Individual differences in attentional networks: Trait and state correlates of the ANT

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ABSTRACT

Several trait and state factors may predict enhanced attentional functioning, but the mechanisms underlying these effects require elucidation. The current study aimed to test relationships between traits (Five Factor Model), three state factors and the Attentional Network Test (ANT). 99 Israeli undergraduates participated. Trait and state factors were differentially related to the ANT indices. As predicted, superior executive control was associated with extraversion, conscientiousness, state task engagement, and low state distress. Differing predictor sets were found for alertness and orienting. Findings are discussed in relation to cognitive neuroscience models of personality and subjective state.

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1. Introduction

Cognitive neuroscience may help us to understand individual differences (IDs) in attention (Matthews, 2008). The present study aimed to investigate associations between trait and state factors and the Attention Networks Test (ANT: Fan, McCandliss, Sommer, Raz, & Posner, 2002). The ANT assesses three key brain circuits for attention; executive control (EC), spatial orienting and alertness. EC is supported by frontal areas associated with resolution of cognitive conflict, including anterior cingulate cortex and lateral prefrontal cortex (PFC). The orienting network controls direction of attention following presentation of a spatial cue, and is supported by the parietal lobules, frontal eye fields, and several subcortical areas. The alertness network is supported by thalamic, frontal, and parietal areas, and maintains readiness to respond to target stimuli. Identification of trait and state effects on these three networks may afford a more precise account of IDs in attention than resource theory explanations. This study is the first to test for associations between the ANT and the Five Factor Model of personality (Saucier, 2002), as well as three broad state factors of task engagement, distress and worry. Next, we review traits and states that may relate to energization of attention and to executive functioning.

1.1. State and trait factors in energization processes

Studies of vigilance, visual search and other attentionally demanding tasks show reliable effects of stimulant and de-arousing agents, prompting the hypothesis that arousal elevates the availability of a resource for sustained information transfer (Humphreys & Revelle, 1984). Matthews, Davies, and Lees (1990) confirmed that subjective energetic arousal predicted attentional task performance. Furthermore, associations between energy and performance were moderated by task demands as predicted by resource theory; the higher the workload, the greater the correlation (Matthews, Warm, Reinerman, Langheim, & Saxby, 2010a). Recent studies investigated subjective task engagement (Matthews et al., 2002), a higher-order state factor associated with motivation and concentration as well as with energy. Like energy, high task engagement predicts superior attention (Matthews et al., 2010a, 2010b). Task engagement correlates with a physiological index of resource mobilization, cerebral bloodflow velocity (CBFV: Matthews et al., 2010a). It also correlates with cognitive appraisal and coping processes that may support attention (Matthews et al., 2002).

Task engagement may relate to executive functioning (Matthews et al., 2010a). The cortical sites for EC are influenced by the ventral tegmental dopamine system (Fan et al., 2002). Dopaminergic pathways regulate active maintenance of task-relevant context in PFC (De Young & Gray, 2009), and support positive emotional states, especially states such as task engagement that reflect motivated goal pursuit, rather than pleasure per se (Berridge & Kringelbach, 2008; Matthews et al., 2010a). Caffeine enhances both

vigilance and EC (Bruny, Mahoney, Lieberman, & Taylor, 2010), whereas sleep deprivation has the opposite effect (Martella, Casagrande, & Lupiáñez, 2011). Studies of executive functioning using other tasks have generally also shown detrimental effects of fatigue associated with sleep loss (Killgore, in press). Effects on other attentional networks appear less robust. Bruny et al. (2010) found that their highest caffeine dosage enhanced alertness, but there was no effect of sleep loss in the Martella et al. study. Orienting was unaffected by caffeine (Bruny et al., 2010), and enhanced by sleep loss (Martella et al., 2011). Thus, associations between engagement and attention, as well as stressor effects on executive functioning, suggest that task engagement should correlate with EC.

Turning to trait energization factors, accounts of dopaminergic support of EC typically focus on the Behavioral Activation System, and related traits including extraversion (De Young & Gray, 2009). If extraversion is associated with dopaminergic activity, it should enhance EC. In addition, performance studies show better multi-tasking performance in extraverts in some task paradigms (Szymura, 2010). A difficulty for the hypothesis is that extraversion is rather weakly related to positive affect and task engagement during performance (Matthews & Gilliland, 1999; Shaw et al., 2010).

Another relevant trait is conscientiousness, which relates to the planning and impulse control functions critical for cognitive control (De Young & Gray, 2009), and volume of the lateral PFC (De Young et al., 2010). Furthermore, conscientiousness is associated with task engagement during task performance, and with cognitive correlates of engagement such as task-focused coping (Matthews et al., 2006, 2010b).

