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## Comparison of the construct validity of the Gray–Wilson Personality Questionnaire and the BIS/BAS scales

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### Abstract

345 subjects completed a translated, shortened version of the Gray–Wilson Personality Questionnaire (GWPQ), along with Russian versions of Carver and White's BIS/BAS scales, the Eysenck Personality Profiler, the Eysenck Personality Questionnaire, and Spielberger's State-Trait Anxiety Inventory. Exploratory factor analysis of GWPQ items pointed to a three-factor solution and three new scales were created which demonstrated adequate psychometric characteristics. Confirmatory factor analysis of the BIS/BAS scales showed that a four-factor model best fitted the data but the three BAS subscales should be treated as sub-factors of a second-order factor. Structural equation modelling showed that GWPQ scales generally explained Eysenck's dimensions better than BIS/BAS scales. The distinction between GWPQ and Carver and White's scales mainly concerned BAS measures. GWPQ BAS captured more of Psychoticism, whereas Carver and White's BAS captured more of Extraversion.

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### 1. Introduction

Gray's theory (Gray, 1970), now known as Reinforcement Sensitivity Theory (RST, Pickering et al., 1997), is a physiological model of personality. Gray proposed three major neuropsychological

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systems, the Behavioural Activation System (BAS), the Behavioural Inhibition System (BIS) and the Fight/Flight system (FFS). In a recent revision of Gray's theory, the FFS has been renamed the Fight–Flight–Freezing system, and mediates all aversive stimuli, conditioned and unconditioned. The BAS is also said to be sensitive to both conditioned and unconditioned appetitive stimuli. The BIS is activated only when "...the animal's primary purpose is to achieve some goal which requires it to move towards a source of danger" (Gray & McNaughton, 2000).

Gray (1970) argued that the interaction of the BIS and BAS underlies the Eysenck superfactors, Extraversion and Neuroticism, high BAS subjects being neurotic extraverts, and low BAS subjects stable introverts. In subsequent revisions of the Eysenck scales (Eysenck & Eysenck, 1975), Impulsivity shifts towards Psychoticism. Consequently, BAS reactivity is thought to be situated nearer to Psychoticism (Pickering & Gray, 1999).

Several BIS and BAS scales have been put forward, Carver and White's (1994) BIS/BAS scales being the most popular. Carver and White began with an analysis of Gray's theory but were uncertain as to what constituted the BAS, ending up with a split among three correlated sub-factors: "reward responsiveness", "drive" and "fun-seeking".

The Gray–Wilson Personality Questionnaire (GWPQ; Wilson, Barrett, & Gray, 1989) was devised to measure six animal learning paradigms upon which Gray's theory of personality is founded. These were: Approach and Active Avoidance (together said to comprise the BAS), Passive Avoidance and Extinction (comprising the BIS) and Fight and Flight (two components of FFS). Factor analyses in Britain (Wilson, Gray, & Barrett, 1990), Japan (Wilson, Barrett, & Iwawaki, 1995) and Russia (Slobodskaya, Safronova, Knyazev, & Wilson, 2001) only partly matched the six trait a priori structure of the GWPQ. More importantly, the hypothesised pairings of the six traits into three major systems was not supported. Approach was associated with Fight rather than Active Avoidance (indeed Approach was negatively related to Active Avoidance). Passive Avoidance was associated with Extinction, but equally so with Flight.

Because factor analysis of the GWPQ items pointed toward a two-factor solution (Slobodskaya et al., 2001; Wilson et al., 1990, 1995), Slobodskaya, Knyazev, Safronova, and Wilson (2003) developed a short-form in the Russian context (GWPQ-S). This collapsed the three main factors and six subscales down to just two major scales, Behavioural activation and Behavioural inhibition. Item reduction was based both on factor analysis and previously validated criteria (adolescent conduct and emotional problems). However, Nagy and Wilson (submitted for publication), utilizing item-level factor analysis, were able to reproduce the three-factor structure of the GWPQ, even though a second-order, scale-level factor analysis returned the two-factor solution. Therefore, a more scrupulous study of the GWPQ factor structure is needed.

The GWPQ shows cross-cultural stability of its constructs and gender differences (Corr, Kumari, & Wilson, 1997; Wilson et al., 1995) and predictive validity. GWPQ scales have been found to be good predictors of adolescents' psychopathology scores (Knyazev, Slobodskaya, Safronova, & Kinsht, 2002; Slobodskaya et al., 2001) and relate consistently with psychophysiological measures (Knyazev & Slobodskaya, 2003; Knyazev, Slobodskaya, & Wilson, 2002; Knyazev et al., 2003).

Why has the GWPQ, which was devised to model Gray's theoretical assumptions, failed to demonstrate the predicted relationships of its scales? Most GWPQ problems are linked with the BAS and FFS constructs. In particular, psychometric evidence queries the existence of FFS as a

unified dimension orthogonal to BIS and BAS. That might suggest that reactions to conditioned and unconditioned stimuli are not separable in human behaviour, which was actually assumed in the last modification of the Gray's theory (Gray & McNaughton, 2000). But in this modification, the FFS still represents a separate unified system assuming positive associations between Fight, Flight and Freezing and negligible associations with anxiety and impulsivity. Treating BIS and Flight as separate dimensions is partly based on the ethopharmacological evidence (Blanchard & Blanchard, 1989) showing that 'fear' and 'anxiety' can be separated in rats' behaviour. But while the Blanchards distinguish fear and anxiety by the presence or absence of a predator (cf. unconditioned vs conditioned stimuli), McNaughton and Gray (2000) see this as a special case of a more general principle: "Pure fear is held to control behaviour which allows an animal to leave a dangerous situation; and anxiety to control behaviour which allows an animal to enter a dangerous situation". Following this definition, a burglar would be anxious when entering a bank, but after the crime has been committed, anxiety would terminate and fear begin. Subsequent nightmares of being captured by the police would be classed as fear, not anxiety. Without getting further into debates about the precise distinction between anxiety and fear, there is little doubt that the two emotions are separable. For example, Kalin, Shelton, Davidson, and Kelley (2001) have shown that in rhesus monkeys an excitotoxic lesion of the amygdala results in dramatic attenuation of behavioural signs of fear with no noticeable impact on the behavioural correlates of the anxious endophenotype.

If fear and anxiety are accepted as distinct, and GWPQ Flight and Passive Avoidance scales taken as their valid measures, why then are they correlated? One possibility is that anxious individuals might tend to be more fearful. Developmental evidence confirms such a view. Kagan, Snidman, Zentner, and Peterson (1999) have shown that infants fearful at 4 months of age are more likely to become anxious children at 7.5 years. Moreover, children of parents with panic disorder (pathological hypersensitivity of the FFS according to Gray) have higher rates of behavioural inhibition.

