Occupational Driving

Calibrating Skills & Performance

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IN BRIEF

- **Humans often make inflated estimates of their own ability or performance, which can affect decision making, risk taking and safety.**
- **This article describes a conceptual framework for calibration in driving, which is grounded in attention and a variety of contextual factors, along with its implications for performance, behavior and risk perception.**
- **It discusses implications for occupational settings and the role and impact of new in-vehicle technology and automation.**
- **The article describes potential inroads for addressing the issues of calibration in the work setting.**

In the course of their daily lives, people selectively attend to available information and render judgments about the state of the world. These occur in various contexts including judgments concerning one's own performance (e.g., how well am I currently doing at this task?) or the amount of risk associated with a given situation. People also carry out, sometimes immodestly, general self-appraisals, evaluating how skillful or capable they are in different contexts. People's perceptions of the world and of their own efficacy and ability can have important implications concerning their decision making and consequent behaviors.

From a safety perspective, it is critical to understand situations where people's perceptions or subjective appraisals deviate from objective reality. For example, a fatigued driver may elect to continue driving because he fails to adequately recognize the signs of fatigue or overestimates his ability to safely drive. Or an inexperienced driver may be overconfident in her driving skills and abilities, and travel at a high speed on a slippery surface. Gaps in subjective and objective measures have been related to calibration, a concept that has been broadly studied in many disciplines (Zell & Krizan, 2014).

This article reviews some extant literature on calibration in various domains, and describes a conceptual driver-focused framework that depicts calibration in the context of human information processing (attention) and an array of local and global contextual factors. It also describes the implications for organizational applications and the role of new automotive technology. Lastly, it discusses potential inroads for addressing the issues of calibration in the work setting.

Calibration

Many studies in diverse domains have revealed that individuals' subjective impressions or self-evaluations are not well-calibrated to more objective measurements. That is, people tend to view themselves in overly favorable or overly optimistic terms (Brown, 1986; DeJoy, 1989; Dunning, Heath & Suls, 2004). This has been referred to as optimism bias, self-enhancement bias and illusory superiority, among other terms. Dunning, et al. (2004), suggest that such errors in calibration can result from incomplete information used in rendering a judgment or neglect of relevant information that could sway a judgment (i.e., a failure to properly weigh the evidence).

Alternatively, errors can be realized through other biases, decision or selection heuristics, or other top-down influences (Slovic, Fischhoff & Lichtenstein, 1977). As noted, this positive self-enhancement bias has been evident in many domains, including academic achievement (Bol & Hacker, 2012), ethics (Baumhart, 1968), health and medicine (Weinstein, 1980), and organizational settings and workplace performance (Larwood & Whittaker, 1977).

These biased self-appraisals are also evident in driving. Many studies have revealed the tendency of most drivers to rate themselves more favorably than other drivers, or to rate their skills as better than average, a statistical impossibility (Brown & Groeger, 1988; DeJoy, 1989; Horswill, Sullivan, Lurie-Beck, et al., 2013; McKenna, Stanier & Lewis, 1991; Svenson, 1981). Others have shown that drivers' self-ratings are much higher than those provided by expert observers (Amado, Arıkan, Kaça, et al., 2014).

In terms of driver distraction, researchers have reported discrepancies between subjective measures, such as performance ratings and rated confidence in dealing with distractions, and actual performance while distracted (Horrey, Lesch & Garabet, 2008). In some instances, these discrepancies appear to vary with driver characteristics (e.g., gender, age) suggesting that some driver groups may be more likely than others to engage in distracting activities while driving (Lesch & Hancock, 2004).

Horrey, Lesch, Mitsopoulos-Rubens, et al. (2015), proposed a conceptual framework for understanding and studying calibration in the context of road safety. The model expands and elaborates on earlier models of demand regulation in driving in which drivers actively balance their capabilities with the momentary demands of the driving task (Davidse, Vlakveld, Doumen, et al., 2010; Fuller, 2005).

