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Review article

A comprehensive review of studies using the Affective Neuroscience Personality Scales in the psychological and psychiatric sciences

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ABSTRACT

Jaak Panksepp's Affective Neuroscience Theory (ANT) belongs to the most prominent emotion theories in the psychological and psychiatric sciences. ANT proposes the existence of seven primary emotional systems deeply anchored in the mammalian brain. These emotional/motivational systems have been shaped by evolutionary processes and function as tools for survival in mammalian species. The systems are called SEEKING, LUST, CARE, and PLAY, as well as ANGER, FEAR, and SADNESS. Panksepp carved out these emotional systems via means of deep brain stimulation, brain lesion and pharmacological manipulation studies.

Davis et al. (2003) designed the *Affective Neuroscience Personality Scales* (ANPS) against the background of findings from ANT. This self-report inventory is meant to enable researchers to assess individual differences in primary emotional systems. Seventeen years have passed since the first version of the ANPS has been published. Therefore, we now provide a comprehensive overview on studies using the ANPS including work from personality science, psychiatry and the neurosciences.

1. Background

Jaak Panksepp's Affective Neuroscience Theory (ANT) (1998) belongs to the most prominent theories in the emotional sciences (for a tribute to Jaak Panksepp see (Davis and Montag, 2018)). Please note that Panksepp also coined the term "Affective Neuroscience" (Panksepp, 1991, 1992).

Whereas emotion theories by Ekman (e.g. Ekman and Friesen, 1978; Ekman et al., 1987) chose to study emotions from the outside by studying emotional expressions in faces, Panksepp's view on emotions chose the perspective from inside of the brain (for a comparison of these perspectives see Montag and Panksepp, 2016). By using deep electrical brain stimulation techniques, various other pharmacological manipulations, and lesion studies all coupled with careful subject observations, Panksepp and his students carved out seven primary emotional systems anchored in subcortical regions of the mammalian brain. For an overview on the neuroanatomy of these systems and biochemical underpinnings see Panksepp (2011) and recent work by Montag and Davis (2018).

SEEKING, LUST, CARE and PLAY represent the positive primary emotional systems, whereas ANGER, FEAR and SADNESS can be found on the negative emotional side. Please note that primary emotional system names are written in upper case to avoid confounding them with the same terms in the literature or common spoken language. Each primal emotional system has been shaped by long evolutionary processes that allowed for species differences and represent inherited tools for survival. To illustrate, we overview the evolutionary functions of the positive primary emotional systems: The SEEKING energy of the mammalian brain can be channeled to seek life resources from food or a partner to safety. This basic motivation-emotional system provides us with energy in everyday life to fulfill our goals and it participates in all our emotional systems. The LUST system is of importance for obvious reproductive reasons for sustaining our species, whereas the CARE system elicits emotional urges to care for our offspring, so they can grow into adults and have offspring themselves. PLAY as a primal emotion is of tremendous importance for social bonding and for shaping skills in the area of social competencies and motor functions as well as possibly contributing to neocortical regulation of emotions.

As for the negative primary emotional systems, the RAGE/ANGER system protects life resources including your life or the lives of loved

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ones and may also be triggered by physical restraint. The FEAR system circuitry keeps us away from bodily harm and "physical pain." FEAR helps us cope with immediate danger by triggering a freezing or flight response that can be specifically influenced by the defensive distance between prey and predator (Blanchard et al., 2001; McNaughton and Corr, 2004). The neural circuitry underlying the SADNESS system is also called the PANIC system (Panksepp and Watt, 2011), in part because it seemed to describe the initial phase of infant separation-distress, e.g. when a child has lost contact with his/her caretakers but also because of its relationship to clinical "panic" attacks. This emotional system is similarly activated when a romantic relationship ends unhappily. From an evolutionary point of view our sapiens species naturally lives in groups and we feel "psychological pain" when we are separated from our loved ones and when we find ourselves socially isolated and alone.

Although our brain is a complex organ, the activation of the positive and negative primary emotional circuits makes it surprisingly easy to understand how emotional consequences affect our learning and behavior. What feels good basically will be repeated in the future and what feels bad will be avoided. While the aforementioned primary emotional systems can be unconditionally activated by evolutionarily significant triggers, they also act as memory systems. The pleasant (rewarding) and unpleasant (punishing) emotional affects that accompany the activity of these ancient brain circuitries enable the formation of memories with the strength of the primary emotional arousal linked to the strength of the memory. An example of how unpleasant affects (pleasant ones as well) help us adapt to specific environments: A child touching a hot oven for the first time (and then experiencing the pain), will FEAR the oven from then on.

