

Psychometric Measures of Pavlovian Temperament Traits and Objective Personality Tests: a Comeback for Cattell's Hypotheses

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Abstract: This study explores some hypotheses developed by Cattell (1972) about the relationships between his objective test factors (U.I.16, U.I.17, U.I.21, U.I.22, U.I.23) and Pavlovian concepts (especially strength of the nervous system as expressed in strength of excitation). A total of 58 subjects were tested individually. Objective test factors were measured with seven tests from the German Objective-Analytic Test Battery (Haecker, Schmidt, Schwenkmezger, & Utz, 1975) and two temperament inventories: (1) the Pavlovian Temperament Survey (PTS; Strelau, Angleitner, Bantelmann, & Ruch, 1990a) and (2) the Formal Characteristics of Behavior-Temperament Survey (FCB-TI; Strelau & Zawadzki, in press). The results supported some of Cattell's hypotheses, and indicated the correctness of his intuitions.

1. Introduction

Since Gray's (1964) reinterpretation of Pavlov's concept of strength of excitation in terms of arousal and arousability, several biologically oriented personality (temperament) researchers have undertaken attempts to search for links between personality/temperament dimensions and the Pavlovian properties of the central nervous system (CNS). Among the four CNS properties: strength of excitation, strength of inhibition, mobility of CNS processes, and balance (equilibrium) of CNS processes postulated by Pavlov (1951-52), most considerations and empirical research have concentrated on strength of excitation or strength of the nervous system; both concepts used interchangeably. This seems to be justifiable if we consider that the biologically oriented personality/temperament dimensions are mainly interpreted by referring to concepts of arousal or arousability. Eysenck's (1970) dimensions of extraversion and neuroticism,

Buchsbaum's (1976) construct of augmenting/reducing, or Zuckerman's (1979) sensation-seeking trait may be mentioned as the most representative examples illustrating the search for links with strength of the nervous system. A detailed review of studies in which personality/temperament dimensions were related to the Pavlovian typology has been presented by Mangan (1982), Strelau (1983), Strelau, Angleitner, and Ruch (1990b), and Ruch, Angleitner, and Strelau (1991).

2. Theoretical Issues Regarding the Relationship Between Temperamental Characteristics as Understood by Pavlov and Cattell

An attempt to search for links between Pavlov's typology and personality dimensions was also undertaken by one of the most distinguished personality researchers—R. B. Cattell (1972). Taking as a starting

point an erroneous assumption¹ that the Pavlovian typology represents a unidimensional approach, as contrasted with his multidimensional one, Cattell limited the comparison between this typology and his personality theory to strength of the nervous system. His view of the relationship between strength of the nervous system and his postulated structure of personality may be sketched as follows.

A concept so broad and important as Pavlov's strength of the nervous system and the Cattell's temperamental factors derived from hundreds of variables and testing situations are surely likely to have considerable overlap (Cattell, 1972, p. 155). Since strength of the nervous system was measured in Teplov's laboratory by means of experimental indices, mainly physiological in nature, it seems to be reasonable to search for links between strength of the nervous system and Cattell's structure of personality by referring to personality factors derived on the basis of objective personality tests. These factors occurred as replaceable empirical patterns in many studies conducted among others by Cattell (1957), Cattell and Howarth (1964), Pawlik and Cattell (1964), and Hundleby, Pawlik, and Cattell (1965). On the basis of these studies, 21 salient variables were organized in a universal index (U.I.) numbering system running from U.I.16 to U.I.36. Their most systematic presentation and description has been given by Cattell and Warburton (1967): Strength of the nervous system connotes strength of excitatory processes.

¹ The idea that the Pavlovian approach is unidimensional, while Cattell's is multidimensional, was probably derived from the fact that Cattell based his conclusion on Gray's (1964) publication alone, in which all but Teplov's chapters are indeed devoted to strength of the CNS.

Cattell (1972), taking as a starting point the Pavlovian assumption that strength is considered as a trait, agreed with Gray's (1964) view according to which strength of the nervous system is inversely related to arousability, that is, to individual-specific chronic level of arousal. Personality dimensions that refer to the construct of arousal and arousability belong to the temperament domain. Taking this statement as a starting point, Cattell asked the following question: What known temperamental factor patterns in humans seem, by their intrinsic meaning, to support best a concept of 'strength of the nervous system'? (1972, p. 155).

