Biological Psychology 123 (2017) 310–323

Contents lists available at ScienceDirect

Biological Psychology

journal homepage: www.elsevier.com/locate/biopsycho

The behavioral approach system and augmenting/reducing in auditory event-related potentials during emotional visual stimulation

Vilfredo De Pascalis[a,*], Francesca Fracasso[a], Philip J. Corr[b]

[a] Department of Psychology, La Sapienza University of Rome, Italy
[b] Department of Psychology, City University London, London, United Kingdom

ARTICLE INFO

Article history:
Received 1 May 2016
Received in revised form 29 October 2016
Accepted 29 October 2016
Available online 2 November 2016

Keywords:
Augmenting/reducing
Event-related potentials
N1/P2 slope
LORETA
Reinforcement sensitivity theory (RST)
Behavioral approach system (BAS)
Goal-drive persistence (GDP)
Reward interest (RI)
Reward reactivity (RR)
Impulsivity (IMP)

ABSTRACT

In the recent Reinforcement Sensitivity Theory Personality Questionnaire (RST-PQ, Corr and Cooper, 2016) the behavioral approach system (BAS) has been conceptualized as multidimensional in which facets of reward interest and reactivity, and goal-drive persistence, are separate from impulsivity. Aim of the present work was to highlight the predictive power of BAS and its facets in differentiating electrocortical responses by using an auditory augmenting/reducing event-related potential (ERP) paradigm during emotional visual stimulation. ERPs were recorded for 5 levels of intensity in 39 women. The RST-PQ was used to measure the total BAS (T-BAS) and its four facets of Goal-Drive Persistence (GDP), Reward Interest (RI), Reward Reactivity (RR), and Impulsivity (IMP). T-BAS and RI, and to a less extent GDP and RR, were significantly associated with higher N1/P2 amplitudes at central sites (C3, Cz, C4) across neutral, positive and negative slides. Similar, but less pronounced relations were found for GDP and RR, but this relation was lacking for Imp facet. In addition, N1/P2 slope at central sites was positively correlated with T-BAS, GDP, RI, RR, but not Imp. Indeed, T-BAS facets failed to maintain a significant correlation with N1/P2 slope, after controlling for T-BAS residual scores, indicating that T-BAS drives these significant correlations. LORETA analysis at 219 ms (P2 wave) from tone onset revealed a significant activation of the right inferior parietal lobule (IPL, BA40) and left anterior cingulate gyrus (BA32) in high T-BAS compared to low T-BAS participants. Results are discussed within a revised RST framework differentiating reward components from impulsivity.

1. Introduction

Augmenting/reducing (A/R) is assumed to reflect individual differences in the modulation of sensory input, and has usually been studied using amplitude measures of event-related potentials (ERP) elicited at different levels of stimulus intensity (e.g., Buchsbaum & Silverman, 1968). A pronounced increase in amplitudes of the auditory N1/P2 component, as a function of stimulus intensity, is thought to reflect sensory inhibition at high levels of stimulations (e.g., Zuckerman, 1994) produced by serotonergic neurotransmission (Hegerl & Juckel, 1993). This mechanism is essential for the filtering properties of a gating mechanism that regulates sensory input to the cerebral cortex (Buchsbaum, Goodwin, Murphy, & Borge, 1971; Buchsbaum & Silverman, 1968). Individuals are classified as augmenters or reducers depending on whether they show a strong increase or weak increase or decrease on ERP amplitudes with increasing of stimulus intensity. Beauducel, Debener, Brocke, and Kayser (2000) found that the N1/P2-slope calculated across 5–6 auditory intensity levels, spanning a wide intensity range, are required for a reliable assessment of auditory A/R. The amplitude-intensity function slope (AIF), defined as the slopes of the linear regression line for the individual P1/N1 and N1/P2 amplitudes across the 5–6 stimulus intensities (Brocke, Beauducel, John, Debener, & Heilemann, 2000; Brocke, Beauducel, Tasche, 1999; Hegerl, Gallinat, & Mrowinski, 1994; Hegerl, Prochno, Ulrich, & Müller-Oerlinghausen, 1989) has been used as index of individual modes of processing sensory input (e.g., Hegerl & Juckel, 1993).