In Gray's theory, Approach and Fight are regarded as separate orthogonal dimensions governed by different neurophysiological systems. The first equates with impulsivity, while the second may be defined as reactive aggressiveness. Reactive or impulsive aggression refers to emotionally charged responses to provocation characterized by loss of behavioural control. This suggests an association between reactive aggression and impulsivity. Berkowitz (1993) notes that reactive aggression often occurs in conjunction with anger and in response to the experience of negative affect, hence behavioural impulsivity, which according to Corr (2002) predisposes to negative emotions such as frustration and hostility, should also predispose to impulsive aggression. BAS (as measured by the BIS/BAS scales) is indeed associated with anger and physical aggression (Harmon-Jones, 2003).

According to Gray, the main FFS structure is the periaqueductal gray region (PAG) and its projections to the hypothalamus and amygdala. Defensive reactions mediated by the PAG depend upon the physical distance of an approaching predator. As the predator gets closer, the prey is likely to sequence its reactions beginning with flight, progressing to fight, and finally to playing dead (Blanchard & Blanchard, 1989). These PAG mechanisms are most ancient and primitive. Morphological data indicate that cells in this region are relatively cut off from direct exteroceptive sensory input, and are primarily responsive to somatosensory and visceral information such that, at its most primitive levels, defensive behaviour is based upon

stimuli actually touching the individual and requiring an immediate response (Bandler & Keay, 1996). The general trend of vertebrate neural evolution is away from specific, reflexive responses to immediate aversive stimuli toward internal mediation of organised responses for dealing with impending threats (Luu, Tucker, & Derryberry, 1998). This was achieved with the evolution of the diencephalon and telencephalon, which exert inhibitory control over the explosive tendencies of PAG. Therefore, in human behaviour, primitive defensive reactions mediated by PAG may appear only in somewhat pathological conditions and play little role in everyday life. Their appearance depends more on a failure of descending inhibitory connections than PAG activity. As Jackson (1958) famously noted: “The higher nervous arrangements inhibit (or control) the lower, and thus, when the higher are suddenly rendered functionless, the lower rise in activity.” Gray’s theory emphasizes motivational influences ascending from evolutionary “old” brainstem and limbic regions, perhaps underestimating the role of descending feedback projections that powerfully modulate motivational impulses. Individual differences in the activity of these (mostly inhibitory) projections no doubt contribute enormously to individual differences in human behaviour. Much evidence links impulsive, antisocial and psychopathic behaviours (BAS features in Gray’s theory) and impulsive aggression (fight) with deficient prefrontal cortex control (e.g., Fuster, 1997; Miller, 1992).

In summary, we doubt that fight/flight should be viewed as a united, separate construct. Rather, we suggest that aggressiveness is a facet of behavioural activation, whereas fear is a facet of behavioural inhibition.

This study examines relationships between different psychometric measures relevant to Gray’s theory. We examine GWPQ properties with both exploratory and confirmatory factor analysis (CFA). We consider whether a two- or three-factor structure is more appropriate and inspect the content of the resulting factors. We also examine the construct validity of Carver and White’s (1994) BIS/BAS scales in the Russian context. Finally, we examine the convergent validities of the BIS/BAS and GWPQ scales and test their overlap with Eysenck’s dimensions.

## **2. Method**

The sample comprised 345 subjects (93 males, 252 females). Their ages ranged from 14 to 65, with a mean of 20.0 years ( $SD = 5.5$ ), distributions being similar for males and females. They were recruited via students of Novosibirsk University, who were asked to complete the questionnaires themselves and to distribute them among the family members and friends. 2% were school students, 6% had completed school or professional college, 58% were university students, and 34% had university degrees.

Instruments used were the Russian short-form of the GWPQ (96 items) (Slobodskaya et al., 2001), BIS/BAS scales (Carver & White, 1994), translated into Russian by the first two authors, the EPP-S (Eysenck, Wilson, & Jackson, 2000; Knyazev, Belopolsky, Bodunov, & Wilson, in press), the Spielberger State-Trait Anxiety Inventory (STAI; Hanin, 1989; Spielberger, Gorsuch, & Lushene, 1970) and the EPQ (Hanin, Eysenck, Eysenck, & Barrett, 1991).

CFAs were performed using LISREL 8.53 (Joreskog & Sorbom, 1996) and Mx (Neale, Boker, Xie, & Maes, 2002). The two programs yielded similar results (see details below).

### 3. Results

Cronbach  $\alpha$ s for the GWPQ scales were 0.56, 0.33, 0.63, 0.61, 0.61, and 0.71 for AP, AA, PA, EX, FI, and FL respectively, which are low by usual standards. The scree plot for a principal component analysis of 96 items revealed that a two-factor solution best fitted the data, although three or even four-factor solutions could be advocated. Eigenvalues for the first 10 principal components were: 7.34, 5.66, 3.35, 2.87, 2.35, 2.28, 2.17, 2.09, 2.04, 1.97. Another way of comparing different solutions is the Maximum Likelihood (ML) method. We used the ratio  $\Delta\chi^2/df$  to evaluate the change in model fit (Bollen, 1989), where  $\Delta\chi^2$  is the  $\chi^2$  difference between two solutions and  $df$  is the difference in degrees of freedom. Comparing a two-factor solution with a one-factor solution yielded  $\Delta\chi^2/df = 9.13$ . Further increases of factor numbers produced indices of 4.31, 3.26, 2.41, 2.33, and 2.29 for three-, four-, five-, six-, and seven-factor solutions respectively. This measure, then, supports a two-factor solution.

A Principal Components analysis with direct oblimin rotation was then performed, taking the first six factors. Inspection of loadings showed that all factors comprised mixtures of the six a priori GWPQ scales. Moreover, analysis of item–total correlations revealed that many items had low or negative correlations with the purported scales. Therefore, following Jackson's (2003) suggestion, the six scales were shortened to eight items each, eliminating those with low item–total correlations. Cronbach  $\alpha$ s of resulting scales were 0.60, 0.48, 0.67, 0.64, 0.67, and 0.70 for AP, AA, PA, EX, FI, and FL respectively, which is acceptable for such short scales. Correlations of the new scales with the full GWPQ scales were 0.86, 0.76, 0.87, 0.87, 0.89, and 0.90 for AP, AA, PA, EX, FI, and FL respectively. Principal Components analysis with direct oblimin rotation of the 48 items was then performed. Eigenvalues of the first seven principal components were 5.30, 3.79, 2.60, 1.99, 1.66, 1.64, and 1.49. The  $\Delta\chi^2/df$  indices for the ML analyses were 10.27, 12.58, 3.58, 3.04, 2.52, and 2.26 for two-, three-, four-, five-, six-, and seven-factor solutions respectively. Thus, for the selected 48 items optimally representing the six a priori GWPQ scales, a three-factor solution fitted best.

