Applied Ergonomics 70 (2018) 88–97

Contents lists available at ScienceDirect

Applied Ergonomics

journal homepage: www.elsevier.com/locate/apergo

Development of a higher-order instruction coding taxonomy for observational data: Initial application to professional driving instruction

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ARTICLE INFO

Keywords:
Higher order skills
Driving instruction
Coding reliability

ABSTRACT

Development of a higher-order instruction taxonomy, informed by best practice in driver education (Goals for Driver Education) and self-determination theory (guiding teaching strategies), was tested. Inter-coder reliability was assessed by coding 93 data elements from 5-min clips from three driving instructors. Seventy-three instruction and 32 teaching approach codes were selected. Reliability between two independent coders was high (IOC = 94.6%). Application to data from 17 randomly-selected, 1-h lessons (n = 3 driving instructors) in a pilot study of professional learner driver lessons assessed taxonomy validity. *Missed*, *taken*, and *untaken* opportunities for higher-order instruction via 9 instruction and 19 teaching-approach categories were identified. Reliability assessment and taxonomy application demonstrates evidence to facilitate a comprehensive understanding of driving instruction content and quality, with implications for assessing and evaluating the impact of higher-order instruction in relation to driving and other safety-critical sectors requiring higher-order skills.

1. Introduction

Higher-order instruction teaches transferable driving practices for application to current and future driving situations aimed at fostering safe *independent* driving for novice drivers (Ehsani et al., 2015; Scott-Parker et al., 2014). Higher-order skills enable performance of complex tasks in dynamic environments requiring immediate decision-making and safety critical judgements (Becker and Schatz, 2010; Ericsson and Charness, 1994; Halpern, 1998; Walker et al., 2009; Yamani et al., 2016). Consequently, higher-order skills may be implicated in improved crash rates critical for novice drivers when they graduate from supervised to independent driving (Isler et al., 2011; Maycock and Forsyth, 1997; Tronsmoen, 2010; Walker et al., 2009). A preliminary study (Scott-Parker et al., 2014) indicates there is provision for improved higher-order instruction in current professional driving instruction (Bailey, 2006; Hatakka et al., 2002).

To evaluate higher-order instruction a tool is required to systematically observe and record instruction provided during the learning phase of driving. This tool could enable evidence-based evaluations of the association between higher-order instruction and crash risk in independent driving. Absent in the literature is an evidence-based tool to investigate the comprehensiveness of professional driving instruction, the nature and quality of higher-order instruction, and the teaching strategies and approaches employed. Scott-Parker et al. (2014) recommended the development of a coding taxonomy to observe and record higher-order instruction informed by the operationalisation of current theoretical best-practice in driver education, the Goals for Driver Education (GDE; Engstrom et al., 2003). This paper is a direct response to this recommendation.

The GDE is a theoretical framework recommending a hierarchy of skills necessary for the development of safe driving practices (Hatakka et al., 2002; Keskinen et al., 1999). The hierarchy develops from basic vehicle operation to higher-order skills with each level requiring a curriculum to be addressed including, (a) knowledge and skills, (b) risk-increasing factors, and (c) self-evaluation. The GDE and higher-order literature highlight the importance of a student-focused approach in training (Bailey, 2006; Hatakka et al., 2002). The framework of the GDE is a constructivist approach to learning (Hatakka et al., 2002), and the coding taxonomy has been developed in line with constructivist instructional models (e.g., Savery and Duffy, 1996). Constructivism suggests effective learning occurs when the learner is encouraged and supported by the instructor to develop their own knowledge (Savery

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https://doi.org/10.1016/j.apergo.2018.02.016
Received 11 May 2017; Received in revised form 14 December 2017; Accepted 16 February 2018

and Duffy, 1996). The traditional approach to driving instruction has been teaching focused because traditional goals of instruction have been to teach procedural driving skills such as steering and changing lanes (Bailey, 2006; Mayhew et al., 2017). Consequently, a teaching-focused approach cannot effectively educate the highest levels of the GDE where the learner driver's goals and motives are central. However, the two approaches are not mutually exclusive. Examples include safety critical incidents, and teaching procedural driving skills in the early learning stages which require a teaching-focused approach. The development of the taxonomy furthermore draws upon self-determination theory (SDT; Deci and Ryan, 2000, 2012) which advocates a student-focused approach to teaching.

The literature suggests the current nature of driving instruction focuses on vehicle operation, road rules, and traffic management with minimal consideration for developing higher-order skills during the learner phase (Kuiken and Twisk, 2001; Simons-Morton and Ehsani, 2016). There is a dearth of literature regarding professional driving instruction specifically; however, a large-scale evaluation of driver education and training showed driving skills taught (e.g., car control skills for emergency situations) are unsustainable in the long term and that learner inexperience, age, and individuality are not well accounted for in driver training (Christie, 2001; Lonero and Mayhew, 2010). The GDE signifies that higher-order skill development is critical to the development of safe driving practices (Hatakka et al., 2002). Additionally, higher-order skills training is recommended following other studies of driver education and training (Assailly, 2017; Mayhew et al., 2017; Yamani et al., 2016). Higher-order instruction recognises learner differences in motivations and experiences and has the potential to improve instruction with consequences for long-term safe driving practices. The GDE has guided pre- and post-licence programs in Europe however, it has not been operationalised as a comprehensive tool for professional driving instruction (Boccara et al., 2015; Engstrom et al., 2003; Molina et al., 2007; Twisk and Stacey, 2007). Furthermore, there is no evidence of the integration of higher-order instruction with professional instruction informing best-practice learner driver instruction.

