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Personality and Individual Differences 29 (2000) 709–727

PERSONALITY AND INDIVIDUAL DIFFERENCES

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Factor structure of psychobiological seven-factor model of personality: a model-revision

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Received 11 September 1998; received in revised form 12 October 1999; accepted 22 October 1999

Abstract

The purpose of this study was to examine the factor structure in the Temperament and Character Inventory [TCI; Cloninger, C. R., Svrakic, D. M., & Przybeck, T. R. (1993). A psychobiological model of temperament and character. *Archives of General Psychiatry, 50*, 975–990.] and to determine appropriate subscales and items to assess the psychobiological seven-factor model with a nonclinical Japanese sample by the use of the TCI short version. Among 383 ex-members of the Japanese Antarctic Research Expedition, confirmatory factor analysis of the TCI showed that temperament consisted of four factors and character of three, as the original model suggested. Harm Avoidance, Reward Dependence, Self Transcendence and Cooperativeness may be interpreted as a constellation of interrelated but possibly discrete dimensions. Most of the items were loaded into each corresponding subscale, although a few of the items were not confirmed as appropriate. Implications and the future direction of personality research are discussed.

Keywords: Factor structure; Temperament and Character Inventory; Factorial validity; Confirmatory factor analysis; Psychobiological seven-factor model

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

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0191-8869/00/$ - see front matter
PII: S0191-8869(99)00227-5

1. Introduction

1.1. Personality psychology and psychobiological model approach

Personality trait is a basic unit of personality structure (Allport, 1937; Cattell, 1965; Eysenck, 1967, 1973; Guilford, 1959, 1967). Personality trait theory has been criticized by many theorists since the 1970s because of the "person–situation controversy", which questions whether people have consistent personality traits (Kenrick & Funder, 1988, for review). To date, two prominent empirical models of the theory appear to have emerged: the Big Five personality model (e.g. Costa & McCrae, 1985, 1988, 1992a, 1995; Digman & Inouye, 1986; Digman, 1989, 1990; Goldberg, 1990, 1992), which is measured by the Neuroticism–Extraversion Openness Personality Inventory (NEO-PI: Costa & McCrae, 1992b) and the psychobiological model (e.g. Cloninger, 1986, 1987; Cloninger, Przybeck & Svrakic, 1991; Cloninger, Svrakic & Przybeck, 1993; Eysenck, 1981, 1990, 1991, 1992; Tellegen, 1985). The psychobiological seven-factor model of personality proposed by Cloninger et al. (1993) assumes that personality structure is divided into temperament and character; while temperament is genetically determined and involves preconceptual biases in perceptual memory and learning of behavior, character matures in adulthood with the development of self-concepts and influences personal and social effectiveness by insight-based learning. Temperament consists of four dimensions: behavioral activation (Novelty Seeking; NS), inhibition (Harm Avoidance; HA), maintenance (Reward Dependence; RD) and perseverance (Persistence; P). Three dimensions of character modify as an individual identifies the self as (1) an autonomous individual (Self-Directedness; SD), (2) an integral part of humanity (Cooperativeness; C) and (3) an integral part of the universe as a whole (Self-Transcendence; ST). In order to assess these dimensions, the questionnaire, Temperament and Character Inventory (TCI), and scoring manual were developed (Cloninger, Przybeck, Svrakic & Wetzel, 1994).

The two models are different in several aspects. While the Big Five model is based on factorial classification of trait adjectives in natural language, the psychobiological model is based on a neurobiological background of personality. The former is almost completely confirmed as a five-factor structure (Costa & McCrae, 1995; Digman & Inouye, 1986; McCrae & Costa, 1985), but the factor structure of the latter is merely partially replicated. Nevertheless, the TCI may excel NEO-PI in two other aspects of validity: clinical predictability and criterion-related validity.

Svrakic, Whitehead, Przybeck and Cloninger (1993) reported that low SD and C strongly predicted the number of personality symptoms of personality disorders. What needs to be emphasized is that this finding is confirmed with the TCI, but not with NEO-PI. Bulik, Sullivan, Joyce and Carter (1995) reported that low SD scores were associated with a substantially increased probability of a coexistence of personality disorder with bulimia nervosa in a clinical sample. Confirming low SD and low C to be the essential features of all personality disorders in outpatients, Bayon, Hill, Svrakic, Przybeck and Cloninger (1996) found that ST was markedly correlated with severe psychiatric disorders, including manic and delusional disorders. Furthermore, Battaglia, Przybeck, Bellodi and Cloninger (1996) indicated that the interaction among three temperament dimensions during development influenced comorbidity of psychiatric and personality disorders with clinical samples. These findings, therefore, lead to the possibility that personality dimensions assessed by the TCI predict the presence of various psychiatric and personality disorders.