A three-factor solution was therefore chosen and three new scales of 12 items each were created (Table 1). The first comprised 4 PA items, 4 FL items, 2 EX items, and 2 FI items of the original GWPQ (Cronbach  $\alpha = 0.79$ ) and could reasonably be identified as the BIS. The second scale (Fight) comprised 7 FI items, 1 AP item and 4 AA items of the original GWPQ ( $\alpha = 0.71$ ). The third scale (Approach) comprised 6 AP items, 2 AA items, 1 EX item, 2 FI items, and 1 FL item of the original GWPQ ( $\alpha = 0.67$ ).

With respect to the relationship between the second and the third scales, three alternative hypotheses could be specified. First, given the previous literature on GWPQ factor structure, the two scales might actually represent just one dimension. Second, following Gray's original theory, these two scales could represent two independent dimensions (BAS and FFS). Finally, these scales could form a second-order factor, i.e., represent subscales of the BAS. In that case, they would be correlated.

Using structural equation modelling via LISREL, we tested the fit of the three potential models of the GWPQ structure. To reduce instability associated with the use of individual items, we followed a procedure suggested by Floyd and Widaman (1995), dividing items in each scale into two item parcels. The item with the highest factor loading in the first-order factor analysis was assigned to parcel 1, the two following items were assigned to parcel 2, the two following to parcel

Table 1

Resulting three-factor solution of the key items of the Russian GWPQ (loadings &gt; 0.30)

	BIS	Fight	Approach
Easily embarrassed (PA+)	0.63		
Fall to pieces if criticised (PA+)	0.62		
Remain placid and calm if events go against one (FI-)	-0.60		
Hand over valuables to mugger (FL+)	0.56		
Avoid contest if loss probable (EX+)	0.56		
Would run from hooligans (FL+)	0.56		
Lost for words in public speech (PA+)	0.51		
Yelp with pain if hurt (FL+)	0.51		
Glad playing with a stronger rival (EX-)	-0.49		
Would panic in an earthquake (FL+)	0.48		
Would call police if suspect robbers in house (FI-)	0.47		
Would avoid sight of blood (PA+)	0.46		
Have felt like killing someone (FI+)		0.57	
Would hit someone back (FI+)		0.56	
Would not hit someone back (FI-)		-0.55	
Curse audibly if things go wrong (FI+)		0.54	
Lie to avoid trouble (AA+)		0.50	
Do not lie to avoid trouble (AA-)		-0.48	
Liable to weaknesses (AP+)		0.46	
Murder never contemplated (FI-)		-0.45	
Redouble efforts if teacher not pleased (AA+)		-0.45	
Involved in fights with other children (FI+)		0.43	
Endeavour to do all homework (AA+)		-0.41	
Would kick an aggressive dog (FI+)		0.40	
Inclined to buy things impulsively (AP+)			0.54
Do not clean teeth regularly (AA-)			0.52
Neglect safety (AA-)			0.49
Get excited in anticipation when opening presents (AP+)			0.48
Think carefully before buying (AP-)			-0.47
Get into debt if easily (AP+)		0.34	0.45
Carry on playing though losing (EX-)			0.45
Would not pass up a favourite food even if not hungry (AP+)	0.31		0.42
Flinch with injection (FL+)			0.42
Would talk louder with a sore throat (FI+)			0.40
Blame other people if injured (FI+)			0.39
At theatre, agitated waiting for start (AP+)			0.33

1, and so on. The two unstandardized factor loadings of the two item parcels assigned to one scale were constrained to be equal. The model fit was assessed using two indices:  $\chi^2$ -value and RMSEA. According to Neale et al. (2002), the RMSEA for a very good fit should be 0.05 or less, and for a good fit between 0.05 and 0.10. We also used three relative fit statistics, the Bentler Bonett or Normed Fit Index (NFI), the Tucker Lewis Index or Non-normed Fit Index (NNFI) and the Bentler Comparative Fit Index (CFI). Their values above 0.90 are considered a good fit (Bentler & Bonett, 1980).

In the two-factor model, BIS and BAS were specified as different latent constructs with BAS loading on all eight parcels representing Fight and Approach scales. In the first three-factor

model, Fight and Approach were specified as independent latent constructs. In the second three-factor model, BIS, Fight and Approach were allowed to correlate. The CFA results showed that the two-factor model fitted rather poorly ( $\chi^2 = 72.65$ ,  $df = 11$ ,  $P = 0.000$ ,  $RMSEA = 0.139$ ,  $CFI = 0.77$ ,  $NFI = 0.75$ ,  $NNFI = 0.69$ ). For the uncorrelated three-factor model the indices of fit were:  $\chi^2 = 44.31$ ,  $df = 12$ ,  $P = 0.000$ ,  $RMSEA = 0.092$ ,  $CFI = 0.90$ ,  $NFI = 0.87$ ,  $NNFI = 0.88$ . When the three factors were allowed to correlate, goodness of fit improved significantly:  $\chi^2 = 25.01$ ,  $df = 9$ ,  $P = 0.003$ ,  $RMSEA = 0.078$ ,  $CFI = 0.95$ ,  $NFI = 0.92$ ,  $NNFI = 0.92$ . The correlations of BIS with Fight and Approach were not significant, while Approach and Fight were positively related (Fig. 1).

In addition, we performed a CFA using the covariance matrix of only Fight and Approach parcels. Two alternative models were specified: one with Fight and Approach as independent factors and another with these factors related. The model with unrelated Fight and Approach fitted significantly worse ( $\chi^2 = 16.44$ ,  $df = 4$ ,  $P = 0.002$ ,  $RMSEA = 0.099$ ,  $CFI = 0.93$ ,  $NFI = 0.92$ ,  $NNFI = 0.90$ ) than a relaxed model, where Fight and Approach were allowed to correlate ( $\chi^2 = 3.88$ ,  $df = 3$ ,  $P = 0.274$ ,  $RMSEA = 0.030$ ,  $CFI = 1.00$ ,  $NFI = 0.98$ ,  $NNFI = 0.99$ ).

