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The Impact of First-Person Perspective Text and Images on Drivers' Comprehension, Learning Judgments, Attitudes, and Intentions Related to Safe Road-Sharing Behaviors

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THE IMPACT OF FIRST-PERSON PERSPECTIVE TEXT AND IMAGES ON DRIVERS' COMPREHENSION, LEARNING JUDGMENTS, ATTITUDES, AND INTENTIONS RELATED TO SAFE ROAD-SHARING BEHAVIORS

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ABSTRACT

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Drivers and cyclists lack an alignment of road sharing knowledge, attitudes, and expectations, resulting in unnecessary fatalities. Educational countermeasures need to present information that captures drivers' interest by being personally relevant, facilitate elaboration and synthesis of new information with existing knowledge, and change attitudes, intentions, and behavior. Well-documented health-related communication methods were employed to determine their effectiveness in a transportation domain. Health countermeasure designers use first-person perspective to improve narrative instruction outcomes, based on the Elaboration Likelihood Model (ELM; Petty & Cacioppo, 1986). Exploring narrative perspective-taking as a design tool requires the integration of multiple disciplines.

Our design case stems from the existing Virginia road-sharing safety educational handbook. The first study evaluated the effects of text-based information written from a first- and third-person perspective on cognitive and affective learning outcomes. The Theory of Planned Behavior framework (TPB; Ajzen, 1991) was used to interpret the following outcome measurements that are predictive of behavior: comprehension, judgments of learning, attitudes, and intentions. The second study employed the Cognitive Theory of Multimedia Learning (CTML; Mayer, 1997) to understand the interactions between text and visual perspectives on

cognitive and affective learning outcomes. In addition, cognitive load, multiple knowledge types, and three behavioral intention components were also considered when evaluating the efficacy of first-person perspective. It was found that the first-person perspective effect used in the health domain does not transfer to a transportation domain. The data were explored further and discussed, as well as key limitations and possible future directions.

For Peggy “Pegoo” Brown Bryson.
“The gull sees farthest who flies highest.”
– Richard Bach, Jonathan Livingston Seagull

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NOMENCLATURE

ANOVA	Analysis of Variance
CTLM	Cognitive Theory of Multimedia Learning
CLT	Cognitive Load Theory
CRSS	Crash Report Sampling System
DMV	Department of Motor Vehicles
ELM	Elaboration-Likelihood Model
HCD	Human-centered Design
IMTPC	Integrative Model of Text and Picture Comprehension
IQR	Interquartile Range
IRB	Institutional Review Board
MAR	Missing at Random
NASA-TLX	NASA Task Load Index
NCHRP	National Cooperative Highway Research Program
NCSA	National Center for Statistics and Analysis
NHTSA	National Highway Traffic Safety Administration
ODU	Old Dominion University
OTS	Over-the-Shoulder
PASS	Power Analysis and Sample Size Software
PBC	Perceived Behavioral Control
SONA	Sona Systems Research Participation System
TIRF	Traffic Injury Research Foundation

TPB	Theory of Planned Behavior
UCD	User-centered Design
VDOT	Virginia Department of Transportation

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CHAPTER I

INTRODUCTION

Preliminary analyses and projections suggest 675 to 891 cyclists died in the U.S. during 2020, when the COVID-19 public health emergency impacted road-sharing patterns (National Center for Statistics and Analysis; NCSA, 2021; Whelan & Fox, 2021). Motor vehicle traffic on roadways reduced by 13.2% (National Highway Traffic and Safety Administration; NHTSA, 2021), public transit options were limited in cities with lockdowns, and year-over-year sales of bicycles rose 57% since April 2020 (Sorenson, 2021) as people turned to bicycles for exercise and transportation. In 2018, 857 cyclists were killed in traffic crashes in the U.S; the highest since 1990 when 859 deaths were reported. Overall, cyclist deaths have decreased by 15% since 1975 but have increased by 27% from the lowest point in 2010 (NCSA, 2019b).

The current research focuses on drivers' knowledge of road rules related to cyclists in the Commonwealth of Virginia, where 560 reported bicycle crashes resulted in eight fatalities in 2020 (Virginia Department of Motor Vehicles; VA DMV, 2020). Road-sharing laws and education materials exist in Virginia to facilitate safe interactions, but Still and Still (2019) describe some challenges that limit their efficacy. Road users lack awareness of existing local and state laws. An opportunity exists to develop road-sharing education countermeasures grounded in theory and evidence that can be delivered to drivers widely and rapidly. The goal of the current research was to translate health communication methods, education theory, and psychosocial behavior theory into the cycling transportation domain. Hopefully, improving drivers' knowledge, attitudes, and behavioral intentions related to safe road interactions with cyclists will reduce cyclist fatalities.

Crash Characteristics

NHTSA defines bicyclists, cyclists, or pedalcyclists as riders of any nonmotorized wheeled vehicle powered by pedals (i.e., as bicycles, tricycles, or unicycles) (NCSA, 2017). The Code of Virginia section on motor vehicles defines bicycles as any device moved solely by human power (§ 46.2-100); although a bicycle is defined as a vehicle when operated on a highway (§ 46.2-800). For clarity, the term *cyclists* is used throughout this document to describe any bicycle riders sharing the road with drivers of motorized vehicles. According to NCSA (2019a), the most common crashes involve a cyclist falling, but the most serious often involve motorized vehicles. NCSA (2019b) found 96% (753) of the cyclists killed in 2018 were involved in a collision with a single motorized vehicle.

Most commonly, cyclists were struck from the front by a light truck such as an SUV. Most cyclist fatalities in 2017 occurred in urban areas (75%), involved individuals over the age of 20 (87%; $\mu = 47$), and occurred outside of intersections (74%) (NHTSA, 2019a). An estimated 45,000 to 49,000 cyclists were injured in crashes each year between 2017 and 2019 (NHTSA, 2019a, 2020). None of these estimates account for the frequency or impact of unreported incidents or reported near misses between cyclists and motor vehicles (Aldred, 2016). Crash fatality rates provide evidence of the scale of safety issues arising from cyclists and drivers sharing the road. However, understanding the underlying causes or predictors of crashes is crucial for determining how best to address and mitigate crashes.