Next, ample evidence exists for the criterion-related validity of the TCI. The Tridimensional Personality Questionnaire (TPQ), a predecessor of the TCI, operationalised three temperament spectrums: NS, HA and RD, related to, respectively, dopamine (DP), serotonin (SR) and norepinephrine (NE) activity (Cloninger, 1987). The last few years have seen a considerable number of empirical findings on relationships between these biological, neurochemical markers and pharmacological response and personality components of temperament. There is supportive evidence that shows the links between D4 DP receptor and NS (Benjamin, Patterson, Greenberg, Murphy & Hamer, 1996; Ebstein et al., 1996), between 5-HT2C (HTR2C) SR receptor gene polymorphism and RD (Ebstein et al., 1997) and between total RD scores and the level of 3-methoxy-4-hydroxyphenyglycol (MHPG), a NE metabolite (Garvey, Noyes, Cook & Blum, 1996). NS scores were positively correlated with serum total triiodothyronine (T3), free T3, the T3/free thyroxine (FT4) ratio and urinary cortisol levels in a sample of combat-related posttraumatic stress disorder subjects (Wang, Mason, Charney & Yehuda, 1997). Joyce, Mulder and Cloninger (1994) showed that the group of patients with low HA and high RD scores who experienced major depression and received clomipramine had a better outcome at 6 weeks. Additionally, Nelson and Cloninger (1995) reported a model that included RD and HA and their interaction was found to significantly predict the response to nefazodone, an antidepressant, and replicated their findings in a large sample study (Nelson & Cloninger, 1997). In contrast to the TCI, the NEO-PI does not lend itself to studies of the biological basis of personality and relationships between physiological, endocrinological, neurochemical and pharmacological indices and personality components.

However, we cannot underestimate the validity of NEO-PI and overestimate that of the TCI. Ball, Tennen, Poling, Kranzler and Rounsaville (1997) found much stronger support for the factor structure of the NEO-PI than the TCI. Moreover, they showed stronger associations of NEO-PI with DSM-IV Axis II disorders in the modeling than those of the TCI. In terms of neurochemical underpinnings for the TCI, some research groups showed no significant correlation of NS with D4 dopamine receptor (Jönsson et al., 1997, 1998; Sullivan et al., 1998). Additionally, NEO-PI has recently produced some remarkable data for a genetic contribution for the five-factor model in twin studies (Jang, McCrae, Angleitner, Riemann & Livesley, 1998; Jang, Livesley & Vernon, 1996). There is room for further investigation on the biological basis of personality.

1.2. Factor structure of TCI/TPQ

Several previous investigations used confirmatory factor analysis to identify the structure of the tridimensional model of temperament by using the TPQ which measures three dimensions (NS, HA and RD) of temperament. Using 216 undergraduates, Bagby, Parker and Joffe (1992) reported results from the confirmatory factor analysis of the 12 TPQ subscales that made up three dimensions; they found a remarkably good fit between the obtained factor structure and the hypothesized dimensions of the model. These findings were replicated in two other studies with a large sample: 583 college freshmen (Sher, Wood, Crews & Vandiver, 1995) and 360 community-based adults and 233 undergraduates (Parker, Bagby & Joffe, 1996). However, in certain studies confirmatory factor analysis indicated the existence of significant differences between the hypothesized three-factor solution and the empirically derived solution: the subscales of the RD dimension shared essentially no variance between them. One such study used a sample of 1236 adults (Waller, Lilienfeld, Tellegen & Lykken, 1991); another used a sample of 413 English males and females (Otter, Huber & Bonner, 1995). Earleywine, Finn, Peterson and Pihl (1992) also failed to replicate the three proposed factors of NS, HA and RD. The finding of Cannon, Clark, Leeka and Keefe (1993) supported neither the original tridimensional structure, nor the factor structures obtained in a nonclinical sample by Cloninger et al. (1991), showing that an exploratory factor analysis yielded five factors that were distinct from the original factors of the TPQ.

The previous literature, however, was of limited generalizability. First, the samples were usually Europeans or Americans; no study examined the psychometric properties among Asian populations. The psychometric properties of a personality test may well be biased by cultural differences. The concept of different personality dimensions may differ from culture to culture. Second, past studies often dealt only with clinical populations while the psychometric properties of the scale may be different for clinical and nonclinical populations. Third, most of the past investigations used the TPQ but rarely the TCI because the latter was not available until recently. The only study of a Japanese population used the TPQ (Takeuchi, Yoshino, Kato, Ono & Kitamura, 1993). Finally, most investigations used an exploratory factor analysis, rather than a confirmatory one to examine the scale's structure. Exploratory factor analysis is important to generate hypotheses as to the number and contents of factor structures of a test with multiple items. However, it cannot determine which hypothesis is better in terms of fitness with the data. Furthermore, review of the literature on the factor structure of the TPQ revealed that a higher-order factor analysis was usually adopted. In addition to factor analysis based on a subscale-to-scale level, that based on item-to-scale level may be necessary to refine the model. Factor-analysis of the TCI based on the item-to-subscale level was performed by Cannon et al. (1993) and Parker et al. (1996), but neither of them carried out factor analysis on the item-to-scale level. We should, of course, be cautious about the interpretation of the confirmatory factor analysis because it cannot 'prove' any hypothesis, but can indicate which hypothesis better fits the data.

We are unaware of any previous studies of the confirmatory factor analysis of the TCI in an Asian population and consequently a study of the factor structure of the TCI is worthwhile. The purposes of this study are (1) to confirm the factor structure of temperament and character separately in the TCI, (2) to determine appropriate subscales and items to measure the psychological model of Cloninger et al. and (3) to examine psychometric validity and reliability (internal consistency) of the TCI and its subscales in an Asian sample.

2. Methods

2.1. Subjects and procedure

The target subjects of our study were ex-members of the Japanese Antarctic Research Expedition (JARE) because the primary subject of the study was mental health and adaptation among members of the JARE before, during and after the mission.