Although primary emotional systems are always active in the human brain, at least in adulthood we are seldom overwhelmed by raw affect, because the cortex is usually able to exert control over the energy produced at the bottom of our minds (Montag and Panksepp, 2017). A more thorough introduction into Panksepian ANT is beyond this review and we refer readers to Panksepp's "Affective Neuroscience" (1998), Panksepp and Biven's (2012) "The Archaeology of Mind" and Davis and Panksepp's (2018) "The Emotional Foundations of Personality". Moreover, the reader will find a popular science book called "Animal Emotions" as a lay introduction into ANT in the Brainstorm Series by Punctum Books (Montag, 2020) . A shorter paper on selected Panksepian principles can be found in Davis and Montag (2019).

2. Relevance of affective neuroscience theory for psychology and psychiatry

Panksepp's AN theory is of considerable relevance to better understand psychological phenotypes such as personality or psychiatric disorders such as depression. Not surprisingly, personality science and the study of affective disorders have a long common history, with the first self-report inventories being designed 100 years ago to recruit for the first world war only those soldiers who likely would not suffer from shell-shock (Montag and Elhai, 2019). Moreover, the early psychoanalysis tradition linked personality to psychopathology (e.g. Freud, 1989; see also affective neuroscience insights into the neuropsychoanalysis movement by Solms and Panksepp, 2012 and Panksepp and Solms, 2012). Further, the personality dimension usually called Emotional Stability or Neuroticism as Big Five or Five Factor Model labels respectively is likely constituted by a mix of Panksepp's ANGER, FEAR, and PANIC/SADNESS primary emotions and higher Neuroticism is a well-known risk factor for depression and other related health conditions (Lahey, 2009). Again, this illustrates that personality science and clinical psychology/psychiatry share common interests and psychological dimensions.

How is AN theory now illuminating different psychiatric conditions? Panksepp and Watt (2011) among others described that in depression, imbalances of the SEEKING and SADNESS systems can be observed, with SEEKING showing low activity (hence less energy, motivation) and high prevailing SADNESS activity (hence a state of negative emotionality). Schizophrenia as another example for a psychiatric/neurological disorder might be characterized by excessive activity of the SEEKING system, in particular in those patient groups suffering from positive symptoms such as hallucinations (or paranoid schizophrenia). Further hypotheses have been put forward such as an overactive PLAY system being relevant to understand ADHD/mania, and also see that in ADHD, a lack of playtime might influence this psychiatric disorder (Panksepp, 2007). For a complete evolutionary view on psychiatric disorders, please see Panksepp (2006).

In the following sections of the article, an overview is provided of studies using the ANPS giving support for some of the assumptions made against the background of AN theory as described in this section. First, the different available versions of the ANPS scales are introduced. Second, a section dealing with studies on ANPS and personality is provided. Third, studies on ANPS in the context of psychiatry are summed up and fourth, biological validation studies of the ANPS are presented.

3. Assessing individual differences in primary emotional systems; the Affective Neuroscience Personality Scales (ANPS)

In order to place human subjects in affective space, Davis et al. (2003) published a self-report tool called Affective Neuroscience Personality Scales (ANPS) that assessed individual differences in Panksepp's primary emotional systems. The original ANPS consisted of 110 items. The ANPS scales were designed to reflect activity in each primal emotion. In the original paper by Davis et al. (2003) it was further described that "Items for all scales were written with the goal of accessing personal feelings and behavior rather than more cognitive social judgments" (p. 56). The ANPS assesses six of the primary emotional systems with the exception of LUST, in part because it was thought that including items on one's own sexual activity would bias responses on the remaining items of the ANPS, but also note that a LUST factor had not been reported in reports of the Big Five or its variants.

Each primary emotional system is assessed with fourteen items. An additional Spirituality dimension was included in the ANPS (only 12 items), because Spirituality was a key element in 12-Step programs for alcoholics, and Spirituality subsequently has been found to predict psychiatric treatment success in patients suffering from addiction problems in general (Jarusiewicz, 2000). A focus on the Spirituality dimension of the ANPS has also been put in the work by Hiebler-Ragger et al. (2018). Please note that the remaining items of the ANPS were either experimental items or part of a short faking scale.

The original ANPS was slightly adjusted to improve psychometric properties with the ANPS 2.4 version as presented in Davis and Panksepp (2011) – here with 112 items. As both the original version of the ANPS and the ANPS 2.4 were too long for some research demands, both Pingault et al. (2012b) and Barrett et al. (2013) published short versions of the ANPS., (Pingault et al., 2012b) named their short version ANPS-S (ANPS short). The ANPS-S consists of 36 items, with all items included on the ANPS 2.4. Barrett et al. (2013) published the BANPS (brief ANPS) consisting of 33 items. They included 28 items of Davis and Panksepp's original ANPS 2.4 and added five new designed items. For a comparison of three ANPS versions (ANPS 2.4, BANPS, ANPS-S) in one study see Pedersen et al., 2014. Using a person-centered approach, three distinct profiles of ANPS dimensions were statistically observed by Orri et al. (2017), but see some effects of sex. Please note that Orri et al. (2018) also investigated longitudinal stability and sex measurement invariance of the ANPS.

