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Determination of Emotional Endophenotypes: A Validation of the Affective Neuroscience Personality Scales and Further Perspectives

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The study of endophenotypes, notably with configured self-reports, represents a promising research pathway to overcome the limits of a syndromal approach of psychiatric diseases. The Affective Neuroscience Personality Scales (ANPS) is a self-report questionnaire, based on neuroethological considerations, that could help to assess emotional endophenotypes related to the activity in 6 core cerebral emotional systems (FEAR, ANGER, SADNESS, CARING, PLAYFULNESS, SEEKING). We further investigated its psychometric properties among 830 young adults and showed that they were satisfactory. As participants also completed several other self-reports that shared potential traits with the ANPS, we offer new validity evidence based on relations to other variables. We also provide additional evidence to consider that the ANPS scores can be validly interpreted for the characterization of emotional endophenotypes involved in a variety of psychiatric disorders. On the grounds of present results, of previous clinical studies, as well as some preliminary neuroimaging findings, we discuss new steps in the ANPS validation.

Keywords: emotion, endophenotypes, personality, validation

Currently, there is a consensus to consider that a major limit in the study of the physiopathology of psychiatric diseases may stem from their phenotypic heterogeneity and instability (i.e., state dependent). Moreover, recent advances, in particular in affective neuroscience, suggest that comorbid disorders share common biological substrates. Consequently, there is a debate on the relevancy of the classification of psychiatric diseases on the basis of overt phenotypes or syndromic behaviors, which uses diagnostic systems that are not based on the underlying neurobiology of psychiatric disorders (*International Classification of Diseases* and *Diagnostic and Statistical Manual of Mental Disorders* classifications; Abou-Saleh, 2006; Davidson, 2004; Gould & Gottesman, 2006; Halligan & David, 2001; Panksepp, 2006; Savitz & Drevets, 2009). For instance, with respect to anxiety, social phobia (Axis I) is quite similar to avoidant personality disorder (Axis II); both are highly comorbid and share psychological as well as biological processes pertaining to emotional regulatory functions (Siever & Weinstein, 2009; Stein & Stein, 2008). Hence, it has been suggested that diagnoses informed by intermediate markers of brain dysfunction may account for developmental continuities and associations between Axis I and Axis II disorders (Davidson, 2001; Goodman, New, Triebwasser, Collins, & Siever, 2010; Markon, 2010).

To better understand the etiology of psychiatric disorders, one strategy—which circumvents the heterogeneity and comorbidity issues raised by their syndromal approach—is to study endophenotypes, that is, "measurable components unseen by the unaided eye along the pathway between disease and distal genotype" (Gottesman & Gould, 2003, p. 636). These "components" or endophenotypes involve biological (e.g., brain morphological or functional changes), cognitive (e.g., attentional bias), or psychological markers, including configured self-report data (e.g., temperamental negative affectivity). For instance, temperamental neg-

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ative affectivity (i.e., anxiety scores measured by self-reports) has been associated with an hypervigilance toward threatening stimuli (i.e., an attentional bias) and an amygdala hyperactivity (i.e., an abnormal brain functional pattern of response); at the genetic level, these endophenotypes have been related to the short allele of the serotonin transporter gene (Brown & Hariri, 2006; Roozendaal, McEwen, & Chattarji, 2009).

Identification of endophenotypes could contribute to both fundamental and applied knowledge of mental illnesses. First, endophenotypes may enhance the understanding of the underlying mechanisms of mental illnesses by reducing the gap between genes and behavior through the study of neural circuits and neurochemistries (Doyle et al., 2005; Goodman et al., 2010; Gould & Gottesman, 2006; Mitterschiffthaler, Ettinger, Mehta, Mataix-Cols, & Williams, 2006; Pearlson & Calhoun, 2007; Savitz & Drevets, 2009). Second, endophenotypes could help increase the effectiveness of therapeutic practices, both psychological and somatic, by setting up tailored therapeutic approaches focusing on the impaired skills (Siever & Weinstein, 2009; Treasure, 2007).

An Evolutionary and Brain-Based Approach of Personality

Along this line of research, some researchers have emphasized that the more tightly a function is linked to brain systems and genetic underpinnings, the more likely it is to be a useful endophenotype for psychiatrically relevant science (Davis, Panksepp, & Normansell, 2003; Gould & Gottesman, 2006; Panksepp, 2006, p. 776; Savitz & Drevets, 2009). They proposed a neuroethological approach to identify emotional endophenotypes. This model is based on the animal and human research showing that emotional experiences and reactions are strongly linked to specific functional neural circuits, homologous in all mammalians (Panksepp, 1998, Panksepp, 2005, Panksepp, 2006). It posits that dispositional socioaffective skills are linked to the neurodynamics of these core cerebral emotional systems and that their excessive or imbalanced activities may be critical in engendering significant psychiatric distress, notably personality disorders (Davis et al., 2003; Panksepp, 2006; Panksepp & Biven, 2011). This conceptualization is of particular interest, as recent neuroimaging studies tend to go beyond a simple association between one deficit, one trait, and one structure. Instead, they rather increasingly take into account the connectivity characteristics of functional networks and how they interact to produce emotional behaviors (Phillips, Ladouceur, & Drevets, 2008). As such, a psychiatric disorder could emerge not only from a deficit in one of the core emotional systems but also from a specific deregulation of the balance of these systems.