1.2. Anxiety and negative affect

Traits and states associated with negative affect may also influence attention and EC. Most relevant research has focused on trait anxiety. Eysenck and Derakshan's (2011) Attentional Control Theory (ACT) identifies anxiety with weakened EC over exogenous, stimulus-driven attention. Anxious individuals may maintain performance effectiveness through compensatory effort, depending on motivational factors. ACT differentiates multiple executive processes, and links anxiety especially to weakness in inhibitory control associated with fronto-parietal brain areas. ACT deals specifically with anxiety, but comparable processes may operate in other negative emotional conditions (Wells & Matthews, 1994). As ACT predicts, anxiety and related traits typically impair inhibitory and other EC functions (Eysenck & Derakshan, 2011).

Two recent ANT studies provide conflicting findings. Moriya and Tanno (2009) found that state and trait anxiety, depression and social anxiety were all negatively associated with the ANT orienting index. No significant correlates of EC and alerting were obtained. Pacheco-Unguetti, Acosta, Callejas, and Lupiáñez (2010; Study 1) failed to replicate these associations between anxiety and orienting, although, consistent with ACT, they found that trait (but not state) anxiety was associated with poorer EC. A further study (Pacheco-Unguetti et al., 2010) found no effect of trait anxiety, but induced anxious mood enhanced orienting and alerting. A review of ANT research (MacLeod et al., 2010) reported specific executive impairments in various clinical conditions, including two associated with negative affectivity, borderline personality and post-traumatic stress disorder.

1.3. Aims and hypotheses

The overall aim of the study was to assess associations between broad trait and state measures and the ANT, in an Israeli sample. The primary focus was on correlates of EC, although we also investigated orienting and alertness. The traits of the FFM (Saucier, 2002) were assessed, as well as three broad subjective states of task engagement, distress and worry (Matthews et al., 2002). Vocabulary was assessed as a potential control variable. Hypotheses were as follows:

State task engagement predicts superior performance on demanding attentional tasks (Matthews et al., 2010a), Also, engagement may be associated with activity in mesolimbic dopaminergic pathways that enhance EC functions of PFC (De Young & Gray, 2009). Thus, state task engagement should correlate with EC (H1).

Extraversion is related to dopaminergic afferents to frontal cortex, and to superior dual-task performance. Extraversion should thus correlate with EC (H2). Conscientiousness is associated with impulse control, task engagement and task-focused coping. It too should correlate with EC (H3).

Existing studies of the ANT and negative affect have yielded inconsistent results (Moriya & Tanno, 2009; Pacheco-Unguetti et al., 2010). However, the broader literature on anxiety, negative affect and attentional impairments (e.g., Eysenck & Derakshan, 2011) suggests that emotional stability should correlate with superior EC (H4).

Finally, we tested whether trait effects were mediated by transient states. On the basis of known trait-state associations (Matthews et al., 2002), as well as the neuroscience of traits (De Young & Gray, 2009), we hypothesized that associations between extraversion and conscientiousness and EC would be mediated by task engagement (H5a). Similarly, associations between neuroticism and EC may be mediated by states of negative affect, operationalized here as distress and worry (H5b).

2. Methods

2.1. Participants

99 undergraduates (66% female) at the University of Haifa participated. Mean age was 24. Forty-two participants self-identified as Jewish; the remainder reported various, predominantly Muslim, religious affiliations.

2.2. Task and measures

2.2.1. Vocabulary
It was assessed with the Verbal subtest of the Level III Milta Intelligence test (Ortar, 1966), which is comprised of 25 multiple choice items. For each word, respondents were asked to choose the best definition from five alternative single words.

2.2.2. Personality
The Mini-Modular Markers (3M40; Saucier, 2002) assessed the FFM traits: Extraversion, Emotional Stability, Agreeableness, Conscientiousness, and Openness. Participants rated 40 personality descriptors on 1–9 response scales, anchored by "extremely accurate" and "extremely inaccurate" as scale endpoints.

2.2.3. Subjective state
The short version of the Dundee Stress State Questionnaire (DSSQ; Guznov, Matthews, Funke, & Dukes, 2011) assessed three subjective state factors: task engagement (energy, task motivation, concentration), distress (tension, unpleasant mood, lack of confidence), and worry (self-focused attention, low self-esteem, cognitive interference related to task and personal concerns). There are 21 items, with 5-point response scales. The short DSSQ is based on the full-version DSSQ: see Matthews et al. (2002) for a description of its psychometric properties.