Recently, Montag and Davis (2018) published an additional short form called the ANPS-AR (Adjective Ratings), which consisted of 24 (adjectives), and which was validated against the scales of the long version of the ANPS. The ANPS-AR was also intended to facilitate "observer ratings" independent of self-ratings. The family of ANPS inventories were designed as trait measures. Although this is also true for the new ANPS-AR, this new adjective-based version also gives scientists

the easy possibility to assess primary emotional systems as states by preceding each adjective with wording such as "Right now, I feel."

While the ANPS measures largely the same personality space as the Big Five, except for the Big Five Conscientiousness dimension, the Big Five/Five Factor Model of Personality was derived using a lexical, statistical approach. By contrast, the ANPS was based on Panksepp's abundant empirical evidence of neural motivational/emotional systems arising from subcortical areas. Whereas the Big Five are a descriptive-taxonomy of personality, the ANPS aims to assess individual differences in terms of primary emotional systems, albeit necessarily at the verbal tertiary level and their underlying neural circuitry, although much more neuropsychological evidence is needed to better establish this idea (see also sections further below). Nevertheless, abundant studies have been published validating the ANPS against Big Five/Five Factor Model measures. By this, at least on a conceptual level, it has been demonstrated that individual differences in primary emotional systems – anchored in phylogenetically ancient brain regions – likely represent the bottom-up emotional foundation of the Big Five (Davis et al., 2003; Montag and Panksepp, 2017).

Although the ANPS still represents a comparably new inventory in the tool box of personality psychologists and psychiatrists (compared to the Big Five), it already has seen translations in several languages. Among these are translations from English/or other languages into Brazilian Portugese (Esposito et al., 2016, BANPS), Chinese (Sindermann et al., 2018a; ANPS 2.4), French (Pahlavan et al., 2008; ANPS; Pingault et al., 2012a; Pingault et al., 2012b; ANPS and ANPS-S), German (Reuter et al., 2017; ANPS), Italian (Giacolini et al., 2017; ANPS 2.4; Pascazio et al., 2015, ANPS), Japanese (Narita et al., 2017; ANPS 2.4), Norwegian (Pedersen et al., 2014; ANPS 2.4., BANPS, ANPS-S), Spanish (Abella et al., 2011; ANPS 2.4), Persian (Amiri and Marzabadi, 2017; BANPS), Polish (Cwojdzińska and Rybakowski, 2015; ANPS 2.4), Portugese (Gurfinkel et al., 2018; BANPS), Serbian (Montag et al., 2019; ANPS 2.4) and Turkish (Jak İçöz, 2012; Özkarar-Gradwohl et al., 2014, ANPS), with Danish (ANPS 2.4), Dutch and Hungarian versions (ANPS 3.1) still unpublished. For more information on the ANPS 3.1, please see information below.

Given the brevity of this review work, we cannot provide psychometric properties of all translations and of all ANPS versions published so far. To give the reader an idea, we mention the psychometric properties of some illustrative translations of the ANPS, which was presented in Davis et al. (2003) and Davis & Panksepp (2011): The Serbian version of the ANPS 2.4 yielded internal consistencies of 0.77 or higher for all primary emotional systems (Montag et al., 2019). An exploratory factor analysis of the primary emotion scales revealed two factors, namely one for negative and one for positive affect. The Spanish version of the ANPS 2.4 by Abella et al. (2011) also had adequate internal consistencies ranging between 0.71 and .78. In addition, the authors reported an adequate model fit when testing a seven factor solution for the ANPS items via means of CFA (with a better fit than a two factor solution). However, for scientists planning to use the ANPS in their research we present the items for the ANPS 3.1, which shifts to a 6-point response scale, in the appendix of this work. Importantly, the ANPS 3.1 maintains all the ANPS 2.4 scale items. Indeed, all ANPS versions starting with ANPS 2.4 contain the same scale items and item numbers. Only some "filler" items were changed. But with version 3, changing from a 4-point to a 6-point scale definitely improved the Cronbach's alphas of the ANPS (see section "7. Outlook and Limitations" below).

4. Links between ANPS and personality

Several studies linked the ANPS to the Big Five personality traits statistically derived using an adjective-based lexical approach, which likely represented a higher order representation of neurobiological brain systems that sometimes combined primary elements. This hypothesis was supported by Davis et al. (2003), which along with Davis and Panksepp (2011) describe in detail that individual differences in primary emotional systems likely represent the evolutionary foundations of human personality with high SEEKING representing the basis of Openness to Experience, high PLAY the basis for Extraversion, low ANGER and high CARE the basis for Agreeableness and high FEAR, SADNESS and ANGER the basis for low Emotional Stability/high Neuroticism. The reliability of these associations was further supported by Montag and Panksepp (2017) - observing these correlations in two further samples from Germany and China (aside from the original US sample described in Davis et al., 2003) - showing a range of correlations starting with 0.33 (ANGER-Neuroticism association) in the German sample and ending with .75 (FEAR-Neuroticism associations) both in the US and German samples (this summary concerns the highlighted correlations in the Montag and Panksepp (2017) work; see also a new meta-analysis on the Big Five-ANPS correlations by Marengo et al., in press). The remaining observed correlations for the aforementioned associations fell in between these numbers in the three investigated samples. In sum, associations between Big Five measures and the ANPS range for the most critical associations between *moderate* and *high* in terms of the observed effect sizes.