Affective Neuroscience Personality Scales (ANPS): Conceptualization, Current Knowledge, and Rationale of the Study

To monitor such imbalances, Davis et al. (2003) constructed an empirically based self-report questionnaire: the ANPS. They operationalized six socioaffective tendencies that have emerged from recent affective neuroscience research: PLAYFULNESS/joy, SEEKING/interest, CARING/nurturance, ANGER/rage, FEAR/anxiety, and SADNESS/separation distress. The scales were modeled in line with the idea that most advantageous self-reports for measuring emotional personality should empirically "attempt to carve personality along the lines of emerging brain systems that help generate the relevant psychological attributes" (Davis et al., 2003, p. 58; see also Cloninger, 1987; Cloninger, Svrakic, & Przybeck, 1993; Ersche, Turton, Pradhan, Bullmore, & Robbins, 2010; Gray, 1987).

Davis et al. (2003) conceptualized PLAYFULNESS as having fun versus being serious, playing games with physical contact, humor, and laughter, and being generally happy and joyful; SEEKING as feeling curious, feeling like exploring, striving for solutions to problems and puzzles, positively anticipating new experiences, and a sense of being able to accomplish almost anything; CARING as nurturing, being drawn to young children and pets, feeling softhearted toward animals and people in need, feeling empathy, liking to care for the sick, feeling affection for and liking to care for others, as well as liking to be needed by others; ANGER as feeling hotheaded, being easily irritated and frustrated, experiencing frustration leading to anger, expressing anger verbally or physically, and remaining angry for long periods; FEAR as having feelings of anxiety, feeling tense, worrying, struggling with decisions, ruminating about past decisions and statements, losing sleep, and not typically being courageous; SADNESS as feeling lonely, crying frequently, thinking about loved ones and past relationships, and feeling distress when not with loved ones (Davis et al., 2003). A SPIRITUALITY scale was introduced in the ANPS "for a hypothesized higher-order affective human attribute" (Davis et al., 2003, p. 59). However, as it was not based on Davis et al.'s neuroethological model, we excluded this scale from the present report.

Davis et al. (2003) tested the psychometric properties of the ANPS in two American samples: The first included college students in psychology (50 male, 121 female), and the second included job applicants (492 male, 106 female). The French version of the ANPS has been tested on college students (95 male, 317 female) in psychology (Pahlavan, Mouchiroud, Zenasni, & Panksepp, 2008). With respect to the norms that have been provided for undergraduate students, the two previous samples included not only a large majority of women (more than 70% in both studies) but also students in psychology exclusively. Yet, different emotional profiles have been observed among men and women, as well as among people according to the subject they studied (e.g., lower empathy in sciences compared with humanities and social sciences; Focquaert, Steven, Wolford, Colden, & Gazzaniga, 2007). Hence, the present study aimed to address these limitations and to provide norms for a diverse sample of undergraduates. Also, both previous studies found an effect of gender for ANPS scores: Women had higher CARING and SADNESS scores (Davis et al., 2003; Pahlavan et al., 2008); women also had higher FEAR but lower PLAYFULNESS scores in the Pahlavan et al. study (2008). These discrepant results might be due to differences in sample sizes and imbalanced proportions of men and women. In the present study, with a large sample and with an equilibrated sex ratio, we expected to replicate significant differences on all four aforementioned scales, specifically for the two scales showing consistent results across studies (CARING and SADNESS).

In the previous studies mentioned above, the internal consistency and stability coefficients of the ANPS scores appeared satisfactory (Cronbach's alphas ranged from .65 to .86 in the Davis et al., 2003, study; they ranged from .71 to .89 in the

Pahlavan et al., 2008, study; test–retest coefficients ranged from .72 for SADNESS to .91 for PLAYFULNESS in the Pahlavan et al. study). We expected to replicate the results regarding internal consistency. Moreover, using the full set of items available in the ANPS 2.4, Pahlavan et al. (2008) concluded the ANPS goodness-of-fit indices of a seven-factor structure were satisfactory (it included the SPIRITUALITY scale; goodness of fit index = .83, adjusted goodness of fit index = .80, root-mean-square error of approximation [RMSEA] = .08). Yet, they were somewhat under the generally accepted cutoffs. In the present study, we conjectured that the confirmatory factor analysis (CFA) of the instrument with the six scales, excluding SPIRITUALITY, would yield adequate goodness-of-fit indices.

Intercorrelations between the ANPS scores were very similar in the two previous studies. The three negative scores were positively intercorrelated in both studies. So were the three positive scores, except for the correlation between SEEKING and CARING in the Davis et al. (2003) study (positive but not significant). All these intercorrelations were small to moderate except for the correlation between FEAR and SADNESS, which was high in both studies. We expected to replicate this pattern of intercorrelations, with significant positive intercorrelations between the scores on the three ANPS negative scales, as well as between the three positive ones. Furthermore, in both previous studies, CARING was positively correlated to FEAR and SADNESS. We believe this pattern of associations is of particular theoretical interest. Indeed, the CARING scale stems from the nurturing emotional system present in mammalian brains to allow the parents (mainly the mother in most species) to adequately meet the needs of her offspring (Panksepp, 2006). As such, an association with the FEAR system is coherent with the necessity to keep the parent at a proper level of alertness. Similarly, in Davis et al.'s model, SADNESS stems from the separation distress observed in animals when a parent–offspring pair is separated: A positive correlation with CARING is thus understandable to discourage distance between parents and offspring. We expected to replicate these associations. Moreover, as gender may play a critical role, we examined the intercorrelations between the ANPS scores for men and women separately to verify whether the observed patterns hold true for both genders.