Multiple environmental, engineering, technology, and human factors play a role in any complex system like shared roadways. The National Cooperative Highway Research Program (NCHRP, 2008) reported that some common problems associated with a higher risk of crash or severity of injury for cyclists include poor intersection design, misalignment of crossing

behaviors, poor visibility, poor traffic law compliance, and improper use of road traffic control devices (e.g., markers, signs, and signal devices used to inform, guide, and control traffic) (Raborn et al., 2008). Robartes and Chen (2017) more recently modeled crash characteristics according to cyclist injuries in Virginia. Their state-specific model aligned with NCHRP (2008), finding that design and engineering factors (e.g., poorly designed road traffic signage, controls, and intersections) and environmental factors (e.g., dense traffic and extreme weather conditions) also exacerbate risk. For example, Robartes and Chen (2017) suggested that the probability of severe bicyclist injuries increases with obscured driver vision, specific vehicle body types, vertical roadway grades, and horizontal curves. Advancements in vehicle technology and automation also interact with the environment and driver behavior on the road (Porter et al., 2010).

Human factors also play a role in crashes. Behavioral factors such as cyclist and driver intoxication and distraction further exacerbate engineering and environmental factors (Robartes & Chen, 2017). NCHRP (2008) also cited excessive speed and inadequate separation between cyclists and motorized vehicles as crash risk factors. Cyclists have control over some of the risks associated with cycling through their behaviors (Ayres, 2006), but accident analyses indicate that driver behavior is also implicated in crashes (Pein, 1996). Of the 560 bicycle crashes reported in Virginia in 2020, 267 cited no improper action on the part of the cyclist (VA DMV, 2020).

In Aldred’s (2016) study of near misses, cyclists reported that preventing accidents was not always in their control. The cyclists believed that six of the seven “very scary” incidents they experience weekly could have been prevented by another person, such as a driver waiting, slowing down, or looking more carefully. In a road-sharing situation, drivers and cyclists may have different expectations and knowledge about the rules or laws governing safe road sharing.

Potential Misalignment of Mental Models

Mental models are cognitive structures or mental representations of how something works and how environmental elements interact (e.g., Craik, 1943; Gentner & Stevens, 2014; Johnson-Laird, 1983). In the context of road-sharing, misalignment between drivers' and cyclists' mental models and related expectation-driven behaviors may increase the risk of crashes. Compared with drivers, cyclists may perceive certain road hazards as presenting a higher risk. Still and Still (2019) evaluated the potential misalignment between cyclists' and drivers' mental models for safe road sharing in Virginia. Drivers may not actively monitor the same types of road hazards as cyclists, potentially increasing the probability of crashes. A lack of understanding or knowledge of bicycle-related laws and recommendations may contribute to drivers' frustration with sharing the road with cyclists. They recommend providing drivers with education and assessment to reduce this level of frustration and thereby create a safer experience for everyone (Still & Still, 2019).

Allen (1997) notes that training is the most practical application of mental models. Scheib's (1998) comparative analysis between bicycle laws in Virginia and in other states reveals that regulations and laws governing cycling are inconsistent across states and may include ambiguous and unclear language. In a review and synthesis of the history of bicycle laws in the United States, McLeod (2016) describes three types of traffic laws that affect bicyclists: (a) rules for cyclist behavior, (b) rules for all road users, and (c) rules for motorized vehicle drivers. If drivers are not aware of the specific laws governing safe cycling, they may engage in unsafe behaviors. A deeper understanding of crash risk factors and the misalignment of mental models between drivers and cyclists can provide a framework for researchers, policy makers, and instructors to prioritize appropriate countermeasures to improve cyclists' safety while sharing the

road with drivers (Brookshire et al., 2016). Drivers and cyclists may also evaluate each other based on their knowledge and understanding of road-sharing situations.

Driver Attitudes Toward Cyclists and Road-Sharing

Attitudes (positive or negative) manifest as three types of evaluative responses: affective, cognitive (i.e., beliefs and knowledge), and intentional responses (e.g., planning to execute an action) (Eagly & Chaiken, 1993). Behaviors refer to observable actions, and intentions refer to the willingness to decide, try, or plan to execute that action. Attitudinal changes about a behavior may enhance self-reported intentions to engage in a new, safe behavior (or reduce unsafe or unwanted behaviors) (Ajzen, 1991). In a survey of 2,283 U.S. residents, Goddard et al. (2016) found that people who commuted primarily by car showed more negative attitudes about bicyclists' rule-following behavior and predictability than toward other drivers.

Cognitive and affective forms of evaluative responses may ultimately impact one's decision-making and behavior while sharing the road. Fruhen and colleagues demonstrated a link between drivers' negative attitudes toward cyclists and their self-reported aggressive behaviors toward cyclists in Europe and Australia (Fruhen & Flin, 2015; Fruhen et al., 2019). Drivers' ratings of a cyclist's "humanness" correlated with their self-reported aggressive behavior toward cyclists, like deliberately cutting them off, driving close to them, or blocking them (Delbosc et al., 2019). These examples are only a few of the interactions among road-sharing knowledge, attitudes, and behavior. A deeper understanding of crash risk factors and the misalignment of mental models between drivers and cyclists can provide a framework for researchers, policymakers, and instructors to prioritize suitable countermeasures to improve cyclists' safety while sharing the road with drivers (Brookshire et al., 2016).

Road Safety Countermeasures

Countermeasures refer to any safety treatment, campaign, program, approach, or intervention intended to mitigate a specific predictor or cause of a crash. Transportation practitioners may take an engineering, enforcement, or education approach to safety when developing countermeasures (Brookshire et al., 2016; Groeger, 2011). Designers and engineers develop safer infrastructure and operations to facilitate safe road-sharing between drivers and cyclists. Law enforcement agencies ensure compliance with laws, ordinances, and regulations around bicycle safety. Educational approaches provide information about specific laws and safe practices or target attitudinal changes within particular demographic groups through training and awareness outreach.