Of note, most other studies observed same correlational patterns (e.g. Abella et al., 2011; Barrett et al., 2010; Hiebler-Ragger et al., 2018; Montag et al., 2019; Montag and Panksepp, 2017; Pahlavan et al., 2008) underlining the robustness of such observations. This said, the logic that primary emotional systems influence the Big Five from the bottom up stems from the idea that such ancient motivational systems are rooted in subcortical areas of the brain (Davis and Montag, 2019). Please note that some studies also validated the ANPS using the HEXACO 6 factor model (Knežević et al., 2020) and also another prominent theory of personality, namely, Cloninger's biosocial theory of personality (Cwojdzińska and Rybakowski, 2015: note that the n in this study was very small).

Finally, an attachment styles poster using the Affective Neuroscience Personality Scales (ANPS) revealed a strong relationship between an "anxious-avoidant adult attachment style" and high ANPS SADNESS scores (İçöz et al., 2013). Work by Gazzillo et al. (2018) presents correlations among others with the interpersonal guilt scale and Yu (2016) even investigates the ANPS in the context of academic performance in Hong Kong students. A new work by Međedović and Petrović (2020) sheds light on associations between indicators of reproductive fitness and individual differences in primary emotional systems in their work with a sample from Serbia. Please see also a work by Sindermann et al. (2018a) investigating the ANPS in the context of vengefulness and a new work by (Montag et al., 2020) linking individual differences in Panksepp's primary emotions to individual differences with satisfaction in Maslow's needs.

The studies presented here, together with theoretical background of AN theory, supports the case, that the ANPS assessment of primary emotional systems goes beyond description and begins explaining why people differ in their personalities, an important question raised by whole trait theory (Fleeson and Jayawickreme, 2015).

5. The ANPS in the context of clinical psychology/psychiatry

A growing number of works also use the ANPS in clinical research. Montag et al. (2017) observed that depressed patients were characterized by higher SADNESS (and FEAR scores) as well as somewhat lower SEEKING and PLAY levels with similar associations being observed in a large control group when correlating Beck Depression Inventory (BDI) scores with ANPS scores (see also an additional positive ANGER-BDI correlation in this group). For supporting evidence of several of these patterns see also the work by (Sindermann et al., 2018b) with multiple sclerosis patients showing higher SADNESS and FEAR associated with depression and ANGER scores predicting cognitive fatigue. Please also see Farinelli et al. (2013) investigating SEEKING and depression levels in stroke patients. Further, Fuchshuber et al., 2019a was able to make predictions using the ANPS not only on depressive tendencies but also on anxiety, somatization, and substance abuse disorders. In this study,

Fuchshuber et al. identified SADNESS as the major ANPS predictor of depression with additional associations between depressive tendencies and FEAR, ANGER, SEEKING and PLAY similar to Montag et al. (2017). Fuchshuber et al. also supported Montag's empirical demonstration of the continuum model – non-clinical personality and clinical pathology can be described using the same dimensions, namely, Panksepp's primary emotions (McDougall, 1908; Davis and Panksepp, 2018). Please see also another work by (Fuchshuber et al., 2019b) among others investigating links between childhood trauma and primary emotional systems. Regarding the ANPS-childhood trauma associations the highest link could be observed between the SADNESS dimension and childhood trauma as depicted in the correlation table in this work (p. 5). Beyond that, work by Malcolm-Smith et al. (2013) is noteworthy, because they observed that medically and psychiatrically healthy university students who had experienced early social trauma reported lower SEEKING scores compared to control persons.

Karterud et al. (2016) analyzed data from 546 clinical patients in their work on the ANPS in personality disorders (PD) and observed that the ANPS „explained 19 % of the variance in borderline and avoidant criteria" (p. 261). Specifically, they found that borderline PD was associated with high ANGER, SADNESS, and SEEKING and avoidant PD with lower ANGER, SEEKING, and PLAY plus high FEAR, illustrating different patterns of primary emotions associated with these two disorders. Of note, Savitz et al. (2008b, 2008c) used the ANPS to provide insights into differentiating the personality structure of patients with bipolar disorder.

Another, heavily investigated area of psychiatric interest is the study of attention deficit hyperactivity disorder (ADHD). In subclinical samples stemming from Germany and China, Wernicke et al. (2019) observed robust links between higher tendencies towards ADHD and higher ANPS negative emotionality scales. Exploring another of Jaak Panksepp's strong interests, work by Carré et al. (2015) used the ANPS to contrast differences between adult patients with autistic spectrum disorders and healthy controls. ASD participants had higher FEAR and pronounced lower PLAY scores. In addition, separate measures of autistic traits were strongly related to lower PLAY (e.g. autism quotient), which they argued could be the basis of the impaired social bonding characteristic of ASD.