After obtaining permission from the President of the National Institute of Polar Research (NIPR) and the Ethical Committee of NIPR, we sent a letter to a total of 36 team leaders. The team leader was the responsible officer of each expedition, and although he no longer had official responsibility, it was appropriate to ask his consent before sending a letter to ex-members of the JARE. Of these 36 ex-leaders, 29 consented to our request to contact their ex-team-members. Accordingly, we sent a letter to the ex-members of the JARE whose team leader gave us consent. We sent a letter along with an endorsement from the President of the NIPR to a total of 1094 ex-members. (The total number of people who had been in the Antarctic as JARE members was 1229.) In this letter, we explained the purpose and procedure of the study and provided the following options for participation: (a) participation only in the questionnaire study, (b) participation only in the interview study, (c) both and (d) refuse. It was also explained that all the information would be treated with confidentiality and would never be released to the NIPR. Of the 1094 ex-members we contacted, 431 responded. Our letter was returned from seven individuals because of a change of address. Of the 431, 411 agreed to participate in the questionnaire study, 336 agreed to participate in both the interview study and the questionnaire study. We then sent a questionnaire to the 411 members and of those returned, 386 were usable. The questionnaire survey was conducted between January and February 1997.

We conducted an interview with a total of 132 members. Because the members of the JARE in the very early stages of the project might have difficulty in recalling mental states and events during the mission and because we had a limited number of trained interviewers, we (a) excluded all the members before the 9th expedition and (b) selected only members of the ($n \times 3$)th and ($n \times 3+1$)th expedition, thus, for example, choosing members of the 9th, 10th, 12th, 13th, 15th, 16th expedition and so on. The latter selection method was used because we were interested both in random sampling and in having many members of a team in order to examine the group dynamics of the expedition. However, 62 members who went to the Antarctic before the 9th expedition were anxious to participate in the study and thus were included. The data of this interview survey will be reported elsewhere.

2.2. Measure

The TCI for Japanese with 125 items (Kijima et al., 1996) was used. This measure is a self-report questionnaire with a 4-point scale (very unlikely, 1, to very likely, 4). The Japanese version of the TCI has already been standardized and back-translated into English by a translator who was unaware of the original version of the TCI. The content of each question was verified by Dr. Cloninger. We deleted three items (two items in C and one item in SD), because data of more than 5 % of all subjects were missing. Thus, 122 items were utilized in this study.

All TCI scales except P have several subscales. TCI subscales are: Exploratory Excitement (NS1), Impulsiveness (NS2), Extravagance (NS3) and Disorderliness (NS4) for NS; Worry and Pessimism (HA1), Fear of Uncertainty (HA2), Shyness with Strangers (HA3) and Fatigability and Asthenia (HA4) for HA; Sentimentality (RD1), Attachment (RD3) and Dependence (RD4) for RD (Persistence was once used for RD2 but factor analyses confirmed its independence as a temperament); Responsibility (SD1), Purposefulness (SD2), Resourcefulness (SD3), Self-Acceptance (SD4) and Congruent Second Nature (SD5) for SD; Self-Forgetfulness (ST1), Transpersonal Identity (ST2) and Spiritual Acceptance (ST3) for ST; Social Acceptance (C1), Empathy (C2), Helpfulness (C3), Compassion and Revenge (C4) and Integrated Conscience (C5) for C.

2.3. Statistical analysis

We conducted a series of maximum likelihood confirmatory factor analyses to examine

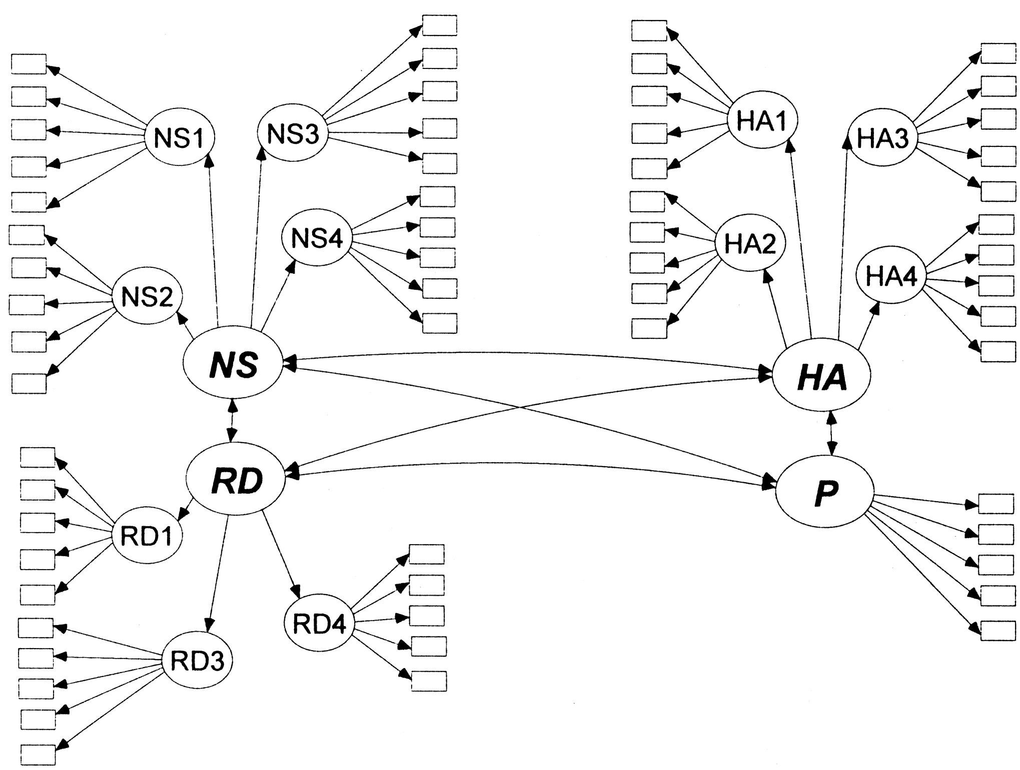

Fig. 1. Temperament based on item-to-scale model including items, subscales and primary factors. Rectangles represent items.

different models of the TCI. They were item-to-scale models of the TCI and item-to-subscale models of each TCI subscale. The item-to-scale models were four and three oblique factor models and contained 60 and 62 items in temperament (Fig. 1) and character (Fig. 2), respectively. Paths were drawn from higher-order (secondary) factors through lower-order (primary) factors to each of the corresponding TCI items. Here, the higher-order (secondary) factors were NS, HA, RD and P in the temperament model and SD, ST and C in the character model. All the higher-order (secondary) factors except P included three or four subscales, which were used as the lower-order (primary) factors.

