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Naturalistic Decision Making: Taking a (Cognitive) Step Back to Take Two Steps Forward in Understanding Experience-Based Decisions

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The field of naturalistic decision making research has hugely advanced understanding of how experts make decisions in operational environments. However, there is still a drive to improve the credibility and transferability of such research. In the current work four studies are presented which used similar methods. Standardised measures of cognitive function were administered to Authorised Firearms Officers (AFOs) after completion of immersive tactical training scenarios. The tests were chosen to examine differences between information modalities (e.g., visual vs. phonological). Results indicate that the demand associated with tactical training scenarios led to cognitive adaptions, resulting in a significant increase in visual processing capacity and reductions in phonological processing capacity. The findings indicate that an adaptive switch to visual information modality may underpin experience-based decision making by AFOs. The findings provide insight into why training and policy should keep verbal and auditory demands placed on AFOs to a minimum.

Keywords: Naturalistic decision making, Police, Firearms, Cognition

General Audience Summary

Historically, the way people make decisions was examined from an idealistic point of view, not capturing the factors impacting decision making such as time pressures, incomplete information, ambiguity, and limited resource capacity. Naturalistic decision making (NDM) research proposes that in the real world, expert decision makers overcome these issues by using prior experience to guide decision in a faster, more intuitive fashion. The current research used standardised cognitive tests to examine whether modality specific information (e.g., visual or verbal) processing differences are observed in experts when making decisions in naturalistic environments. Four studies were conducted that examined the processing capacity of Authorised Firearms Officers (AFOs) as they completed highly realistic tactical training scenarios. The studies revealed that the visual processing capacity of AFOs increased, whilst the verbal processing capacity (speaking and listening) simultaneously decreased. This indicated that AFOs have less capacity to process verbal information, such as listening and talking, which supported previous research demonstrating that the communications strategies of operators in naturalistic environments becomes more simplistic as demand increases. However, AFOs simultaneously have increased capacity to process visual information, to inform their situation awareness of the environment, potentially to facilitate threat assessments. All AFOs in the current study made appropriate tactical decisions; therefore, the current work provides insight into the at-the-time cognitive capacities of AFOs when operating effectively in highly demanding contexts. This work can inform the training and policy requirements of AFOS, suggesting that verbal communications (speaking and listening) should be minimised where possible.

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Naturalistic decision making (NDM) is characterised by uncertain, dynamic environments, ill-structured problems, competing goals, data overload, and time constraints (Gore, Flin, Stanton, & Wong, 2015; Klein, 2015; Klein et al., 2003). When operating in demanding contexts there is potential for cognitive overload, resulting in decrements to attentional resources available for perception and decision making (Baddeley, 2000; Barulli & Stern, 2013; Sliwinski, Smyth, Hofer, & Stawski, 2006). Cognitive capacity limitations have been demonstrated to impact decision making in many settings including treatment implementation by patients with heart failure (Dickson, Tkacs, & Riegel, 2007), interaction with automation when driving (Young & Stanton, 2002), utilisation of mobile technologies (Oulasvirta, Tamminen, Roto, & Kuorelahti, 2005), and weapon discharge by police officers (Kleider, Parrot, & King, 2010). However, such research was not conducted in naturalistic environments or did not examine expert decision makers, which are essential constituents of NDM theory (Klein, 2015). Expert decision makers overcome capacity issues via use of cognitive strategies, allowing natural cognitive storage limits to be circumvented (Ward et al., 2008). The NDM field has promoted understanding of the different strategies, heuristics, and adaptive processes used to cope with and make decisions in high-stakes naturalistic environments (Endsley & Garland, 2000; Klein, 1997, 2008, 2015; Lipshitz, Klein, Orasanu, & Salas, 2001).

