Biological Psychology 137 (2018) 91–106

Contents lists available at ScienceDirect

Biological Psychology

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

Extraversion and behavioural approach system in stimulus analysis and motor response initiation

Vilfredo De Pascalis*, Kathrin Sommer, Paolo Scacchia

Department of Psychology, La Sapienza University of Rome, Italy

ARTICLE INFO

Keywords:
Extraversion
Behavioural approach system
Reaction time
Event-related potentials
Lateralized readiness potential
Sensorimotor processes

ABSTRACT

In this study, we attempt to validate previous findings on extraversion-related differences in speed of sensorimotor processing and to extend them into Behavioural Approach System (BAS) subtraits within the framework of the revised Reinforcement Sensitivity Theory (rRST) of personality. Here, we assessed psychological traits of extraversion (E), four BAS facets (Goal-Drive Persistence, BAS-GDP; Reward Interest, BAS-RI; Reward Reactivity, BAS-RR; Impulsivity, BAS-I), Behavioural Inhibition System (BIS), and Fight-Flight-Freeze System (FFFS) in 51 volunteers (28 women). Stimulus-locked lateralized readiness potential (S-LRP), response-locked LRP (R-LRP), stimulus-locked and response-locked forearm electromyogram (S-EMG and R-EMG), and P3 components of the event-related potentials (ERPs), were recorded during the performance of a two-choice Go/NoGo visual letter-digit discrimination task varying in task difficulty. High extraverts, relative to introverts and individuals high relative to low on BAS-RI, were more likely to exhibit shorter S-LRP latencies and stimulus- and response-locked EMG latencies. Additionally, high BAS-I had a shorter R-RLP latency than low BAS-I participants for the difficult task. High FFFS levels were associated with longer S-LRP and S-EMG latencies, while high BIS levels had larger response accuracy. Extraverts, relative to introverts, along with those high relative to low on BAS-RR and BAS-I, exhibited smaller P3 amplitudes.

The faster cortical premotor initiation, found in individuals high on extraversion, BAS-RI and low on FFFS, may account for their faster peripheral motor response initiation and execution.

Smaller P3 amplitudes in extraverts and individuals high on BAS-RR and BAS-I may indicate reduced perceptual processing capacity in these individuals.

1. Introduction

Individual differences in central and peripheral speed of information processing constitute a major source of variation in personality traits. A number of experimental accounts of extraversion and mental ability, representing respectively a basic dimension and a cognitive dimension of personality, suggest that individual differences in both of these aspects of personality are functionally associated to individual differences in information processing (Eysenck & Eysenck, 1985). There is a good deal of experimental evidence that indicates differences in speed of sensorimotor information processing between introverts and extraverts (for review see Bullock & Gilliland, 1993; Rammsayer, 1998; Stelmack & Michaud-Achorn, 1985). A number of complex experiments conducted by Brebner and coworkers indicated that extraverts are more prone to stimulus inhibition compared to introverts (Brebner & Cooper, 1974, 1978), that response excitation is stronger in extraverts than in introverts (Brebner & Cooper, 1974, 1978, 1985; Brebner & Flavel, 1978). They proposed that extraverts, being "geared to respond", perform better at simple time demanding tasks. As the tasks get more difficult, or stimuli get more complex, introverts, being "geared to inspect", gain an advantage. In addition, to account for extraversion-related differences in overt motor behavior and speed of responding, Brebner and colleagues suggested two stages of information processing, known as stimulus-analysis (S-analysis) and response-organization (R-organization). They postulated that introverts are facilitated in S-analysis and inhibited in R-organization. In contrast, extraverts are inhibited in S-analysis and facilitated in R-organization. Thus, in general terms, this model predicts more elaborate analysis of sensory information for introverts than for extraverts and faster motor response preparation for extraverts compared to introverts (Brebner & Cooper, 1985; Brebner, 1990).

Under controlled conditions, extraverts tend to show shorter response times (RT), more frequent movements, and faster response rates than introverts (for review see Doucet & Stelmack, 2000; Stelmack &

* Corresponding author: 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).

https://doi.org/10.1016/j.biopsycho.2018.07.004
Received 4 December 2017; Received in revised form 30 June 2018; Accepted 9 July 2018

Houlihan, 1995). These effects may be attributable to faster initiation of movement or faster motor execution in extraverts compared to introverts (e.g., Doucet & Stelmack, 1997; Wickett & Vernon, 2000). Individual differences in sensorimotor information processing can be assumed to be prominent at processing stages characterised by capacity limits (Cooper & Regan, 1982; Troche & Rammsayer, 2009).

However, current biological theories of Extraversion and Neuroticism are notably influenced by the work of his refulgent student Jeffrey Gray, who developed a personality theory identifying a 'conceptual nervous system' based on approach and avoidance processes (Gray, 1982; Pickering & Gray, 1999). Additionally, the current revision of Gray's theory (Gray & McNaughton, 2000) has largely superseded Eysenck (1967a) arousal theory of personality, and incorporated (Zuckerman, Murtaugh, & Siegel, 1974) sensations seeking factor under an impulsivity component of approach processes. In this respect, Matthews and Gilliland (1999) observed that associations of extraversion with cortical arousal are moderated by the reward properties of the situation in which arousal are measured. Pharmacological reports have shown that dopamine affects the association of extraversion with patterns of cortical arousal (Wacker, Chavanon, & Stemmler, 2006).