On the contrary, the item-to-subscale models (Parker et al., 1996) were separate models of seven scales in the TCI, including their subscales. Each model included one primary factor such as NS1 and three or four secondary factors such as NS. Paths were drawn from higher-order (secondary) factors to lower-order (primary) factors. Here, the higher-order (secondary) factors were NS, HA, RD, P, SD, ST and C and P in the model. All the factors except P included three or four subscales; they were thus the secondary factors (Fig. 3).

We calculated several indices of the goodness-of-fit; χ^2 values to degrees of freedom ratios (CMIN/df), goodness-of-fit index (GFI), adjusted goodness-of-fit index (AGFI) and root mean

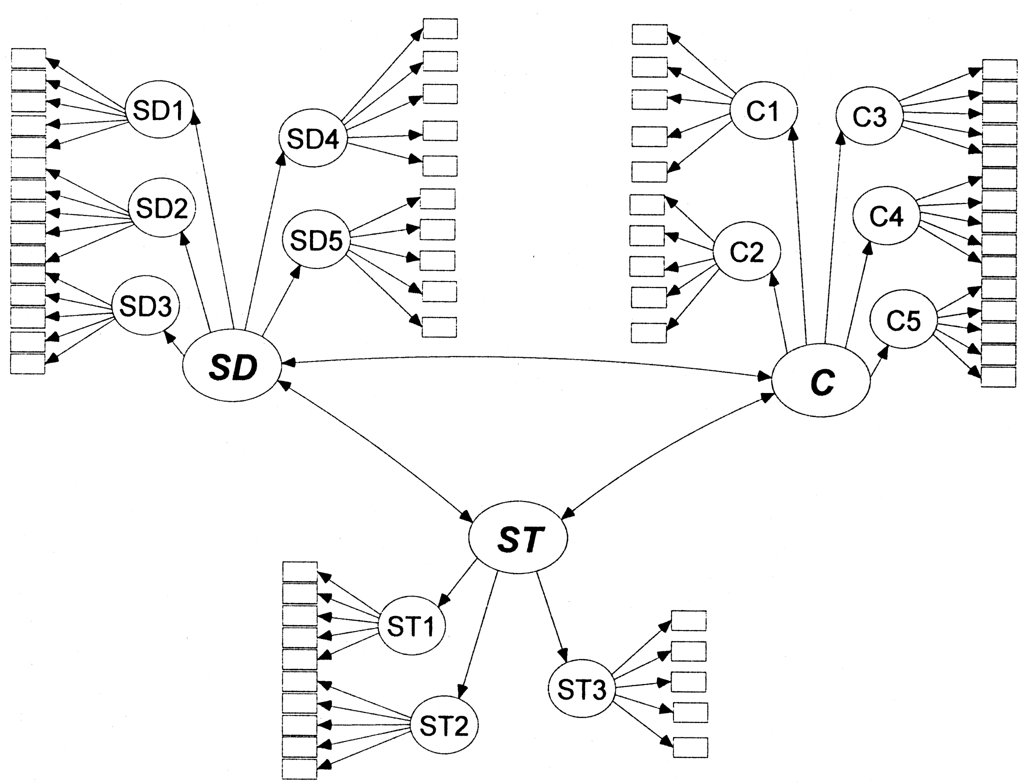

Fig. 2. Character based on item-to-scale model including items, subscales and primary factors. Rectangles represent items.

square residual (RMR). The following four criteria were used to indicate the goodness-of-fit statistics for adequacy of the model to the present data: (a) CMIN/df $\leq$2.0, (b) GFI $\geq$0.85, (c) AGFI $\geq$0.80 and (d) RMR $\leq$0.10 (Anderson & Gerbing, 1984; Cole, 1987; Marsh, Balla & McDonald, 1988; Marsh & Hocevar, 1985). We are aware of a recent trend of setting higher GFI indices as acceptable. For example, Hu and Bentler (1995) and Shevlin and Miles (1998) recommended values above 0.90 for GFI. We, however, took more conventional values in this study for accepting GFI and other indices because we were interested in refining rather than proving or disproving the TCI structure and because the TCI is based on the assumption that scales were mutually influential in developing personality throughout the course of life.