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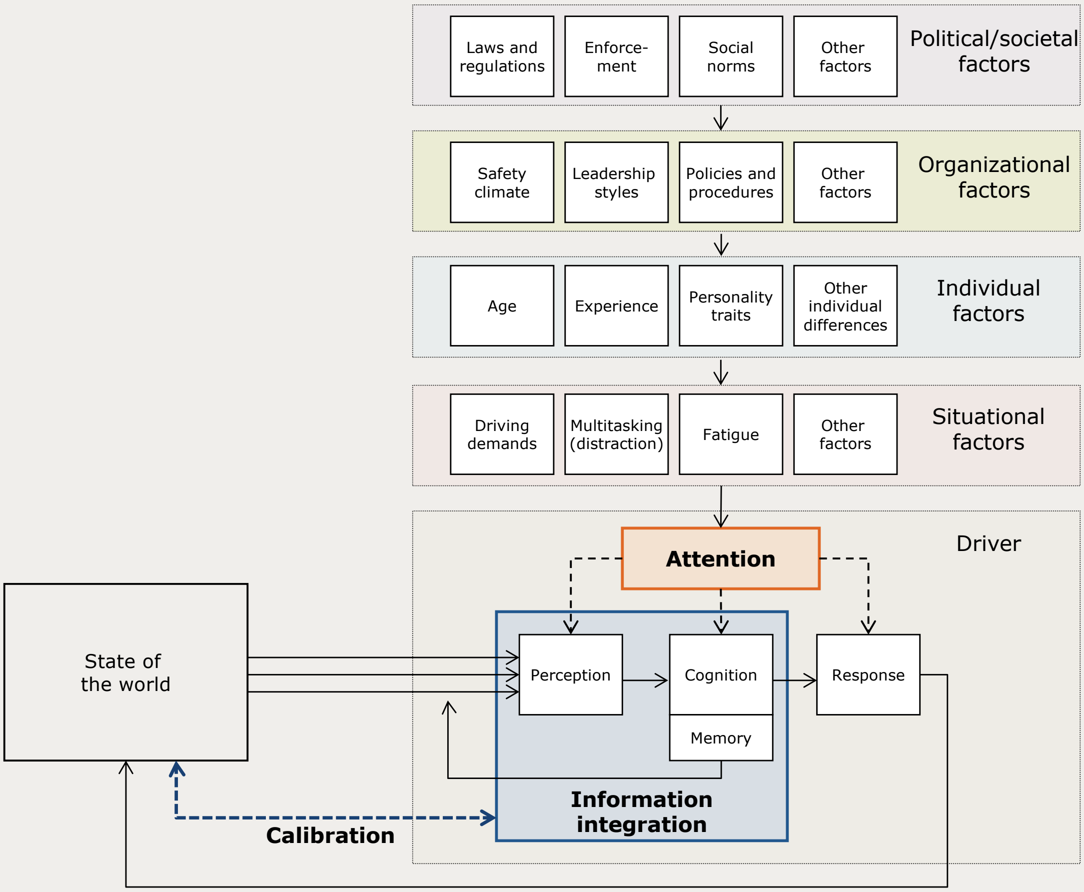
FIGURE 1

Conceptual Framework of Calibration in Driving



Driver capabilities are influenced by biological factors, knowledge, skills and other factors, while driving demands are determined in part by many contextual factors. When driving demands exceed a driver's ability to service the demands (i.e., demands are greater than capabilities), a driver who is well-calibrated should recognize the discrepancy and take measures to reduce the momentary demands (e.g., by reducing speed to ease time pressure and difficulties in vehicle control). Errors in calibration can lead to failures to take such countermeasures to align demands with capabilities, thereby increasing risk (Deery, 1999; Spolander, 1983). The case of driver distraction is another example: If a driver is unaware of his/her performance decrements while distracted, s/he may be less likely to cease secondary activities while driving.

A complete accounting of the Horrey, et al. (2015), framework is beyond the scope of this article; however, a simplified version is presented that provides a more thorough elaboration of the contextual factors that can affect calibration in driving, especially in commercial operations.

