e. .79 for NS, .87 for HA, .65 for RD, .50 for P, .85 for SD, .85 for C and .84 for ST (see: op. cit., p. 50) and they were comparable with the original data (Cloninger et al., 1994, p. 81). The structure of the Polish TCI generally resembles the structure obtained in the US sample, including a replication of both primary and secondary loading patterns, except for minor deviations for some of the facets (see: Hornowska, 2002, p. 64-66).

The participants also completed *The Formal Characteristics of Behavior - Temperament Inventory* (FCB-TI) which measures the six traits described by Strelau in the Regulatory Theory of Temperament (Zawadzki & Strelau, 1997). The FCB-TI consists of 120

items (each scale consists of 20 items) and is rated in a "yes-no" format. The temperament traits may be shortly described as follows (see Strelau, 2008, p. 95): Sensory sensitivity as "the ease with which the individual reacts to stimuli whose stimulating value is very low" (e.g. *I see clouds flying through the night sky*), Emotional reactivity as "the tendency to react intensively to emotion-generated stimuli" (e.g. *Slamming the door makes me nervous*), Endurance as "the ability to react adequately in situations requiring prolonged or highly stimulating activity or under conditions of intensive external stimulation (e.g. *I feel fresh and strong even after long journey*), Activity as "the tendency to undertake highly stimulating behaviors or behaviors providing intensive external (environmental) stimulation" (e.g. *I visit my friends very often*), Briskness as "the tendency to react quickly, keep a high tempo in performing activities" (e.g. *Usually I work quickly, even if I have a lot of time*), and Perseveration as "the tendency to continue and repeat behavior and experience emotional states after cessations of stimuli evoking this behavior or states" (e.g. *Sometimes I hum the same melody all day long*). The reliability coefficients (Cronbach's alpha) for each scale are good: Briskness ($\alpha = .77$), Perseveration ($\alpha = .79$), Sensory sensitivity ($\alpha = .73$), Endurance ($\alpha = .85$), Emotional reactivity ($\alpha = .83$), Activity ($\alpha = .83$) (Zawadzki & Strelau, 1997, p. 66).

Data analysis

Correlations, regression analysis, factor analysis, and path analysis were used to assess the hypotheses. Means and standard deviations were calculated for the TCI and FCB-TI for the total sample and two sub samples (women and men). The gender differences in the scores were

Table 2
Correlations between the main TCI temperament dimensions and the FCB-TI (N=282).

FCB-TI Scales	TCI Temperament Scales			
	NS	HA	RD	P
Briskness	.18**	-.51**	-.01	.19**
Perseveration	-.01	.48**	.36**	.01
Sensory Sensitivity	.16*	-.16*	.03	.10
Emotional Reactivity	-.22*	.73**	.23**	-.20**
Endurance	.06	-.57**	-.21**	.13**
Activity	.40**	-.54**	.02	.21**

Note: * $p \leq .05$; ** $p \leq .01$; NS – Novelty Seeking, HA – Harm Avoidance, RD – Reward Dependence, P – Persistence, S – Self-Directedness; C – Cooperativeness; ST – Self-Transcendence;

examined by t-tests. Pearson correlations were calculated (1) between the TCI and FCB-TI temperamental scales, (2) among the character variables and temperamental scales in both questionnaires: TCI and FCB-TI. Then, the multiple regression analyses were performed. The analysis was carried out independently for FCB-TI and the TCI. The TCI scale scores were used as predictor variables followed by the use of the FCB-TI scales. To have a more integrated view on the associations between the TCI dimensions and the FCB-TI traits an exploratory factor analysis, based on scales scores (with Varimax rotation) was applied. The analysis of correlations and the regression analysis were used as a part of the model building process for path analysis.

Results

The means and standard deviations for TCI and FCB-TI dimensions are presented in Table 1. Noted differences between women and men, which are rather typical for the inventories of temperament, were expected. For this reason the sample was constructed in such a way that the proportions of men and women were similar, as were the means and standard deviations of age in these two sub-samples.