Two criteria were used to revise the models: (1) poor goodness-of-fit indices and (2) the problematic parameter estimate among subscales and items (e.g. greater parameter estimates than one). When either of these criteria was met, we confirmed two new models. First, we determined whether the scale is a *one-factor model*, which assumes that each scale has only one factor structure without subscales. Paths were directly drawn from scales (e.g. NS) to each of the corresponding TCI items. Second, we confirmed the goodness-of-fit statistics for *covariance model*, which assumed that the covariance model included subscales and the covariance among subscales (e.g. NS1 to NS4), instead of paths between the primary and secondary factors, removing the secondary factor. Paths were drawn from subscales (e.g. NS1) to each of the corresponding TCI items. Double-headed arrows representing covariance were also drawn

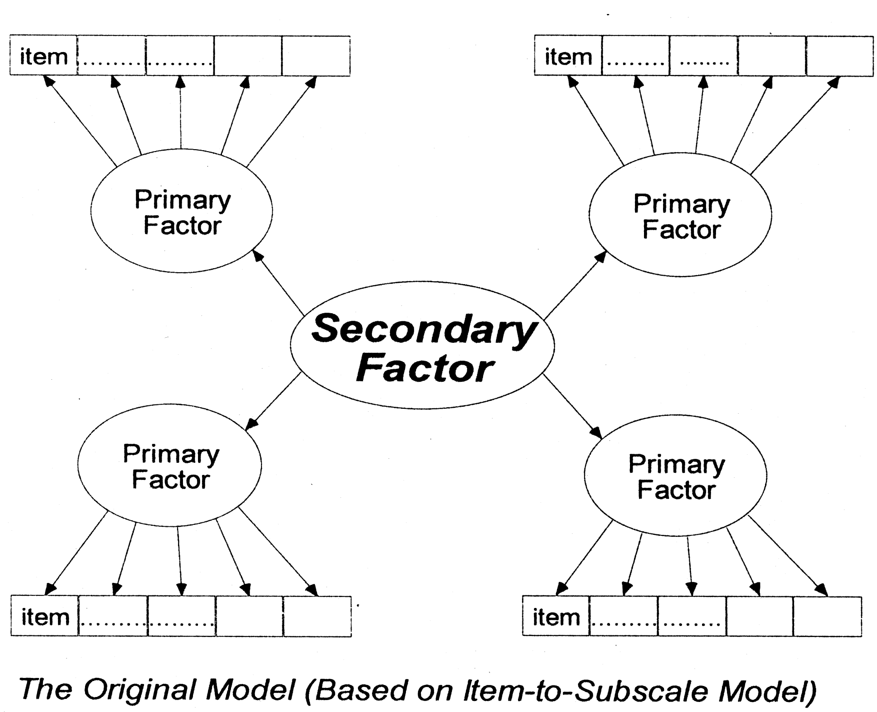

Fig. 3. The original model based on item-to-subscale model including items and subscales. Rectangles represent items.

among subscales in the path diagram. If the goodness-of-fit statistics were not improved even at the second stage, we deleted subscales and items in order to improve the goodness-of-fit statistics. For these revisions, we again performed the goodness-of-fit statistics, including AIC to compare the original models with the revised ones.

SPSS 7.5.1 for Windows95 (SPSS Inc., 1997) and Amos 3.61 (Arbuckle, 1997) were used for statistical analyses.

3. Results

Descriptive statistics for temperament (NS, HA, RD and P) and character (SD, ST and C) are shown in Table 1. We calculated Cronbach's α coefficient in order to evaluate the internal consistency of the subscales of the TCI. While Cronbach's α coefficients for NS, RD and P are poor, those of HA, SD, ST and C are fair or excellent.

Table 2 shows the Pearson product–moment correlation matrix among the TCI scales. As can be seen in this table, NS was moderately negatively correlated with HA ($r = -0.38$). HA was moderately negatively correlated with SD ($r = -0.51$) and C ($r = -0.37$). RD was moderately positively correlated with C ($r = 0.48$). SD was moderately positively correlated with C ($r = 0.38$). Although other significant correlations among the scales are also found (e.g. the correlation between NS and P), their magnitude is weak.

3.1. Confirmatory factor analyses: item-to-scale model

Table 3 shows goodness-of-fit statistics for item-to-scale models of temperament (Fig. 1) and character (Fig. 2). Of the goodness-of-fit indices, all but RMR were poor in both temperament and character models.

Table 1
Descriptive statistics of the TCI scales[a]

Scale	No. of items	No. of subscales	*M*	S.D.	Range	Cronbach's α index
Temperament						
NS	20	4	48.67	5.52	31–67	0.68
HA	20	4	47.93	7.38	27–74	0.85
RD	15	3	40.82	4.43	26–54	0.66
P	5	1	13.32	2.18	7–20	0.60
Character						
SD	24	5	69.90	7.99	49–89	0.83
ST	15	3	29.46	6.20	17–49	0.83
C	23	5	64.64	5.41	50–85	0.72

[a] Two items of C and one item of SD were deleted because of missing cases constituting more than 5% of all subjects.

Table 2
Pearson product–moment correlation coefficients among TCI scales[a]

	NS	HA	RD	P	SD	C
HA	−0.38**					
RD	−0.02	−0.07				
P	−0.14**	−0.12*	0.18**			
SD	−0.02	−0.51**	0.09	0.09		
C	−0.02	−0.37**	0.48**	0.11*	0.38**	
ST	0.11*	−0.14	0.06	0.22**	−0.15**	0.01

[a] *$p < 0.05$; **$p < 0.01$.

3.2. Confirmatory factor analyses: item-to-subscale model

To examine item-to-subscale models, goodness-of-fit indices for each of the TCI scales are shown in Table 4. To compare our results with previous ones, goodness-of-fit statistics (GFI, AGFI and RMR) for each TPQ scale of nonclinical adults (Parker et al., 1996) are also shown.