Next, the properties of the Russian BAS/BIS scales were analysed. Principal Components analysis of the 20 items with direct oblimin rotation of the first four factors was performed. Inspection of item loadings showed that six items had to be rejected because they showed substantial loadings on the “wrong” scales. The scree plot for a Principal Components analysis of the remaining 14 items favoured a four-factor solution (eigenvalues for the first six principal components being 2.79, 1.96, 1.33, 1.04, 0.90, and 0.88). The order of the first four factors corresponded to (1) BIS, (2) BAS Drive (BASD), (3) BAS Reward (BASR), and (4) BAS Fun-Seeking (BASFun). The four-factor solution explained 50.8% of the variance (Table 2). When a cutscore of 0.40 was set as criterion, all items loaded on their respective scales.  $\alpha$ s for the scales were 0.71 for BIS (6 items), 0.65 for BASD (3 items), 0.40 for BASR (3 items), and 0.37 for BASFun (2 items).

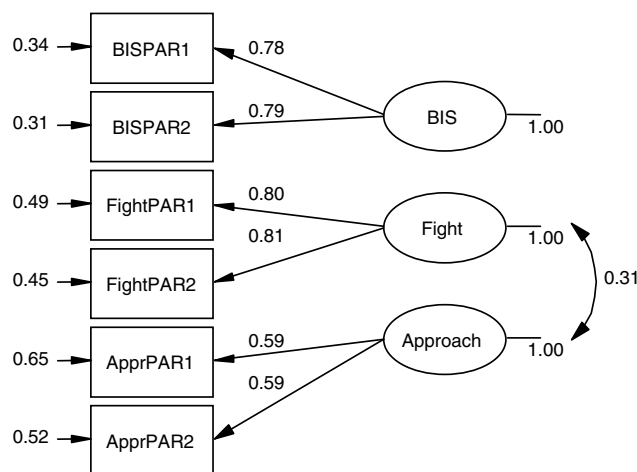


Fig. 1. Structural equation model of Russian GWPQ structure. Standardized solution.  $\chi^2 = 25.01$ ,  $df = 9$ ,  $P$ -value = 0.00296,  $RMSEA = 0.078$ .

Table 2

Resulting four-factor solution of the Russian BIS/BAS scales (Carver &amp; White, 1994) (loadings &gt; 0.30)

	BIS	BASD	BASR	BASFun
Criticism or scolding hurts me quite a bit	0.68			
I feel pretty worried or upset when I think or know somebody is angry at me	0.70			
If I think something unpleasant is going to happen I usually get pretty “worked up”	0.65			
I feel worried when I think I have done poorly at something	0.61			
I have very few fears compared to my friends	-0.53			
I worry about making mistakes	0.62			
When I want something, I usually go all-out to get it		0.80		
I go out of my way to get things I want		0.81		
If I see a chance to get something I want, I move on it right away		0.63		
When I am doing well at something, I love to keep at it			0.79	
When I get something I want, I feel excited and energized			0.54	
When good things happen to me, it affects me strongly			0.51	
I will often do things for no other reason than that they might be fun				0.70
I often act on the spur of the moment				0.79

We then tested the fit of the two- and four-factor models of the BIS/BAS scales using the Mx statistical package. Because only a small number of items remained in the BAS subscales, we did not make item parcels but used a covariance matrix of individual items in the analyses. In the two-factor model, BIS and BAS were specified as latent constructs, with all 8 items from the BASD, BASFun and BASR subscales loaded on the BAS. A four-factor model comprised BIS, BASD, BASFun and BASR as separate factors. In both models, factors were permitted to intercorrelate. The four-factor solution was significantly better ( $\chi^2 = 116.80$ ,  $df = 71$ ,  $RMSEA = 0.043$ ,  $CFI = 0.94$ ,  $NFI = 0.90$ ,  $NNFI = 0.92$ ) than the two-factor solution ( $\chi^2 = 174.69$ ,  $df = 76$ ,  $RMSEA = 0.062$ ,  $CFI = 0.87$ ,  $NFI = 0.80$ ,  $NNFI = 0.83$ ). In the two-factor model, the BIS/BAS correlation was significant ( $r = 0.18$ ,  $P < 0.05$ ). In the four-factor model, BIS related to BASR ( $r = 0.53$ ,  $P < 0.001$ ), but not BASFun and BASD. All three BAS subscales were intercorrelated.

The most important question was whether BAS subscales should be regarded as independent dimensions or could be used as a summed index of BAS. To answer this, we did an additional CFA using LISREL with the covariance matrix of BAS items. Two models were tested: one with BASD, BASFun and BASR uncorrelated, and the other with BASD, BASFun and BASR treated as related factors. The first showed poor fit ( $\chi^2 = 63.61$ ,  $df = 21$ ,  $P = 0.000$ ,  $RMSEA = 0.077$ ,  $CFI = 0.85$ ,  $NFI = 0.80$ ,  $NNFI = 0.80$ ), while relaxed model fitted much better—the discrepancy  $\chi^2$  being non-significant ( $\chi^2 = 26.5$ ,  $df = 17$ ,  $P = 0.066$ ,  $RMSEA = 0.040$ ,  $CFI = 0.97$ ,  $NFI = 0.92$ ,  $NNFI = 0.94$ , Fig. 2).

Table 3 shows means, SDs and  $\alpha$ s for all measures. Allowing for number of items, the new GWPQ scales, Russian BIS/BAS scales and shortened original GWPQ scales showed adequate reliabilities. Cross-correlations of all measures are shown in Table 4. The two BIS measures showed a moderate correlation, while the correlation of summed BAS measures was rather weak.

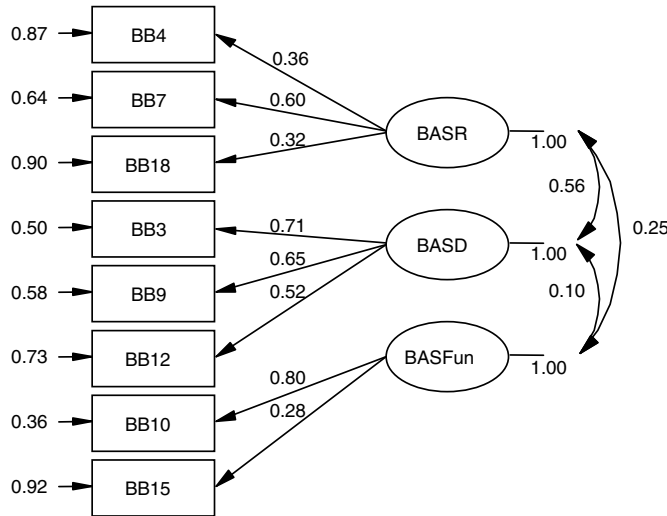


Fig. 2. Structural equation model of the Carver and White’s BAS structure. Standardized solution.  $\chi^2 = 26.50$ ,  $df = 17$ ,  $P$ -value = 0.06575, RMSEA = 0.040.

