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Individual latent error detection: Simply stop, look and listen

Justin R.E. Saward*, Neville A. Stanton

Transportation Research Group, Civil, Maritime and Environmental Engineering and Science Unit, Faculty of Engineering and the Environment, Southampton University, Southampton SO17 1BJ, UK

ABSTRACT

Human error is a by-product of performance variability caused by system failures, for which undetected error generates a latent error condition that can lead to an undesired outcome. Individual Latent Error Detection (I-LED) has been observed in naval air engineers at work where system-induced errors not detected at the time they occurred were later recalled by the individual who suffered the error at some point post-task completion. Using system cues several I-LED interventions are tested in the current study with the aim of mitigating system-induced latent error conditions, for which a simple stop, look and listen approach is found to be the most effective. I-LED research offers a step-change in Safety II thinking by offering a level of safety within normal operations that has not previously been accounted for in organisational safety strategies and thus should be of benefit to safety critical organisations seeking to enhance their safety management system.

1. Introduction

Use of the term human error is perhaps becoming out-dated when highlighting safety failures within complex sociotechnical systems. New terms such as erroneous acts, human performance variability or system failures have emerged to describe error effects associated with human activity where the real causes of safety failures are deep-routed in system factors such as organisational decisions, design, equipment, management oversight and procedures (Woods et al., 2010; Dekker, 2014; Stanton and Harvey, 2017). Any attribution of individual blame is a failure to understand systemic causal factors. Application of a systems perspective opens a more productive dialogue on performance variability that includes normative and non-normative behaviours and therefore a need to engineer resilient workplace safety systems. This encompasses an operator's ability to self-monitor for system traps (risks) and correct as necessary to help manage safety at a local level in the workplace (Stanton and Baber, 1996; Reason and Hobbs, 2003; Cornelissen et al., 2013). Arguably though, the term human error can survive as a valid descriptor in systems safety but only if it is used carefully to highlight the need to analyse the causal effects of safety failures generated by the system and not by the individual. For the purpose of the current research, human error that passes undetected creates a latent error condition, which can impact future safety performance (Reason, 1990). Here the term latent error refers to the residual effects created when the required performance was not enacted as expected due to system-induced sociotechnical traps generated by the organisation, i.e. system failures that pass undetected and therefore lie hidden (Reason, 1990). Examples of everyday failures might be leaving the gas on when leaving the home or failing to lock the door of their car or house. Both could have potentially negative consequences, if left unchecked. Most people have experienced the phenomenon of spontaneously wondering if they 'left the gas on' or 'locked their front door'. This paper focuses on naval aircraft maintenance where wondering if the tools were removed from the engine bay or if the oil filler cap was replaced after replenishing the oil is not uncommon (Saward and Stanton, 2015) and drives the need to design practicable system interventions in light of the phenomenon to enhance overall safety in aircraft maintenance.

Individual Latent Error Detection (I-LED) has been observed where errors suffered by naval air engineers at work appear to be later detected spontaneously by the individual at some point post-task completion, and without reference to recognised procedures (Saward and Stanton, 2015). A study by Saward and Stanton (2017) found I-LED to be most effective when engaging with system cues that trigger recall within a time window of two hours. Detection appeared to be improved whilst the engineer worked alone in the same environment that the error occurred, particularly if physical cues such as equipment and written words were present. This suggests a level of safety exists within the workplace that has not previously been accounted for in organisational safety strategies. Human error is often quoted as contributing to 70+% of accidents (Wiegmann and Shappell, 2003; Reason, 2008; Saward and Stanton, 2015) but this belies systemic causes that do not adequately control or manage human performance variability to achieve safety within the workplace (Leveson, 2004; Morel et al., 2008;

* Corresponding author.
E-mail addresses: j.saward@soton.ac.uk (J.R.E. Saward), n.stanton@soton.ac.uk (N.A. Stanton).

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Amalberti, 2013). I-LED research adopts the systems perspective where it is system cues that trigger recall but from a human-centred approach (Stanton and Salmon, 2009) to reveal understanding of how individual acts of post-task error detection contribute to total safety within complex sociotechnical systems. This involves the interaction between humans and technical aspects of the environment such as equipment, technology and workplace processes (Walker et al., 2008; Niskanen et al., 2016).

The step-change from studying error as a causal attribution of blame to a symptom of wider systemic issues has led to a paradigm shift in the etiological approach to safety performance using systems thinking (Leveson, 2004). Little is known about individual error detection (Blavier et al., 2005; Saward and Stanton, 2015), although it is argued I-LED can offer a further shift in safety thinking. The phenomenon addresses everyday errors that could be considered insignificant but where accident causation modelling later revels complex paths of latent error convergence within the system as a whole. It is argued safety is created by controlling risks (system traps) that can cause harm, which encompasses all system-induced operator errors regardless of perceived significance. Morel et al. (2008) observed safety is the product of controlling safety risks (system controls such as rules and procedures, training and experience, and supervisory controls) and managing safety risks locally (through the adaptive capabilities of operators within system controls). Therefore it is believed that the safety aim of an organisation should not be preventing all errors occurring but more towards using a systems approach to risk management of latent error conditions; especially where safety control mechanisms are exhausted through exceptional conditions (Amalberti, 2013; Chatzimichailidou et al., 2015; Saward and Stanton, 2017). This can include occasions where operators find rules and procedures are ineffective or unavailable for a task, equipment is poorly designed or not available or organisation-driven error promoting conditions such as fatigue, task pressure and workplace distractions.