Many educational approaches have been implemented in the United States to improve safety and create a better environment for bicyclists. Each year, a team at NHTSA reviews dozens of traffic safety countermeasures' effectiveness as a reference for State Highway Safety Offices (SHSO) to select effective, science-based traffic safety countermeasures targeting specific problem areas (Venkatraman et al., 2021). The 10^{th} edition of the report published July 2021 included 12 countermeasures designed to address cyclist safety. Two of these countermeasures focused on driver education involving training or awareness about sharing the road with cyclists. State driver manuals and licensing exams address sharing the road with cyclists (Ayres, 2006). Many states do not emphasize the cyclists' presence, relevant state laws, or best practices for sharing the road (Venkatraman et al., 2021). Educational standards, learning objectives, and associated assessments around road sharing are also not implemented consistently across the country.

The most current Virginia Driver's Manual (2019) includes 23 references to bicycles or bikes, 17 to mopeds, 54 to motorcycles, and 43 to pedestrians. The two paragraphs dedicated to "sharing the road" with bicycles address bike lane road markings and bike-sharing road signage. There is one reference to areas where vehicles should not park, including bicycle lanes. The remaining references are general instructions to drivers to watch for all other vehicles, combining bicycles with motorcycles and mopeds. For example, there are three repetitions of the following sentence: "Be sure to check for less visible vehicles such as motorcycles, bicycles, and mopeds." Education approaches focusing on perception of hazards that impact cyclists on the road generally do not target drivers (Still & Still, 2019).

In their review of safe driving behaviors, Kuiken and Twisk (2001) discuss concerns about the existing driver training models that primarily focus on vehicle operation and skill acquisition, targeting the in-person driver's test for state licensing. For example, some evidence suggests that taking a training program in and of itself may lead to an overestimation of one's skills. Ultimately, an inability to self-assess skill mastery can lead to unsafe driving behavior. Regardless of a driver's actual level of knowledge, "a skilled driver is not necessarily a safe driver" (Drummond, 1996). More education approaches are needed to address other crucial factors involved in safe driving, such as attitudes and intentions. These driver education approaches can also be ineffective in reducing overall crash rates with other vehicles (Venkatraman et al., 2021).

The second type of education countermeasure, an awareness campaign, has also been implemented to increase knowledge and change attitudes about safe road behaviors (Venkatraman et al., 2021). One example of a national public awareness program is the Share the Road campaign that NHTSA (2001) developed to address and advance a national strategy for

bicycle safety. In coordination with state and local governments, the Share the Road campaign has been implemented across the country using multiple methods, including road signage. This campaign has shown mixed results regarding cyclist and driver comprehension and behavioral outcomes (Hess & Peterson, 2015; Kay et al., 2013). Inconsistent comprehension of and behavior resulting from a single message may provide additional evidence of a misalignment between the knowledge or attitudes of drivers compared with cyclists.

Overall, inconsistencies are evident in the development, effects, and evaluation of road-safety countermeasures and their influence on knowledge of road-sharing, attitudes toward safe behaviors, calibration of estimates of knowledge and actual skills, intentions to adopt safe behaviors, and the behaviors themselves. Several decades of reviews offer "scant and equivocal" evidence for the direct safety benefit of driver education countermeasures despite their face validity (Groeger, 2011, p. 3). As such, evidence-based instructional design changes should be made to existing safety education countermeasures. Road safety experts agree that the best road safety countermeasures are based on research-driven, evidence-based psychosocial behavior theories (Robertson & Pashley, 2015). Researchers have successfully applied two such theories in a variety of contexts, including road safety and healthcare, with multiple desired outcomes.

Theory of Planned Behavior

Ajzen's theory of planned behavior (TPB) describes how human factors such as attitudes, social factors (including social norms), and perceived behavioral control are predictors of one's overall intentions to carry out a specific behavior (Ajzen, 1991; Ajzen et al., 2018; Fishbein & Ajzen, 1977, 2010). TPB suggests that a driver would be most likely to go through the steps of planning and providing a safe distance between themself and a cyclist on the road when passing the cyclist if they placed a high value on adopting the behavior, had seen that behavior modeled

within their peer group, and perceived a high level of control over their behavior. Wundersitz et al. (2010) concluded that safety education countermeasures aim to mitigate risk by designing a message that captures the target audience's interest and leads them to adopt the desired safe behavior. However, Phillips et al. (2011) state that mere exposure to a countermeasure does not guarantee that the intended audience will pay attention to and learn the message by encoding the information into long-term memory.

Elaboration Likelihood Model

The elaboration likelihood model (ELM) has been applied to the design of education countermeasures. Petty and Cacioppo (1986) established ELM by synthesizing theories of behavior change and social persuasion. Craik and colleagues (1973) suggested that the process of elaboration can create memories that are easier to recall than merely memorizing facts. Through elaboration, learners evaluate the message's content and meaning, creating semantic significance and associations with other knowledge and experiences stored in long-term memory. ELM proposes that a person's motivation and ability to engage in elaborative encoding of any given situation predicts the probability of their attitude and behavior changes. Individuals are more interested in a message, and more motivated to learn it, if they perceive it as personally relevant or feel a high level of personal or social responsibility about the target behavior (Slater, 2002; Wundersitz et al., 2010). A person engaging in elaboration might be accessing opinions, previous knowledge, and experiences, and activating connections to schemas (Green & Brock, 2000). This type of elaboration can alter one's affective, attitudinal outcomes about a specific behavior (Petty & Cacioppo, 1986). Ultimately, an educational countermeasure is evaluated as successful when it elicits behavioral changes.

Narrative Perspective

Health communication encompasses a wide range of topics including disease control, emergency preparedness, injury prevention, environmental health, and even workplace safety (Parrott, 2004). Awareness campaigns often focus on the presentation of facts and statistics to persuade or educate the target audience (Phillips et al., 2011). A recent meta-analysis by Slater and Rouner (2002) confirmed that few messages incorporate both statistics and narrative information. However, research shows that methods other than the presentation of facts and statistics may be more effective depending on the targeted outcomes. For example, a narrative format is more persuasive than more traditional messages with fact-based information (e.g., Hinyard & Kreuter, 2007; Kreuter et al., 2010; Murphy et al., 2015). Narratives have been particularly successful in health education countermeasures, but its effectiveness differs across health-related outcomes.