The aim of this paper is to describe the development, assess the reliability, and present an initial application of a higher-order instruction coding taxonomy to determine validity. The aim of the taxonomy is to identify and classify higher-order instruction, unexploited opportunities for higher-order instruction and complementary teaching approaches and strategies during professional driving instruction of learner drivers. The taxonomy aims to provide a tool for consistency in driving instruction observation studies which assess current practice and consequently evaluate the effectiveness of higher-order instruction as recommended by Mayhew et al. (2017) in a recent driver education evaluation. The results of these studies have the potential to inform the development of practical interventions integrating best-practice higher-order instruction with current practice, with implications for improved safe driving outcomes.

2. Development of the taxonomy

The development activities are shown in Fig. 1. Agreement between two coders on inclusion or exclusion of data elements was needed (author 1 and a research assistant). If arbitration was required a third coder (author 2) was consulted.

2.1. Operationalised GDE coding taxonomy

The GDE was operationalised by identifying elements within the hierarchy that were both amenable to being observed (i.e., were not solely cognitive processes) and that were relevant to the process of learning to drive. Thirty data elements were identified as meeting these criteria, all from the first three levels of the framework's hierarchy (Fig. 1). These elements were formatted into a matrix which incorporated higher-order instruction to be coded across the elements when observed. This initial matrix was tested by coding observational data from pilot study data of professional learner driver lessons (details regarding the dataset are reported in section 3.6.1.1. and in Scott-Parker et al., 2014). Five hours of video data was observed in the application which operationalised the GDE matrix. Specifically, the data was used to determine if each coding element could be retrieved from the video footage and was relevant to the end goal of the analysis; development of an evidence-based tool to evaluate higher-order instruction.

Analysis of the pilot study data allowed for a comparison between the GDE taxonomy and current practice in driving instruction. It became evident the GDE framework explains, theoretically, what needs to be achieved in training novice drivers (Boccara et al., 2015). However, in its hierarchical and matrixed form it was not effective as an evidence-based tool for evaluating higher-order instruction. Furthermore, the GDE recommends, but does not include, the best-practice strategies and teaching approaches important to and complementing higher-order instruction (Boccara et al., 2015; Hatakka et al., 2002). Therefore, the GDE was reconsidered and the intention of the GDE was applied to inform the goals of the taxonomy, and the literature was engaged to further develop the taxonomy (see Fig. 1).

2.2. The revised coding taxonomy

The data elements from the operationalised GDE matrix were regrouped into nine codes (detailed in section 3). Codes were redefined based on learnings from the initial application and literature on higher-order instruction (Becker and Schatz, 2010; Bolstad et al., 2010; Chipman, 1986; Isler et al., 2011; Vlakveld, 2011). A codebook was developed detailing and defining the categories and codes including inclusion and exclusion criteria, examples, and coding rules. The inclusion criteria and detailed description of each code were mutually inclusive and were read together to determine the appropriate code allowing reliable coding. For example, *mastery of traffic situation* is defined as the awareness and application of rules and/or processes allowing for safe and effective interaction with other drivers. The inclusion criteria includes *indication* which is also included in *car knowledge* and is distinguished only by the *detailed description.*

Furthermore, recognition of a student-focused approach in effective higher-order instruction guided the inclusion of teaching approach codes (Bailey, 2006; Hatakka et al., 2002; Keskinen et al., 1999). Teaching approaches which support (e.g., autonomy supportive strategies) or undermine (e.g., test focused which is explained in section 3.4) the provision of higher-order instruction were included. Inter-instructor variation of teaching strategies observed in the pilot study data also informed the data elements. For example, *positive feedback, general* and *specific*, were included as content-specific feedback supports self-evaluation, a higher-order skill (Krasnova et al., 2016; Kuiken and Twisk, 2001).

3. The final higher-order coding taxonomy

The coding taxonomy categorises instruction as: (a) higher-order instruction with sub-categories of *taken*, *untaken*, and *missed* opportunities, (b) functional instruction, and (c) teaching approaches.

3.1. The coding rules

The relative proportion, not quantity, of higher-order instruction, the sub-categories, and functional instruction is important to understanding higher-order instruction effectiveness. Therefore, it is necessary to code every recorded utterance in a complete lesson. The codes have been developed to represent verbal instruction as it occurs per the intention of the driving instructor in the observed driving scene. Coding of the transcripts alone will not result in an accurate representation of the instruction without considering the *context*. Higher-order