A rich collection of findings have been reported by Buchsbaum, Haier, and Johnson (1983) and (Hensch, Herold, Diers, Armbruster, & Brocke, 2008) of psychiatric and psychological phenomena associated with augmenting-reducing. In addition, reserch has demonstrated that the N1/P2 AIF of the ERPs is one of the numerous endophenotypes that are gaining importance in psychiatry and genetic research (e.g., Brocke et al., 2006; Gottesman & Gould, 2003). The N1/P2 AIF is considered important for clinical practice as it has been good to predict responses to lithium and selective serotonin reuptake inhibitors treatments (Gallinat et al., 2000;

* Corresponding author at: Department of Psychology, La Sapienza University of Rome, Via dei Marsi 78, 00185 Rome, Italy.
E-mail address: vilfredo.depascalis@uniroma1.it (V. De Pascalis).

http://dx.doi.org/10.1016/j.biopsycho.2016.10.015
0301-0511/© 2016 Elsevier B.V. All rights reserved.

Juckel et al., 2004; Mulert et al., 2007; Tien-Wen, Younger, Chen, & Tsai, 2005). The N1/P2 AIF has been proved to be associated with 5-HTTLPR, a genetic polymorphism of the serotonin transporter coding gene (Gallinat et al., 2003; Hensch et al., 2006; Strobel et al., 2003), and thus heritable (Sándor, Áfra, Proietti-Cecchini, Albert, & Schoenen, 1999).

In terms of personality traits, it was found that individuals scoring high on sensation seeking facets, and mainly on its disinhibition subscale, were augmenters and reducers tend to be sensation avoiding (Brocke et al., 2000; Brocke et al., 1999; Lukas, 1987; Stenberg, Rosén, & Risberg, 1988; von Knorring, 1980; Zuckerman, 1990; Zuckerman, 1994; Zuckerman, Murtaugh, & Siegel, 1974; Zuckerman, Simons, & Como, 1988). Moreover, Eysenck's extraversion trait was found positively associated with augmenting (Friedman & Meares, 1979; Soskis & Shagass, 1974; Stenberg et al., 1988). The validity of these findings was further supported by linking sensation avoiding and introversion with the defensive reducing pattern. The N1/P2 AIF was found correlated with a risk factor for bipolar disorder in healthy individuals (Hensch, Herold, & Brocke, 2007), and with sensation seeking trait, which is suggested to be characterized by low serotonergic neurotransmission and a potential risk factor for mental disorders (Brocke et al., 1999; Hegerl, Gallinat, & Mrowinski, 1995). In contrast, individuals with strong sensation-seeking tendencies are believed to be characterized by high dopaminergic, low noradrenergic, and low serotonergic activity (for a review see Zuckerman, 1994).