Framework

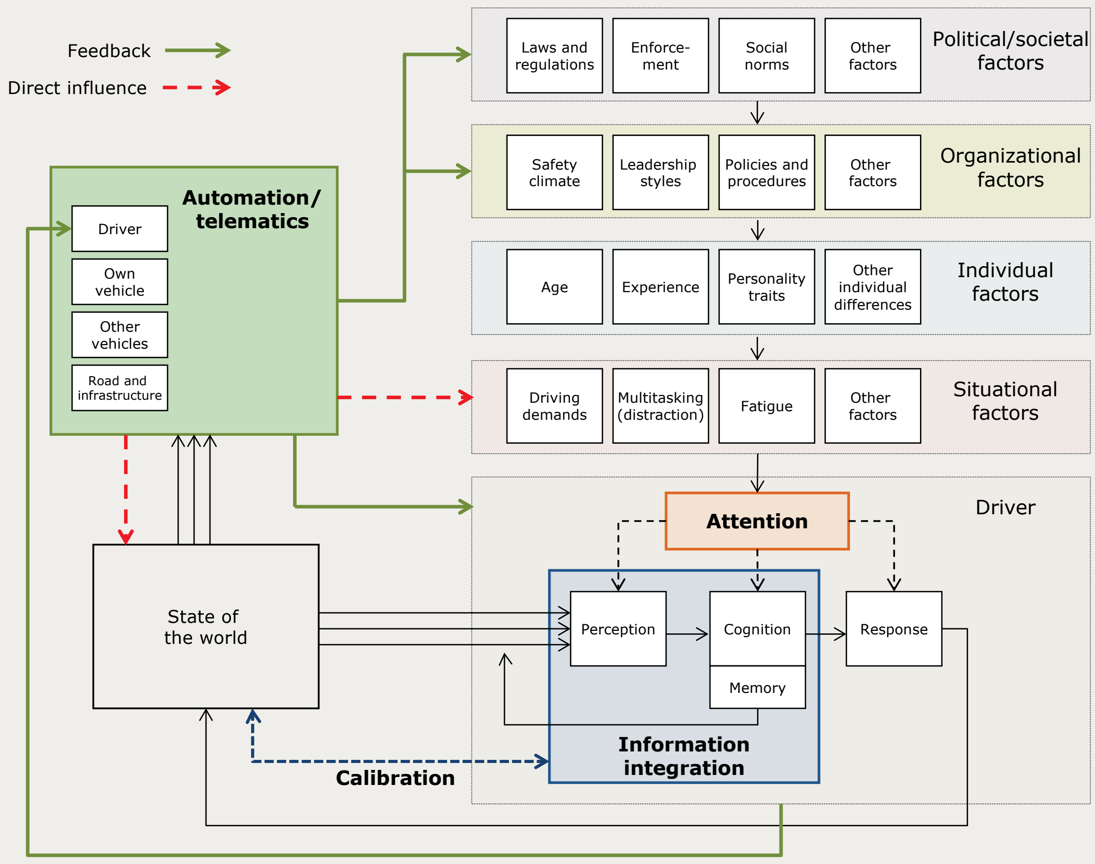
The conceptual framework of calibration in driving introduced in Figure 1 is complex, but is easily broken down into simpler subcomponents. The true state of the world is at the lower left, which can be characterized by some objectively defined or mutually agreed on measure of performance. While calibration can apply to a wide variety of behaviors and/or states, the current focus will be on driver performance and the implications of failures of calibration for risk perception and decision making. The driver (lower right) perceives, processes and acts on information gathered from the world. This portion of the framework draws from attention-based models of human information processing (Wickens & Hollands, 1999) as well as the lens models of information selection and utilization (Brunswik, 1955).

These processes and actions do not occur in a vacuum; the stacked boxes in the top right-hand portion provide contextual factors (i.e., situational, individual, organizational, political/societal), all of which can influence the driver. Following is an elaboration on this brief description of the framework that revisits each subcomponent in turn.

Although the means of defining or measuring the state of the world can be debated, it represents some objectively defined truth about the world. The world contains a vast amount of information and drivers must perceive, process and inte-

FIGURE 2

Elaborated Framework Showing Impact of Automation & Telematics



grate this information through cognitive processes (Wickens & Hollands, 1999). The driver's resulting actions or responses change the state of the world, creating a closed loop.

Unfortunately, the amount of information humans can process is limited, so people often must be selective about what information to attend to. Consequently, they often act on incomplete information (Brunswik, 1955). The processes of perception and information integration (cognition) constitute the basis of performance appraisal. More generally, information selection and integration can form the basis of risk perception.

The correspondence (or lack thereof) between the driver's performance appraisal and actual performance in a given situation is a reflection of the driver's level of calibration. While drivers vary in terms of what information they attend to and how they weigh available information (Dunning, et al., 2004), the concern increases in situations where a driver's failures in calibration of performance are likely to produce responses that increase associated risks.