Table 2 presents the correlations for the TCI temperament dimensions and temperament traits measured through FCB-TI. The correlations for the TCI dimensions of character and temperament traits measured through FCB-TI as well as TCI appear in Table 3.

As far as the RTT defined traits are concerned, positive correlation were observed between Perseveration and Harm Avoidance as well as Reward Dependence, Emotional Reactivity and Harm Avoidance, and between Activity and Novelty Seeking. High negative correlations could be noticed between: Briskness, Endurance, Activity and Harm Avoidance.

It is also worth noting that there was quite a strong relation between Self-Directedness and Emotional Reactivity. Taking this result into consideration, one can

Table 3
Correlations between the TCI character dimensions and the TCI/FCB-TI temperamental scales (N=282).

TCI Temperament Scales	TCI Character Scales		
	S	C	ST
Novelty Seeking	-.12*	-.12*	.18**
Harm Avoidance	-.43**	.03	.02
Reward Dependence	-.09	.42**	.21**
Persistence	.15*	.16**	.17**
FCB-TI Scales			
Briskness	.29**	.18**	.00
Perseveration	-.34**	-.05	.12
Sensory Sensitivity	.16**	.19**	.06
Emotional Reactivity	-.40**	-.05	.07
Endurance	.25**	-.04	-.04
Activity	.09	-.11	.14**

Note: * $p \leq .05$; ** $p \leq .01$; S – Self-Directedness; C – Cooperativeness; ST – Self-Transcendence;

presuppose that Self-Directedness shows a similarity to temperamental traits that is large enough to be taken into account when analyzing this scale (Angleitner & Spinath, 2003, p. 126).

Among character scales the last one, i.e., Self-Transcendence consequently did not correlate with the results measured through FCB-TI, the only exception being the low associations of this scale with Activity. Thus, it seems to be the most autonomous character scale. Similar results have been obtained by Angleitner and Spinath (2003, p. 127). It is worth to stress here that the associations between the scales were very similar when the age was controlled for.

The next method applied was multiple regression analysis in order to define the explained percentage of variance in both models. The analysis was carried out independently for FCB-TI and the TCI. The TCI scales scores were once used as predictor variables (see Table 4) and once as dependent ones (see Table 5). The beta weights, R and R^2 were calculated.

As can be seen from the data above, when the TCI scales were used as predictors of RTT dimensions, they explained the dimension of Emotional Reactivity (57% of variance), Activity (40% of variance), Perseveration and Endurance (about 37%), as well as Briskness (31%). In reverse when FCB-TI scales were used as predictors of TCI scales, the strongest relation revealed itself in Harm Avoidance (65% of variance).

To have a more integrated view on the associations between the TCI dimensions and the FCB-TI scales an exploratory factor analysis, based on scales scores (with Varimax solution) was applied. The main purpose of this analysis was to locate the TCI temperament dimensions among FCB-TI temperamental traits. Because the aim was to clarify the results, only temperamental dimensions of the TCI were taken into account (character scales were excluded).

Table 4
Beta coefficients and multiple regression coefficients for TCI dimension scales predicting FCB-TI scales.

TCI Scales	FCB-TI Scales					
	BR	PE	SS	ER	EN	AC
Novelty Seeking	.053	.016	.195	-.019	-.082	.242
Harm Avoidance	-.491	.421	-.027	.676	-.628	-.461
Reward Dependence	.036	.340	-.049	.137	-.139	.178
Persistence	.048	.154	.076	-.020	-.053	.167
Self-Directedness	.016	-.088	.106	-.046	-.089	-.032
Cooperativeness	.173	-.203	.191	-.118	.160	-.159
Self-Transcendence	-.047	.026	.030	.060	-.032	.024
R	.553	.606	.313	.752	.599	.635
R-square	.306	.367	.098	.566	.359	.403

Note: Beta weights which are significant at $p \leq .01$ are printed in bold.