Among the 21 U.I. factors, the following 7 were distinguished by Cattell (1972) as temperamental in nature, thus as possible candidates for being related to strength of the nervous system: U.I.16 (Assertive Ego), U.I.17 (General Inhibition), U.I.18 (Hypomanic Temperament), U.I.21 (Exuberance), U.I.22 (Cortertia), U.I.23 (Capacity to Mobilize-vs-Regression), and U.I.32 (Exvia-vs-Invia). Particular attention was paid by the author to factors U.I.16, U.I.21, U.I.22, and U.I. 23, which are closely related to the concept of arousability, thus to strength of the nervous system. According to Cattell (1972, pp. 157-158), Assertive Ego refers, among other things, to the "capacity to endure stimulation", Exuberance to the temperamental quality of excitability and impulsiveness, and Cortertia may be regarded as an acronym for "cortical alertness", which seems to make the greatest contribution to strength. "A strong claim could also be made for identifying some aspects of 'strength of the nervous system' with our 'capacity to mobilize' in U.I.23" (Cattell, 1972, pp. 156-157).

Cattell's hypotheses on the relationship between strength of the nervous system and his U.I. temperamental factors have never been subjected to systematic verification. Orlebeke (1972) has examined the relationship between Cattell's structure of personality and strength of the nervous system in two independent studies, but, instead of the objective test battery, he used the 16 PF Questionnaire. Strength of the nervous system was assessed on the basis of the RT max/RT min index².

The only factor among the 16 measured that correlated positively with strength of the CNS in both studies was Surgency.

This factor includes such characteristics as: cheerful, sociable, energetic, humorous, talkative, and placid (see Cattell, 1965). Thus it is closely associated with Exvia-vs.-Invia, one of the seven, but not the four, major U.I. factors hypothesized by Cattell to be related to strength of the nervous system. Many other studies, mainly referring to extraversion as understood by Eysenck (1970), have confirmed a positive relationship between strength of the CNS and extraversion (Ruch et al., 1991; Strelau, 1983; Strelau et al., 1990b).

As far as we know, there are no studies in which Cattell's U.I. temperamental factors as measured by means of objective tests have been related to strength of the CNS. Since the Pavlovian typology represents not a unidimensional but a multidimensional approach, it seems to be interesting also to relate the other Pavlovian CNS properties, such as strength of inhibition and mobility of CNS processes, to Cattell's U.I. temperamental factors.

The aim of our study was: (1) to verify Cattell's hypotheses regarding the relationship between the most probable candidates among the U.I. temperamental factors that could be related to strength of the nervous system (U.I.16, U.I.21, U.I.22 and U.I.23) and strength of excitation, and (2) to search for links between these U.I. factors and the two remaining Pavlovian properties of the CNS--strength of inhibition and mobility of CNS processes. Cattell's temperament factors are sometimes interpreted in terms of rigidity, perseverance, and speed (Cattell & Warburton, 1967). Therefore the third aim of our study was to examine the relationship between the U.I. temperamental factors and temperamental traits that directly refer to these characteristics.

We developed the following hypotheses on the relationship between Cattell's U.I. temperament factors and the Pavlovian properties of the CNS:

1. Strength of excitation should relate to those tasks from the objective personality test battery that are saturated by such salient variables as: U.I.16, U.I.21, U.I.22, and U.I.23, as predicted by Cattell.

2. Strength of inhibition should correlate with tasks strongly loaded on U.I.21 (Exuberance) in which inhibitory processes are important.

3. Mobility of CNS processes should contribute to efficiency of performance on tasks requiring a rapid switch from one activity to another.

4. Tasks requiring accuracy should relate to strength of inhibition, whereas tasks in which the speed component is strongly involved should correlate with mobility and other temporal characteristics.

² A detailed description of this method may be found in Nebylitsyn's (1972) and Strelau's (1983) monographs.

3. Method

3.1 Subjects

Fifty-eight subjects with an average age of 29.09 years ($SD = 10.52$) participated. Among them 37 were females and 21 males. Most of them were students from different departments, excluding psychology. Subjects were not paid for taking part in this study.

