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Looming auditory warnings initiate earlier event-related potentials in a manual steering task

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Automated collision avoidance systems promise to reduce accidents and relieve the driver from the demands of constant vigilance. Such systems direct the operator's attention to potentially critical regions of the environment without compromising steering performance. This raises the question: What is an effective warning cue?

Sounds with rising intensities are claimed to be especially salient. By evoking the percept of an approaching object, they engage a neural network that supports auditory space perception and attention (Bach et al. 2008). Indeed, we are aroused by and faster to respond to 'looming' auditory tones, which increase heart rate and skin conductance activity (Bach et al. 2009).

Looming sounds can differ in terms of their rising intensity profiles. While it can be approximated by a sound whose amplitude increases linearly with time, an approaching object that emits a constant tone is better described as having an amplitude that increases exponentially with time. In a driving simulator study, warning cues that had a veridical looming profile induced earlier braking responses than ramped profiles with linearly increasing loudness (Gray 2011).

In the current work, we investigated how looming sounds might serve, during a primary steering task, to alert participants to the appearance of visual targets. Nine volunteers performed a primary steering task whilst occasionally discriminating visual targets. Their primary task was to minimize the vertical distance between an erratically moving cursor and the horizontal mid-line, by steering a joystick towards the latter. Occasionally, diagonally oriented Gabor patches (10° tilt; 1° diameter; 3.1 cycles/deg; 70 ms duration) would appear on either the left or right of the cursor. Participants were instructed to respond with a button-press whenever a pre-defined target appeared. Seventy percent of the time, these visual stimuli were preceded by a 1,500 ms warning tone, 1,000 ms before they appeared. Overall, warning cues resulted in significantly faster and more sensitive detections of the visual target stimuli ($F_{1,8} = 7.72$, $p < 0.05$; $F_{1,8} = 9.63$, $p < 0.05$).

Each trial would present one of three possible warning cues. Thus, a warning cue (2,000 Hz) could either have a constant intensity of 65 dB, a ramped tone with linearly increasing intensity from 60 dB to approximately 75 dB or a comparable looming tone with an exponentially increasing intensity profile. The different warning cues did not vary in their influence of the response times to the visual targets and recognition sensitivity ($F_{2,16} = 3.32$, $p = 0.06$; $F_{2,16} = 0.10$, $p = 0.90$). However, this might be due to our small sample size. It is noteworthy that the different warning tones did not adversely affect steering performance ($F_{2,16} = 1.65$, $p < 0.22$). Nonetheless, electroencephalographic potentials to the offset of the warning cues were significantly earlier for the looming tone, compared to both the constant and ramped tone. More specifically, the positive component of the event- related potential was significantly earlier for the looming tone by about 200 ms, relative to the constant and ramped tone, and sustained for a longer duration (see Fig. 1).

The current findings highlight the behavioral benefits of auditory warning cues. More importantly, we find that a veridical looming tone induces earlier event-related potentials than one with a linearly increasing intensity. Future work will investigate how this benefit might diminish with increasing time between the warning tone and the event that is cued for.

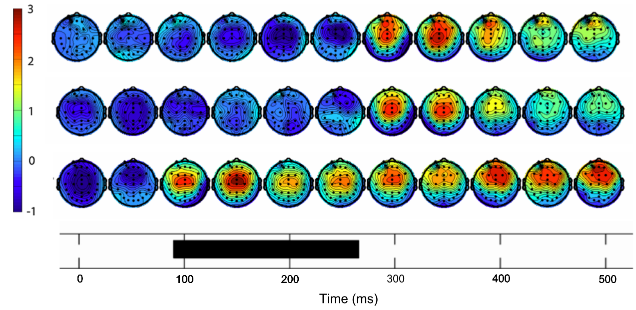

Fig. 1 The topographical plot shows the 500 ms after sound offset, with scalp maps plotted every 50 ms, for the constant (*row* 1), the ramped (*row* 2), and the looming tone (*row* 3). The looming cues evoked a strong positive deflection about 200 ms earlier than the other sounds. The *black bar* at the bottom of the figure indicates where the significance level of 0.01 was exceeded using a parametric test on the combined Fz, FCz, Cz, and Pz activity

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The creative process across cultures

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Creativity is the driving force of innovation in societies across the world, in many domains such as science, business, or art. Creativity means to come up with new and useful ideas (e.g., Funke 2008). Past research has focused on the individual, the creative process and its product, and the role of the social environment when evaluating creative products. According to previous research, individual difference variables such as intelligence and extraversion can partially predict creativity (e.g., Batey and Furnham 2006). Researchers have also shown the importance of the social environment when labeling products as creative or not (e.g., Csikszentmihalyi 1988). Although, creativity could be influenced by and differ among cultures, the influence of culture on creativity has been rarely studied.

Creativity and Culture
Culture can be defined as the knowledge base used to cope with the world and each other, shared by a group of people and transmitted from generation to generation (e.g., Güss et al. 2010). This knowledge encompasses, for example, declarative world knowledge, values and behaviors (e.g., norms, rituals, problem-solving strategies). Following this definition, different cultures could value different aspects of creativity (e.g., Lubart 1990).