BR - Briskness; PE - Perseveration; SS - Sensory Sensitivity; ER - Emotional Reactivity; EN - Endurance; AC - Activity

Table 5
Beta coefficients and multiple regression coefficients for FCB-TI predicting TCI-scales.

FCB-TI Scales	TCI Scales						
	NS	HA	RD	P	S	C	ST
Briskness	.004	-.105	.195	.098	.101	.189	.000
Perseveration	-.043	.136	.314	.151	-.175	-.006	.091
Sensory Sensitivity	.098	.031	.014	.019	.065	.156	.068
Emotional Reactivity	-.015	.397	.167	-.181	-.317	-.004	.132
Endurance	.002	-.143	-.084	-.010	-.070	-.020	.039
Activity	.373	-.297	.089	.128	-.088	-.189	.181
R	.417	.804	.415	.289	.447	.288	.215
R-square	.174	.647	.173	.083	.200	.083	.046

Note: Beta weights which are significant at $p \leq .01$ are printed in bold.

NS - Novelty Seeking, HA - Harm Avoidance, RD - Reward Dependence, P - Persistence, S - Self-Directedness; C - Cooperativeness; ST - Self-Transcendence;

Table 6
The results of factor analysis of TCI and FCB-TI scales scores.

Scale	Component*		
	I	II	III
Novelty Seeking		.565	
Harm Avoidance	.635	-.600	
Reward Dependence	.675		
Persistence			.796
Briskness	-.389	.611	
Perseveration	.794		
Sensory Sensitivity		.512	
Emotional Reactivity	.726	-.488	
Endurance	-.690		
Activity		.741	

* The absolute factors loadings less than .39 are not printed

Extraction method: Principal Axis Factoring

Rotation method: Varimax with Kaiser Normalization

The three factors (eigenvalue $\Rightarrow 1$) were identified which explained 62.8% of the variance (see Table 6).

Factor I (eigenvalue = 3.69; 26.62% of the explained variance) located Harm Avoidance and Reward Dependence among Perseveration, Emotional Reactivity, Briskness (-) and Endurance (-). This configuration of scales was in accordance with what was expected. Factor

II (eigenvalue = 1.40; 24.09% of the explained variance) showed the relationship between Novelty Seeking, Activity and Briskness. This result also confirmed the earlier assumptions. Factor III (1.20 and 12.05% respectively) was defined by one FCB-TI scale - Persistence. This last factor is especially interesting - Cloninger's Persistence seems to be the most different from the RTT temperamental scales.

The findings suggest that the two models overlap in some aspects. This is especially true for Cloninger's Harm Avoidance and Novelty Seeking. The other TCI temperamental scales, i.e. Reward Dependence and mostly Persistence are rather outside the RTT trait.

The last step of this research was to perform the path analysis. The analysis was performed on the covariance matrix using LISREL 8.5 with maximum likelihood estimation (Jöreskog & Sörbom, 1996).

Two multivariate multiple regression models for directly observed variables were elaborated. First, the four temperamental dimensions defined by the Psychobiological Theory of Personality were considered as dependent variables and six scales from Formal Characteristics of Behavior were treated as independent ones. In the second model the relationships were reversed.

Regression analysis was used as part of the model building process. Some form of stepwise selection was used to determine an equation for the dependent variables

Table 7
Summary statistics of structural equation modeling of the TCI and FCB-TI scales.

Model	df	χ^2	χ^2 p value	GFI	AGFI	RMSEA (90% CI)
Model a	11	16.25	.13	.99	.94	.042 (.0; .073)
Model b	14	20.85	.11	.99	.94	.042 (.0; .078)

GFI – Goodness of Fit Index; AGFI – Adjusted Goodness of Fit Index; RMSEA = root mean square error of approximation; 90% CI = 90% confidence interval

Model a - the FCB-TI traits being dependent variables

Model b - the TCI traits being dependent variables

in which only the significant, independent variables were included in the model. As a starting point a full model with all paths defined as free elements was formulated, the successive less significant explanatory variable was removed (the path was established as a fixed element with no correlation between the independent and the dependent variables), and the fit indices were calculated. The procedure was continued until the resulting model had a good fit. Since the correlations between the dependent variables were mostly significant (both in case of TCI and FCB-TI), they were all included into the model.

