The influence of anxiety on visual entropy in simulated car driving

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Abstract

The aim of this study was to investigate the effects of anxiety on drivers' visual scanning behavior. Experienced drivers drove three minutes in a simulator, aiming to maintain the car speed between 100 and 120 km/h and to avoid collisions, under low- and high-anxiety conditions. Drivers' anxiety scores and heart rate increased due to experimental manipulation. Under anxiety, drivers made more fixations transitions between lane and speedometer; however the order of transitions became more random. The entropy results suggest that anxiety impaired the top-down control of visual scanning.

Resumo

O objetivo do estudo foi investigar os efeitos de ansiedade sobre o comportamento do olhar de motoristas. Motoristas experientes dirigiram por três minutos em um simulador, mantendo a velocidade do veículo entre 100 e 120 km/h e evitando se envolver em colisões, sob condições de baixa e alta-ansiedade. Motoristas relataram mais ansiedade e tiveram uma frequência cardíaca media maior. Durante a condição de alta-ansiedade, os motoristas realizaram mais transições das fixações entre a pista e o velocímetro, entretanto em ordem aleatória. Os resultados de entropia sugerem que a ansiedade prejudicou o controle consciente da estratégia de busca visual.

Introduction

Anxiety is an emotional state that occurs in threatening circumstances, affecting perceptual and motor behavior. It has been shown that high levels of state-anxiety increase the propensity to be distracted by irrelevant stimulus (Williams & Elliot, 1999; Allsop & Gray, 2014), cause attentional narrowing (Janelle, Singer & Williams, 1999), reduce processing efficiency and, often, performance effectiveness (Williams, Vickers & Rodrigues, 2002). Entropy is a metric derived from information theory (Shannon, 1948) that indicates the randomness of a system, varying from the highest (e.g., random) to least complex (e.g., predictable) and it has been used to quantify the drivers' visual scanning complexity. Previous studies have shown that visual entropy changes with increasing driver age and task processing demands. However, anxiety effects on visual scanning behavior are still unclear. The aim of this study was to identify changes on drivers' visual scanning provoked by anxiety.

Method

Sixteen experienced drivers (26.38 ± 2.80 years old) drove three minutes in a car driving simulator, aiming to maintain the speed between 100 and 120 km/h and to avoid collisions, under low- and high-anxiety conditions. Anxiety was manipulated using competition between participants, the presence of an evaluator, external video camera, and traffic noise. Fixations were analyzed per Areas of Interest (AOIs) (Fig. 1). The frequency of transitions between three AOIs was characterized by calculating first-order transition matrices. In addition, transitions probability was calculated using 1st order Markov process, considering the fixations transitions and dwell time between AOIs, and adjusted into the Entropy equation.

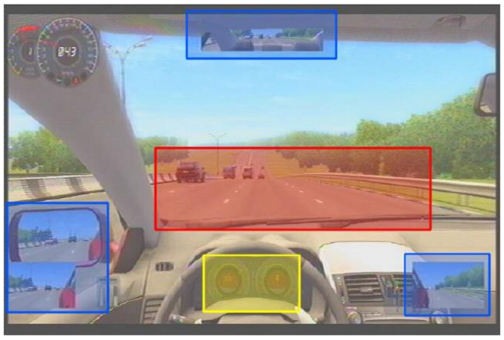

Figure 1. AOIs: lane (red), speedometer (yellow) and blue (rearview mirrors).

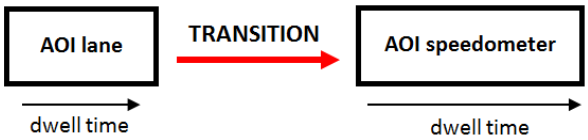

Figure 2. Example of a fixation transition 'from' lane 'to' speedometer. Dwell time represents glance duration in each AOI.

Results and Discussion

Drivers self-reported more anxiety score on STAI-S (13.52 ± 0.53 pts) and had higher mean Heart Rate (91.41 ± 2.62 bpm) during high-anxiety than low-anxiety condition (STAI-S = 09.37 ± 0.53 pts; HR = 79.43 ± 2.04 bpm), confirming the effect of experimental manipulation.