Zebregs et al. (2015) conducted a meta-analysis of health communication to evaluate the effects of statistical versus narrative evidence on beliefs, attitudes, and intentions. They hypothesized that statistical evidence would provide an overall benefit across those outcomes compared with narrative evidence because statistical evidence presents information based on many individuals who have engaged in a behavior. Across studies, statistical evidence had a stronger influence than narrative evidence on beliefs and attitudes toward health-related behaviors, while narrative evidence had a stronger influence on intentions to engage in those behaviors. Schank (1998) has also suggested that a narrative helps learners understand information by conveying meaningful context around different types of information. In this view, narratives provide the opportunity for a learner to elaborate on the material and make meaningful

connections with their past experiences. Learners may also be able to make these connections through multiple representations of information.

Multimedia Learning

Education countermeasures often focus on text-based, printed information presented to the learner or target audience. Instructional designers have also proposed specific instructional techniques intended to facilitate learning, including presenting learners with multiple representations of information. Mayer’s (1997) cognitive theory of multimedia learning (CTML) suggests that presenting learners with multiple representations of information, such as text with images, is superior to text alone, assuming that it is designed appropriately and aligns with the intended learning objectives. Mayer (2003) later showed experimentally that students learn material better through “well-designed multimedia messages consisting of words and pictures than from more traditional modes of communication involving words alone” (p. 125). Guo et al.’s (2020) recent meta-analysis revealed that the inclusion of graphics alongside text had a moderate overall positive effect on students’ reading comprehension scores. Although a significant difference was not observed among specific graphics in pictures, pictorial diagrams, and flow diagrams, pictures had a greater effect on comprehension scores than mixed graphics.

This joint benefit of image and text can be explained by a concept similar to elaboration, the theory of dual coding (Clark & Paivio, 1991). This theory proposes that learning occurs by processing related material in both visual and verbal cognitive systems. Combinations of text and graphics like those used in health education countermeasures could be applied to the current road-sharing context. Perspective also plays a role in influencing cognitive and affective learning outcomes through instruction that includes images and video. For example, viewing a first-person video of an instructor or a model completing a task can promote learning. Conversely,

showing a task from a third-person or other viewpoints may require the learner to mentally rotate between an instructor's or model's perspective and their own (Fiorella et al., 2017), adding to their cognitive effort.

Within the framework of cognitive load theory (CLT) (Chandler & Sweller, 1991), instruction must be designed not to contribute to additional cognitive load to be effective. Overload occurs when the cognitive processing or mental effort required to learn designed instruction exceeds the learner's available cognitive capacity limits (Mayer & Moreno, 2003). Transferring knowledge to a new or different context is one ultimate objective of any education and training program (Halpern & Hakel, 2003). Transfer refers to the extent to which learning a new skill, or adapting a learned skill to a new environment, relies on or applies what has been learned before (Holding, 1987; Singley & Anderson, 1989). However, learners may experience high cognitive load or workload when trying to solve a novel scenario due to their lack of prior knowledge.

Goal of the Current Research

The current research attempted to translate and apply existing evidence-based psychosocial behavior theories within public health and medicine to the transportation domain. First, an education countermeasure for a driver-cyclist road-sharing paradigm was designed by applying ELM (Petty & Cacioppo, 1986). Under ELM, it is beneficial when developing education countermeasures to employ methods that increase the likelihood of information elaboration and retrieval. One component of narrative instruction, perspective, was manipulated in the first study based on its success in facilitating elaboration and self-referencing. Text-based information from an existing Virginia road-sharing safety handbook was reframed from the driver's first-person or third-person perspective. By targeting one specific component of a

narrative construct, either the narrator's or the audience's perspective, the current work contributes to the theoretical understanding of the underlying constructs within narrative instruction that facilitates outcome variables such as learning comprehension or attitudes.

The text-based perspective component of narrative instruction was extended to visual perspective in a second study based on CTML, which posits that instruction combining multiple representations of information is more effective than one representation (Mayer, 2009). All images were remodeled from a driver's first-person or a top-down perspective to assess the interactions among text-based and image-based perspectives on outcome measures. CLT was applied to ensure learners did not experience high levels of cognitive load during a knowledge transfer task (Chandler & Sweller, 1991). TPB (Ajzen, 1991) was also applied as a framework to carry out this research. Through TPB, a countermeasure can target multiple desired outcome variables that predict behavior change, including comprehension, self-evaluations of learning, attitudes, and intentions. The next chapter provides in-depth review of the theoretical foundations of ELM and TPB, and text-based narrative perspective's impact on drivers' comprehension of road rules about cycling, and judgments of learning, attitudes, and intentions related to sharing the road with cyclists.

CHAPTER II

STUDY 1 BACKGROUND LITERATURE

Authors of meta-analyses and reviews of safety education countermeasure effectiveness recommend addressing issues of inconsistencies by designing materials that help individuals pay attention to messages and connect new information with existing knowledge (see review from Venkatraman et al., 2021). Instead of merely exposing learners to new information, instructional designers can help learners integrate information with their existing knowledge and perspective (Schank, 1998). Storytelling-based instructional methods, such as those that use narrative, are standard in health-based education and are thought to facilitate this integrative approach to learning (Gray, 2009). This chapter outlines some theoretical constructs of narrative, followed by the processes and stages involved in memory, such as elaborative encoding. Next, the cognitive and affective learning domains and two psychosocial behavior theories that impact both types of learning outcomes are described. Finally, an explanation is provided about how text-based healthcare education countermeasures employing narrative perspectives could be translated to road-sharing safety.