Three papers investigated the ANPS in the context of gambling (Iliceto et al., 2016; e.g. Gambling Related Cognitions Scale) and Internet Use Disorders (Montag et al., 2011b, 2016a) correlations of the ANPS with the Internet Addiction Test) and provided evidence that the ANPS scales are able to predict/is related to psychopathology in the realm of non-substance related use disorders.

In a different area, Lenzo et al. (2013) conducted a study with patients suffering from bowel disorder. The ANPS scales turned out to be linked to metacognitions/coping strategies in patients suffering from this disorder. Pascazio et al. (2010) contrasted renal transplant recipients and healthy controls, with the recipient group characterized by lower FEAR and ANGER scores – perhaps reflecting "a form of psychological adaptation (coping strategy) to these problems and to the transplantation experience itself." (p. 3588).

Beyond the clinical domain, the ANPS has been also used in other areas. Sindermann et al. (2017) investigated links between upbringing in rural vs. urban areas and individual differences in primary emotional systems in both Germany and China. They observed that growing up in Chinese urban areas was associated with lower FEAR and SADNESS in females. Sariyska et al. (2019) used the ANPS to investigate dietary choices and reported higher CARE and SADNESS coupled with lower PLAY scores in vegans/vegetarians compared to omnivores. On a psychometric note, Montag and Reuter (2008) investigated whether ANPS completion time affected its reliabilities (it did not).

6. Biological validation studies

Beyond psychometric validation, several studies have started exploring the biological validation of the ANPS. We deem such work to be of particular relevance, because the ANPS scales have been designed as tertiary measures of Jaak Panksepp's primary emotions and therefore should also be linked to individual differences in brain related variables. Panksepp (2011) reported in one of his papers a summary of brain areas and brain molecules underlying each primary emotional system (which was originally prepared by Doug Watt (personal communication)). This table has been also presented in several of our follow up works such as Montag and Davis (2018), which is available open access. The overview provided originally in Panksepp (2011) represents a guide with many neuroanatomical brain regions and brain molecules to be tested in human neuroscience. Biological validation studies of the ANPS basically aim to find relationships between ANPS scale scores of participants and particular biological candidates. As one can see from the following overview, some of the findings map well onto Panksepp's ideas.

Our starting point is the linkage between genes and phenotype, namely, Panksepp's primary emotional systems (Montag and Reuter, 2014). In this context, Montag et al. (2016a, b) studied twins to provide heritability estimates for the primary emotional systems assessed with the ANPS, which ranged from 0.31 for ANGER to 0.69 for PLAY. Having established ANPS scale heritabilities, a logical next step is to search for genetic markers in DNA explaining individual differences in primary emotional systems. Here, we note that Savitz et al. (2008a) investigated several candidate gene variants linked to bipolar disorder and did not find associations with the ANPS. However, Reuter et al. (2009) reported an association between a genetic marker of the DARPP-32 gene with ANGER. In addition, Montag et al. (2011a observed an interaction of OXTR / serotonin transporter gene genetics on the negative emotionality of FEAR and SADNESS. Felten et al. (2011) reported an interaction of dopaminergic gene candidates (variants of DA/COMT genes) on SADNESS. Harro et al. (2019) linked a genetic variant of the orexin/hypocretin gene to individual differences in ANGER, and finally Plieger et al. (2014) reported an influence of 5-HTTLPR on extreme response styles when filling in the ANPS (see also heritability estimates for response style in Melchers et al., 2018). Individual differences in extreme response style are discussed in this work as an implicit marker for anxiety. Also of interest and recently (Sanwald et al., 2020) observed that "SADNESS significantly moderated the association between BDNF Val66Met and executive functions as well as masked RT priming." (p. 699). In sum, there is a growing collection of papers linking the ANPS to genetic markers, although one can see that molecular genetics studies have been largely investigating the negative primary emotional systems and associations with the positive primary emotional systems are lacking.

Most of these ANPS genetic studies fit well with Panksepp's ANT. For instance, Montag et al. (2011a) findings map onto Panksepp's ANT, because on the one hand oxytocin is known to downregulate SADNESS/FEAR and on the other hand serotonin is postulated to be general arousal modulator. Also Plieger et al. (2011) linking the serotonin transporter polymorphism to the FEAR system fits with the general arousal modular function of serotonin. Other findings will need to be explored further in the future (and also the earlier molecular genetics findings need to be replicated). Among others a genetic variant of the orexin/hypocretin pathway would have been mostly expected to enhance SEEKING, but was associated with ANGER (Harro et al., 2019). But, please note that the SEEKING system as a broad motivational system also energizes emotional systems including the ANGER system.

