Relations of naturally occurring variations in state anxiety and cognitive functioning

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ABSTRACT

Although effects of anxiety on cognitive performance have been extensively examined, anxiety–cognition relationships are often defined by between-person relationships. The current research investigated the effects of within-person variations in state anxiety on cognitive performance based on measures from three separate sessions in a sample of 1769 healthy adults ranging from 18 to 99 years of age. Some of the adults in the sample exhibited a wide range of state anxiety across the three sessions, whereas others were fairly stable. Although one might have expected that cognitive performance would be low only on sessions in which the level of state anxiety was high, this pattern was not evident in any of five different cognitive abilities (vocabulary, memory, reasoning, spatial relations, or perceptual speed tasks). Instead, one's average level of anxiety was a more important determinant of cognitive performance than one's current level of state anxiety. Specifically, for memory and reasoning abilities, trait anxiety alone related to decreased cognitive function, regardless of state anxiety. For spatial relations and speed abilities, low state anxiety was related to *decreased* cognitive function in participants with high trait anxiety.

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1. Introduction

According to Eysenck, Derakshan, Santos, and Calvo (2007), anxiety is defined as, "An aversive emotional and motivational state occurring in threatening situations" (p. 337). The term can be used to describe a chronic condition, in the form of a trait, or a transient experience corresponding to a state. State anxiety refers to an individual's anxiety in a particular situation, while trait anxiety is the tendency to become anxious in many situations and represents a personality dimension of that individual (Eysenck et al., 2007). Prior research has found that high levels of both trait and state anxiety are associated with low levels of cognitive performance (e.g. Eysenck et al., 2007; Salthouse, 2012). These anxiety–cognition relations have been found in both correlational studies, involving comparisons of the cognitive performance of people with different reported levels of anxiety (e.g. Derakshan & Eysenck, 2009, Markham & Darke, 1991, Salthouse, 2012, Sommer, 2014), and in experimental studies in which cognitive performance is evaluated before and after the manipulation of anxiety (e.g. Cumming & Harris, 2001, Leininger & Skeel, 2012, Lupien et al., 1997).

1.1. Anxiety and cognition

According to the processing efficiency theory (Eysenck & Calvo, 1992), anxiety can have competing effects on cognition: worry (an aspect of state anxiety) can impair the working memory capacity of an individual, and simultaneously increase effort for a task resulting in improved performance. The combination of these two processes can produce a peak in performance when the anxiety level is moderate but when tasks are complex the load on working memory will increase and result in poor performance.

1.2. Theory

Much of the prior research examining relations between anxiety and cognition has been based on between-person comparisons in which cognitive performance is examined across different people with differing levels of anxiety (e.g. Salthouse, 2012, Waldstein, Ryan, Jennings, Muldoon, & Manuck, 1997). However, levels of anxiety can also vary within the same individuals and relatively little is known about the relations between within-person fluctuations in anxiety and within-person fluctuations in cognitive performance (e.g. Waldstein et al., 1997). The available evidence is thus insufficient to determine whether people perform at lower levels on days when their self-reported anxiety is high than on days when their self-reported anxiety is low.

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This question is challenging to investigate for a number of reasons. For example, two or more measures of state anxiety and cognition must be available from each participant to allow comparisons of different levels of anxiety in the same individual. In addition, the measures of cognition should be sensitive, and different abilities or domains should be represented to allow the generalizability of the phenomenon to be examined. Most importantly, because participants are likely to have relatively small natural across-session fluctuations in their level of state anxiety, moderately large samples are necessary to identify individuals who have sessions with both low and high levels of anxiety.

1.3. Calculation

Data with these characteristics are available in the Virginia Cognitive Aging Project (VCAP; e.g., Salthouse, 2007, 2009; Salthouse, Pink, & Tucker-Drob, 2008). A unique feature of this project is a measurement burst design in which participants complete a state anxiety questionnaire and perform parallel versions of cognitive tests on three separate sessions within a span of about two weeks. Each of five cognitive ability domains (vocabulary, inductive reasoning, spatial visualization, episodic memory, and perceptual speed) is represented by either three or four separate tests, which can be combined into composite scores to provide sensitive measures of each of the abilities.

Participants in VCAP performed three testing sessions that last between 90 and 120 min each within a period of about two weeks. Each session consisted of the completion of a self-report state anxiety scale and performance of sixteen different cognitive tests. Participants also completed a trait anxiety measure at home between the first and the third session. Most of the individuals had similar values of state anxiety on each session, but some of them had one or more sessions with 'high' levels of anxiety and other sessions with relatively low levels of anxiety. The individuals with highly variable levels of anxiety were of particular interest because cognitive performance on higher state anxiety sessions could be compared with cognitive performance on moderate or low state anxiety sessions.