Narrative

Storytelling has been used as a tool for education and training in various disciplines including business, medicine, aviation, and law. Health education countermeasures employing storytelling-based instructional methods have been successful in improving learning in contexts such as clinical interaction, patient education, and physician education (Gray, 2009). Narrative has become a colloquial term to describe a story’s general structure (Gudmundsdottir, 1995). Many definitions and models of narrative exist across disciplines (for a review, see Green & Brock, 2000). Branaghan (2010) named five components of narrative structure: (1) a storyteller

or narrator, (2) an audience, (3) a geographical, temporal, and social context, (4) a set of events that occur in a specific sequence, and (5) a message, intent, or moral. Branaghan's definition is comprehensive and describes multiple interrelated factors that may make narrative an effective instructional method. Narratives offer context, sequential organization, and personal perspectives, distinguishing them from other kinds of storytelling.

There are questions about the underlying constructs within the narrative component of narrative instruction. Narrative instruction involves multiple interrelated constructs, such as the audience, narrator, or sequential events (Branaghan, 2010). Narrative instruction is widely used across disciplines under the assertion that it provides effective instructional outcomes, but it is challenging to make inferences about directional or causal effects as a function of each construct on various outcomes (Andrews, 2010). De Graaf et al. (2016) describes perspective or viewpoint as one narrative component employed in many studies of persuasive health-related education countermeasures. Elaborative encoding of memories may be one mechanism through which narrative, especially perspective, facilitates information processing and learning.

Narrative Instruction and Memory

Memory and learning are highly interrelated constructs. Sternberg (1999) defines memory as "the means by which we draw on our past experiences in order to use this information in the present." Learning, however, is a generally stable change in behavior or knowledge based on practice and experience (e.g., Ebbinghaus, 1885; Kimble, 1961). Learning involves how experience changes the mind and behavior, while memory describes how such changes are stored and reactivated. There is a general agreement that there are multiple memory processes that work together. Atkinson and Shiffrin (1968, 1971) proposed a three-stage model through which information flows: sensory memory, short-term memory, and long-term memory.

Rehearsal is the process by which memories are retrieved from long-term memory and stored in short-term memory, such as attending to or practicing material. Without the rehearsal of that information at each stage, memories can be forgotten.

Elaboration of New Information

Elaborative rehearsal requires an individual to attach meaning to information. Maintenance rehearsal does not, and consequently, not all information is encoded equally. In their seminal research on memory, Craik and Lockhart (1972) hypothesized that successful encoding and retrieval of information depends on *how* the information is rehearsed. Craik and Watkins (1973) proposed that information is encoded through two kinds of rehearsal: maintenance rehearsal and elaborative rehearsal. Maintenance rehearsal is comparable to rote memorization, which involves repeating information in short-term memory until it is encoded in long-term memory. Elaborative rehearsal describes how an individual elaborates on the meaning of the material, creating semantic significance and associations with other knowledge and experiences in long-term memory. Craik and colleagues suggested that maintenance rehearsal is less effective in facilitating recall, but a more meaningful elaborative encoding of material can create easier recall memories.

According to Craik and Lockhart's (1972, 1990, 2002) levels of processing theory, the retention of information is related to how "deeply" an individual processes semantic meaning. Their view is widely applied to learning contexts, but it is vague and cannot be easily observed or measured. Researchers, including Eysenck (1978), have stated that levels of processing theory is more of a description than an explanation (2014). At the same time, elaborative encoding is described as one benefit of narrative messaging. Bruner (1991) described how people tend to organize experiences as personalized stories to understand concepts and events.

Schank and Berman (2002) argue that narratives may closely resemble the structure of human autobiographical memory, a form of episodic memory. Episodic memory encompasses personal experiences relevant and significant to one's life and one's environment (Tulving, 1983). Research suggests that narrative enables learning by providing a sequence of instruction (Bruner, 1966) within a contextual form (Tennyson & Park, 1980), which prompts episodic memory (Jonassen, 1991). A review of learning types, outcomes, and theory is required to better understand how certain aspects of narrative may be effective in improving memory outcomes.

Cognitive Learning

Anderson (1982, 1983) makes a distinction between declarative knowledge and procedural knowledge. Declarative knowledge (or verbal or factual knowledge) encompasses facts and general information learned through memorization. Initial instruction may begin with terminology or vocabulary associated with any given topic area or skillset to be developed. Procedural knowledge, sometimes referred to as tacit or compiled knowledge, encompasses the skills a person knows how to perform (Driscoll & Bruner, 2005; Gagne, 1984). Experts have a large amount of declarative knowledge and procedural knowledge based on practice over time (Charness et al., 2004; Ericsson et al., 1993; Proctor & Vu, 2006).

According to Newell (1994), knowledge compilation occurs when declarative knowledge progresses to procedural knowledge. At the early cognitive phase of skill acquisition, individuals are using and developing declarative knowledge. In the associative phase, individuals begin to establish procedural knowledge by developing rules for production and knowledge computations until they reach the autonomous, automatic skill phase (Anderson, 1982; Fitts & Posner, 1967; Newell, 1994; Singley & Anderson, 1989).

In the 1950s, Bloom and other educational psychologists developed three learning domains: cognitive, psychomotor, and affective (Bloom et al., 1956). Their goal was to identify learning behaviors that could be addressed with specific teaching and assessment methods. Learning objectives must be defined to guide instructional design decisions that will target specific outcomes through an appropriate instructional method. The original taxonomy focused on six levels or categories of cognitive, knowledge-based learning (from lowest to highest levels): knowledge, comprehension, application, analysis, synthesis, and evaluation.

This taxonomy is hierarchical, so complex cognitive skills require the learner to achieve preceding lower-order categories. Bloom, Krathwohl, and colleagues added an affective learning domain to their educational objective's taxonomy in the 1970s based on further research and feedback from the scientific community (e.g., Krathwohl et al., 1973; Krathwohl, 2002). In 2001, Anderson, Krathwohl and colleagues also revised their cognitive taxonomy by changing the noun descriptors for the categories to verbs (i.e., remember, understand, apply, analyze, evaluate, and create) to emphasize what the learner does at each level.