Trait Anxiety (STAI) correlated with GWPQ BIS, Carver and White’s BIS and Passive Avoidance. The corresponding correlations with EPP Anxiety were similar but somewhat lower. EPP Impulsivity correlated with GWPQ BAS, Fight, Approach, Carver and White’s BAS, Fun Seeking, and AP. Correlations of psychometric measures with demographic variables were consistent with previous findings. Females were higher than males on both BIS measures, both anxiety measures, PA, EX, FL, and Neuroticism. They were also higher on Reward sensitivity, Approach and Impulsivity. Males were higher on Fight, FI and Psychoticism. Age was negatively related to Fight, Drive, FI, Impulsivity, and E.

Then we performed a second-order Principal Components analysis with varimax rotation of the new GWPQ, Carver and White’s, Trait Anxiety (STAI), EPP, and EPQ scales. Three factors with eigenvalues greater than one together explained 58.3% of variance (Table 5). These corresponded to the three Eysenck dimensions. As expected, BIS measures, Trait Anxiety (STAI) and EPP Anxiety loaded on Neuroticism. BAS measures loaded on different factors: Approach, Fight and Fun Seeking went with Psychoticism and Impulsivity, while Drive and Reward went with Extraversion.

Next, we tested whether Gray’s constructs could be viewed as basic to “surface” personality dimensions (Jackson, 2002; Matthews & Gilliland, 1999) represented by EPQ scales. Structural equation modelling was performed using LISREL with the new GWPQ, Carver and White’s or shortened original GWPQ scales specified as exogenous independent variables and EPQ scales as endogenous dependent variables.

First, GWPQ BAS and BIS scales were used to predict Extraversion, Neuroticism and Psychoticism. According to Gray’s original theory, both BIS and BAS relate to both Extraversion and Neuroticism, while FFS underlies Psychoticism. Therefore, causal paths from all BIS and BAS measures to all Eysenck dimensions were specified in the initial model but only significant paths were retained. This model showed good fit, the discrepancy  $\chi^2$  being non-significant

Table 3

Means, standard deviations and  $\alpha$ s of all measures

	Number of items	$\alpha$	Mean	SD
BIS <sup>a</sup>	12	0.79	11.64	5.70
Fight <sup>a</sup>	12	0.71	13.95	5.12
Approach <sup>a</sup>	12	0.67	6.18	4.47
BAS <sup>a</sup>	24	0.73	20.13	7.44
BIS <sup>b</sup>	6	0.71	11.10	3.49
Drive <sup>b</sup>	3	0.65	6.7	1.77
Fun <sup>b</sup>	2	0.37	3.24	1.52
Reward <sup>b</sup>	3	0.40	7.75	1.30
BAS <sup>b</sup>	8	0.53	19.09	3.54
AP <sup>c</sup>	8	0.60	6.85	3.65
AA <sup>c</sup>	8	0.48	10.35	3.36
PA <sup>c</sup>	8	0.67	8.25	3.91
EX <sup>c</sup>	8	0.64	8.83	3.76
FI <sup>c</sup>	8	0.67	9.19	3.74
FL <sup>c</sup>	8	0.70	8.56	3.72
TA	20	0.86	41.83	9.91
Anxiety <sup>d</sup>	13	0.82	12.48	6.59
Impulsivity <sup>d</sup>	16	0.79	12.28	6.89
E <sup>e</sup>	19	0.83	14.22	3.86
N <sup>e</sup>	19	0.83	8.73	4.48
P <sup>e</sup>	17	0.52	3.71	2.25
L <sup>e</sup>	20	0.84	7.16	4.53

<sup>a</sup> New GWPQ.<sup>b</sup> Carver and White.<sup>c</sup> Shortened original GWPQ.<sup>d</sup> EPP.<sup>e</sup> EPQ; TA—Trait Anxiety (STAI).

( $\chi^2 = 7.12$ ,  $df = 4$ ,  $P = 0.130$ ,  $RMSEA = 0.053$ ,  $CFI = 0.98$ ,  $NFI = 0.96$ ,  $NNFI = 0.96$ ). According to estimated residual variances, this model explained 30% of Neuroticism, 28% of Psychoticism, and 7% of Extraversion. Neuroticism was mostly predicted by BIS ( $\beta$  weight = 0.46), but also by both BAS measures ( $\beta$  weights = 0.13 and 0.23 for Fight and Approach, respectively). In accord with Gray's theory, Extraversion was negatively related to BIS and positively to Fight, but both relations were rather weak ( $\beta$  weights = -0.19 and 0.18 respectively). Psychoticism was negatively related to BIS ( $\beta$  weight = -0.19) and positively related to both BAS subscales ( $\beta$  weights = 0.33 and 0.31 for Fight and Approach, respectively).

Secondly, Carver and White's scales were used to predict EPQ scores. The fit was reasonable ( $\chi^2 = 21.93$ ,  $df = 11$ ,  $P = 0.025$ ,  $RMSEA = 0.059$ ,  $CFI = 0.95$ ,  $NFI = 0.92$ ,  $NNFI = 0.91$ ). When error terms for Neuroticism and Psychoticism were allowed to covary, the  $\chi^2$  discrepancy of the model became non-significant. This model explained 30% of Neuroticism, 15% of Psychoticism, and 18% of Extraversion. According to parameter estimates, Neuroticism was predicted by BIS ( $\beta$  weight = 0.51) and Fun seeking ( $\beta$  weight = 0.17). Extraversion was negatively related to BIS ( $\beta$  weight = -0.28) and positively related to Drive ( $\beta$  weight = 0.30) and Fun Seeking ( $\beta$  weight =