Beyond genetics, studies tried to associate individual differences in hormone levels to the ANPS scales. Whereas van der Westhuizen and Solms (2015) did link testosterone:cortisol ratio to an ANPS experimental Dominance scale, they were not able to link cortisol/testosterone measures to the primary emotion ANPS scales. However, Sindermann et al., 2016 could link the 2D:4D digit ratio marker – discussed as an indirect marker for prenatal testosterone (to estrogen ratios) - to the FEAR system in females. In earlier work by Reuter et al. (2005) it was observed that SEEKING was related to creativity (see also Milton et al.,

2008), and that higher SEEKING was associated with higher testosterone levels.

The ANPS has been also investigated in relation to brain imaging. The already mentioned work by Reuter et al. (2009) not only investigated the DARPP-32 gene in the context of ANGER, but also observed that lower gray matter density of the left amygdala went along with higher ANGER scores. Deris et al. (2017) linked SADNESS scores to resting state fMRI data in two independent samples. They showed an inverse association between functional connectivity between basolateral amygdala and subgyral parts of the parietal lobe and SADNESS. Another recent work by Unterrainer et al. (2017) linked higher FEAR scores to lower fractional anisotropy of the superior longitudinal fasciculus (SLF) in patients with poly drug use disorder. A new poster from a conference yields also new validation for the ANPS scales in the context of brain imaging: Li et al. (2019) investigated in a neuroeconomic paradigm dealing with unfair offers among others the role of SEEKING and ANGER on the activation of the temperoparietal junction. In the context of brain imaging studies, we also want to refer to recent work investigating how stroke brain-lesions link to primary emotions as measured by the ANPS (Farinelli et al., 2015). Farinelli's group was able to extend earlier work cited above (Farinelli et al., 2013) by showing in a larger sample that regardless of the stroke location SEEKING scores were lower in all stroke patients with SADNESS and ANGER scores being higher. More specifically, they were also able to show that SADNESS and FEAR scores were higher in patients with anterior cortical lesions.

The many studies so far provide interesting insights into ANPS-brain structure/function-molecule associations, some underlining straightforward Panksepp's ANT, others warranting further investigations. For instance, Panksepp's research would predict the amygdala to be involved in ANGER, which fits well with the imaging findings from Reuter et al. (2009).

In this biological-correlates-section, one should not forget that Jaak Panksepp mapped the brain anatomy underlying the primary emotional systems mainly via electrical stimulation, thereby being able to be very precise – something which is hard to achieve with non-invasive brain methods such as MRI. Indeed, human brain imaging is not ideally suited to clearly visualizing the densely packed subcortical regions of the brain where primary emotions arise. It is also not easy to link the ANPS to molecules of the brain, because many methods, such as genetics or hormone analysis of the blood or saliva only represent an indirect picture on processes occurring in the mammalian brain.

At the end of this section on biological validations studies, there are also several works investigating the ANPS in the context of psychological/neuroscientific music studies. Barrett et al. (2010) observed that proneness for experiencing nostalgia while listening to music was strongly predicted by SADNESS and to a lesser extent by SEEKING. However, Barrett and Janata (2016) went one step further and investigated the neuroscientific underpinnings of such nostalgic feelings, when listening to music. The authors reported that "ANPS *SADNESS* scores predicted a negative relationship between BOLD signal and ratings of nostalgia in the anterior cingulate, whereas they predicted a positive relationship between BOLD signal and ratings of nostalgia within a brainstem region" (p. 239). This finding once again supports the cross-species Panksepian principle that subcortical-cortical midline brain networks are essential for processing emotions. In the context of music perception and chills we also point to an interesting work by Laeng et al. (2016) investigating pupil size. Interestingly, in this work, higher ANGER scores were related to lower number of experienced total chills, and it was the ANPS Spirituality scale that predicted pupil size when experiencing the chills.

7. Outlook and limitations

As one can see from this review, the investigation of ANPS in the psychological and psychiatric sciences is still young, but also yields interesting fresh insights into the underpinnings of diverse psychological and psychopathological phenotypes. Nevertheless, the field also struggles with some challenging issues, which need to be solved. First of all, it would help to find a gold standard concerning agreement on the preferred ANPS version to be used. Although most existing ANPS versions relate in a way to the originally formulated ANPS, in some studies "only" short versions of the ANPS are used and this might cause problems in terms of comparability of results across studies (but see the work of Pedersen et al., 2014). Beyond that some psychometric properties of the inventory could be improved, but please note the Cronbach's alphas for the ANPS scales (using version 3 with the 6-point response scale) ranged from 0.743 for CARE to 0.879 for ANGER (Davis and Feren, 2015). It would be nice, if the latent factor structure of the scales could be improved. However, we know from the Big Five that the statistical latent factor structure of psychometric instruments does not always conform to the underlying biological structure.