Finally, regarding validity evidence based on relations to other variables, previous correlational analyses showed that the three ANPS negative emotions were linked to a common five-factor model dimension: FEAR, SADNESS, and ANGER were strongly negatively related to Emotional stability (ranging from −.65 to −.75). ANGER was also negatively related to Agreeableness. Relative to the three ANPS positive emotions, specific positive associations were found between SEEKING and Openness to Experience, PLAYFULNESS and Extraversion, CARING and Agreeableness (Davis et al., 2003; Pahlavan et al., 2008). Yet, in these two previous psychometric studies, this type of validity evidence was investigated with five-factor model scales only. Hence, to further explore this line of validity evidence regarding the ANPS, we selected a battery of self-reports that shared potential traits with the ANPS and predicted that specific associations would be found between PLAYFULNESS and positive affectivity, CARING and empathic skills, SEEKING and systemizing propensity (i.e., to figure out the rules of a system or construct systems), FEAR and trait anxiety, SADNESS and depression, ANGER and trait anger.

Method

The study was approved by the Paris Ile de France VI Ethics Committee and conducted in line with the Declaration of Helsinki.

Participants

One thousand questionnaires were distributed and completed during class. The participants were studying or working in various fields (social workers, psychology, art, biology and biotechnologies, computer science, and general engineering). Eight-hundred sixty-nine questionnaires were returned, of which 32 had a consent form partially uncompleted (either identity or signature was missing, though the questionnaires were filled up). For the 837 remaining participants, seven had not answered all the ANPS items, leading to a final sample of 830 healthy young adults (54.8% of women; mean age = 20.6 years, *SD* = 2.1), with an intermediate to high level of education except for two participants who did not complete high school (31.2% graduated from high school, 29.6% with less than 2 years of college, 39.2% with more than 2 years of college).

Instruments

We used the French version of the ANPS 2.4 translated by Pahlavan et al. (2008) from the original work of Davis et al. (2003). Each ANPS scale encompasses 14 items (seven reverse scored), and answers are given on a 4-point scale (*strongly agree*, *agree*, *disagree*, *strongly disagree*).

We first selected an instrument to assess positive and negative affectivity: the 31-item Positive and Negative Emotionality Questionnaire (EPN-31; Pélissolo, Rolland, Perez-Diaz, Jouvent, & Allilaire, 2007; Rolland & De Fruyt, 2003). This questionnaire encompasses a list of 31 French words of positive and negative emotions or affects (e.g., *fear*, *worry*, *anxiety*, *despair*, *loneliness*, *rage*, *joy*, *love*, *pride*, *tenderness*) that were adapted from the work of Diener, Smith, and Fujita (1995) and in accordance with Watson and Clark's (1991) tripartite model of affects. This instrument was validated in a sample of 400 psychiatric patients, as well as in 460 French male military (see, respectively, Pélissolo et al., 2007, and Rolland & De Fruyt, 2003). We hypothesized that the scores of the three positive scales (PLAYFULNESS, SEEKING, and CARING) would correlate positively with the score of the positive dimension of the EPN-31 (Cronbach's alpha in the present sample was .84), whereas the scores of the three negative scales (FEAR, ANGER, and SADNESS) would correlate positively with the score of the EPN-31 negative dimension (Cronbach's alpha in the present sample was .91).

We selected several other instruments assessing one trait that we considered conceptually linked with one scale of the ANPS (which we refer to "corresponding scale" in the rest of the article). All the instruments used in the present study were previously validated for use in French language.

- The CARING scale was hypothesized to relate to the Empathic Concern subscale of the Interpersonal Reactivity Index (IRI–EC; Berthoz, Wessa, Kedia, Wicker, & Grèzes, 2008; Cronbach's alpha in the present sample was .74).
- The SEEKING scale was hypothesized to relate to the Systemizing Quotient (SQ, short version; Sonié et al., 2011; Cron-

bach's alpha in the present sample was .84), which assesses the propensity for systemizing (i.e., to figure out the rules of a system or construct systems).

- For the FEAR scale, we chose the Trait Scale of the Spielberger State and Trait Anxiety Inventory (STAI–Trait; Bruchon Schweitzer & Paulhan, 1990; Cronbach's alpha in the present sample was .84).
- For the ANGER scale, we used the Multidimensional Anger Inventory (MAI; Devouge, Falissard, Pouga, Grèzes, & Berthoz, 2011; Cronbach's alpha in the present sample was .86). This instrument assesses the following dimensions of anger: frequency, duration, magnitude, mode of expression, hostile outlook, and range of anger-eliciting situations. Here we used only the MAI total score.
- For the SADNESS scale, we chose the shortened version of the Beck Depression Inventory (BDI-13; Collet & Cottraux, 1986; Cronbach's alpha in the present sample was .79).

There was no instrument available in French similar to the PLAYFULNESS scale in content. Therefore, we hypothesized that this score would show the highest correlation with the EPN-31 positive score.