3.2.1. Novelty Seeking

The GFI, AGFI and RMR for the Novelty Seeking four-factor model satisfied the criteria for adequacy of fit for the model (Table 4). Table 5 shows parameter estimates for the paths between primary (NS) and four secondary factors (NS1, NS2, NS3 and NS4). All estimates are statistically significant, ranging from 0.49 to 0.78. Parameter estimates among items are shown in Table 6. While parameter estimates among two items (No. 53 and 63) in NS1 and one item (No. 77) in NS4 were not statistically significant, those among 17 other items were significant, ranging from 0.14 to 0.74.

3.2.2. Harm Avoidance

Table 4 shows the goodness-of-fit statistics for the Harm Avoidance four-factor model. While RMR satisfied the criteria for adequacy of fit of the model, GFI and AGFI did not reach the required standard. Thus, we calculated the goodness-of-fit statistics for the HA one-factor model. Because the goodness-of-fit statistics, including AIC, for the HA one-factor model were poorer than those for the four-factor model (Table 4), the HA one-factor model was rejected. We also calculated the goodness-of-fit statistics for the HA covariance four-factor model. The goodness-of-fit statistics for the HA covariance model were equal to those for the

Table 3
Goodness-of-fit indices for separate models of temperament and character

Model	χ^2	df	χ^2/df	GFI	AGFI	RMR
Temperatment	4399.43	1693	2.60	0.646	0.617	0.055
Character	3899.43	1813	2.15	0.711	0.689	0.046

Table 4
Goodness-offit indices for scales of the TCI

Scale	Reference	GFI	AGFI	RMR	AIC
Temperament					
NS	present study	0.850	0.809	0.052	–
	Parker et al. (1996)	0.852	0.827	0.073	–
HA	present study (original)	0.792	0.737	0.046	815.138
	one-factor model	0.765	0.710	0.049	917.714
	revised (three-factor model)	0.851	0.794	0.045	471.310
	Parker et al. (1996)	0.852	0.824	0.070	–
RD	present study (original)	0.931	0.905	0.032	279.271
	one-factor model	0.894	0.859	0.038	366.189
	Parker et al. (1996)	0.872	0.850	0.076	–
P		0.993	0.980	0.012	–
Character					
SD		0.890	0.866	0.034	–
ST	present study (original)	0.904	0.868	0.034	346.889
	one-factor model	0.904	0.872	0.034	344.603
C	present study (original)	0.843	0.807	0.038	810.898
	one-factor model	0.821	0.786	0.036	883.627
	revised (four-factor model)	0.873	0.835	0.034	514.615

HA four-factor model. Because the estimate for the unique error component of HA1 was not significant and the estimate for the path from HA to HA1 was problematic, we deleted HA1 and its items. We used one primary factor (HA), three subscales (HA2, HA3 and HA4) and 15 items in order to calculate the goodness-of-fit statistics for the HA revised three-factor model. The goodness-of-fit statistics, including AIC, for the revised model were better than those of the original model (Table 4). Although the GFI as well as RMR for the revised model satisfied

Table 5
Parameter estimates for the paths from the primary to the secondary factors[a]

Temperament			Character		
Subscales		estimate	subscales		estimate
NS	1	0.49*	SD	1	0.92*
	2	0.65*		2	0.79*
	3	0.78*		3	0.95*
	4	0.55*		4	0.65*
				5	0.89*
HA	2	0.76*	C	1	0.67*
	3	0.81*		2	0.83*
	4	0.75*		3	0.94*
				4	0.72*

[a] * $p < 0.05$.

the criteria for adequacy of fit of the model, AGFI did not. Table 5 shows parameter estimates for the paths between the primary (HA) and three secondary factors (HA2, HA3 and HA4) except HA1. All estimates were statistically significant, ranging from 0.75 to 0.81. Parameter estimates among items are shown in Table 6. All the parameter estimates among 15 items were significant, ranging from 0.15 to 0.77.

3.2.3. Reward Dependence

While the goodness-of-fit statistics for the Reward Dependence three-factor model satisfied the criteria standards for adequacy of fit of the model (Table 4), the parameter estimate for the

Table 6
Parameter estimates among items for TCI subscales[a]

Subscale	Temperament				Character		
	NS	HA	RD	P	SD	ST	C
1	0.70* (1)	– (2)	0.44* (20)	0.22* (8)	0.43* (3)	0.52* (32)	0.40* (4)
	0.06* (53)	– (46)	0.54* (31)	0.47* (22)	0.36* (17)	0.63* (43)	0.56* (12)
	0.06 (63)	– (61)	0.51* (54)	0.62* (37)	0.60* (34)	0.59* (52)	0.55* (28)
	0.42* (105)	– (64)	0.39* (65)	0.62* (55)	0.54* (49)	0.64* (107)	0.27* (93)
	0.41* (125)	– (82)	0.39* (97)	0.48* (116)	0.46* (66)	0.59* (113)	0.40* (123)
2	0.49* (10)	0.74* (9)			0.57* (6)	0.23* (25)	0.047 (74)
	0.46* (36)	0.33* (38)			0.46* (57)	0.62* (42)	−0.25* (89)
	0.61* (47)	0.70* (70)			0.51* (69)	0.34* (68)	0.41* (101)
	0.65* (71)	0.15* (104)			0.37* (87)	0.62* (108)	– (18)
	0.14* (103)	0.69* (115)			0.03 (94)	0.52* (114)	
3	0.32* (14)	0.56* (19)	0.45* (15)		0.55* (23)	0.54* (29)	0.25* (7)
	0.42* (42)	0.77* (30)	0.59* (79)		0.67* (58)	0.54 (73)	0.33* (27)
	0.65* (65)	0.61* (45)	0.40* (96)		0.54* (92)	0.38* (91)	0.28* (50)
	0.43* (76)	0.34* (78)	0.64* (111)		0.36* (109)	0.64* (110)	0.37* (84)
	0.53* (106)	0.68* (86)	0.24* (119)		0.11 (122)	0.11* (121)	0.68* (95)
4	0.15* (44)	0.54* (16)	0.21* (11)		0.55* (21)		0.67* (5)
	0.49* (51)	0.52* (62)	0.35* (26)		0.79* (35)		0.66* (33)
	0.74* (60)	0.48* (81)	0.38* (39)		0.72* (48)		0.28* (67)
	0.01 (77)	0.55* (98)	0.56* (72)		0.82* (83)		0.48* (80)
	0.37* (99)	0.56* (124)	0.24* (85)		0.58* (120)		0.13* (118)
5					0.47* (56)		– (13)
					0.59* (90)		– (75)
					0.05 (112)		– (88)
					0.62* (117)		– (102)