Table 4  
Cross-correlations of all measures

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	
1. Sex (0 = M, 1 = F)	–																					
2. Age	–0.02	–																				
3. BIS <sup>a</sup>	0.37**	0.09	–																			
4. Fight <sup>a</sup>	–0.12*	–0.15*	–0.09	–																		
5. Approach <sup>a</sup>	0.07	–0.08	0.10	0.20**	–																	
6. BIS <sup>b</sup>	0.25**	0.06	0.53**	–0.21**	0.01	–																
7. Drive <sup>b</sup>	–0.05	–0.20**	–0.06	0.01	–0.03	0.05	–															
8. Fun <sup>b</sup>	0.02	–0.06	0.05	0.32**	0.28**	0.04	0.03	–														
9. Reward <sup>b</sup>	0.16**	–0.06	0.18**	–0.03	0.01	0.27**	0.29**	0.14*	–													
10. AP <sup>c</sup>	0.13*	–0.02	0.21**	0.36**	0.66**	0.05	–0.12*	0.27**	0.09	–												
11. AA <sup>c</sup>	0.05	0.09	0.05	–0.42**	–0.41**	0.17**	0.08	–0.29**	–0.06	–0.34**	–											
12. PA <sup>c</sup>	0.29**	0.08	0.82**	–0.08	0.04	0.55**	–0.08	0.07	0.22**	0.16**	0.06	–										
13. EX <sup>c</sup>	0.19**	0.09	0.57**	–0.10	–0.13*	0.35**	–0.11*	–0.05	0.03	0.00	0.06	0.50**	–									
14. FI <sup>c</sup>	–0.21**	–0.15**	–0.21**	0.88**	0.19**	–0.23-	0.05	0.22**	–0.07	0.23**	–0.26**	–0.18**	–0.19**	–								
15. FL <sup>c</sup>	0.34**	0.08	0.72**	0.06	0.12*	0.34**	–0.07	0.04	0.06	0.23**	0.01	0.51**	0.33**	–0.03	–							
16. TA	0.16**	0.09	0.56**	–0.06	0.13*	0.62**	–0.07	0.13*	0.19**	0.18**	–0.02	0.54**	0.39**	–0.11	0.28**	–						
17. Anxiety <sup>d</sup>	0.30**	0.02	0.47**	0.01	0.17**	0.57**	–0.01	0.15*	0.28**	0.21**	–0.07	0.44**	0.28**	–0.02	0.35**	0.66**	–					
18. Impuls <sup>d</sup>	0.10	–0.17**	0.10	0.26**	0.37**	–0.03	–0.14*	0.52**	0.08	0.37**	–0.38**	0.08	–0.07	0.15*	0.12	0.08	0.28**	–				
19. E <sup>c</sup>	0.09	–0.12*	–0.20**	0.20**	0.04	–0.25-	0.30**	0.15*	0.15*	0.03	–0.07	–0.24**	–0.30**	0.19**	0.02	–0.39**	–0.17**	0.17**	–			
20. N <sup>c</sup>	0.20**	–0.01	0.47**	0.13*	0.30**	0.52**	–0.04	0.18**	0.21**	0.30**	–0.20**	0.46**	0.26**	0.04	0.27**	0.71**	0.71**	0.26**	–0.20**	–		
21. P <sup>c</sup>	–0.19**	–0.08	–0.19**	0.40**	0.35**	–0.27-	0.00	0.25**	0.02	0.27**	–0.36**	–0.24**	–0.16**	0.36**	–0.13*	–0.09	–0.05	0.23**	0.12*	0.05	–	
22. L <sup>c</sup>	0.08	0.07	–0.12*	–0.60**	–0.23**	0.06	–0.01	–0.21**	–0.04	–0.34**	0.34**	–0.12*	0.02	–0.44**	–0.22**	–0.03	–0.04	–0.24**	–0.15**	–0.20**	–0.36**	

\*  $p < 0.05$  (2-tailed).

\*\*  $p < 0.01$  (2-tailed).

<sup>a</sup> New GWPQ.

<sup>b</sup> Carver and White.

<sup>c</sup> Original GWPQ.

<sup>d</sup> EPP.

<sup>e</sup> EPQ; TA—Trait Anxiety (STAI).

Table 5

Second-order factor analysis of all measures (loadings &gt;0.30). Varimax rotated component matrix

	Component		
	N	P	E
Trait Anxiety <sup>STAI</sup>	0.88		
Anxiety <sup>EPP</sup>	0.82		
N <sup>EPQ</sup>	0.80	0.30	
BIS <sup>CW</sup>	0.80		
BIS <sup>GWPQ</sup>	0.72		
Impulsivity <sup>EPP</sup>		0.71	
Fun Seeking <sup>CW</sup>		0.67	
p <sup>EPQ</sup>		0.65	
Fight <sup>GWPQ</sup>		0.65	
Approach <sup>GWPQ</sup>		0.64	
Drive <sup>CW</sup>			0.79
Reward <sup>CW</sup>	0.34		0.68
E <sup>EPQ</sup>	-0.39		0.60

0.13). Psychoticism was negatively related to BIS ( $\beta$  weight = -0.31) and positively related to Fun seeking ( $\beta$  weight = 0.24). Reward Responsiveness did not predict Eysenck dimensions.

Thirdly, shortened original GWPQ scales were used to predict EPQ Extraversion, Neuroticism and Psychoticism scale scores. The resulting model showed a good fit ( $\chi^2 = 14.78$ ,  $df = 11$ ,  $P = 0.193$ ,  $RMSEA = 0.035$ ,  $CFI = 0.99$ ,  $NFI = 0.97$ ,  $NNFI = 0.97$ ) and explained 29% of Neuroticism, 27% of Psychoticism, and 13% of Extraversion. According to parameter estimates, Neuroticism was predicted by PA ( $\beta$  weight = 0.45), AP ( $\beta$  weight = 0.15) and AA ( $\beta$  weight = -0.17). Extraversion was negatively related to PA ( $\beta$  weight = -0.22) and EX ( $\beta$  weight = -0.26) and positively related to FL ( $\beta$  weight = 0.21), Psychoticism was positively related to FI ( $\beta$  weight = 0.23) and AP ( $\beta$  weight = 0.19) and negatively to PA ( $\beta$  weight = -0.22) and AA ( $\beta$  weight = -0.23).

Finally, in order to compare the contribution of the two inventories, GWPQ and Carver and White's BAS and BIS scales were used together to predict EPQ scores. After removing non-significant paths, the resulting model (Fig. 3) showed good fit ( $\chi^2 = 26.15$ ,  $df = 14$ ,  $P = 0.025$ ,  $RMSEA = 0.055$ ,  $CFI = 0.98$ ,  $NFI = 0.96$ ,  $NNFI = 0.93$ ) and explained 43% of Neuroticism, 30% of Psychoticism and 18% of Extraversion. Neuroticism was predicted by both BIS measures ( $\beta$  weights = 0.43 and 0.23 for Carver and White's and GWPQ scales, respectively) and by both GWPQ BAS measures ( $\beta$  weights = 0.19 and 0.29 for Fight and Approach, respectively). Psychoticism was predicted by Carver and White's BIS ( $\beta$  weight = -0.25) and again by both GWPQ BAS measures ( $\beta$  weights = 0.30 and 0.24 for Fight and Approach, respectively). Extraversion was predicted by Carver and White's BIS ( $\beta$  weight = -0.31), BASD ( $\beta$  weight = 0.27) and BASR ( $\beta$  weight = 0.13). Fun Seeking did not predict anything.