Analyses and Statistics

Descriptive statistics were computed for the ANPS scores by sex; we tested sex differences and estimated their magnitude. An internal consistency coefficient (Cronbach's alpha) was computed for each of the scores as well as a 95% confidence interval based on a bootstrapping procedure (Falissard, 2005). To test the normal distribution of the data, we used two tests of normality: the Anderson–Darling normality test and the Shapiro–Francia normality test (Thode, 2002). For a specific assessment of skewness and kurtosis, we used the D'Agostino skewness test (D'Agostino, 1970) and the Anscombe–Glynn kurtosis test (Anscombe & Glynn, 1983).

Regarding the validity evidence based on internal structure, a CFA was performed. This analysis provides approximate fit indices that assess how the model fits the data set. The way these indices should be interpreted is currently debated. For some authors (see Barrett, 2007), all approximate fit indices should be banned and only the chi-square accepted. But even the chi-square has serious flaws (e.g., Goffin, 2007). Chen, Curran, Bollen, Kirby, and Paxton (2008) exemplify these difficulties with the RMSEA: The capacity of the commonly reported .05 cutoff to reject false models and accept true ones depends on the number of subjects and the misspecifications of the model so that any universal cutoff seems meaningless. With this word of caution in mind, we followed the recommendations of Kline (2004) and Bentler (2007) and used the three indices they proposed and their commonly reported cutoffs: standardized root-mean-square residual (SRMR) that should remain under .10, RMSEA under .05, and comparative fit index (CFI) above .90. We also specified the pathways introduced in the model after an analysis of the residuals, as recommended by Bentler.

For the examination of the validity evidence based on relations to other variables, we assessed five traits (see Instruments section) that were conceptually close to the five ANPS scales (except PLAYFULNESS, for which we did not have a corresponding scale). Furthermore, we adopted a procedure inspired from the multitrait–multimethod matrix (MTMM), first introduced by Campbell and Fiske (1959) to assess convergent and discriminant evidences (see Watson et al., 2008, for an example). It has to be said that the approach of the present study is not a pure MTMM approach, as we did not assess the ANPS scales by another method (e.g., clinical interviews), but we constituted a battery of other theoretically related self-reported questionnaires. Nevertheless, it is a stringent approach that allows estimating the specificity of the relationship of each ANPS scale to the corresponding dimension, beyond a simple positive correlation. Therefore, we first expected the correlation between the score of each scale of the ANPS and each corresponding scale score in the battery to be positive and highly significant (e.g., SEEKING and SQ). Moreover, Raykov (2011) developed a new approach of MTMM that gives (a) a confidence interval for the convergent correlations and (b) an estimate of the mean difference between the convergent correlations and the discriminant correlations, as well as its confidence interval. This method yields estimates of these coefficients in the population and gives a synthetic index of the discriminant evidence for the instrument. Finally, to identify potential sources of low discriminant evidence, we compared each convergent correlation with 16 specific correlations in the matrix and expected it would be significantly superior to each of them (see Table 5 for an illustration). Every pair of correlations had one variable in common. Therefore, we used one-tailed tests (Steiger, 1980) to estimate the difference between two correlations with an index in common (difference between r_{12} and r_{13}).

Results

Descriptive Scores

Table 1 gives the scores for the scales of the instrument by sex as well as significant sex differences and effect sizes. The means of the six scores are very close to what Davis et al. (2003) reported for college students. Four sex differences emerged. Cohen's *d* (see Table 1) indicated that the magnitude of the difference was small for PLAYFULNESS and medium for CARING, SADNESS, and FEAR.

Internal Consistency and Normality

Internal consistency coefficients for the six ANPS scores ranged from .64 to .87 (see Table 2). In the present study, only the coefficient for the SEEKING score was below .70.

Although graphical displays showed that the distributions were close to normality (available on request from the authors), the large sample size yielded a significant departure from normality for all the scores at $\alpha = .05$ level on the two selected composite tests of normality. To test for specific characteristics of the distributions, we used a test for skewness and for kurtosis: The skewness was significant only for PLAYFULNESS score; ANGER score was the only one that slightly differed from the null hypothesis of no kurtosis (see Table 2). In all, values were close to zero for skewness (ranging from -0.51 to 0.16) and for kurtosis (-0.31 to 0.20).

Table 1
Descriptive Scores of the Affective Neuroscience Personality Scales by Sex

	Men			Women			
Scale	Range	*M* (*SD*)	*Mdn* (IQR)	Range	*M* (*SD*)	*Mdn* (IQR)	Sex differences (Cohen's *d*)
PLAYFULNESS	6–40	30.04 (5.46)	31 (27–34)	10–42	28.86 (5.75)	29 (25–33)	0.21**
SEEKING	12–40	27.27 (5.29)	27 (24–31)	14–40	27.47 (4.42)	28 (24–30)	−0.04[a]
CARING	7–40	24.51 (5.80)	24 (21–28)	7–41	27.61 (5.99)	28 (24–32)	−0.52***
FEAR	1–40	20.81 (7.29)	21 (16–25)	5–42	24.97 (7.02)	25 (20–30)	−0.58***
ANGER	1–39	19.45 (7.19)	19 (14–25)	0–39	19.91 (7.37)	20 (15–25)	−0.06[a]
SADNESS	1–39	19.91 (6.14)	20 (15–24)	5–42	23.86 (5.85)	23 (20–28)	−0.66***

Note. For each scale and each sex, the table presents the range (minimum and maximum), mean and standard deviation, and median and interquartile range (IQR). The last column indicates the size effects (Cohen's *d*) for the differences between men and women, as well as the significance of the difference based on a *t* test.
[a] Not significant.
** $p < .01$. *** $p < .001$.