1.4. Potential outcomes

Evidence suggests that state and trait anxiety might interact with different types of cognitive abilities in unique ways (Bishop, Duncan, Brett, & Lawrence, 2004; Derakshan & Eysenck, 1998; Eysenck et al., 2007; Harris & Cumming, 2003). At least three possibilities can be identified to describe how cognitive performance might vary across 'high' and 'normal' anxiety days. These possibilities can be termed state-dominant, trait-dominant, and state–trait-discrepant. The state-dominant pattern would be apparent if cognitive performance is lower only on the days when the participants report high levels of state anxiety. Because an outcome such as this would resemble the between-person relation between anxiety and cognitive performance, it would be consistent with an interpretation that the same mechanisms linking anxiety to cognition operate across different people at a single point in time and within the same person across different points in time. In other words, since state anxiety produces inefficiency (Eysenck & Calvo, 1992), there would be a direct correlation between high state anxiety and low cognitive scores, regardless of the individual's average level of anxiety.

According to the Attentional Control Theory, consistent anxiety impairs a person's ability to ignore distractors and thereby diminishes performance, especially when tasks are demanding (Eysenck et al., 2007). The consistent nature of trait anxiety might impair one's inhibition even if they are not anxious in the moment. Hence, a pattern in which cognitive performance in the variable individuals is low even on days in which they have low levels of anxiety can be characterized as 'trait-dominant' because performance is more closely related to the average state, or trait, level of anxiety than by the level of state anxiety on a given session. If people with varying (and therefore higher) levels

of trait anxiety perform worse than people with stable (and therefore lower) trait anxiety regardless of state anxiety level, the relevant factor varying with cognitive functioning may not be the individual's current level of state anxiety, but his or her trait anxiety.

Some researchers have suggested that performance on certain tasks may be optimized if the person's mood state is consistent with their mood trait (Tamir, Robinson, & Clore, 2002). This leads to a third possible outcome that can be designated as 'state–trait-discrepant' in that the major factor associated with cognitive performance may not be one's current level of state anxiety or trait anxiety, but instead could be the discrepancy between the individual's trait level of anxiety and his or her reported state anxiety level on a given session. Because the variable participants will tend to have higher average levels of anxiety than the stable participants, the expectation from this perspective is that variable participants would have lower cognitive performance on the session in which his or her self-reported state anxiety is lowest because the discrepancy from their trait level of anxiety will be highest.

2. Materials and methods

2.1. Participants

Participants were recruited through advertisements, flyers, and referrals from other participants. They reported to the laboratory on three separate days within about two weeks. Informed consent was obtained from each participant at the beginning of the first session. Only participants with complete data from all three sessions were included in the current study.

2.2. Preliminary analyses

In order to determine what should be considered high levels of anxiety in this sample, an initial analysis examined the relation between anxiety and cognitive performance across different people on the same session. There was a significant decline in cognitive performance for individuals with the state version of the State–Trait Anxiety Inventory (STAI-S; Spielberger, 1983) scores greater than 36. Therefore, in the main analyses, participants of interest were assigned to the variable group if they had at least one session with anxiety scores above 36 in the between-person comparison (because anxiety scores from this range were associated with significantly lower cognitive ability), and at least one session with anxiety scores in the "normal" range in which the average cognitive performance was high. This selection allowed for a direct comparison between cognitive performance on high- and low-state anxiety days.

Because some across-session fluctuation in cognitive performance would be expected in everyone, individuals with low levels of across-session variability in state anxiety were included in addition to the individuals with high across-session variability in order to determine whether variable participants' performance when they report low anxiety is similar to that of the low-variation (stable) group.

2.3. Group selection

The variable group consisted of participants whose highest state anxiety score was at least 36 and their lowest state anxiety score was at least 19 points below their highest state anxiety score. (Given that the minimum score on the STAI-S was 20, the actual minimum value in the high-anxiety session in the variable group was 39.) The stable comparison group consisted of participants whose highest state anxiety score was less than 36, and who had a difference between the highest and lowest state anxiety score of less than 20. For example, an individual with state anxiety scores of 30, 27, and 23 would have a high-low difference of 7 (i.e., session 1 score of 30 minus session 3 score of 23), and would be assigned to the stable group. In contrast, an individual with state anxiety scores of 28, 57, and 33 would have a high-low