Affective Learning

Affective learning outcomes such as attitudes and motivations also play a critical role in education countermeasure efficacy. Bloom, Anderson, Krathwol, and other researchers later added an affective domain to the educational objectives taxonomy (e.g., Anderson et al., 2001; Krathwohl et al., 1973). The affective domain includes the way a learner processes emotional information, like feelings, values, motivations, and attitudes. There are five potential affective learning outcomes in the hierarchy which move from simple awareness to complex, internalized attitudes: perceiving phenomena (awareness or selected attention), responding to phenomena (actively participating and reacting), valuing (attaching worth or value to something), organizing

values (organizing values into priorities and synthesizing them), and internalizing values (values consistently characterize the learner's behavior).

Multiple existing models explain the relationship between attitudes and behavior. For example, Fishbein and Ajzen (1977) proposed the theory of reasoned action (TRA), which includes personal and social factors that may explain the attitude-behavior relationship. First, they propose that one must experience a favorable attitude concerning a behavior, and second, subjective social norms may influence the likelihood of engaging in those behaviors. These personal values and social norms then affect behavior by promoting a plan, decision, or intention to act. As Webb and Sheeran (2006) explain, a behavioral intention is the "proximal determinant of behavior and mediates the influence of both the theory's predictors (attitude and subjective norm) and external variables (e.g., personality and demographic characteristics)." In other words, Fishbein and Ajzen (1977) propose that an intention is the most critical predictor of behavior.

One concern with TRA is that it proposes to predict purposeful behaviors over which the individual has control. Some behaviors are outside an individual's control and may have differential effects on intentions. To account for this possibility, Ajzen (1991) added perceived behavioral control to the TRA as an additional predictor of intention. Therefore, the theory of planned behavior (TPB) is an extension of TRA and includes individuals' need to feel a sense of control over behavior. Humans are guided by three beliefs about engaging in specific behaviors: beliefs about the behavior's likely consequences (i.e., behavioral beliefs), beliefs about the social norms and expectations around the behavior (i.e., normative beliefs), and beliefs about factors impeding or facilitating the behavior (i.e., control beliefs) (Ajzen, 2010).

TPB proposes that people's intentions about any given behavior can be modified by changing their attitudes and perceptions of social norms about the behavior and their perceptions

of control over that behavior (Ajzen, 1991). Education countermeasures sometimes focus on articulating, emphasizing, and modeling road safety social norms (Delhomme et al., 2009). Providing practical solutions and models addressing social situations is particularly important when current norms do not align with safe practices (Guttman, 2015), such as drivers not knowing the safe distance to pass cyclists. Intentions, encompassing the three beliefs, are thought to be the immediate precursor to behavior. Sheeran (2002) found a large effect of intentions on behavior ($d = 1.47$) based on Cohen's (1992) effect size estimation.

To address concerns about the influence of a third-variable correlation, Webb and Sheeran (2006) conducted another meta-analysis of 47 experimental interventions across multiple target health-related behaviors to investigate the associated effect sizes of specific interventions. They found that changes in behavioral intentions (medium-to-large effect; $d = 0.66$) affected behavior outcomes (moderate effect size; $d = 0.36$). This meta-analytic work illustrates the predictive relationship between intentions and behaviors. Researchers in the health behavior field continue to investigate cognitive and emotional self-regulatory mechanisms that may explain the "intention–behavior gap."

Some individuals are more successful than others in implementing intentions and carrying out the intended behavior (Sheeran & Webb, 2016). For example, Gollwitzer (1993) has investigated the role and effectiveness of implementation intentions (i.e., if-then plans to specify goal-directed intentions to do X in situation Y) in explaining why some people who have strong intentions to achieve a goal succeed, while others do not. Metacognitive theory constructs such as self-regulation may also help explain this gap between intentions and behavior (Abraham & Johnston 1998). Understanding any underlying self-regulatory predictors of the intentions-

behavior gap could help inform the material, assessment method, or selection of outcome variables to target through education countermeasures.

Judgments of Knowledge

Metacognitive theory posits that learners' knowledge about their knowledge plays a vital role in processing tasks such as problem-solving (Metcalfe, 1986). Metacognitive processes or "cognition about one's own cognition" (Metcalfe, 2000) assists memory function development overall (Hart, 1965). Self-regulation interventions are successful in promoting behavior change across a range of health behaviors (Wittleder & Kappes, 2019). Cognitive self-regulation involves a learner becoming "metacognitively, motivationally and behaviorally active participants in their own learning process" (Zimmerman, 1986, p. 308). According to Keskinen and Hernetkoski (2011), self-evaluation as a form of metacognition is an essential component of driver education programs as drivers transition through multiple levels of skills and knowledge. Metacognitive experiences are often measured through subject ratings, such as predictions of performance (POPs), familiarity ratings, feelings of knowing (FOK), judgments of learning (JOL), or confidence ratings (CR) (see a review from Dunlosky & Metcalfe, 2009).

The familiarity hypothesis argues that an individual's familiarity with a topic increases their support of that topic. Familiarity measures focus on self-reports of knowledge instead of or in conjunction with an individual's declarative knowledge (Dunlosky & Metcalfe, 2009). Similarly, CRs are measured after a knowledge test and require participants to rate their level of confidence in correctly retrieving a specific piece of information (Miner & Reder, 1994). According to Koriat and Goldsmith (1996), people use these feelings of confidence in their knowledge to guide their behavior. For example, FOKs help people decide whether they know specific information, and therefore guide decisions about pursuing additional learning. JOLs are

ratings about the likelihood they will remember the acquired information on a later memory test following a learning trial (Koriat, 1997).

Health and education scholars suggest that measures of declarative knowledge and feelings of knowledge may be separate constructs (Hansford & Hattie, 1982). There may be ideal calibration levels between learners' estimates of their ability and their actual performance level (Dunlosky & Metcalfe, 2009). In Still and Still's (2019) study about road-sharing laws and recommendations, drivers scored low on a comprehension test, but their low ratings of knowledge about the laws governing bicycling and familiarity with the laws governing interactions with bicyclists were calibrated with their low knowledge scores. In other cases, a driver who has some familiarity with road-sharing best practices may overstate judgments of knowledge and thereby underestimate the need for increased education on that topic.