Confirmatory Factor Analysis

In the final model, the index value was .06 for the SRMR, .039 (90% CI [.038, .040]) for the RMSEA, and .78 for the CFI. The residuals entered in the model were related only to residual covariance between items of the same scale (e.g., two items of CARING). Thus, none of the residuals introduced in the final model jeopardized the theoretical structure of the instrument. We also conducted a graphical analysis comparing the median of the correlations between the items of a given scale with the median of the correlations of the items of that given scale with the items of each one of the five other scales (available on request from the authors). The medians of the intracorrelations were always superior to the medians of the intercorrelations, showing an internal structure conform to what was expected, except for SADNESS (the median of intracorrelations being slightly inferior to the median of the correlations with the items of the FEAR scale).

Intercorrelations

Table 3 presents the intercorrelations between the scores of the ANPS for women and men. The three positive scales' scores—for PLAYFULNESS, SEEKING, and CARING—were significantly intercorrelated for both genders (.21–.28 for men and .27–.38 for women). So were the three negative scales' scores, for FEAR, ANGER, and SADNESS (.27–.63 for men and .35–.68 for women). Four correlations between negative and positive scales' scores were significant. For both men and women, first, the PLAYFULNESS score was negatively correlated with the FEAR and SADNESS scores; second, the CARING score was positively related to the SADNESS score. The CARING score was also positively related to the FEAR score, but for women only.

Table 2
Internal Consistency Coefficients and Normality Indices of the Affective Neuroscience Personality Scales

Scale	α	95% CI	Skewness	Kurtosis
PLAYFULNESS	.77	[.74, .79]	−.51***	.20
SEEKING	.64	[.60, .67]	−.07	−.06
CARING	.74	[.72, .77]	−.14	−.23
FEAR	.87	[.85, .88]	−.008	−.23
ANGER	.82	[.80, .84]	.16	−.31*
SADNESS	.77	[.75, .80]	.08	−.002

Note. The internal consistency coefficients are Cronbach's alphas given with a 95% confidence interval (CI) obtained by bootstrapping (Falissard, 2005). The skewness and kurtosis were tested respectively with the D'Agostino skewness test (D'Agostino, 1970) and the Anscombe–Glynn kurtosis test (Anscombe & Glynn, 1983).
* $p < .05$. *** $p < .001$.

Relations to Other Variables

As expected, the PLAYFULNESS, SEEKING, and CARING scores were positively correlated with the EPN-31 positive score; so were the FEAR, ANGER, and SADNESS scores with the EPN-31 negative one (see Table 4). Three additional correlations were significant, but of smaller magnitude: the PLAYFULNESS score was negatively correlated with the EPN-31 negative one; the FEAR and ANGER scores were negatively correlated with the EPN-31 positive one. CARING was not related to the EPN-31 negative scores.

Each of the SEEKING, CARING, FEAR, ANGER, and SADNESS scores correlated positively and significantly with its expected corresponding scale score (between .33 and .75; correlations given with 95% confidence intervals in Table 5). The mean difference between these five correlations and all the other correlations (see Analyses and Statistics section about the MTMM approach) was highly significant and fairly large (.40; 95% CI [.37, .43]). This result means that the ANPS scores correlated specifically with their respective corresponding score and not indiscriminately with other dimensions. For a more precise picture, we compared each of the five correlations with its 16 direct comparison correlations (see Table 5, with an example provided for SEEKING). For each of the SEEKING, CARING, and ANGER scores, the correlation with the corresponding scale score (respectively SQ, IRI–EC, MAI) was always significantly higher than all the 16 comparison correlations. FEAR score correlated highly with trait anxiety score (STAI–Trait; .54; 95% CI [.49, .59]), and this correlation was significantly higher than 14 of the 16 comparison correlations

Table 3
Intercorrelations Between the Affective Neuroscience Personality Scales Scores for Men and Women

Scale	PLAYFULNESS	SEEKING	CARING	FEAR	ANGER
		Men			
SEEKING	.28***				
CARING	.25***	.21***			
FEAR	−.25***	−.05	.09		
ANGER	−.01	.04	−.06	.32***	
SADNESS	−.13*	−.07	.25***	.63***	.27***
		Women			
SEEKING	.38***				
CARING	.33***	.27***			
FEAR	−.25***	.05	.17***		
ANGER	−.01	.02	.09	.35***	
SADNESS	−.17***	.01	.22***	.68***	.35***

* $p < .05$. *** $p < .001$.

(the dissonant correlations included SADNESS and BDI-13 scores). In the same way, SADNESS score correlated positively with the BDI-13 score (.45; 95% CI [.39, .50]), and this correlation was significantly higher than 13 of the 16 comparison correlations (the dissonant correlations were related to FEAR and STAI–Trait scores).

Discussion

There is growing evidence showing that "basic brain emotional systems may be among the most useful endophenotypes for evolutionary biological psychiatry" (Panksepp, 2006, p. 776; see also Cannon & Keller, 2006; Savitz & Drevets, 2009). The ANPS was designed as a tool to assess endophenotypes related to the activity in subcortical brain emotional systems that help generate key components of affective experience in all mammalian species (Davis et al., 2003; Pahlavan et al., 2008; Panksepp, 2005, Panksepp, 2006). The aim of the present study was to further validate the Affective Neuroscience Personality Scales. We investigated the properties of the ANPS in a large and diverse sample of young, educated French people. The psychometric properties of the scales seem satisfactory and in line with the above-mentioned previous studies. We further investigated validity evidence regarding the ANPS based on relations to other variables, and it also yielded satisfactory results. We discuss the findings, limitations, and further perspectives on the ANPS below.