#### 4. Discussion

In a recent GWPQ study using a sample of adolescents two short BAS and BIS scales were proposed (GWPQ-S, Slobodskaya et al., 2003). Item reduction was based partly on factor

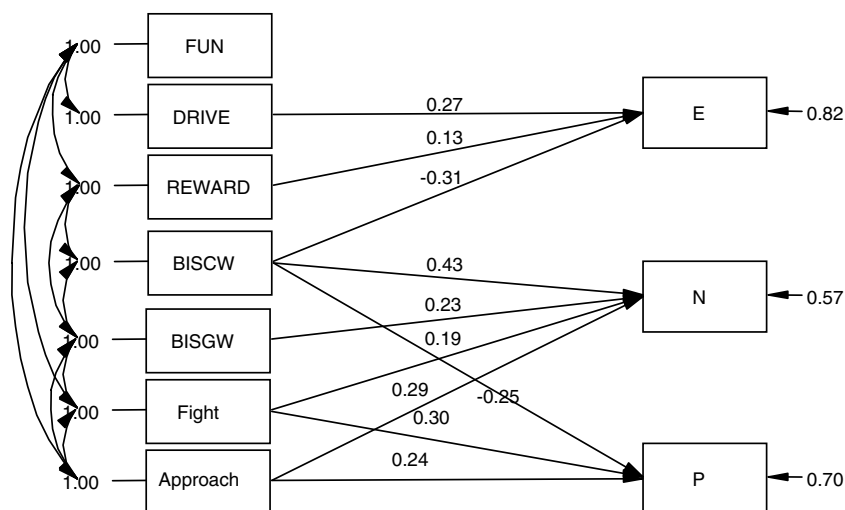


Fig. 3. Structural equation model of relationships between GWPQ and Carver and White's BIS and BAS scales and EPQ dimensions. Standardized solution.  $\chi^2 = 26.15$ ,  $df = 14$ ,  $P$ -value = 0.02474, RMSEA = 0.056.

analysis, which indicated a two-factor solution, and partly on external criteria (conduct and emotional problems). An additional restraint was that chosen items had to be balanced for the direction of scoring. In the present study, a three-factor solution was chosen. This decision was based on factor analysis of 48 items which best represented the initial scales. To compare the three new scales with the two previous scales, participants completed, in addition to other measures, the GWPQ-S. The GWPQ-S scales showed adequate reliabilities (0.70 for both scales) and strong correlations with the new GWPQ scales ( $r = 0.76$  and  $0.75$  for BIS and BAS, respectively), the GWPQ-S BAS correlated higher with Fight ( $r = 0.76$ ) than Approach ( $r = 0.38$ ).

Six shortened scales of the original GWPQ showed reasonable reliabilities, but their separation was not supported by factor analysis. Jackson (2003) attempted to extract six orthogonal GWPQ scales, but found only two solid factors, most loadings on the other four being  $<0.25$ . Jackson notes that it is difficult to separate Passive Avoidance and Extinction items from Flight items, and Approach items from Active Avoidance items. Therefore, GWPQ findings do not support the idea that fear and anxiety are separable. All items representing fear, anxiety and frustration, whether conditioned or unconditioned, form a clear unitary factor. That seems strange given the ethopharmacological evidence (Blanchard & Blanchard, 1989) and the effects of excitotoxic lesioning of the amygdala (Kalin et al., 2001). Perhaps self-report questionnaires artificially increase the association of fear and anxiety. Clearly, we cannot by this method observe actual reactions to unconditioned stimuli. The threatening situations described in questionnaire items do not amount to real threats, only imaginary ones. Anxious individuals might over-rate their fearful reactions to threatening stimuli in the self-report context, spuriously enhancing anxiety/fear correlations. Such an idea could only be tested by objective measurement of actual reactions to fear evoking stimuli.

The high correlations among all BIS and anxiety measures support homogeneity of this construct. BAS measures, however, are more problematic. The three-factor solution for the GWPQ items might at first seem to accord with the theoretical background of the questionnaire, the three factors corresponding to BIS, BAS and FFS, but detailed content analysis does not confirm this

interpretation. First, the Flight scale separated from Fight and went to the BIS. Second, CFA showed that Fight and Approach should be treated as subscales of a common factor (BAS). Therefore, a two-factor solution (Slobodskaya et al., 2003) is equally acceptable.

CFA suggests that Carver and White's BAS subscales underlie a second-order BAS construct and may legitimately be summed. The pattern of correlations of these scales with other measures corresponds to that previously found for the English version (Carver & White, 1994; Jackson & Smillie, *in press*), which confirms the validity of the translation.

Both anxiety measures showed moderate correlations with both BIS measures. These correlations were somewhat higher for Carver and White's BIS. EPP Impulsivity correlated most strongly with Fun Seeking, perhaps because the item "I often act on the spur of the moment" was present in both scales. Looking at total BAS measures, correlations with EPP Impulsivity were 0.21 and 0.41 for Carver and White's and GWPQ BAS, respectively. It may be concluded therefore, that the GWPQ scale is closer to the relevant proxy. Comparing the extent to which the three inventories based on Gray's theory explain Eysenckian personality space, it may be noted that Neuroticism was equally well explained by Carver and White's scales, the shortened original GWPQ scales, and the three new GWPQ scales. Psychoticism was better explained by the two GWPQ inventories, while Extraversion was better explained by Carver and White's scales. On the whole, Neuroticism was explained best and Extraversion worst. Global fit indices were better for models with GWPQ inventories, the two GWPQ versions explaining Eysenck dimensions almost equally well. For the model with Carver and White's scales, an exact fit was achieved only when error terms for Neuroticism and Psychoticism were allowed to covary. This means that part of the covariance of these dimensions remained unexplained in the model. Therefore, on the whole, the GWPQ conforms better to the theory underlying the EPQ than Carver and White's scales.

The difference between the GWPQ and Carver and White's questionnaire mainly concerns BAS measures. Second-order factor analysis showed that both GWPQ BAS subscales loaded on the Psychoticism factor, while Carver and White's BAS subscales loaded mostly on Extraversion. Only two items representing Fun Seeking went with Psychoticism. Structural equation modelling showed that GWPQ BAS captures more of Psychoticism, Carver and White's BAS captures more of Extraversion. This is consistent with Carver and White's (1994) data showing substantial correlations of their BAS subscales with Extraversion.