Furthermore, this review makes it clear that much more biological validation work needs to be done to better understand if the proposed molecules and brain structures/functions indeed underlie the ANPS (again see Montag and Davis, 2018). Here, the possitilities range from extending Damasio et al. (2000) to relating ANPS scores to brain activity focusing especially on subcortical regions to further exploring affective neuroscience through network neuroscience techniques (Markett et al., 2018). Finally, it will be of importance to also investigate primary emotional systems as states (see that the ANPS was originally designed to assess traits but also see the Affective Neuroscience Personality Scales-Adjective Ratings (Montag and Davis, 2018)) and to understand how they relate to traits in the realm of personality and psychiatric disorders.

For more information on new ANPS research in the future you can visit www.anps-research.com

and

Appendix A. Scoring the Affective Neuroscience Personality Scales 3.1, Copyright © 2015 version

These scoring formulas assume a 6-point strongly disagree, disagree, slightly disagree, slightly agree, agree, and strongly agree response scale. Please note: ans1 refers to the first ANPS item, ans17 refers to the 17th ANPS item, etc.

The following items are scored on a response scale from 5 to 0 rather than 6 to 1 in order, to allow for a minimum score of zero on each scale. For example, when hand scoring, each of the positively worded SEEK scale items (numbers 1, 17, 33, 49, 65, 81, and 97) would be scored as follows: strongly agree = 5, agree = 4, slightly agree = 3, slightly disagree = 2, disagree = 1, and strongly disagree = 0. Correspondingly, each of the negatively worded SEEK scale items (numbers 9, 25, 41, 57, 73, 89, and 105) would be reverse scored as follows: strongly agree = 0, agree = 1, slightly agree = 2 slightly disagree = 3 disagree = 4, and strongly disagree = 5.

The ANPS scales can also be obtained from the following formulas. Using these formulas assists computer processing data in a database, and the algebra returns the same results as hand scoring with scale scores running from 0 to 70 except for the Spirituality scale, which would run from 0 to 60. Sprituality only has 12 items rather than the 14 items used for the 6 primary affective neuroscience scales. Most ANPS papers printed data for 0 based scales, using a scoring algorithm using values from 0 to 5. Most psychometric assessments make the lowest scale scores equal to 0. With ANPS version 3.1, there are 15 "filler" items. These include 8 Social Dominance items, which is not considered a primary emotion but consists of "filler" items comprising an experimental research scale with adequate alphas. However results have not been published.

SEEK score = (+35 +ans1 +ans17 +ans33 +ans49 +ans65 +ans81 +ans97 -ans9 -ans25 -ans41 -ans57 -ans73 -ans89 -ans105).

FEAR score = (+35 +ans2 +ans18 +ans34 +ans50 +ans66 +ans82 +ans98 -ans10 -ans26 -ans42 -ans58 -ans74 -ans90 -ans106).

CARE score = (+35 +ans3 +ans19 +ans35 +ans51 +ans67 +ans83 +ans99 -ans11 -ans27 -ans43 -ans59 -ans75 -ans91 -ans107).

ANGER score = (+35 +ans4 +ans20 +ans36 +ans52 +ans68 +ans84 +ans100 -ans12 -ans28 -ans44 -ans60 -ans76 -ans92 -ans108).

PLAY score = (+35 +ans5 +ans21 +ans37 +ans53 +ans69 +ans85 +ans101 -ans13 -ans29 -ans45 -ans61 -ans77 -ans93 -ans109).

SADNESS score = (+35 +ans6 +ans22 +ans38 +ans54 +ans70 +ans86 +ans102 -ans14 -ans30 -ans46 -ans62 -ans78 -ans94 -ans110).

Spirituality score = (+30 +ans7 +ans23 +ans39 +ans55 +ans71 +ans87 -ans15 -ans31 -ans47 -ans63 -ans79 -ans95).

The Social Dominance score = (+20 +ans8 +ans40 +ans88 +ans103 -ans56 -ans72 -ans111 -ans32).

The ANPS 3.1 items use a 6-point response scale: strongly disagree, disagree, slightly disagree, slightly agree, agree, strongly agree.