Table 4
Correlations Between the Affective Neuroscience Personality Scales and Positive and Negative Emotionality Questionnaire Scores

Scale	Positive	Negative
PLAYFULNESS	.32***	−.22***
SEEKING	.26***	.01
CARING	.23***	.06
FEAR	−.12***	.54***
ANGER	−.08*	.35***
SADNESS	−.05	.51***

* $p < .05$. *** $p < .001$.

Psychometric Properties and Relations to Other Variables

As expected from previous studies (Davis et al., 2003; Pahlavan et al., 2008), significant sex differences emerged for four scales: PLAYFULNESS (higher scores for men), CARING, SADNESS, and FEAR (higher scores for women). The effect sizes were medium for CARING, SADNESS, and FEAR and small for PLAYFULNESS. They replicate the evidence that women display greater propensity for nurturing and empathizing than men (Davis et al., 2003; Derntl et al., 2010; Schulte-Rüther, Markowitsch, Shah, Fink, & Piefke, 2008) and are consistent with those of clinical studies showing that depression and anxiety disorders are more common in women than men (Leibenluft, 1999; McLean & Anderson, 2009; Parker & Brotchie, 2010).

We also replicated the results regarding internal consistency, with coefficients ranging from .64 to .87, which are very close to the .65–.86 values found by Davis et al. (2003). Only the SEEKING scale had a Cronbach's alpha of less than .70 (Davis et al., 2003, found such values for both the SEEKING and PLAYFULNESS scales).

With respect to the ANPS's internal structure, two of the three fit indices (RMSEA and SRMR) for the CFA were in agreement with the generally accepted cutoffs, whereas one (CFI) was not. Although the interpretation of these indices is still controversial (see Analyses and Statistics section), these results suggest an acceptable fit of the factorial structure that, nonetheless, is susceptible to be improved (we present several propositions in the next section).

Intercorrelations between the different ANPS scores were highly similar to what was previously reported (Davis et al., 2003; Pahlavan et al., 2008). We also found small to moderate positive intercorrelations between the three positive ANPS scores, as well as between the three negative ANPS scores (except for the high correlation between SADNESS and FEAR). This was true for both women and men. Furthermore, we replicated the positive correlation between CARING score, on the one hand, and FEAR and SADNESS scores on the other hand, but only for women (small effect sizes). For men, CARING score was positively correlated

Table 5
Correlations Between the Five Affective Neuroscience Personality Scales and the Other Selected Scale Scores

Scale	SEEKING	CARING	FEAR	ANGER	SADNESS	SQ	IRI–EC	STAI–Trait	MAI	BDI-13
SEEKING	—									
CARING	**.24**	—								
FEAR	**.01**[a]	.19	—							
ANGER	**.04**[a]	.03[a]	.33	—						
SADNESS	**−.02**[a]	.29	.69	.30	—					
SQ	*.33* [*.27*, *.39*]	***−.11***	***−.16***	***−.07***	***−.23***	—				
IRI–EC	***.13***	.55 [.49, .59]	.25	−.09	.33	**−.12**	—			
STAI–Trait	***−.10***	.01[a]	.54 [.48, .59]	.29	.50	**−.16**	.04[a]	—		
MAI	***−.03***[a]	−.05[a]	.41	.75 [.72, .78]	.37	**−.06**[a]	−.11	.35	—	
BDI-13	***−.12***	−.04[a]	.44	.19	.45 [.39, .50]	**−.07**	.07[a]	.70	.24	—

Note. The corresponding instruments for each scale of the Affective Neuroscience Personality Scales (ANPS) were, for SEEKING, the Systemizing Quotient (SQ); for CARING, the Interpersonal Reactivity Index–Empathic Concern (IRI–EC); for FEAR, the Trait Scale of the Spielberger State and Trait Anxiety Inventory (STAI–Trait); for ANGER, the Multidimensional Anger Inventory (MAI); and for SADNESS, the 13-item Beck Depression Inventory (BDI-13). The data are presented as a multitrait–multimethod (MTMM) matrix (Campbell & Fiske, 1959). Correlations given with a 95% confidence interval are forming the equivalent of the convergent diagonal and are correlations between each ANPS scale and its corresponding dimension. All the correlations of this diagonal were expected to be positive and significant. Each of them was then compared with 16 comparison correlations as in a MTMM matrix. We give the example of the correlation between SEEKING and SQ scores (shown in italics). This correlation is expected to be higher than 16 correlations, namely (a) correlations analogue to heterotrait–monomethod (shown in bold): between SEEKING and the other ANPS scores (CARING, etc.) and between SQ and the other non-ANPS scores (IRI–EC, etc.); and (b) correlations analogue to heterotrait–heteromethod (shown in bold italics): between SEEKING and the other non-ANPS scores (IRI–EC, etc.) and between SQ and the other ANPS scores (CARING, etc.). This analysis was conducted on 815 participants, as data were missing for 15 participants on some of the non-ANPS scales.
[a] Nonsignificant at the .05 level; all other correlations were significant at this level.

with SADNESS score only. As mentioned in the introduction, this finding is of particular theoretical interest, as the CARING scale was conceptualized based on animal models of parent–offspring relationships (mainly mothers in mammals) that imply a certain level of alertness and reluctance to separate from relatives, which are two dimensions tapped respectively by FEAR and SADNESS. The only discrepant finding was that we found significant but small negative correlations between PLAYFULNESS and both FEAR and SADNESS scores. Although this finding was not present in previous studies, it is not contradictory with the conceptualization of the scale: PLAYFULNESS was defined partly by having fun and engaging in games with physical contact, which can be opposed to SADNESS and FEAR.