3.2 Measures

To measure Cattell's U.I. temperament factors (U.I.16, U.I.21, U.I.22, U.I.23), selected tasks from the German version of the Objective Personality Tests Manual (Haecker, Schmidt, Schwenkmezger & Utz, 1975) were used. The tasks with loadings on the four U.I. factors were the following³:

1. *T1 Backward Writing* (U.I.23). Two variables were derived from the test: T1/1: number of backward written letters; and T1/3: ratio of forward to backward written letters.

2. *T3 "Wechselbilder"* (U.I.22, U.I.23). The frequency of changes in visual image was measured.

3. *T33 Hidden Pictures* (U.I.16, U.I.21, U.I.23). The two following indices were taken into account: T33/2-number of hidden objects seen (not scored for accuracy); T33/3-number of hidden objects correctly seen.

³ The symbols of tasks refer to the German version of the Objective Personality Tests adapted by Haecker et al. (1975). Apart from the U.I. temperament factors mentioned above also some other, nontemperamental, salient variables also contribute to the efficiency of task performance. For reasons of clarity, they are not mentioned here (for details, see Haecker et al., 1975, pp. 29-31).

4. *T42 Mazes* (U.I.16, U.I.22, U.I.23). Three indices were taken as measures of test performance: T42/1-speed measured by length of the route taken through the maze; T42/2-number of errors; and T42/3-ratio of speed to errors.

5. *T44 Letter and Number Comparison* (U.I.16, U.I.21, U.I.23). The number of letters and numbers attempted was counted (T44/1).

6. *T45 Line-Length Judgement* (U.I.16, U.I.21). The two following indices were applied: T45/1-speed of line-length judgement; and T45/2-number of correctly judged lines.

7. *T203 Complex Task: Line Drawing* (U.I.23). Number of errors (T203/1) and speed (T203/2) during line drawing were taken into account.

The Pavlovian properties of the CNS were measured with the Pavlovian Temperament Survey⁴ (PTS, Strelau, Angleitner, Bantelmann, & Ruch, 1990a). The PTS is a 72-item questionnaire with a 4-point answer format. It contains three scales (24 items each): Strength of Excitation, Strength of Inhibition, and Mobility. The scales may be sketched as follows:

Strength of Excitation (SE): This refers to the functional capacity of the CNS and manifests itself in the ability to endure intense or long-lasting stimulation. In psychological terms, SE is equivalent to endurance.

Strength of Inhibition (SI): This reveals itself in the ability to maintain a state of so-called conditioned (ontogenetically de-

⁴ The PTS was originally published under the label: Strelau Temperament Inventory-Revised (STI-R). For reasons given elsewhere (see Strelau & Angleitner, in press), we decided to rename this questionnaire.

veloped) inhibition such as extinction, differentiation, or delay. In psychological terms, SI resembles an impulse control dimension.

Mobility of Nervous Processes (MO): This refers to the ability of the CNS to shift adequately from one state to another in response to changes in the environment. From the psychological perspective, MO means the ability to switch from one reaction (behavior) to another one.

Reliability of the PTS scales as measured on German samples varies from 0.79 (SI) to 0.89 (MO). Detailed psychometric characteristics of the PTS and a comprehensive description of the scales may be found elsewhere (Ruch et al., 1991; Strelau & Angleitner, in press; Strelau et al., 1990a).

Additionally, the German version of the Formal Characteristics of Behavior--Temperament Inventory (FCB-TI, Strelau & Zawadzki, in press) constructed by Strelau, Zawadzki, and Angleitner was used in this study. The FCB-TI is a 120-item inventory with a yes/no answer format. It consists of the six following scales:

1. *Briskness (BR)*: Tendency to react quickly, to maintain a high tempo when performing activities, and to shift easily from one behavior to another in response to changes in the environment.

2. *Perseverance (PE)*: Tendency to persist and to repeat behavior after cessation of stimuli (situations) evoking this behavior.

3. *Sensory Sensitivity (SS)*: Ability to react to sensory stimuli of low stimulative value.

4. *Emotional Reactivity (ER)*: Tendency to react intensively to emotion-generating stimuli, expressed in high emotional sensitivity and in low emotional endurance.

5. *Endurance (EN)*: Ability to react adequately in situations demanding long-lasting or highly stimulating activity and under intensive external stimulation.