For example, as suggested by Lesch and Hancock (2004), drivers may more likely drive distracted if they perceive their own driving performance while distracted to be better than their actual performance while distracted (also see Horrey, et al., 2008). Another example is when drivers underestimate the current degree of risk if they are unaware of certain hazards in the local environment, and adopt a speed that is unsafe for the given conditions. In essence, failures in calibration of performance can result in decisions to act that actually increase associated risks.

As the framework further illustrates, perceptual, cognitive and response processes all require driver attention (orange box). Attention is a core concept in the framework and to driving. Attention can be regarded as a limited resource that a person must allocate and manage (Wickens, 2002). A person can allocate attention to different tasks, such as in the case of multitasking (e.g., trying to read or send a text message while driving), as well as within a single task, as in the selective processing of different bits of information (e.g., attending to the status of a traffic signal while failing to attend to a vehicle pulling out in front).

As the availability of attentional resources is reduced, the underlying processes can suffer and, consequently, performance deteriorates. It follows, too, that calibration is affected by reduced availability of mental resources to effectively weigh and integrate information, that is, resources that would

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normally be used in support of situation awareness (Wickens, 2001; 2002).

Many factors can influence, either directly or indirectly, the availability of attentional resources and an individual's allocation policy. As illustrated in the framework, these factors operate at many levels, including situational or local, individual, organizational, and political/societal level. These factors provide the important context in which the driver processes information regarding the state of the world. The higher levels (political/societal, organizational) are more likely to influence how a driver will process information (allocation policy) and the nature of the responses.

For example, organizational policies and procedures can impact how an individual prioritizes certain information. If productivity is valued in an occupational setting (e.g., over safety), an individual will likely attend more closely to, weigh more heavily and react to information that supports productivity. This can lead to the downplay or outright neglect of other types of information, even if it is safety-critical.

Individual factors can impact the allocation policy and the availability of resources (capacity); these factors include age, experience and (following from the discussion above) propensity toward overconfidence and biased self-evaluation. Situational or local factors will more likely affect the availability of resources. For example, many local factors may be considered forms of impairment.

New Automotive Technologies

The framework can be expanded to illustrate how new technological advances can impact driver calibration, risk perception and attention. Figure 2 (p. 27) shows the framework in the context of in-vehicle automation and telematics devices.

The left side of the framework [upper left (green) box] depicts the role and influence of telematics and other automated systems that are rapidly becoming ubiquitous in today's vehicles and fleets. As with their human (driver) counterpart, these systems monitor and gather information regarding the state of the world from multiple sources. These do not always correspond completely with the information available to drivers. For example, these systems can gather information regarding the driver (e.g., making inferences about the driver's state), the driver's vehicle or other nearby vehicles, as well as from the road and traffic infrastructure (e.g., downstream traffic conditions).

The major implication is that the system's appraisal of the state of the world can be quite different from that of the driver. Thus, calibration can play an important role in drivers' understanding, agreement and trust in information provided by telematics devices or automated systems. Calibration can also play an important role in the utility of such technological innovations, particularly for systems that infer whether drivers are impaired (e.g., distracted) or for systems where drivers need to monitor system function and takeover when deemed necessary (e.g., level 3, Society of Automotive Engineers levels of automation, SAE International, 2014). A discrepancy between the driver's and the system's estimates of the state of the world could result in operator-system conflicts, reduced trust in the system and, ultimately, system disuse (Lee & See, 2004; Parasuraman & Riley, 1997).

However, depending on system function, the feedback provided can enhance or improve a driver's perception of the world, or it can be directed to other parties, such as supervisors or other stakeholders, so that the effects can be realized indirectly (e.g., Horrey, Lesch, Dainoff, et al., 2012). Alternatively, more sophisticated systems can actively take control of the vehicle (e.g., adaptive cruise control, steering assist, auto-pilot), changing the state of the world directly or altering the situational constraints. For example, more active automation in the vehicle would reduce the overall driving demands for the driver, likely changing that individual's attentional allocation policy toward other activities unrelated to driving. While this would not be an issue under routine operations, it carries important ramifications when automated systems are imperfect and subject to failure.

Implications

The conceptual framework articulates the importance of calibration to driving safety, while also illustrating the role of attention through the various stages of information processing (some of which culminate in an appraisal of situational risk). Moreover, the model stresses the importance of many different factors that can influence both the availability of attentional resources, and the manner that information is integrated and decisions or judgments are rendered. Given that errors in calibration can lead to risky behavior or worse, what can be done? The topics and strategies discussed next can offer some guidance to OSH professionals to improve safety outlooks.