Finally, examination of the validity evidence based on relations to other variables supported our hypotheses of positive associations between the three positive and the three negative ANPS scores with, respectively, positive and negative affectivity scores. The PLAYFULNESS score was the most positively correlated with positive affectivity score. For the other five ANPS scores, the analysis showed that each scale score correlated positively with a selected scale score assessing related content. Furthermore, this association was demonstrated to be specific and not simply the result of indiscriminate associations between scale scores.

ANPS: Potential Ameliorations

Although satisfactory, the results suggest several possible ameliorations of the instrument, in particular regarding the SEEKING scale and the distinction between the FEAR and SADNESS scales (with both these issues potentially affecting the overall factorial structure of the instrument). Psychometric considerations should not be the only criterion to make decisions: Evolutionary arguments based on animal models should be considered whenever relevant.

First, the internal consistency coefficient of the SEEKING score was below .70. This value does not mean that the SEEKING scale should not be used. Indeed, Lance, Butts, and Michels (2006) noted that Nunnally (1978), the source of this commonly reported cutoff, did not make a standard of the .70 cutoff, but rather proposed that the value should depend on how a measure is being used. A low internal consistency coefficient can lower the correlation of the construct with an outcome variable, which means that a true correlation of SEEKING score with an outcome could be underestimated or undetected on small samples. Thus, for research purpose with a fairly large sample size, the SEEKING scale can be fruitfully implemented, as in the present study, where we did find significant correlations between SEEKING and the propensity to analyze, explore, and extract rules and figure out how things work. Additional validity evidence in favor of the SEEKING scale was provided in a study designed to identify biological markers of creativity (Reuter et al., 2005). In this sample of 48 German undergraduate students, not only was the internal consistency coefficient of the SEEKING score good (Cronbach's $\alpha = .82$), but, more importantly, SEEKING scores were positively correlated with the performances to the Inventiveness battery of the Berlin Intelligence Structure Test (Jäger, 1982).

Yet, we believe this scale could be improved. Davis et al. (2003, p. 60) stated that their intention was "eventually to reduce the scale to ten items per category." With this respect, it has to be said that the use of the word *problem* in some items of the SEEKING scale (e.g., "I am not the kind of person that likes probing and investigating problems"; reversed item) might have been an issue. This word, besides signifying an intellectual challenge, is also negatively connoted (synonymous with *dilemma*, *difficulty*). Items including this word had, contrary to other items of SEEKING, positive residual correlations with items of FEAR in the CFA. Hence, the potential lack of unidimensionality of the SEEKING

items (and the ambiguous relationship the ones encompassing the word *problem* have with the FEAR scale) may have influenced the overall factorial structure. As a matter of fact, taking out the items with the word *problem* did slightly improve the internal consistency coefficient in our data set.

Second, although the FEAR and SADNESS scores had fairly high internal consistency coefficients, the constructs of the two scales seem to partially overlap. This was shown by their high intercorrelation, the CFA, and the examination of their relations to other variables. In our data set, this closeness of the two constructs was not restricted to the ANPS: The two scale scores designed to assess anxiety and depression (STAI–Trait and BDI-13 scores) correlated in the present sample as highly as the FEAR and SADNESS scores did (.70 for the former and .69 for the latter). Regardless of whether anxiety and depression are operationalized as traits, states, or diagnostic categories, the fact they covary is a common pattern in personality and psychopathology research (Anderson & Hope, 2008; den Hollander-Gijsman, de Beurs, van der Wee, van Rood, & Zitman, 2010; Mineka, Watson, & Clark, 1998; Parker & Brotchie, 2010). At the cerebral level, fear and sadness have been related to common but also specific cerebral structures and neurotransmitters (see Panksepp, 2006, p. 780; see also Fusar-Poli et al., 2009; Murphy, Nimmo-Smith, & Lawrence, 2003; Phan, Wager, Taylor, & Liberzon, 2004). With respect to ANPS clinical findings, in a study of bipolar spectrum illness, Savitz, van der Merwe, and Ramesar (2008a) examined whether the ANPS FEAR and SADNESS scores would be equally high in patients with bipolar or unipolar depression and their unaffected relatives. Though the FEAR and SADNESS scores were highly correlated (Spearman correlation coefficients $> .65$), the diagnostic groups did differ significantly from each other on SADNESS (with highest scores in the bipolar groups), but not on FEAR. Therefore, even if SADNESS and FEAR seem to partially overlap, there is some evidence that their clinical correlates could be different.

