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Adverse effects of anxiety on attentional control differ as a function of experience: A simulated driving study

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ABSTRACT

This study tested whether adverse effects of state anxiety on attention and performance may be modulated by experience. Sixteen experienced and eleven inexperienced drivers drove in a simulator under low- and high-stress conditions. Anxiety was manipulated by competition, the presence of an evaluator, external video camera, and traffic noise. Most drivers showed greater anxiety scores and higher mean heart rates following manipulation. In both groups increased state anxiety decreased car speed control and caused more collisions, accompanied by fewer fixations of longer duration towards the driving lane across a horizontally narrower region. Inexperienced drivers increased the number of short fixations towards cars, while experienced drivers increased the number of short fixations on the speedometer. Although anxiety impairs processing efficiency and performance effectiveness for both groups, attentional changes differ as a function of experience. Inexperienced drivers tended to shift attention to threatening stimuli, while experienced drives were more likely to consciously monitor task goal.

1. Introduction

The often-detrimental effects of anxiety on performance have been investigated for a long time. However, recent advances in gaze-tracking technology *during* action has recently renewed interest in how attention modulates the performance decrements following an increase in anxiety in dynamic situations such as sports, policing and car driving (Allsop and Gray, 2014; Briggs et al., 2011a; Causer et al., 2011; Nibbeling et al., 2012; Vickers and Williams, 2007; Navarro et al., 2012; Williams et al., 2002; Nieuwenhuys and GJPOudejans, 2015; Pijpers et al., 2005; Navarro et al., 2013; Malhotra et al., 2014). Typically, anxiety can be understood as a (transitory) state or a personality trait. According to Eysenck, state anxiety is an aversive transitory emotional and motivational state evoked by threatening and/or stressful circumstances (Eysenck et al., 2007a), while trait anxiety is an individual's propensity towards anxiety. It has been shown that increased levels of state anxiety can disrupt performance by enhancing a performer's propensity for distraction (Allsop and Gray, 2014; Wilson et al., 2009a; Janelle et al., 1999), attentional narrowing (Briggs et al., 2011a; Janelle et al., 1999), and/or reduced processing efficiency (Nibbeling et al., 2012; Behan and Wilson, 2008; Causer et al., 2014; Wilson et al., 2009b).

Recently, Nieuwenhuys and Oudejans proposed an integrated model that encompasses anxiety and perceptual-motor performance for explaining the disparate behavioural responses observed under threatening and stressful circumstances (Nieuwenhuys and Oudejans, 2012, 2017). This model builds heavily on Attentional Control Theory (ACT) (Eysenck et al., 2007b) that is suitable for cognitive tasks, yet extends it to fit the specific characteristics of perceptual-motor performance, including the critical role of visual attention. According to the integrated model, and in line with ACT, increased anxiety provokes performance

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decrements because it impairs attentional control; it intensifies the engagement of the stimulus-driven system at the expense of the involvement of goal-directed system. The goal-directed system regulates the conscious control of attention. This top-down system directs attention in accordance with a performer's expectations, knowledge and current task goals. The stimulus-driven system recruits attentional resources via automatic processing. This bottom-up system serves to detect maximally salient and/or threatening stimuli in the environment. In low stressful situations, the contributions of two attentional systems are optimally coordinated for achieving the task goal. However, with increased levels of anxiety, the systems' coordination is disrupted. Attentional control may shift more to the stimulus-driven system, increasing attention to conspicuous stimuli (Allsop and Gray, 2014; Briggs et al., 2011a; Nibbeling et al., 2012; Janelle et al., 1999; Eysenck et al., 2007b) and away from the goal-directed system. To counter this and with increased mental effort, one may manage to maintain goal-directed attention; in that case, performance is maintained but with decreased processing efficiency (Masters and Maxwell, 2008). On the other hand, if there is indeed a shift toward the stimulus-driven system under high anxiety then the time visually fixating irrelevant/threatening cues is increased (Allsop and Gray, 2014; Williams and Elliott, 1999) and the number of fixations towards relevant areas of the visual scene is reduced (Allsop and Gray, 2014), leading to hampered performance. In addition, it provokes a relatively narrow range of visual scanning (Briggs et al., 2011a). However, it is not particularly clear whether, and if so to what degree, the effects of increased anxiety differ as a function of the level of experience or expertise.

In car driving -the task under study here-the level of experience (or perhaps expertise) does influence perceptual and motor performance (Underwood, 2007; Crundall and Underwood, 1998). For example, inexperienced drivers have been shown to have a reduced visual exploration (e.g., less fixations with a relatively narrower distribution) compared to experienced drivers, in particularly when potential hazards are more likely to occur (e.g., driving in dual carriageway, night and rain visibility). The less developed capacity to acquire information (Crundall and Underwood, 1998; Mourant and Rockwell, 1972; Crundall et al., 1999; Konstantopoulos et al., 2010) goes together with an enhanced susceptibility for getting involved in traffic accidents in the first years after obtaining a driving license (Underwood, 2007; Clarke et al., 2005). Likely, less experienced drivers require stronger conscious monitoring and control of their driving skills, whereas the experienced drivers' skills proceed more automatically (Brown and Carr, 1989; Fitts and Posner, 1967). Less experienced drivers would thus require more processing resources to assure safe driving. Yet, there is a dearth of studies examining whether, and if so how, anxiety mediates these experience-related attentional differences.