6. *Activity (AC)*: Tendency to undertake behavior of high stimulative value or to use one's behavior to obtain strong stimulation from the environment.

In an unpublished study conducted on 123 subjects (34 males and 87 females; for 2 subjects gender unknown) aged from 14 to 55 ($M = 25.07$; $SD = 6.03$), the reliability scores of the six scales (measured with Cronbach's alpha) were as follows: BR = .80, PE = .76, SS = .80, ER = .81, EN = .82, and AC = .68.

3.3 Procedure

Before test performance, subjects were asked to fill out the two temperament inventories -PTS and FCB-TI in random order. The tests selected from the "Objektive Testbatterie OA-TB 75" were administered according to the instruction of the OA-TB 75 manual.⁵

4. Results

Limitations of space do not allow us to present the data in detail. We will limit ourselves to the most crucial issues directly related to our hypotheses. As suggested by Cattell, tasks loaded on the four U.I. temperament factors (U.I.16, U.I.21, U.I.22, U.I.23) should correlate with strength of excitation. According to our prediction, tasks loaded on U.I. 21 (Exuberance: T33, T44, T45), and tasks requiring precision in

⁵ Pretests have shown that the time limits for the tests T45 and T203 have to be shortened. These time limits were fixed at 60 seconds for T45 and 90 seconds for T203.

Table 4.1: Correlations Between the PTS Scales and Performance Indices From the Objective Personality Tests

Tasks	PTS scales		
	SE	SI	MO
T1/1	.09	-.03	.11
T1/2	.29*	.08	.21
T1/3	-.18	-.07	-.09
T3/1	.16	.15	.03
T33/2	-.04	-.17	-.07
T33/3	-.22	-.20	-.16
T42/1	.38**	.24	.10
T42/2	.47**	.38**	.16
T42/3	-.03	-.03	-.03
T44/1	.26	.19	-.02
T45/1	.19	-.04	.33*
T45/2	.21	-.02	.28*
T203/1	.25	.05	.15
T203/2	.16	.05	.22

Note: SE=Strength of Excitation, SI=Strength of Inhibition, MO=Mobility.

* $p \leq .05$

** $p \leq .01$

performance (T42/2 and T203/2) may correlate with the SI scale. Tasks in which the speed component is involved (T3/1, T42/1, T44/1, T45/1) should be related to the temporal characteristics of behavior, that is, to mobility, briskness, and perseverance. T1/2, requiring a rapid switch from one activity to another, should be strongly related to mobility. Pearson correlation coefficients between Cattell's tasks and the Pavlovian temperamental traits are depicted in Table 4.1

Among the 42 correlation coefficients, 6 were statistically significant. Strength of excitation correlated positively with tasks T1 (T1/2) and T42 (42/1 and 42/2), both of which had loadings on the U.I.23 factor (Capacity to Mobilize). Task 42 also has loadings on factors U.I.16 (Assertive Ego) and U.I.22 (Cortical Alertness). In addition, strength of inhibition correlated with T42/2. Mobility correlated positively with both indices of task T45 (T45/1 and T45/2),

Table 4.2: Correlations Between the FCB-TI Scales and Performance Indices From the Objective Personality Tests

Tasks	FCB-TI scales					
	BR	PE	SS	ER	EN	AC
T1/1	-.12	-.01	-.25	-.05	-.07	.05
T1/2	.02	-.09	-.06	-.15	.18	.11
T1/3	-.04	.07	-.09	.10	-.17	-.07
T3/1	.15	.00	.14	-.11	.15	.03
T33/2	-.14	.23	.14	-.04	-.15	-.09
T33/3	-.18	.30*	-.02	.22	-.34**	-.19
T42/1	-.30*	-.28*	-.11	-.34**	.25	-.04
T42/2	.18	-.25	-.11	-.28*	.46**	.01
T42/3	.09	-.02	.04	-.05	-.26	.03
T44/1	.01	-.06	-.17	-.06	.17	-.07
T45/1	.02	-.14	.17	.06	.06	.19
T45/2	.14	-.09	.15	.08	.12	.18
T203/1	.22	-.23	-.21	-.30*	.29*	.15
T203/2	.00	-.08	-.10	-.03	.06	.02

Note: BR=Briskness, PE=Perseverance, SS=Sensory Sensitivity, ER=Emotional Reactivity, EN=Endurance, AC=Activity.