At the end the predefined model was refined. One of the indices of a possible re-specification of the model is the modification index (MI), which is calculated for each non estimated relationship. The MI can be used to decide which parameters should be added to the model. The MI are measures of the predicted decrease in the Chi-square value that results if a single parameter (fixed or constrained) is freed and the model re-estimated, with all other parameters maintaining their present values (Jöreskog & Sorbom, 1996). When none of the modification indices suggested further refining of the model the analysis stopped and the model reached its final version.

The following statistics were used to evaluate the adequacy of the model fit: the chi squared (χ^2) test, the Goodness of Fit Index (GFI), the Adjusted Goodness of Fit Index (AGFI) and the Root Mean Square Error of Approximation (RMSEA) – see Table 7. The last one is a especially good indicator of model parsimony adjustment and one of the most effective indices for detecting misspecifications in complex models (see: Hu & Bentler, 1999).

Apparently, not all the identified path coefficients were equally strong. This was the reason the completely standardized solution for path coefficients had to be found. In the completely standardized estimates all the estimates are presented in a standardized metric which makes it easy to compare them. The complete standardized solution gave standardized coefficients ranging from .09 to .73. These estimates can be interpreted as the correlations between the corresponding variables. The minor (but significant) coefficients still remained useful for understanding the relational data in multivariate systems and removing them made the model invalid (see Table 7 and 8 for complete standardized solution).

Table 8
Completely Standardized Parameter Estimates for two models.

Model a						
Trait	NS	HA	RD	P		
SS	.15	-	-	-		
BR	-	-.49	-	-		
AC	.26	-.44	.11	.15		
PE	-	.45	.28	.13		
EN	-	-.54	-.12	-		
ER	-	.70	.12	-		

Model b						
Trait	SS	BR	AC	PE	EN	ER
NS	-	-	.40	-	-	-
HA	-	-	-.32	.15	-.16	.40
RD	-	.21	-	.33	-	.18
P	-	-	.15	-	-	-.16

NS – Novelty Seeking, HA – Harm Avoidance, RD – Reward Dependence, P – Persistence, SS – Sensory Sensitivity, BR – Briskness, AC – Activity, PE – Perseveration, EN – Endurance, ER – Emotional Reactivity

Model (a) - the FCB-TI traits being dependent variables

Model (b) - the TCI traits being dependent variables

As it can be noted from the data presented above, the results generally confirmed the hypothesis, according to which the two models partially overlap. When the TCI temperament scales were used as predictors of RTT dimensions (Model a), the strongest relationships occurred between Harm Avoidance and all FCB-TI scales except Sensory Sensitivity, and when the FCB-TI scales were used as predictors of TCI scales (Model b), the strongest relations occurred between the Activity (negative), Emotional Reactivity and Harm Avoidance, as well as Activity and Novelty Seeking.

Discussion

The results obtained in this study confirm the hypothesis of the resemblance of the two models of temperament: The Psychobiological Model of Personality and The Regulatory Theory of Temperament. The strongest associations were found between the dimension of Harm Avoidance from Cloninger's concept and Strelau's RTT scales (positive correlations from $r = .73$ for Emotional Reactivity to

$r = .48$ for Perseveration, and negative correlations from $r = -.57$ for Endurance to $r = -.51$ for Briskness). The weakest correlation was observed between Harm Avoidance and Sensory Sensitivity.

Such relationships are in line with the expectations. Individuals who obtained high results on the Harm Avoidance scale tend to react strongly to emotion-evoking stimuli (high Emotional Reactivity), are inactive (low Briskness) and withdrawing from situations that require long-lasting activity (low Endurance). Individuals characterized by a high intensity of Novelty Seeking (people who lose their temper easily and are excitable, exploratory, interested, enthusiastic, full of life and vigor, tend to involve themselves quickly in everything that is new and unknown to them – Cloninger et al., 1994, p. 22) also easily engage themselves in highly stimulating behaviors (high activity).