Kuiken and Twisk (2001) reported that new drivers tend to overestimate their level of ability to anticipate and adapt to risks and underestimate the actual cognitive demands of those kinds of driving tasks (i.e., learners have poor calibration). Driving students tend to overestimate the safety effects of the training they receive, so they believe they have already acquired the necessary skills to be a safe driver. Such poor calibration can lead to unsafe behaviors such as speeding or overtaking a bicycle due to a lack of self-regulation of those behaviors. One way to enhance road safety is to improve drivers' calibration and awareness of the mismatch between perceived and actual skills (Kuiken & Twisk, 2001).

It is also crucial to determine what instructional strategies are most effective in transitioning a learner from the general awareness of or familiarity stages of affective learning to the more complex, internalized attitudes (Krathwohl et al., 1973). To change intentions, and thereby better predict behavior. One potential strategy to facilitate this learning process may be

to provide abundant opportunities for elaborative encoding. Learners can link their perspective and value systems to new information. In the following sections, one component of narrative instruction, perspective, is described. Perspective may provide opportunities for learners to elaborate upon their existing experiences and synthesize those experiences with new information. A general discussion of perspective is necessary to lay the groundwork for a more in-depth discussion of theories of behavior applied in healthcare education countermeasures that employ different perspectives.

Perspective in Narrative Instruction

Similar to how learners construct schemas, scripts (Schank & Abelson, 1977) are used to describe memory structures encoded with general knowledge of exemplar situations and events that involve routine procedural activities (Bower et al., 1979). A script consists of some of the core constructs within a narrative, including “roles” (i.e., individual people in the event) and “scenes” that indicate the order of events represented in that context. Scripts are written from one role’s point of view (Mueller, 2002; Schank & Abelson, 1977). Research suggests that adopting a particular role’s perspective can help learners extract information relevant to understanding a text (Brunyé et al., 2011; Gernsbacher et al., 1992). One goal of the current research was to isolate specific components of narrative that enable effective instructional outcomes. Using existing educational material, the audience’s viewpoint or perspective was adjusted alongside the roles within the text, such as the narrator. The narrative voice, or perspective, has been described as “the most fundamental” feature of narrative (Kaufman & Libby, 2012).

Brunyé et al. (2009, 2011) note that narratives can use multiple perspectives by describing an individual through specific pronouns or perspectives. A first-person perspective would employ the pronoun *I*; for example, “I fell off my bicycle when a car collided with me in a

designated bicycle lane." A third-person perspective would employ the pronoun *They/He/She* (or the name of the individual); for example, Alex fell off her bicycle when a car collided with her in a designated bike lane." A second-person perspective would employ the pronoun *You*. Some research presents text in a way that indicates the reader, or research participant, is the individual performing an action or perceiving an object (i.e., *You rode the bicycle* or *I ride the bicycle*). Pronouns can therefore elicit internal or external visual perspectives (Brunyé et al., 2009, 2011, 2016).

Developmental psychologists have suggested that taking the perspective of another person requires a variety of complex skills for someone to be able to differentiate their view from the other's (e.g., Zhao et al., 2010). Perspective involves perceptual (i.e., what does someone else see?), cognitive (i.e., what does someone else think?), and affective (i.e., what does someone else feel?) skills (Kurdek & Rodgon,1975). Black et al. (1979) found that students read statements with a consistent point of view faster than statements with a changing point of view across multiple experiments. Students also rated statements with an inconsistent perspective as less comprehensible and recalled those statements less accurately. When asked to edit inconsistent statements, they most frequently edited the information so the perspective would be consistent. Black and colleagues concluded that a consistent point of view makes a sentence sequence more coherent, making it easier to recall.

Participants recall content depending on the narrator's perspective when they are asked to recall a story with different characters (Anderson & Pichert, 1978; Owens et al., 1979). If a particular point of view is not defined and omits pronouns, readers mentally simulate or visualize situations from an internal perspective (Sato & Bergen, 2013). Brunyé et al. (2016) found that readers differentially adopt a specific perspective as a function of the pronouns encountered

while reading a narrative. In their work, Brunyé et al. assert that adopting different visual and action-based perspectives while reading serves five functions.

First, pronouns and other self-referential language cues provide a signal to readers to isolate self-relevant information (Libby et al., 2009). Second, perspectives help readers meaningfully categorize aspects of scenes and actions (Lozano et al., 2006). Third, employing differential perspectives allows the reader to adopt more accurate causal inferences among the elements in their mental model of events (Jones, 1972). Fourth, perspectives allow readers to prepare for various actions based on self-relevance (Scorolli & Borghi, 2007). Finally, adopting different perspectives can help readers extract self-relevant emotional information (Brunyé et al., 2011; Gernsbacher et al., 1992).

Given that readers can differentially adopt perspectives and need consistent perspective for comprehension, employing the learner's perspective within narrative-based instruction may prompt the learner to construct self-referential mental models. In one line of research, readers are prompted to adopt the perspective of a burglar before being exposed to text describing different houses. Readers interpret certain information in the text as more important or relevant (Pichert & Anderson, 1978). For example, valuable household items are more interesting and important to a burglar than other information (e.g., mold in a room). That perspective-relevant information draws the reader's attention (Kaakinen & Hyönä, 2008) and is better remembered (Baillet & Keenan, 1986). Rogers et al. (1977) suggest this self-reference effect facilitates elaborative cognitive processes and improve memory performance and retention (Branaghan, 2010; Rogers et al., 1977). When designing educational material, it is useful to provide the reader with the opportunity to engage in self-referencing by thinking about how the information is relevant to their current situation based on the past (i.e., retrospective memories) or potential future (i.e.,

anticipatory, imagining future events). ELM is one theory of behavior used to explain this phenomenon. A message that is relevant to a learner or invokes personal or social responsibility can be motivating and engaging (Slater, 2002; Wundersitz et al. 2010).

Like mental models, schemas (Bartlett, 1932) allow learners to categorize pieces of information based on how they were used (Greasser & Nakamura, 1982). A person engaged in elaboration might be accessing opinions, existing knowledge, and past experiences, and activating connections to schemas (Green & Brock, 2000). Such an effect also has positive implications for other learning outcomes, like intentions and attitudes. De Graaf et al. (2016) described perspective or viewpoint as a commonly employed narrative component in studies of persuasive health-related education countermeasures; in the form of first-, second-, and third-person text-based narratives.