Augmenting has been also related to impulsivity (Barratt, Pritchard, Faulk, & Brandt, 1987; Carrillo-De-La-Pena & Barratt, 1993). Considering that impulsivity is an important trait of the reinforcement sensitivity theory (RST) of personality, it is surprising that no or little research has been done to evaluate the relation between RST traits and A/R of the ERPs. The most recent version of the RST (Corr & McNaughton, 2012; McNaughton & Corr, 2004, 2008; McNaughton & Gray, 2000) postulates three major neuropsychological systems controlling approach and avoidance behavior: (1) the Behavioral Approach System (BAS) controls active approach behavior in response to signals of reward and non-punishment and is activated by all forms of appetitive stimuli (including relief of nonpunishment); (2) the Fight-Flight-Freeze system (FFFS) as a primary system that controls active avoidance and is activated by all forms of aversive stimuli (including frustrating nonreward); (3) the Behavioral Inhibition System (BIS) controls passive avoidance in response to signals of punishment, nonreward, novelty, and by all forms of goal conflict, mainly for the co-activation of the FFFS and BAS. This is a revision of the original RST formulated by Gray (1982) that highlighted only two of these systems, the BIS and the BAS. In the original RST what is less apparent is the hidden complexity in and between these systems which renders any attempt to provide a psychometric description of them far from ordinary and prone to confusion (Corr, 2016). As a consequence of this state of affairs existing rRST questionnaires fail to provide a *comprehensive* descriptive model and all of the existing ones have significant theoretical and operational limitations with the result that there are still no comprehensive psychometric measures of the three revised systems. The most significant change to RST is the separation of FFFS/fear and BIS/anxiety processes (for a review see Rafael Torrubia, Caseras, Torrubia, & Caseras, 2008). Although the newer classes of RST measures have addressed the separation of FFFS and BIS, most of them still conceived the BAS, as a unitary dimension. However, there is compelling evidence that the BAS is multidimensional, both on the basis of empirical evidence (Carver & White, 1994; De Pascalis, Varriale, & D'Antuono, 2010) and theoretical grounds (Corr, 2008; Smillie, Cooper, Wilt, & Revelle, 2012). In order to move along the temporo-spatial gradient to the final primary biological reinforcer, Corr (2008) argued that it is necessary to engage in *sub-goal scaffolding*. These processes, at each stage of the temporo-spatial gradient, consists of a number of operations (i.e., identifying the biological reinforcer, planning behavior, and executing the plan) that involve other systems as working memory, executive control, etc.; this is in accordance with the type of required cognitive operations. The function of the BAS is to coordinate these functions as they relate to approach behaviors. BAS controlled approach may be expected to entail a series of subprocesses, some of which sometimes oppose each other: (1) *behavioural restraint* serving to plan and execute effective sub-goal scaffolding; and (2) *impulsive behaviour* serving when cognitive planning can be replaced, at short temporo-spatial distance, by fast 'getting', or a physical grabbing of the final biological reinforcer at near-zero temporo-spatial distance (Carver, 2005; Corr, 2008). This theoretical assumption does not imply that the emotional component of BAS behaviour would be attenuated at the early stages of approach behaviour, since the fulfilment of sub-goals is likely to entail periodic bursts of emotional excitement to maintain motivation across time/space ('temporal bridging', Corr, 2008) during which approach behaviour is not being immediately reinforced (goal drive persistence).

Consistent with both theoretical and empirical considerations, Corr and Cooper (2016) developed the Reinforcement Sensitivity Theory Personality Questionnaire (RST-PQ) that is recommended as the most appropriate measure of the rRST that allows the separation of the FFFS and BIS and the important distinction of reward sensitivity and impulsivity (Corr & Cooper, 2016). Mainly, the four sub-scales of the BAS (Reward Interest, RI; Goal-Drive Persistence, GDP; Reward Reactivity, RR; Impulsivity, Imp) makes this tool to test an open empirical question, i.e., if the four BAS facets exhibit an unique predictive power, or they are redundant. According to Corr and Cooper (2016) it is especially important to separate reward interest and reactivity from impulsivity. This is since the first facet concerns with individual disposition to identify the biological reinforcer, the second with individual differences in emotional response to reward, the third reflects the need for a rapid action sufficient to 'capture' the final biological reinforcer, at the later stages of BAS behavior, when continued planning and behavioral caution are not appropriate.

In line with this view, Lang (1995) conceived the emotional system as consisting of the appetitive motivational and aversive system. The former facilitates approaching behaviors, such as mating, food taking or exploration, whereas the latter facilitates defensive behavior, such as avoidance, escape or defence. Lang and co-workers (Lang, Bradley, & Cuthbert, 1997) regard arousal and valence as the fundamental dimensions of the emotions, that is, arousal determines the intensity and valence the direction of activation. A "gating" function exerted by dopamine in regulating access of context representations into active memory in prefrontal cortex (a fuction which is impaired in schizophrenia) has been proposed by Braver and Cohen (2000). More recently, Berridge (2007, 2012) has examined three competing dopamine hypotheses which are debated in the current literature, i.e., (*i*) dopamine mostly mediates the hedonic impact of reward ('liking'), or (*j*) mediates learned predictions of future reward ('learning'), or (*k*) motivates the pursuit of rewards by attributing incentive salience to reward-related stimuli ('wanting'). Dopamine was neither necessary nor sufficient to mediate changes in hedonic 'liking' for sensory pleasures or learning, while dopamine activation was necessary for normal 'wanting' and to enhance cue-triggered incentive salience. The incentive reward system is equivalent to the BAS and produces motivation to approach reward, but the hedonic system is the pleasure system responsible for the enjoyment experienced following the gaining of reward (see Corr, DeYoung, & McNaughton, 2013; Corr & McNaughton, 2012).

Personality research on A/R has been centered almost exclusively on individual differences in extraversion-related constructs