It may thus be hypothesized that Harm Avoidance is the main dimension influencing the facets measured by FCB-TI. High scorers of Harm Avoidance are worrying, pessimistic, fearful, doubtful, shy, and fatigable, they need more reassurance and encouragement than most people, and are usually sensitive to criticism and punishment (see: Cloninger et al., 1994, p. 20). This description overlaps to a considerable extent with the description of individuals with high scores in Emotional Reactivity and Perseveration (high emotional sensitivity and low emotional endurance), and low scores in Briskness, Activity and Endurance (low ability to react adequately under intensive external stimulation). Thus it can be stated that Harm Avoidance is substantially explained by the FCB-TI facets and by itself explains most of the RTT dimensions.

The correlation between Perseveration and Reward Dependence ($r = .36$) is an interesting result. Individuals with high scores on the Reward Dependence scale are socially dependent, sentimental, sensitive to negligence, discrimination and criticism. Perhaps the latter traits are the bases for the coexistence of emotional sensitivity, detailed event analysis and also the tendency to go back to past life experiences (regardless their gratification level).

The remaining temperament dimensions from Cloninger's model exhibit medium or weak correlations to the RTT dimensions. Interestingly, the character scale of Self-Directedness also shows medium relations with almost all the RTT dimensions, Activity being the only exception. Thus, it can be assumed that this TCI dimension is unspecific and defined both by behaviors of a temperamental nature and those which belong to the character domain. It can be understood if we take into account the fact that Self-Directedness quantifies the extent to which an individual is responsible, reliable, resourceful, goal-oriented, and self-confident. The most advantageous summary feature of self-directed individuals is that they are realistic and effective, i.e., they are able to adapt their behavior in accordance with

individually chosen, voluntary goals, based on a realistic assessment of facts (Cloninger et al., 1994, p. 24). There are a lot of findings showing that temperament has an effect on self-control and social adaptation (Marszał-Wiśniewska, 2001). People of different temperamental possibilities differ with regard to personality, volitional properties as well as applied motivational strategies and efficiency of intentions engaged in various types of life situations (Marszał-Wiśniewska, 2001). This is probably the reason why Self-Directedness correlates positively with Briskness ($r = .29$) and Endurance ($r = .25$), and negatively with Emotional Reactivity ($r = -.40$) and Perseveration ($r = -.34$).

The examination of the models brings one more interesting conclusion. When the four TCI temperament scales (character dimensions excluded) are used as independent variables, they form some relationships with all the FCB-TI facets. Differently, not all dimensions of FCB-TI are in relation with TCI temperament scales, and the number of the relationships is smaller. Thus it may be hypothesized that the TCI temperamental facets are the more basic dimensions explaining observed behavior than FCB-TI, and FCB-TI facets describe temperamental characteristics of behavior in a wider aspect than the TCI.

The results of factor analysis and path analysis give a good picture of the associations between the two models. Both analyses show the way the models overlap. In factor analysis three main factors describe the similarity between the TCI scales and other temperamental dimensions taken into consideration. The following TCI dimensions are crucial for the similarity of the two models – Harm Avoidance, Reward Dependence and Novelty Seeking. Harm Avoidance involves a heritable bias in the inhibition of behavior in response to signals of punishment and frustrating non-reward. It is observed as pessimistic worrying in the anticipation of problems, fear of uncertainty, shyness with strangers, and rapid fatigability. Reward Dependence reflects a heritable bias with maintaining behavior in response to cues of social reward. It is observed as sentimentality, social sensitivity, attachment, and dependence on approval by others (Cloninger et al., 1994, p. 20). Their similarity to Perseveration (tendency to continue behavior when the situations eliciting this behavior are no longer present) and Emotional Reactivity (intense emotional reactivity to provocative stimuli) and dissimilarity to Briskness (tendency to react quickly and to perform activities at a high speed) and Endurance (capacity to react adequately in situations of intense and long-lasting stimulation) is not surprising given the similarity in its content (Strelau & Zawadzki, 1995).