Nonetheless, besides testing whether these two scales may allow differentiating distinct forms of depression, further attempts to better distinguish the two scales could be conducted by refining their content based on the animal models. On the one hand, the SADNESS system was based on the protest or panic manifested by baby animals when that are left by their caretaker (Panksepp, 2006), a first reaction that is progressively replaced by despair and depressive behaviors (i.e., the "biphasic reaction" to social separation; Mineka & Suomi, 1978). In the ANPS, some SADNESS items assess the misgiving a person has to lose relatives, and the SADNESS and FEAR scales are thus related to some extent. A first solution that may one allow to differentiate better these two scales could be to focus the SADNESS items less on anxious anticipation of a possible loss and more on the sadness of enduring separation from loved ones and of isolation.

On the other hand, as defined by Panksepp (2006) and others (e.g., McNaughton, 2011), fear refers to a system that prompts autonomic and other responses that are necessary to escape from dangers. Moreover, ethology, behavioral pharmacology, and neural analyses tend to suggest that fear should be distinguished from anxiety (McNaughton, 2011), with two available conceptualizations: (a) Fear deals with immediate threats, whereas anxiety deals with potential ones (Blanchard, Hynd, Minke, Minemoto, & Blanchard, 2001), and (b) fear and anxiety induce opposite defensive responses, that is, respectively an avoidance of threat and an approach to threat (McNaughton & Corr, 2004; Perkins & Corr, 2006). The FEAR scale, as it stands, assesses a mix of fear (e.g., "My friends would say that it takes a lot to frighten me"; reversed item) and anxiety (e.g., "I often worry about the future"). Hence, a clearer distinction between fear-related defenses and anxiety-related defenses could represent a further refinement of the instrument and could also clarify the relationship of both these constructs with SADNESS.

ANPS: Further Perspectives

Here, we first report additional arguments for considering the ANPS as a promising tool in a multilevel approach integrating genes, brain, and psychiatric distress, and then mention further perspectives.

First, as the scales of the instrument were conceptualized to measure endophenotypes, they should demonstrate (a) heritability and (b) specific neurobiological correlates. Several authors have started to address these questions. Savitz, van der Merwe, and Ramesar (2008c) demonstrated that four of the seven ANPS scales are moderately to highly heritable. Regarding the biological bases of the ANPS scales, using the German version of the ANPS 2.4, Montag, Fiebach, Kirsch, and Reuter (2011) revealed an interaction between the serotonin transporter polymorphism (5-HTTLPR) and the oxytocin receptor gene (OXTR) on the ANPS FEAR and SADNESS scores. Moreover, the same research team (Reuter, Weber, Fiebach, Elger, & Montag, 2009) highlighted that carriers of the T-allele of the dopamine polymorphism DARPP-32 had higher ANPS ANGER scores than subjects without a T-allele. They also detected a negative correlation between ANGER scores and the volume of amygdala, which plays a key role in emotional behavior, whereas other authors observed a negative correlation between FEAR scores and the volume of this brain area (Berthoz, Orvoën, & Grèzes, 2010).

Second, additional studies in clinical groups should be conducted to test the hypothesis that excessive or imbalanced activities in the six core emotional systems measured by the ANPS may be critical in engendering significant psychiatric distress. Savitz, van der Merwe, and Ramesar (2008b) have already shown that the ANPS scales were linked to several psychiatric conditions, and researchers are presently working further on these issues with a variety of psychiatric outcomes, in particular depression, substance use, and eating disorders, as well as autism spectrum disorders (Berthoz, Pouga, Fruchart, Courty, & Grèzes, 2009).

Finally, further investigations should be conducted on the incremental value of the ANPS, which we will exemplify with the CARING scale. We observed an association between CARING and IRI–EC. Nonetheless, as defined by Davis et al. (2003), CARING is not restricted to empathy and could predict specific behaviors, in particular regarding parenting, beyond a mere empathy measure. For that purpose, the ANPS is currently being administrated to the parents of a Canadian cohort of 400 families participating in the Montreal Prematurity Study (Kramer et al., 2009). Besides confirming its psychometric properties and clinical predictions—with the available measures of mothers' psychopathology—this cohort will allow us to study the links between mothers' scores and several domains of child development (as-

sessed at 24, 36, and 48 months): health, motor and cognitive development, temperament, and prosocial behavior. Furthermore, as parenting behaviors were also assessed, we will explore whether they represent putative mediators between ANPS traits in mothers' and children's outcomes.

Limitations and Strengths

One limit of our study is that participants were young, educated, normal adults. Further studies should target more socially diverse participants at different ages and provide clinical ANPS scores representative of a broad range of psychiatric disorders. Another limitation is that the present study relied only on self-report instruments. It raises the possibility that some or all of the observed relationships were biased. Of note is the fact that ANPS scores did not correlate indiscriminately with other self-reported scale scores but specifically correlated with related scores that were selected on a theoretical basis, which rules out the fact that the method in itself was responsible for the correlations. Still, a similarity in items between each ANPS scale and the corresponding scale could have artificially generated the pattern of correlations. Nevertheless, emerging findings (see previous section) revealed genetic, neurological, and clinical correlates of ANPS scores, and this represents another line of validity evidence for the ANPS and strengthens our confidence that the results reported in the present study are relevant.

We replicated important findings with a larger and more diverse sample than the previous validation studies. We also offered new insights into validity evidence regarding the ANPS based on relations to other variables, and provided additional arguments to consider the ANPS as a suitable instrument to characterize emotional endophenotypes involved in a variety of psychiatric disorders. Finally, we offered several ways to improve the instrument.

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