Working Memory

In the UK, an Authorised Firearms Officer (AFO) is a police officer certified to carry and use firearms, operating in teams of at least 2–4 officers. Errors in tactical decision making by police officers have been attributed to reduced working memory (WM) capacity (Kleider et al., 2010). WM is a limited capacity cognitive system responsible for the active maintenance and manipulation of task-relevant information. It acts as an interface between the external environment, internal memory constructs, and action (Baddeley, 2000; Miyake & Shah, 1999). A prominent behavioural model of WM proposes a modality-free, controlling central executive and two modality-specific subsidiary slave systems (phonological and visuospatial) for the temporary storage of information (Baddeley, 2000). This model is criticised for neglecting other sensory inputs (e.g., olfactory and somatosensory) and for some of its accounts of functionality, a debate that is outside the scope of the current research (Miyake & Shah, 1999). However, this model provides a sound basis for examining the modality-specific aspects of WM.

Decision making in naturalistic environments relies on experience-based pattern matching, and a key challenge for decision makers is making sense of the conditions rather than choosing between multiple options (Klein, 2015). Situational awareness (SA) requires the use of environmental cues to generate a perceptual map of an incident to inform decision making and action. WM is crucial for adequate SA, particularly in directing attention to critical information or cues (Endsley, 1997). An experienced police officer will pay varying levels of attention to SA elements in an encounter based upon assessment of threat or their relative importance to basic survival (Page, Thibeault, Page, & Lewinski, 2008; Shomstein & Yantis, 2004). Malleable attentional resources theory (MART) proposes that attentional resources are not fixed; rather, they are flexible pools that shrink and expand (within bounds) depending on current demand (Young & Stanton, 2002). Measuring WM processes in naturalistic environments could promote understanding of which information modalities are most prevalently used by experts across different domains (Brewer, Ball, & Ware, 2016).

In teams, decision making relies upon good teamwork and communication (Stanton, 2011). Communication does not just provide insight into team cognition; it actually represents cognitive processing at the level of the team (Cooke, Gorman, & Kiekel, 2008). Teamwork processes such as verbal communication can become the limiting factor in determining the workload of the team, rather than the work itself (Carletta, Anderson, & McEwan, 2000; Driskell, Salas, & Driskell, 2017; Salas & Cannon-Bowers, 2001). The phonological loop is assumed to have evolved for the production (and maintenance) of complex language essential for verbal communication (Christianson & Kirby, 2003). Research examining verbal communication in a jet cockpit found that verbal language use differed depending on the abnormality of a flight simulation (Sexton & Helmreich, 2000). Communication failures between flight crew outweigh technical difficulties as a primary cause of aviation accidents (Connell, 1995; Kanki, 1995). During highly demanding situations surgeons tend to reduce communication or language complexity with their team, whilst visual attention is maintained (Wetzel et al., 2006). The visuospatial processing system is the most dominantly used modality in situations of threat or high demand (Liddell et al., 2005). The completion of visual search tasks is usually improved as a result of increased physiological arousal, even to excessively high levels (Lambourne & Tomporowski, 2010). Attentional focusing ensures that emotionally salient features from complex environments are preferentially processed; in high-risk environments this will likely be visually based threat cues, such as the presence of a weapon (LaBar & Cabeza, 2006).

Modality Specific Cognitive Adaptions

A key question for naturalistic decision making is how cognition adapts to complexity (Gore et al., 2015). Excessive physical, cognitive, and emotional demand can result in physiological changes, or adaptions, to facilitate coping with demand (Goldstein, 2001; McEwen, 2000). The primary (measurable) effects of increased physiological arousal include elevations in heart rate, pupil size, and core temperature (Charmandari, Tsigos, & Chrousos, 2005). Physiological arousal induced by cognitive, physical, and emotional demand has been demonstrated to impact police officers' decision making (Hoing & Lewinski, 2008; Kleider et al., 2010; Vrij & Dingemans, 1996). A heightened physiological response can result in improved cognition and focused attention, although this is achieved by neurophysiological changes that actually reduce cognitive capacity (Charmandari et al., 2005; Hoing & Lewinski, 2008; Sliwinski et al., 2006). Stress hormone administration to

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