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The predictive utility of cue utilization and spatial aptitude in small Visual Line-Of-Sight rotary-wing Remotely Piloted Aircraft operations

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ABSTRACT

The aim of this research was to examine the relationship between cue utilization, spatial aptitude and skill acquisition in learning to fly a simulated small Visual Line-Of-Sight (VLOS) rotary-wing Remotely Piloted Aircraft (RPA) or Unmanned Aerial Vehicle (UAV). The participants were 95 university students with no prior RPA or conventional aviation experience. Participants completed the EXPERT Intensive Skills Evaluation (EXPERTise) 2.0 web-delivered cue-based Situational Judgement Test (SJT) to ascertain their level of cue utilization and a series of spatial aptitude batteries. The participants then completed two 15 min simulated small VLOS rotary-wing RPA piloting tasks. A performance score, based on the proportion of successful trials, comprised the dependent variable for task one and a composite performance score, based on the proportion of successful trials, progression through the obstacle course, and time to complete a course, comprised the dependent variable for task two. The results indicated that, during the initial task, performance was explained by total video game experience and levels of spatial visualisation, while performance during the second task was explained by levels of cue utilization. This outcome suggests the involvement of different cognitive constructs at different stages in the initial and immediately subsequent stages of unstructured learning to operate a simulated VLOS rotary-wing RPA. The results suggest that the small VLOS remote pilot training industry might benefit from the development of cue-based training packages that assist trainees acquire interpret, integrate, calibrate and adapt the right sorts of cues that facilitate or accelerate the acquisition of competence and ultimately the progression to expertise.

1. Introduction

The prediction of individual differences in performance during skill acquisition and the subsequent development of expertise have been the subject of much interest in applied psychology across a range of domains, including aviation, sports, music, and medicine (Christensen et al., 2016; Ericsson, 2005, 2014a; Geeves et al., 2013; Loveday, Wiggins, Searle, Festa and Schell, 2013b; McCormack et al., 2014; O'Hare, 1997; Wiggins & O'Hare, 2003b; Williams et al., 2012). The nature of these differences can help identify, explain and model the cognitive, perceptual and psychomotor skills that facilitate expert performance (Ericsson, 2014a; Wiggins, 2014b). Moreover, the outcomes of skill acquisition and expertise research have significant implications for the design of education, instruction and training programmes.

Not only do many organisations, industry associations and regulatory authorities define and oversee the requisite skill sets for entry to a given profession, they also require members of those professions to regularly demonstrate ongoing competency and/or further professional development (Cheetham and Chivers, 2001; Webster-Wright, 2009). For example, the Australian Civil Aviation Safety Authority (CASA) has established and regulates the skills and ongoing competencies required of both pilots and engineers. However, there has been significant controversy regarding pilot training, competency and requisite experience, which has resulted in a reconsideration and reassessment of what constitutes competence and how to acquire it effectively and efficiently (Dow and Defalque, 2013; FAA, 2013; IATA, 2013; ICAO, 2013; Taylor, 2011; Todd and Thomas, 2012).

The concerns regarding technical skill acquisition, training, experience, competency, selection, and licensing in civil aviation have now extended into the burgeoning domain of Remotely

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Piloted Aircraft Systems (RPAS) or Unmanned Aircraft Systems (UAS).[1] From a military perspective, Remotely Piloted Aircraft (RPA) have transformed war fighting doctrine, practice and outcomes. Their proliferation, rate of technological change, diversity, and subsequent capabilities in a wide variety of civil aviation applications has exceeded the ability of many civil aviation regulatory authorities to implement practical and prudent legislation in a timely and consistent fashion to govern the safe, effective and responsible use of RPAS (CASA, 2014).

1.1. Remotely piloted aircraft

Remotely Piloted Aircraft (RPA) or Unmanned Aerial Vehicle (UAV) operations have precipitated an irreversible transformation in civil and military aviation (Volpe National Transportation Systems Center [VNTSC], 2013). In particular, RPA have become indispensable in both civil and military operations because of their cost-effectiveness and the elimination of many of the safety risks confronting a pilot and/or crew of a conventional aircraft (Fahlstrom and Gleason, 2012). However, RPA have also presented an array of challenges for human operators and their supporting elements, advanced technology system designers and engineers, civil aviation regulatory authorities and their military equivalents, as well as philosophers and ethicists (Goodrich and Cummings, 2015; Hobbs, 2010).