* $p \leq .05$

** $p \leq .01$

which loaded on the two factors U.I.16 and U.I.21.

The correlations between the objective personality tests and the FCB-TI scales are presented in Table 4.2.

Altogether 84 correlation coefficients were obtained. Nine of them were significant. Briskness correlated positively with task T42 (T42/1). Perseverance correlated positively with task T33 (T33/3), which had loadings on U.I.16, U.I.21, and U.I.23, and negatively with task T42 (T42/1). Emotional reactivity correlated negatively with tasks T42 (T42/1 and T42/2) and T203 (T203/1); the latter task was loaded by factor U.I.23. Endurance, a trait that resembles strength of excitation, correlated with three tasks: positively with T42 (T42/2) and T203 (T203/1) and negatively with task T33 (T33/3), which had loadings on factors U.I.16, U.I.21, and U.I.23. It has to be noted that two scales—Sensory Sensitivity and Activity, did not

Table 4.3: Loadings on Factors Derived From the 14 Performance Indices

Tasks	Factor I	Factor II	Factor III	h2
T45/1	.75	.04	-.26	.65
T1/2	.71	.20	.35	.67
T45/2	.71	.07	-.36	.64
T1/3	-.68	-.15	.02	.49
T203/2	.63	-.11	.22	.45
T33/2	.45	.02	.42	.37
T33/3	.41	-.20	.29	.29
T44/1	.39	.35	.23	.32
T203/1	-.09	.74	.06	.56
T42/2	.08	.73	-.23	.59
T42/1	-.01	.61	.52	.64
T3/1	.40	.51	-.18	.45
T42/3	.03	-.16	.76	.60
T1/1	.02	.06	.62	.39

Note: h2=communality

correlate with any of the tasks from the objective personality test battery.

As shown above, the same OA-TB 75 task may load on several U.I. temperament factors, and, vice versa, the same factor may be present in several tasks. The common denominators present in separate tasks should refer to U.I. factors that are supposed to correlate with strength of the nervous system and, perhaps, also with the remaining temperamental traits. If so, it seems to be reasonable to correlate the factors derived from tasks of the objective personality tests with the temperament traits under study.

Starting with the intercorrelation matrix of the 14 performance indices from the seven tasks performed by subjects, we factor analyzed the data according to the principal component method with Varimax rotation. As shown in Table 4.3, three factors emerged that explained 50.7% of the common variance (V). Factor I (eigenvalue = 3.35, $V = 23.9\%$) loaded mainly on tasks referring to U.I.16, U.I. 21, and 23 (T1/2,

Table 4.4: Factor Scores Derived From the Objective Personality Tasks Related to PTS and FCB-TI Scales

Temperament scales	Factor I	Factor II	Factor III
PTS: SE	.17	.49**	.01
PTS: SI	-.02	.33*	-.04
PTS: MO	.10	.27*	.07
FCB-TI: BR	-.02	.30*	-.04
FCB-TI: PE	.01	-.32*	.04
FCB-TI: SS	.12	-.16	-.17
FCB-TI: ER	.05	-.40**	-.11
FCB-TI: EN	.04	.50**	-.19
FCB-TI: AC	.08	.07	-.09

Note: SE=Strength of Excitation, SI=Strength of Inhibition, MO=Mobility

BR=Briskness, PE=Perseverance, SS=Sensory Sensitivity, ER=Emotional Reactivity, EN=Endurance, AC=Activity.

* $p \leq .05$

** $p \leq .01$

T1/3, T45/1, T45/2, T203/2). Factor II (eigenvalue = 1.96, $V = 14.0\%$) had its highest loadings on tasks that were saturated on all U.I. factors except U.I.21 (T42/1, T42/2, T203/1). Factor III (eigenvalue = 1.80, $V = 12.8\%$) highly loaded on tasks T42/3 (U.I.16, U.I.22, U.I.23) and T1/1 (U.I.23).

The next step was to compute factor scores and relate these factor scores to the PTS and FCB-TI scales. The data are presented in Table 4.4.