Student's *t* test revealed that, under high-anxiety condition, drivers made more fixations transitions between lane and speedometer AOIs ($p = .001$) and decreased the transitions between lane and mirrors ($p = .003$) compared to the low-anxiety. The frequency of transitions between speedometer and mirrors was unchanged with anxiety (Fig. 3). Student's *t* test indicated that under high-anxiety condition the entropy of the

fixations transitions between AOIs increased (p = .049), indicating that drivers' visual scanning became more random under pressure. Although drivers had more fixations transitions between lane and speedometer than lane and mirrors or speedometer and mirrors, the order of the transitions was less predictable. A higher visual scanning randomness implies into less acquisition of information as well as a higher effort spent. Furthermore, the visual scanning is controlled by the goal-directed attentional system in order to direct attention towards task-relevant information. However, according to the Attentional Control Theory (ACT), anxiety reduces the goal-directed and intensifies the stimulus-driven attention (Eysenck, et al., 2007). The entropy results therefore suggest that anxiety impaired the top-down control of drivers' attention.

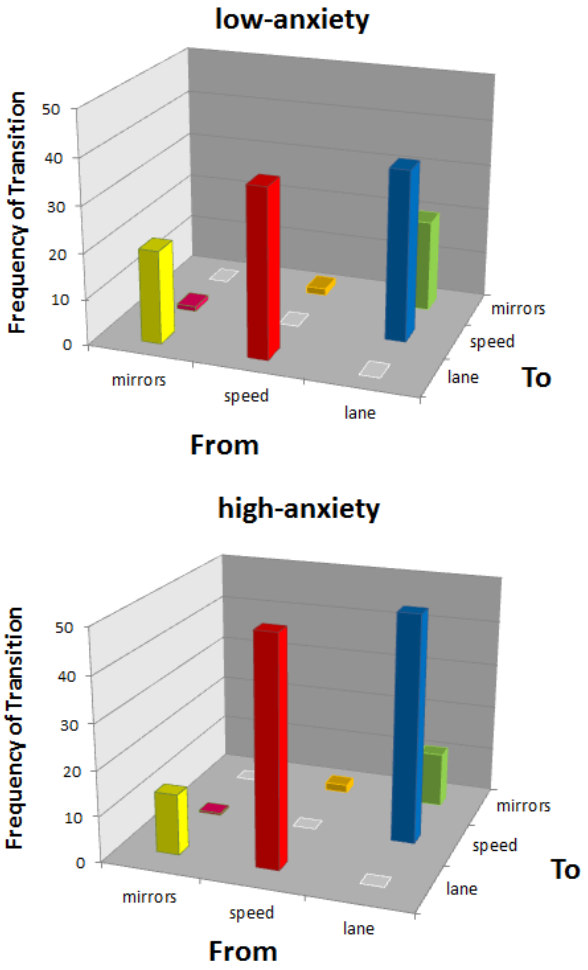

Figura 3. Frequency of transitions between AOIs in both experimental conditions. Transitions within the same AOI were excluded (zero).

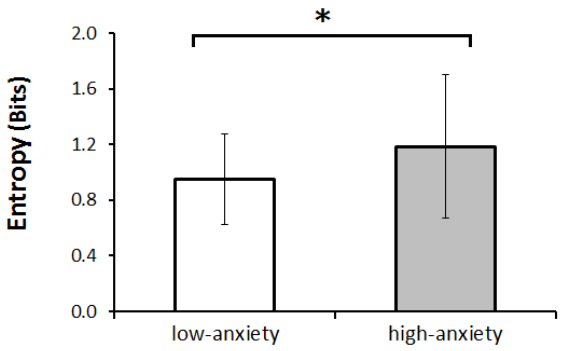

Figura 4. Normalized entropy in both experimental conditions.

Conclusion

Anxiety evoked a restricted visual scanning between lane and speedometer, however the fixations transitions becomes more random.

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