[a] Parameter estimates for each subscale are shown from upper to lower figures. For example, in NS1, there are five estimates from upper (0.70; item No. 1) to lower (0.41; item No. 125). Each of the subscales shown here includes three to five estimates. Dashes indicate the item was deleted in order to revise each of TCI item-to-subscale models. While RD and ST were estimated as covariance model and one-factor model, respectively, other scales were estimated as item-to-subscale model. Item numbers are presented in parenthesis. *$p < 0.05$.

path from RD to RD1 was problematic. Thus, we examined the RD one-factor model. Because the goodness-of-fit statistics, including AIC, for the RD one-factor model were poorer than those for the three-factor model (Table 4), the RD one-factor model was rejected. Therefore, we turned to the RD covariance three-factor model. The goodness-of-fit statistics, including AIC, for the RD covariance model were equal to those for the RD three-factor model. Because there is no parameter estimate greater than one, the solution of the model was best fitted. Consequently, we used three subscales (RD1, RD3 and RD4) and 15 items in order to calculate the goodness-of-fit statistics for the RD covariance three-factor model. The parameter estimates for the covariance among three subscales (RD1, RD3 and RD4) are as follows: 0.25 between RD1 and RD3, 0.57 between RD1 and RD4 and 0.77 between RD3 and RD4. These estimates are statistically significant. The parameter estimates among items are shown in Table 6. All the parameter estimates among 15 items were significant, ranging from 0.21 to 0.64.

3.2.4. Persistence

Table 4 shows the goodness-of-fit statistics for the Persistence one-factor model, in which there is no subscale. The GFI, AGFI and RMR satisfied the criteria for adequacy of fit for the model. The parameter estimates among items are shown in Table 6. All the parameter estimates among 5 items were significant, ranging from 0.22 to 0.62.

3.2.5. Self-Directedness

The GFI, AGFI and RMR for the Self-Directedness five-factor model satisfied the criteria for adequacy of fit for the model (Table 4). All the parameter estimates for the paths between the primary (SD) and five secondary factors (SD1, SD2, SD3, SD4 and SD5) were statistically significant, ranging from 0.65 to 0.95. Parameter estimates among one item (No. 94) in SD2, one item (No. 122) in SD3 and one item (No. 112) in SD5 were not statistically significant. Those among the other 21 items were significant, ranging from 0.36 to 0.82 (Table 6).

3.2.6. Cooperativeness

While AGFI and RMR for the Cooperativeness five-factor model satisfied the criteria standards for adequacy of fit of the model, the GFI was slightly poor (Table 4). We calculated the goodness-of-fit statistics for the C one-factor model. Because the goodness-of-fit statistics, including AIC, for the C one-factor model were poorer than those for the five-factor model (Table 4), this model was rejected. We also calculated the goodness-of-fit statistics for the C covariance three-factor model. The goodness-of-fit statistics for the C covariance model was equal to those for the C five-factor model. Because the estimate for the unique error component of the C5 subscale and one item (No. 18) was not significant and the estimates for the path from C to C5 was problematic, we deleted C5 and this item. Consequently, we used one primary factor (C), three subscales (C1, C2, C3 and C4) and 18 items in order to calculate the goodness-of-fit statistics for the C revised four-factor model. As expected, the goodness-of-fit statistics, including AIC, for the revised model were better than those of the original model (Table 4). The goodness-of-fit statistics for the revised model satisfied the criteria standards for adequacy of fit of the model. Table 5 shows parameter estimates for the paths between primary

(C) and three secondary factors (C1, C2, C3 and C4) except C5. All estimates are statistically significant, ranging from 0.72 to 0.94. Parameter estimates for items are shown in Table 6. While a parameter estimate for one item (No. 74) in C2 was not statistically significant, those among the other 17 items were significant, ranging from −0.25 to 0.68.

3.2.7. Self-Transcendence

While the goodness-of-fit statistics for the Self-Transcendence three-factor model satisfied the criteria for adequacy of fit of the model (Table 4), the parameter estimate for the path from ST to ST1 was problematic. We calculated the goodness-of-fit statistics for the ST one-factor model and the covariance model. While the goodness-of-fit statistics, including AIC, for the ST one-factor model were slightly better than those for the three-factor model (Table 4), the goodness-of-fit statistics, including AIC, for the ST covariance model were equal to those for the ST three-factor model. Therefore, the ST one-factor model without covariance among subscales was best fitted. Parameter estimates among items are shown in Table 6. All of the parameter estimates among 15 items were significant, ranging from 0.11 to 0.64.