Novelty Seeking reflects a heritable bias in the approach of rewarding signals, active avoidance of conditioned signals of punishment, skilled escape from unconditioned punishment and the initiation or activation of an appetitive approach in response to novelty (Cloninger et al., 1994a,

p. 22). Novelty Seeking reflected variation in the brain's incentive, or behavioral activation system. All of these are hypothesized to co-vary as part of one heritable system of learning (Cloninger, 1987a). Its relationship to Activity (tendency to undertake behaviors of a high stimulative value or to provide, through behavior, strong stimulation from the surroundings) is then theoretically grounded.

The third factor is defined by one TCI dimension. Persistence (a heritable bias in maintaining behavior despite frustration, fatigue, and intermittent reinforcement, observed as industriousness, determination, and perfectionism is not similar to the FCB-TI traits. It constitutes the third factor by its own (the factor loading is .80). According to Cloninger (Cloninger et al., 1994, p. 24) individuals who score high in Persistence tend to be industrious, hard-working, persistent, and stable despite frustration and fatigue, whereas those who score low endorse a tendency to give up quickly when not continuously reinforced. It can be shown that Persistence has been regulated by a specific neural network related to the partial reinforcement extinction effect. This effect "...refers to an increase in resistance to the extinction of an operant response acquired under partial reinforcement relative to that acquired under continuous reinforcement" (Gusnard, et al., 2003, p. 3484).

Interestingly, the TCI quality of being determined to do or achieve something (firmness of purpose) has no common variance with Strelau's Perseveration (the tendency to continue behavior when the situations eliciting the behavior are no longer present). The latter is expressed in the energetic and temporal rather than the motivational or goal-directed aspects of behavior and this is the basic difference between the dimensions. Although the present study has demonstrated that there are several interesting relationships between Cloninger's temperamental dimensions and the RTT, the two models cannot be considered as equivalent instruments measuring individual differences. The obtained findings assume that both concepts stem from similar theoretical principles of biological foundations of temperament. Still, two models differ in terms of the ways in which they explain how temperamental traits are revealed in behavior.

According to RTT, temperamental traits are expressed in formal characteristics of behavior (energetic and temporal) and every kind of behavior (irrespective of its content) can be described in the same formal categories. In contrast, in the Psychobiological Model of Personality the traits are characterized rather by the content or goals of behavior. This model, apart from underlining the biological variations of heritable traits (temperament) also reflects the social, cultural and phenotypical level of behavior (character – Cloninger, 1994a, 1994b, 1997).

The interesting features of Cloninger's model are the associations between personality dimensions and the activity in the monoaminergic pathways. This could be

used to provide further evidence for the neuroanatomical bases of temperament (cf. results of Angleitner & Spinath, 2003). It is worth to mention here that in the research provided by Dragan and Oniszczenko (2005; also Dragan & Oniszczenko, 2006) it was demonstrated that the 5-HTTLPR polymorphism is associated with the RTT temperamental traits – activity (in males and females) and endurance (in females). The association between emotional reactivity as a temperamental trait and the dopamine D4 receptor (DRD4) exon III polymorphism has been also confirmed in males in a Polish population (Oniszczenko & Dragan, 2005). These findings suggest a role of the genetic polymorphism in the modulation of some temperamental traits measured by the FCB-TI.

Assuming the biological basis of the TCI is supported and the mapping of Cloninger's dimensions within the RTT domain is replicable, then it might be possible to hypothesize about the relationships between some RTT traits and the monoaminergic activity. While the FCI-TI was developed in order to account for individual differences among adults without psychopathological symptoms, the variance shared with the TCI dimensions may suggest the possible extension of the RTT model's applicability also to the psychopathological domains.

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