ICAO (2011) has advocated that RPA licensing and training requirements should be similar to those for conventional aircraft with modifications made according to the nature and characteristics of the remote pilot station (RPS) environment, aircraft type, and associated applications. However, ICAO has also acknowledged that "qualifications for certain categories of remote crew (e.g., VLOS helicopter) may be significantly different from those pertaining to the traditional qualifications pertaining to manned aviation" (p. 34). Furthermore, the US Federal Aviation Administration (FAA) has stated that:

UAS training standards will mirror manned aircraft training standards to the maximum extent possible, including appropriate security and vetting requirements, and will account for all roles involved in UAS operation. This may include the pilot, required crew members such as visual observers or launch and recovery specialists, instructors, inspectors, maintenance personnel, and air traffic controllers (FAA, 2013, p. 28).

Many legacy and current civilian UAVs, small UAVs (sUAVs), and micro air vehicles (MAVs),[2] are required to be operated within Visual Line-Of-Sight (VLOS) and, as a minimum, require a dedicated controller with significant training and use of a dedicated two handed controller and/or laptop computer and/or tablet (Cummings et al., 2012). The cognitive demands associated with the teleoperation of a MAV are high, particularly workload, because of the need for the operator to maintain continuous attention to controlling the vehicle via line of sight while having to contend with limited sensor/camera field of view, time delay, frame rate, and orientation problems (Cummings et al., 2012; Pitman and Cummings, 2012; Chen et al., 2007). Given the commercial and military market projections for the use of UAVs, and especially MAVs, potential users will require ease of operation and condensed training time to perform safe and cost-effective operations. Various degrees of automation and autonomy will assist, in part, but the operator may still need to be able to manually operate a VLOS UAV or to manually intervene in the event of automation degradation or failures.

1.2. Skill acquisition and expertise

While there are various definitions and markers of expertise in specific professions or industries, the Expert Performance (EP) approach converges on the notion that skill acquisition, or the development and the attainment and reproducibility of high levels of performance requires extensive, deliberate and targeted practice (Ericsson, 2005). For example, four to five hours of deliberate practice a day for up to 10 years is presumed required to acquire and maintain expert performance levels in many different domains such as sports, music, writing, chess, and surgery (Ericsson, 2006). Overall, the expertise literature across various domains indicates that somewhere between 1000 and 10,000 h of deliberate practice in a specified domain is required to reach expert levels of performance (Ericsson et al., 1993; Charness et al., 2005). In addition, experts must also be able to consistently reproduce superior levels of performance (Charness and Tuffiash, 2008). It should also be noted that expertise appears to be task dependent, brittle and inflexible and does not transfer readily across domains, which may, in part, help explain some of the performance problems that conventional aircraft pilots have experienced when transitioning to RPA (Charness and Tuffiash, 2008; Mann et al., 2007).

While experience is a component of expertise, it does not appear to be sufficient to ensure consistently superior, exceptional or expert levels of performance. In addition, there is some evidence to suggest that senior professionals with significant experience and qualifications in a particular domain can be surpassed by their less experienced colleagues (Norman et al., 1992). The differences and similarities in performance between experienced and higher performing but less experienced individuals within a given domain have indicated that experience alone is not a sufficient measure of expertise and that measures with greater diagnosticity are required (Small et al., 2014).

There is significant evidence to suggest that the effective operational control of complex socio-technical systems, including the various technological components or platforms such as aircraft, requires human operators, such as pilots, to utilise cue-based reasoning and judgements (Wiggins, 2014a; Wiggins, 2014b; Wiggins et al., 2014a; Wiggins et al., 2014b; Wiggins & O'Hare, 2003a). Moreover, a consistent finding that has emerged from expertise-related research in applied domains is that experts have a highly-developed capacity to rapidly identify and assess salient features of a situation by cross-referencing or associating those features with events in memory to form a cue which facilitates the accurate recognition of, and response to, a given problem, situation or system event (Klein et al., 2010; Loveday et al., 2014). The practical application of this finding is that it provides a means to improve skill acquisition and to accelerate the development of expertise.

1.3. Cue-based processing

Many of the applied research findings related to cue-based processing arguably have their foundation in the Brunswikian approach to perception and action known as probabilistic functionalism typified by the lens model (Brunswik, 1955, 1956) (See Fig. 1). The lens model posits that cues mediate human performance in two ways (Kirlik, 2009). Firstly, the left side of the model proposes that human performance is dependent upon the

[1] ICAO (2011) has advocated use of the term Unmanned Aircraft Systems (UAS), also known as Remotely Piloted Aircraft Systems (RPAS), when referring to a Remotely Piloted Aircraft (RPA), Remote Pilot Station (RPS), and Command and Control (C2) data links and Communications links (C3).

[2] A micro air vehicle (MAV), or micro aerial vehicle, is a class of small UAV that has a size restriction and may be autonomous. MAVs weigh less than 5 kg and have a wing span less than 1 m but typically weigh less than 1 kg and can be as small as 15 cm in length, width or height.