Kontogiannis (2011) demonstrated that error detection could be used in the design of error tolerant systems, which contributes to the mitigation of system-induced error effects to help assure safety in the workplace. This view is similar to Hollnagel's (2014) modelling of accident causation, which highlighted Safety II events where safety is managed effectively at the local level in complex sociotechnical environments despite a myriad of system influences on human performance. Here, it is essential the operator possesses error detection skills in a working environment that promotes the cues needed to detect and recover from system induced latent errors (Cornelissen et al., 2013). I-LED is a Safety II strategy aimed at supporting operator detection of their latent errors post-task completion. Thus current research is not focused on error prevention but the management of operator engagement with system cues to help support the timely detection of latent error conditions before they propagate and combine with other factors to become an accident (Reason, 1990). For example, Amalberti (2013) noted that routine error rates can be high but the true safety performance of a safety critical organisation should be judged against the rate of detection and recovery since the risk of error comes from its consequences if not intervened early. He noted that, in addition to established safety rules and procedures, the safest hospitals are those with the overriding ability of its operators to detect their errors before an unwanted consequence occurs. It is argued that a safer aircraft maintenance environment is similarly one in which its operators possess effective I-LED skills.

Saward and Stanton (2017) found system cues such as time, location and other socio-technical factors, that are present within the workplace and other environments such as at home, trigger successful I-LED. Their findings were based on a research using schema theory, which describes information represented in memory about our knowledge of the world we interact with to carry out actions (Bartlett, 1932). The associated schema-action-world cycle is characterised by the Perceptual Cycle Model (PCM), which describes the transactional relationship between the operator and system cues in the external world (sociotechnical environment) that trigger intended actions (Niesser, 1976; Norman, 1981; Mandler, 1985; Stanton et al., 2009a; Plant and Stanton, 2013). The execution of an action requires the bottom-up processing of information from system cues in the world against top-down prior knowledge from memory (schema) to enact the action successfully (Niesser, 1976; Cohen et al., 1986; Plant and Stanton, 2013). It is important to note this function since I-LED relies upon system cues to trigger a review of past schema-action-world cycles to determine the success of previous actions (Saward and Stanton, 2017). Specifically, visual or auditory cues are effective cues to trigger I-LED where written word cues and physical objects have generally been found to be more likely to trigger recall than picture cues (Kvavilashvili and Mandler, 2004; Mazzoni et al., 2014). Saward and Stanton (2017) argued ergonomically designed I-LED interventions that make use of physical objects and written word cues as well as a 'Stop, Look and Listen' (SLL) approach are most likely to be effective at detecting latent errors. For the SLL approach, the 'Stop' refers to pausing on-going activity to facilitate a review by the PCM, 'Look' refers to sensing physical cues, written words or the internal visualisation of past tasks and 'Listen' refers to phonological cues from internally 'voicing' activity associated with past tasks or simply listening to sounds in the external environment.

Amalberti and Wioland (1997) showed errors suffered by skilled operators can be frequent whilst experience improved an operator's ability to detect more of their own errors due to an enhanced 'capacity' to detect important cues present in the external environment (Blavier et al., 2005; Wilkinson et al., 2011). The current study observes a new cohort of naval air engineers in the workplace that are grouped by experience: junior 'operatives' and more experienced 'supervisors'. Thus it was hypothesised that the supervisors in this study would commit more errors than the operatives yet detect more of their own errors. Further, any I-LED intervention would improve the self-detection of latent errors due to the deliberate schema-action-world review of past actions. Word cues were thought more likely to trigger recall than pictures for supervisors (Kvavilashvili and Mandler, 2004; Mazzoni et al., 2014) as they spend more of their time managing maintenance documentation than operatives. Finally, the SLL intervention was hypothesised to be the most effective I-LED intervention for both operatives and supervisors since the technique is arguably the only intervention to be observed that promotes the review of past actions using internal cues in memory and physical objects in the socio-technical environment; thereby offering the potential to maximise the PCM's I-LED capability. Saward and Stanton (2017) argued that the PCM also exhibits an autonomous schema 'housekeeping' function where the routine monitoring of the schema-action-world cycle already provides a level of error checking and is also used to collect feedback from completed actions to facilitate learning and the acquiring of experience. This housekeeping function is thought to explain why I-LED events were reported by previous cohorts of naval air engineers who experienced recall within a time window of two hours of the error occurring, and thus it was anticipated the control groups described in the method would also experience error detection events post task completion but without an intervention applied.

2. Method

2.1. Participants

The Royal Navy Air Engineering and Survival Equipment School (RNAESS) was selected for the current study as it provided an accessible, safe and controlled environment in which to observe I-LED events. Here two training squadrons exist, which emulate operating squadrons using aircraft and standard maintenance procedures, and is therefore representative of the real-world environment. One squadron provides maintenance courses to operatives and the other to