1.1. Eysenck and Gray theories of personality

It is important to note that Hans Eysenck theory of personality is based on the assumption that brain processes can be characterized by means of a simplified 'conceptual nervous system' consisting of two key components relevant to personality and behavior: the reticulo-cortical and reticulo-limbic systems (Eysenck, 1967a, 1994). The first system controls cortical arousal generated by incoming stimuli and is responsible for individual differences in extraversion (Hebb, 1955; Moruzzi & Magoun, 1949). The second system controls responses to negative emotional stimuli and is responsible for individual differences in neuroticism. Eysenck theory of extraversion proposed that individual differences in extraversion could be understood in terms of differences in optimal levels of arousal. This theory proposes that the set point of activation (arousal threshold) of the ascending reticular system of introverts is lower than for extraverts so that introverts are typically more aroused than extraverts. Extraverts, on the other hand, who are characterized by higher arousal thresholds, reach their optimal level of arousal at higher levels of stimulation. Although the physiological mechanisms of arousal and arousability were not explicitly defined, the hypothesis of optimal level of arousal proved to have a strong heuristic value (De Pascalis, 2004).

Early version of Gray's personality theory, although seen as an alternative theory derived from basic animal learning research, began as an extension of Eysenck theory (Gray, 1981). This theory sees approach and avoidance processes as the basic elements for the description of behavior. These processes are engaged by reinforcing stimuli in the environment (rewards and punishments, threats and incentives) and impulsivity and anxiety are the personality traits reflecting, respectively, individual differences in sensitivity to reward and punishment stimuli. For this reason, Gray's theory has been termed 'Reinforcement Sensitivity Theory' (RST; see Corr, 2008). The link between Eysenck and Gray theories have been operatively provided by the assumption that anxiety and impulsivity traits are typically represented graphically as a rotation (thought to be around 30°, see Pickering, Corr, & Gray, 1999) to Eysenck (1967b) extraversion-neuroticism model.

Today have been underlined a hidden complexity in and between these systems and this is captured in the revised RST (rRST) which postulates three major neuropsychological systems: the *behavioural approach system* (BAS), and two defensive behaviours, namely the *fight-flight-freeze system* (FFFS) and *behavioural inhibition system* (BIS). The BAS is thought to mediate responses to all and any appetitive stimuli; FFFS is activated by all and any aversive stimuli; and the BIS is activated by stimuli indicating conflict between goals (e.g., co-activation of FFFS and BAS). One of the most significant advancement in rRST is the separation of FFFS-fear and BIS-anxiety processes, which are postulated to have different functional properties and distinct neuropsychopharmacological bases (see Corr & McNaughton, 2012; Gray & McNaughton, 2000; McNaughton & Corr, 2004, 2008). Corr (2008) has drawn attention to the inadequate conceptualization of the BAS, especially as it relates to impulsivity. The main function of BAS system is to move the animal up the temporo-spatial gradient, from a start state, to the final primary biological reinforcer, that entails a number of relatively separate, albeit overlapping, processes. These processes, at each stage of the temporo-spatial gradient, consist 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. At the simplest level, there seems an obvious difference between the 'reward interest' and 'goal drive' components of the BAS, that characterizes the early stages of approach behavior, and the characteristic emotional excitement of impulsive approach, experienced as the animal reaches the final biological reinforcer (Carver, 2005; Corr, 2008). In the former case can be experienced 'anticipatory pleasure', whereas in the latter case something akin to an 'excitement attack' (Pickering & Corr, 2008). From these theoretical considerations can be easily derived that the BAS is multidimensional. The neurobiology of the BAS is primarily located in the basal ganglia, with a central role played by mesolimbic dopamine projections from the ventral tegmental area to the ventral striatum (mainly the nucleus accumbens), and also mesocortical dopamine projections to prefrontal cortex (Depue & Collins, 1999; Knutson & Cooper, 2005; McClure, York, & Montague, 2004; Pickering & Gray, 1999). Tonic dopaminergic activity is necessary to enable behavioural activation (Schultz, 1998). Phasic activity of dopaminergic neurons is sustained when rewards are fully predicted, increases in response to unpredicted reward, and decreases in response to unpredicted non-reward (Day, Roitman, Wightman, & Carelli, 2007; Pickering & Corr, 2008), indicating that dopamine communicates reward prediction error. Inter-individual variation in individual sensitivity to reward (i.e., the typical activity of the BAS) is thought to be linked with extraversion, perhaps being today the most accepted trait (Smillie, 2008). DeYoung (2010) has outlined how the traits encompassed by extraversion, such as assertiveness and talkativeness, are associated with different aspects of approach behavior: dopamine plays a key role in there regulation of assertiveness and the sensitivity to reward (for the drive and interest to achieve a reward, i.e., for 'wanting'), while endogenous opioid systems are associated with talkativeness (for the enjoyment of reward once it is achieved, i.e., for 'liking'; Berridge, Robinson, & Aldridge, 2009). Opioid systems are also involved in the positive emotions that follow acquisition or consumption of reward and which are particularly important in social affiliation (Depue & Morrone-Strupinsky, 2005). Thus, on these bases reward interest and drive components of the BAS, serving the early stages of approach behavior, may be the approach components candidate to be associated with extraversion since both share the assertiveness aspect to receive a reward that has been linked to dopaminergic activity (Knutson & Cooper, 2005), rather than to the emotional excitement that encompass impulsive approach, likely to reflect the action of endogenous opioid systems, which is mainly activated by the final biological reinforcer.

1.2. Extraversion and approach/avoidance traits: neurocognitive correlates in sensorimotor processing

Most of previous electrophysiological research has attempted to elucidate personality-related differences in speed of central nervous system processing. The major event-related potential (ERP) component, usually related to cognitive processing, is the P3 wave that has been associated with processes related to classifying or updating memory representations of stimuli. This positive ERP deflection is peaking at about 300 ms after stimulus onset. P3 amplitude increases as the