Factor II was the only one that correlated with the temperamental traits under study. This factor correlated positively with strength of excitation, strength of inhibition, briskness, and endurance; and negatively with perseverance and emotional reactivity.

5. Discussion

The results of our study partially support Cattell's hypothesis on the relationship between strength of excitation and the four temperamental U.I. factors. This is expressed in correlational as well as in factor analysis data. The highest positive correlations occur between strength of excitation and task T42 (indices T42/1 & T42/2). According to Cattell and Warburton (1967), task T42 has high loadings on Cortertia (U.I.22), reflecting cortical alertness, Assertive Ego (U.I.16), related to capacity to endure stimulation, and on Capacity to Mobilize (U.I.23). Also the positive correlation between the SE scale and the T1 task (index T1/2) is consistent with Cattell's hypothesis. Additional support comes from the FCB-TI data.

The Endurance scale is comparable to the Strength of Excitation scale (see Strelau & Zawadzki, in press). If we consider the correlation coefficients between the EN scale and the indices of the OA-TB 75 tasks, the highest positive correlation is found for task T42 (T42/2). The correlation between the EN scale and task 203 (index T203/1) is also in line with this result. Furthermore, the negative correlation between endurance and task T33 (index T33/3) supports Cattell's prediction of a negative correlation between the performance index T33/3 and Exuberance, a factor hypothetically related to strength of the nervous system. If we consider relations between the remaining temperamental characteristics and performance indices of the OA-TB 75 tasks, the results are not very supportive for our hypotheses. The SI scale correlates with task T44 (the T44/2 index that refers to accuracy of performance) in an unpredicted direction. This finding is difficult to explain. No other significant relationships

between the objective personality tests and strength of inhibition are found. Three scales from the PTS and FCB-TI refer to the temporal characteristics of behavior—MO, BR, and PE. We predicted that indices T1/2, T3/1, T42/1, T44/1, and T45/1, which refer to speed or duration of performance, should correlate positively with these temperamental scales. This prediction is supported by positive correlations between mobility and T45/1, and between briskness and T42/1 as well as by a negative trend between perseverance and T42/1. No contradictory results are found in respect to temporal characteristics of behavior. The hypothesis that mobility correlates with speed of performance on task T1 (T1/2) is not confirmed. Emotional reactivity correlates negatively with tasks T42 (T42/1 & T42/2) and T203 (T203/1). This seems plausible, if we consider that ER has much in common with emotionality or neuroticism, and, as our studies have shown (see Angleitner, unpublished data; Strelau & Zawadzki, in press), this temperament trait is reversely related to strength of excitation and to endurance. To our surprise, activity, which is a temperamental trait interpreted in terms of arousal mechanisms (see Strelau, 1993), does not correlate with any of the objective personality tests.

The data obtained on the basis of factor analysis are striking, in that they show that Factor II is the only one that correlates significantly with our temperamental scales. Factor II differs from the two remaining ones in that performance on the majority of tasks loaded on this factor (three to four) has been explained by Cattell and Warburton (1967) by the contribution of the U.I. 22 salient factor. In agreement with Cattell, Factor II may be called "Cortical Alertness". Thus one has to conclude that

Cortical Alertness is highly associated with strength of excitation and endurance, and may be equivalent to the Pavlovian concept. This result supports Cattell's (1972) intuition according to which strength of the nervous system is expressed most strongly in Cortertia, one of the four U.I. temperamental factors hypothetically related to this Pavlovian construct. It is not surprising that such traits as briskness (with positive sign), perseverance, and emotional reactivity (both with negative sign) are also related to Factor II.

We should nonetheless raise one cautionary note concerning the selection of our tasks. First of all, the German version of the Objective Analytic Test Battery contains only 50 easily administered paper-and-pencil tests from about 400 tests suggested by Cattell. Furthermore, time restrictions did not allow us to use all relevant test markers for measuring the relevant temperamental factors in Cattell's system. Things are further complicated by the fact that the same task allows different scoring devices for different factors. This leads to further difficulties, especially in the evaluation of our factor analytic results.

However, after almost 100 years of research with questionnaires and rating scales, it seems important to move beyond this kind of research "in which the language of observation and the language of theory intermix" (Pawlik, 1973, p.36). In spite of all shortcomings of objective test devices, we consider this to be a step in the right direction.

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