Training & Feedback

Given the prominence of feedback loops in the framework, it follows that training can have an important role not only in the development of driving skills, but also in calibrating drivers to the appropriate level of these skills. Earlier work in driver training found that in some conditions the training of specialized skills (e.g., skid control) led to worse safety outcomes (Elvik, Høye, Vaa, et al., 2009), because drivers tended to also become overconfident (poorly calibrated) over the course of training (Mayhew & Simpson, 2002).

In trying to address these unintentional outcomes, researchers and various agencies advocate training approaches that improve calibration skills as well, such that drivers do not overestimate their skills and, consequently, underestimate driving risks (Kuiken & Twisk, 2001). Insight training, in which drivers receive direct experience and insight into their own limitations, has been lauded as an effective way to reduce errors in calibration (Gregersen, 1996). In some ways, insight training can also provide more opportunities for pertinent feedback; in reality, little feedback exists for drivers to gauge how well they are doing, short of being involved in a crash or traffic violation.

Practicing OSH professionals should consider the type of training and, more specifically, the type of feedback that employees receive through formal training and other avenues. As noted, approaches that try to mitigate overconfidence, such as insight training, may lead to better calibration in drivers and, consequently, to better and more informed driving decisions.

Technology & State Monitoring

The model demonstrates how the introduction of technology can change the framework (from Figure 1 to Figure 2). Despite these changes, technology can effectively ameliorate drivers' calibration errors. That is, telematics and related platforms can become effective means of conveying feedback based on actual performance, as well as coaching and other training, providing OSH professionals another tool for addressing errors in driver calibration (Horrey, et al., 2012; Lotan & Toledo, 2005). Note that it is not enough to simply have the technology; it must be effectively utilized in a manner that is well integrated into company policies, procedures and overall philosophy.

At the same time, OSH professionals might consider use of on-board sensors that monitor driver state (e.g., distracted, fatigued/drowsy), which can also offset risky behaviors that arise from poor calibration. This can be in the form of directed feedback concerning appropriate and inappropriate behaviors to engage in while driving.

For example, targeted feedback and coaching can be used to address the issue of drivers using smartphones while driving. Alternatively, these can alert drivers in real time that their focus should be on driving, serving as a reminder that driving is a priority and helping drivers adjust their current appraisal of risk.

Eventually, these systems could become integrated with other more advanced automation features, where the system can assist drivers who place themselves in risky situations, whether due to poor calibration or other factors. Again, such devices should be integrated into a broader company program (e.g., training or supervisor model) that is consistent with organizational policy and day-to-day operations.

As seen in the framework, calibration failures (and, potentially, the effectiveness of methods to address them) are partially determined by the context (individual and situational) in which they occur. Older drivers' calibration may be more greatly affected than younger drivers by age-related (individual context) cognitive changes in vision and attention such that they might not have the information needed to form accurate judgments; that is, they may be more likely to miss details or to become distracted in more complex driving environments or situations.

A commercial (situational context) driver's ability to form accurate judgments might be further challenged by the policies held by the employer. The delivery driver, whose performance is judged primarily on the basis of productivity (e.g., number of deliveries made within a given time frame), may be more likely to rush or multitask, which may further reduce the driver's capacity to process information in the environment. The problem is further exacerbated when the driver does not perceive that company leadership values safety. OSH professionals should be aware of these factors and other issues surrounding the corporate climate and how they influence individual driver or employee perceptions and behaviors.

While commercial drivers face additional stressors that may further negatively affect their calibration, commercial driving environments typically provide greater latitude in implementing technologies that can help address calibration failures. These systems, including those noted, can augment sensory information, provide feedback designed to change behavior or automate portions of the driving task.

Note that to gain the benefits drivers must accept the technology and use the devices as intended. In a commercial setting, OSH professionals can use rewards to incentivize technology use and consequent behavior change. However, organizations should also ensure that feedback based on performance is viewed as coaching rather than monitoring (Ghazizadeh & Lee, 2014), since performance monitoring has been shown to be associated with increased stress levels, which can divert attention from task-relevant activities (Horrey, et al., 2012).

Conclusion

In elaborating the proposed framework, the authors hope to make clear the importance of calibration as it relates to risk perception, attention and contextual factors. Knowledge of this construct, as well as potential countermeasures, can be a valuable tool for road safety, OSH practitioners and researchers alike. **PS**

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