1. Almost any little problem or puzzle stimulates my interest.
2. People who know me well would say I am an anxious person.
3. I often feel a strong need to take care of others.
4. When I am frustrated, I usually get angry.
5. I am a person who is easily amused and laughs a lot.
6. I often feel sad.
7. Feeling a oneness with all of creation helps give more meaning to my life.
8. I like to be the one in a group making the decisions.
9. I do not get much pleasure out of looking forward to special events.
10. I am not frequently jittery and nervous.
11. I think it is ridiculous the way some people carry on around baby animals.
12. I never stay irritated at anyone for very long.
13. My friends would probably describe me as being too serious.
14. I seem to be affected very little by personal rejection.
15. Feeling like a part of creation is not an important source of meaning for my life.
16. I would very much dislike the feeling of not having someone who loves me.
17. I really enjoy looking forward to new experiences.
18. I often think of what I should have done after the opportunity has passed.
19. I like taking care of children.
20. My friends would probably describe me as hotheaded.
21. I am known as one who keeps work fun.
22. I often have the feeling that I am going to cry.
23. I am often spiritually touched by the beauty of creation.
24. I usually avoid activities in which I would be the center of attention.
25. I am usually not highly curious.
26. I would not describe myself as a worrier.
27. Caring for a sick person would be a burden for me.
28. I cannot remember a time when I became so angry that I wanted to break something.
29. I generally do not like vigorous games which require physical contact.
30. I rarely become sad.
31. I rarely rely on spiritual inspiration to help me meet important challenges.
32. I prefer to enjoy participating rather than take the lead in group work.
33. Seeking an answer is as enjoyable as finding the solution.
34. I often cannot fall right to sleep because something is troubling me.
35. I love being around baby animals.
36. When I get angry, I often feel like swearing.
37. I like to joke around with other people.
38. I often feel lonely.
39. For me, experiencing a connection to all of life is an important source of inspiration.
40. When I play games, it is important for me to win.
41. I usually feel little eagerness or anticipation.
42. I have very few fears in my life.
43. I do not especially like being around children.
44. When I am frustrated, I rarely become angry.
45. I dislike humor that gets really silly.
46. I never become homesick.
47. For me, spirituality is not a primary source of inner peace and harmony.
48. I sometimes "panic" a bit, if I lose sight of my companions in a crowd.
49. I enjoy anticipating and working towards a goal almost as much as achieving it.
50. I sometimes cannot stop worrying about my problems.
51. I feel softhearted towards stray animals.
52. When someone makes me angry, I tend to remain fired up for a long time.
53. People who know me would say I am a very fun-loving person.
54. I often think about people I have loved who are no longer with me.
55. Contemplating spiritual issues often fills me with a sense of intense awe and possibility.
56. If my peers have outperformed me, I would still be happy, if I have nearly met my goals.
57. I am usually not interested in solving problems and puzzles just for the sake of solving them.
58. My friends would say that it takes a lot to frighten me.
59. I would generally consider pets in my home to be more trouble than they are worth.
60. People who know me well would say I almost never become angry.
61. I do not particularly enjoy kidding around and exchanging "wisecracks."
62. It does not particularly sadden me when friends or family members are disapproving of me.
63. My sense of significance and purpose in life does not come from my spiritual beliefs.
64. I often feel uncomfortable when alone.
65. My curiosity often drives me to do things.
66. I often worry about the future.
67. I feel sorry for the homeless.
68. I tend to get irritated if someone tries to stop me from doing what I want to do.
69. I am very playful.
70. I tend to think about losing loved ones often.
71. Feeling a connection with the rest of humanity motivates me to make more ethical choices.
72. When I play games, I do not mind losing.
73. I rarely feel the need just to get out and explore things.
74. There are very few things that make me anxious.
75. I do not like to feel "needed" by other people.
76. I rarely get angry enough to want to hit someone.
77. I do not tend to see the humor in things many people consider funny.
78. I rarely have the feeling that I am close to tears.
79. The goals I set for myself are not influenced by my spirituality.
80. I like to invite people to do things with me even if they might turn me down.
81. Whenever I am in a new place, I like to explore the area and get a better feel for my surroundings.
82. I often worry about whether I am making the correct decision.
83. I am the kind of person that likes to touch and hug people.
84. When things do not work out the way I want, I sometimes feel like kicking or hitting something.
85. I like all kinds of games including those with physical contact.
86. I frequently feel downhearted when I cannot be with my friends or loved ones.

87. Spiritual inspiration helps me transcend my limitations.
88. I am not satisfied unless I can stay ahead of my peers.
89. I am not the kind of person that likes probing and investigating problems.
90. I rarely worry about my future.
91. I do not especially want people to be emotionally close to me.
92. I hardly ever become so angry at someone that I feel like yelling at them.
93. I do not frequently ask other people to join me for fun activities.
94. I rarely think about people or relationships I have lost.
95. My choices are not guided by a sense of connectedness with all of life.
96. I would feel comfortable living alone.
97. I often feel like I could accomplish almost anything.
98. I often feel nervous and have difficulty relaxing.
99. I am a person who strongly feels the pain of other people.
100. Sometimes little quirky things people do really annoy me.
101. I see life as being full of opportunities to have fun.
102. I am a person who strongly feels the pain from my personal losses.
103. When working on a project, I like having authority over others.
104. Being embarrassed or looking stupid are among my worst fears.
105. I am not an extremely inquisitive person.
106. I almost never lose sleep worrying about things.
107. I am not particularly affectionate.
108. When people irritate me, I rarely feel the urge to say nasty things to them.
109. Playing games with other people is not especially enjoyable for me.
110. It would not bother me to spend the holidays away from family and friends.
111. Striving to be better than my peers is not important for me.
112. I often fear that bad things may happen.

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