From the perspective of the integrated model of Nieuwenhuys and Oudejans, 2012, 2017, we can predict increased processing demands and/or increased attention for conscious/threatening stimuli. Increased levels of anxiety can cause a reduction in processing efficiency, that is, more attentional resources are consumed to monitor and control the skill (which, for instance, may be reflected in more or longer fixation to task relevant information such as direction of heading, or speedometer). If auxiliary attentional resources are available to compensate anxiety decrements, performance effectiveness can be maintained under pressure, but at the cost of a reduced processing efficiency (Nibbeling et al., 2012; Eysenck et al., 2007b; Williams and Elliott, 1999). Among inexperienced drivers, for whom driving already is more effortful than for experienced ones, the attentional capacity limits may be more likely to be exceeded (Nibbeling et al., 2012), thus resulting in larger drops in performance effectiveness compared to more experienced drivers counterparts (Nibbeling et al., 2012; Williams and Elliott, 1999). Alternatively, novices drivers may be more easily distracted by conspicuous or threatening stimuli and thus at increased risk of unsafe driving performance (i.e., which, for instance, may be reflected in more or longer fixations for threatening stimuli such as toward other cars to avoid collision).

In the traffic, personal factors, such as, work-related stress or fatigue, hurry, adverse life events, and/or environmental factors such as a gridlock, an overload of auditory or visual noise can induce increased levels of anxiety and thus affect driver's performance. In this respect, it has been reported that increased anxiety causes deterioration in motor performance (Allsop and Gray, 2014; Briggs et al., 2011b) and is related to more frequent involvement in traffic accidents (Clapp et al., 2011; Roidl et al., 2014; Dula et al., 2010). A better understanding of how attentional control mediates the relation between anxiety and driving performance can be a first step in further improving safety of cars and the traffic environment to reduce the adverse effects of increased anxiety. For example, if anxious drivers would indeed be more easily distracted by conspicuous stimuli, then it is important to take this into account in the design of a car's dashboard or permitting advertisements (Fioravanti-Bastos et al., 2011).

The aim of this study was to investigate, whether, and if so how adverse effects of anxiety on perception and action in drivers are modulated by driving experience In line with previous findings (Allsop and Gray, 2014; Briggs et al., 2011a; Nibbeling et al., 2012; Eysenck et al., 2007b; Williams and Elliott, 1999; Murray and Janelle, 2003), it was hypothesized that high levels of state anxiety would shift drivers' attention from task-relevant stimuli toward threat-related and/or salient stimuli. We suspect that the particular shift in balance between the two attentional systems may depend on the available attention resources. Accordingly, because they need fewer resources for regular driving, experienced drivers may more likely maintain contribution of the goal-directed systems and thus attention for stimuli that inform about heading and speed (e.g., fixations toward the lane, speedometer). On the other hand, inexperienced drivers may be more easily distracted by conspicuous and/or threatening stimuli that inform about collisions (e.g., more fixations toward hard shoulder, other cars, rearview mirror) and would thus show a drop in performance effectiveness (e.g., less car speed control or more occurrences of collisions), due to non-automatized steering control which makes this group unable to allocate sufficient resources to minimize anxiety decrements.

2. Materials and method

2.1. Participants

Forty drivers (25 male, 15 female) voluntarily participated in this experiment and filled out the Driving Experience Questionnaire (DEQ), which was developed by the experimenters to quantify the drivers' experience, prior to participation. This questionnaire consisted of three items for gauging the frequency of driving in the city (*Q1- How long have you been driving a car weekly? Q2- How many days a week are you typically driving a car? Q3- How many kilometers are you typically driving per day?*), and two items about the frequency of driving on the highway (*Q4- Monthly, how often have you been driving a car on the* highway*?; Q5- How many kilometers are you typically driving during such a trip?*). To quantify the driving experience (DE) of the drivers, experience in the city was summed with the experience on the highway using the following equation:

$$DE = [((Q2 * 4) * 12 * Q1 * Q3) + (Q4 * Q5)]$$

Where *Q2* is the weekly driving rate in the city and was used to calculate the annual driving rate in the city [(*Q2**4) *12]. To estimate the total rate of driving in the city, the annual driving rate was multiplied by the number of years of the driving license (*Q1*), which was multiplied by the number of kilometers traveled per day (*Q3*). To estimate the total rate of driving on the highway, the monthly driving rate on the highway *(Q4)* was multiplied by the total number of kilometers in each trip (*Q5*).

Drivers were classified into an inexperienced group (n = 20), when