This difference may partly reflect the evolution of personality theory. At first, the BAS-dimension was located along the diagonal between Neuroticism and Extraversion, but in subsequent revisions of Eysenck's scales Impulsivity shifted nearer to Psychoticism. At the same time, starting from the EPQ (Eysenck & Eysenck, 1975), Extraversion was progressively conceptualised in terms of sociability, whereas sociability plays no obvious role in Gray's theory. Carver and White (1994) saw the BAS construct as conceptually different from Extraversion, yet their BAS overlaps considerably with Extraversion. This could be because, in constructing their BAS scale, they put an emphasis on positive emotionality. In their study, all three BAS subscales (especially Drive and Reward) showed substantial correlations with Positive Affectivity, as measured by PANAS. Indeed, in Gray's theory, the activity of reward systems, such as the BAS, should underpin positive affect and subjective energy, hence impulsivity should relate to positive emotions (Matthews & Gilliland, 1999).

However, Corr (2002) notes that impulsivity is characterized by intolerance of delayed reward and a high rate of temporal discounting, both of which connect with negative emotions such as

frustration and hostility. This would explain why individuals with a putatively hyperactive BAS (attention-deficit/hyperactive children and aggressive criminals) so often display negative emotions. The association of impulsivity and antisocial behaviour could result from this vulnerability to frustration. By contrast, Extraversion is clearly characterized by positive emotionality (Matthews & Gilliland, 1999).

As measured by the GWPQ, BAS is situated between Neuroticism and Psychoticism (Fig. 3). This might explain an apparent contradiction between the EPP and the NEO-PI, which locate Impulsivity toward Psychoticism and Neuroticism dimensions respectively. To clarify the content of the two new GWPQ BAS measures, we performed a backward regression analysis with the EPP and EPQ scales entered as predictors and the two GWPQ BAS measures as criteria. EPQ L ( $\beta = -0.48$ ), Risk Taking ( $\beta = 0.18$ ), Psychoticism ( $\beta = 0.14$ ), Assertiveness ( $\beta = 0.16$ ), and Activity ( $\beta = -0.14$ ) together predicted 45% of Fight variability, while 26% of Approach variability was predicted by Impulsivity ( $\beta = 0.25$ ), Psychoticism ( $\beta = 0.27$ ), and Neuroticism ( $\beta = 0.23$ ). It thus seems that Approach captures a less malignant aspect of Impulsivity, nearer to Neuroticism, and perhaps more like that measured by the NEO-PI (Costa & McCrae, 1992). According to Davidson (2002), anxiety depends on an interplay between the amygdala and medial prefrontal cortex. The latter exerts an inhibitory influence over the amygdala, which represents an active component of extinction. In the absence of this inhibitory input, the unchecked amygdala maintains the learned aversive response. Diminished prefrontal function may be common to some aspects of anxiety and impulsivity, underlying their positive association. The main predictor of the Fight is a lack of social conformity, accounting for 36% of its variability. We recently found that the GWPQ-S BAS (which mainly reflects the Fight component) is a potent predictor of substance use (Knyazev, in press; Knyazev, Slobodskaya, Kharchenko, & Wilson, in press).

Inspection of the Fight and Approach scale items reveals that Fight mainly concerns hostility and aggression (“Have felt like killing someone”) and lack of conscientiousness (“Fail to do homework”) and correlates more with Psychoticism. Approach, on the other hand, includes items describing pure impulsivity (“Inclined to buy things impulsively”) and nonchalance (“Neglect safety”) and correlates more with Impulsivity. Hence Approach, with lack of behavioural control as its main feature, might connect with diminished prefrontal function (Fallgatter & Herrmann, 2001) and the Big Five’s Impulsivity, located within the Neuroticism dimension. Fight, however, appears to be part of the Psychoticism dimension, which has been viewed by Eysenck (1992) as the opposite pole of Big Five Agreeableness and Conscientiousness. The neuropsychological basis of this might be in the functioning of the dopaminergic reward system (Robbins & Everitt, 1996). Gray’s theory assumes higher dopaminergic activity in impulsive individuals (Gray & McNaughton, 2000). To the contrary, Cloninger (1988) suggested that novelty seeking, which closely resembles the BAS, is associated with low basal dopaminergic activity (hence postsynaptic supersensitivity), implying lower hedonic tone in persons who are high on this dimension. Similarly, Comings and Blum (2000) have proposed that defects in various combinations of the genes for “reward” neurotransmitters, primarily (but not exclusively) dopamine, result in a Reward Deficiency Syndrome with consequent risk of drug abuse. A lack of positive reinforcement in everyday life could yield hostility and a craving for excitement (thus behavioural activation), whereas an excess of positive emotions should reduce an individual’s thrill-seeking. Yet there are psychophysiological indications that high BAS is associated with negative emotions (Knyazev et al., 2002). Although the two kinds of behavioural activation are distinguishable, our findings

confirm that they should be regarded as facets of the BAS rather than independent factors. Their common base might be prefrontal regulation, since aggression, anger, and impulsivity are all associated with impaired prefrontal function (Lishman, 1995).

Among Carver and White's BAS subscales, only Fun Seeking is related to GWPQ BAS measures. Only this subscale correlates with Psychoticism and particularly with EPP Impulsivity. The other two subscales are mainly related to Extraversion, and could be considered as proxies of Dickman's (1990) Functional Impulsivity. This dimension refers to individual differences in appropriate spontaneity ("seizing the moment"), as opposed to the more widely used construct of impulsivity focusing on potentially problematic disinhibition, which Dickman terms Dysfunctional impulsivity. Jackson and Smillie (in press) have shown that Functional Impulsivity is related to all of Carver and White's BAS subscales and most strongly (0.54) to BASD. They have also shown that Functional Impulsivity, along with Carver and White's BASD and BASR, is positively correlated with the NEO-PI Conscientiousness, while EPP Impulsivity and Dickman's Dysfunctional impulsivity are negatively correlated with this scale. Therefore, Functional Impulsivity, along with Carver and White's BASD and BASR, could be considered as yet another facet of impulsivity (and BAS) mostly related to Extraversion. However, it is questionable whether this facet concerns true impulsivity or just combines assertiveness (correlations of BASD with EPP Assertiveness were 0.40 in our sample and 0.46 in Jackson and Smillie's study), positive emotionality and ability to act quickly.

One limitation of this study is that it uses translated inventories, in a cultural context other than that in which these inventories were developed. Nevertheless, the pattern of correlations among the various scales is very similar to that found in US and UK samples, which inclines us to think that the translated scales measure similar constructs.

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