4. Discussion

The salient findings of this study are that: (1) the TCI consists of four temperaments and three characters with acceptable item-to-subscale models though some revisions were recommendable and (2) HA, RD, ST and C may be better interpreted as a constellation of interrelated but possibly discrete dimensions. Despite the acceptability of TCI items belonging to each TCI scale, the confirmatory factor analysis using the whole TCI items in the item-to-scale models (Figs.1 and 2) did not satisfy the indices of goodness-of-fit statistics. This suggests room for improving the TCI the TCI personality model construction applicable across different cultures.

To date, almost all factor analytic studies of the TCI or TPQ have examined only European and American people; few studies have been conducted on Asian samples. In the present study, the internal consistency and factorial validity of the TCI were confirmed in a Japanese sample. To the best of our knowledge this is the first study with an item-based factor structure of the TCI using such a sample.

In this study, Cronbach's α coefficients of the temperament scales were slightly low with the exception of the HA. The lowest α index was the P scale, which involves five items. The magnitude of α coefficients depends on how many scale items are included, as well as whether the items are internally consistent. Most previous studies showed that the α index of the TCI P scale and the TPQ RD2 scale was less than 0.70, regardless of the number of corresponding items (e.g. Cannon et al., 1993; Cloninger et al., 1993; Kijima et al., 1996; Otter et al., 1995; Sher et al., 1995). Additionally, although α indices of both NS and RD exceeded 0.70, they were low compared with those of other TCI scales in previous studies (e.g. Cloninger et al., 1993; Kijima et al., 1996). These findings suggested that the internal consistency of the P scale is not satisfactory and that HA and the three character scales are more reliable than the NS, RD and P scales.

It should be remembered that the original TCI scale construction was based not on results of factor analysis, as with NEO-PI, but on theoretical considerations. Nevertheless, the subscale structures based on item-to-subscale model were nearly replicated. Therefore, the factorial replicability partially supported the construct validity of the TCI.

Having confirmed the basic structure of the TCI, however, we found several aspects that did not support Cloninger's model. HA and C were replicated as the three- and four-factor model, respectively. While HA1, which was deleted in the HA new model, was referred to "Worry and Pessimism"; C5, which was deleted in the C new model, was referred to "Integrated Conscience." The former concept is mainly related to anxiety and personal distress about the future and one's surroundings, the latter is related to moral sense and ethical feeling. We agree with Cloninger et al. that item selection of personality assessment should be primarily founded on *meaning* of the personality concept. Our results, however, indicate that a few subscales of the TCI should be reconsidered in its reference to higher-order factors.

Second, ST was interpreted as one-factor. This factor refers generally to identification with everything conceived as essential and consequential parts of a unitive perspective, involving frequent meditation and spiritual prayer to an immanent God as one-in-all (Cloninger et al., 1993). This concept is based on Christianity, which is so common in the beliefs and practices of Western nations that Western customs, habits and ethical principles are often related to divine will. In Japan, however, there are not one but many deities; there is no single sacred book (like the Bible), but religious scriptures. In Japan, a person usually participates in more than one religious tradition and ethical codes are more closely related to family life and philosophy than to organized religion. We thus suggest that it is difficult for Japanese subjects to consider that the power of God controls them. Future research is required to investigate the ST scale structure in terms of cultural differences between Japan and Western countries.

Finally, we confirmed that RD may be composed of three subscales that are interrelated but different from each other on an item-based level, based on factorial considerations with confirmatory factor analysis. Given this unique factor structure, a foreseeable extension of this study would be to examine the presence of RD and its subscales using the biological and possibly psychosocial markers. Specifically, it is indispensable to investigate the links between each RD subscale (RD1, RD2 and RD3) and neurochemical markers such as MHPG, a metabolic end-product of norepinephrine.

We must pay attention to two methodological drawbacks. First, our subjects were selected without randomization. Second, we cannot decide whether our results are generalized as in other samples such as clinical cases and female subjects. The subjects were ex-members of JARE, who had participated in research at the South Pole for one year. For a thorough understanding these results should be replicated with a randomized population. Are our results specific to these subjects? If the stability of TCI factors had not been supported, then, these factors would not have been replicated in statistical analyses. The factorial stability of the TCI in this study may suggest psychometrical availability of Cloninger's theory, though the subjects were not randomized in the present study.

In conclusion, the results of this study, though provisional, replicated the scale construction of the TCI, as well as the reliability of the assessment. We hope that psychologists, psychiatrists, biologists, neurophysiologists and other collaborative scholars will conduct empirical studies with the TCI based on an interdisciplinary approach to psychobiological theory of personality. Despite some revisions necessary to improve the goodness-of-fit statistics for the TCI scales, we, nonetheless, hope that the TCI will, after revisions to fit international comparison studies, continue to be employed as an assessment device for both normal and abnormal personality in psychology, psychiatry and various relevant areas. Validity of a personality measure is partly supported by finding out about its factor structure but also by the scales' relationships with biological, psychological and social correlates. Because factor structure does not necessarily reflect underlying biological or psychological mechanisms, revisions of the measure should be bilateral. We do not recommend a fundamental departure from Cloninger's TCI theory, but an accumulation of evidence may justify a substantial revision or rewriting of the theory in future. For the time being, however, the revision that we suggested for some TCI items should be tested in terms of different types of validity indices.

Acknowledgements

This research was carried out as a part of "Space Utilization Frontiers Joint Research Projects". We are deeply indebted to Professor Takeo Hirasawa at National Institute of Polar Research, Japan and to the ex-members in JARE for their assistance in collecting the data.

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