First-person Perspective in Healthcare

In a review of 153 experimental studies, de Graff et al. (2016) described two perspectives commonly employed in health-related narrative persuasion interventions: first-person perspective in which an individual tells a story about their own experiences (De Wit et al., 2008; Falzon et al., 2015), and third-person perspective in which a narrator tells a story about something that happened to someone else (Dunlop et al., 2010; Gray & Harrington, 2011). Second-person perspective is often not the focus of health-related interventions. Research suggests that describing a character with a *you* pronoun can promote an internal perspective and increase readers’ empathy (Goldman, 2006).

First-person perspective narrative has had differential effects on comprehension, attitudes, risk perception, behavior, intentions, and behavior outcomes. Nan et al. (2015) conducted a controlled experiment with 174 college students who had not received the human

papillomavirus (HPV) vaccine. They presented students with a news story using only facts, narrative, or a combination of both, and presented information from a first-person or third-person perspective. Results showed that a hybrid message with both statistical and narrative descriptions of HPV increased perceived risk compared with a message using only facts. The first-person news story about an HPV vaccination was most effective in increasing the perceived risk of getting HPV compared with a third-person news story. However, the different perspectives had no effect on the participants' intentions to ultimately get the HPV vaccine. Janssen et al. (2013) found that tanning bed users exposed to narrative information (vs. non-narrative, fact-based information) could better imagine themselves developing skin cancer and thus reported higher feelings of risk of skin cancer risk. Ultimately, Winterbottom et al. (2008) reviewed health communication studies and concluded that first-person narratives impact individuals' health decisions twofold compared to third-person narratives despite outcome variable differences across studies.

Others have not found any effect of first-person perspective on health outcomes. Meadows (2012) investigated narrative perspective in the contexts of texting while driving, binge drinking, smoking, and HIV prevention. There was a significant difference between the behavioral intentions of those exposed to first-person versus third-person perspective audio-based narratives. Nan and colleagues (2017) conducted a follow-up study to investigate HPV risk perception to understand the interaction between communication modality and perspective. When the messages were audio-based, there were no differences in risk perception based on the perspective of the information. When the messages were text-based, the first-person narrative was more persuasive than the third-person perspective.

Goal of the First Study

One goal of the current study was to translate the efficacy of text-based, first-person perspective in improving health-related outcomes to road safety outcomes. The *Sharing Virginia Roads* handbook (6th ed., NVRC, 2018) was used to carry out this research. Sections of the handbook's content were rewritten using a first-person or third-person perspective from the role of a driver sharing the road with a cyclist. The impact of perspective on cognitive and affective learning outcomes was investigated using TPB as a framework (Ajzen, 1991). Five hypotheses were developed based on previous research.

First, ELM proposes that individuals are motivated to learn a message when they perceive it as relevant to their personal experience (Slater, 2002; Wundersitz et al., 2010). Narratives provide the opportunity for learners to elaborate on material because they can make those meaningful connections (Schank, 1998). First-person perspective is one aspect of narrative that may increase the likelihood that learners will elaborate on new information as they relate it to their current situation to past or anticipated future behavior. Referencing oneself while reading facilitates elaboration, improves memory, and aids retention (Branaghan, 2010; Rogers et al., 1977). Readers can better recall perspective-relevant than perspective-irrelevant text information (e.g., Baillet & Keenan, 1986). First-person perspective was predicted to facilitate better comprehension of the content about road rules in the Virginia road-sharing handbook than third-person perspective across educational material (H1).

Two versions of educational material were developed to carry out this research: (1) a revision of the full existing handbook that reduced the content and removed pedestrian references, and (2) a redesigned brochure employing visual and organizational design principles (Appendix A). The visual design improvements made to the redesigned brochure were predicted

to improve learning outcomes. The redesigned brochure was predicted to facilitate better comprehension than the revised handbook across perspectives (Hypothesis 2).

An interaction between perspective and educational material was predicted on the remaining outcomes. Learners' estimates of knowledge may or may not be calibrated with actual performance (Dunlosky & Metcalfe, 2009; Hansford & Hattie, 1982). Drivers may not be aware of their own knowledge, skills, and abilities when sharing the road with other road users. Participants reviewing first-person perspective in the redesigned brochure were hypothesized to report higher judgments of learning (JOLs) than participants reviewing the third-person perspective in the revised handbook (Hypothesis 3).

Elaboration can also influence affective learning outcomes like attitudes (Petty & Cacioppo, 1986). De Graff et al. (2016) found that first-person perspective print narratives produced effects on attitudes, and third-person had no advantage in an extensive review of health countermeasures. First-person perspective was associated with more positive attitudes about a specific health concern than third-person perspectives in other health communication studies (e.g., Fagerlin et al., 2001; Winterbottom et al., 2008). Fishbein and Ajzen (1977) proposed that positive attitudes toward a behavior increase the likelihood of setting intentions about behavior change. Those intentions are associated with behavior outcomes (Webb & Sheeran, 2006). Therefore, if first-person perspective influences drivers' attitudes, those positive attitudes should increase road-sharing behavioral intentions. Across educational material, road-sharing information written in a first-person perspective was predicted to facilitate more positive attitudes toward cyclists (Hypothesis 4) and higher self-reports of intentions to safely share the road with cyclists (Hypothesis 5) than a third-person perspective.

CHAPTER III

STUDY 1 METHOD

Participants

Based on Cohen's (1992) recommendations, an estimate of adequate sample size was calculated to detect an interaction effect hypothesized in the study. PASS Sample Size Software (Version 16; NCSS, 2017) was used to conduct an a priori power analysis with an observed power of .80 and a significance level of p < .05 (Cohen, 2013; Maxwell et al., 2017). A medium effect size (*Cohen's d* = .50) was selected based on the range of effect sizes found in previous research across dependent measures. Researchers investigating the impact of narrative on healthcare-related intentions and attitudes have found small effects (*r* = .044 - .060; Shen et al., 2015). ELM and TPB countermeasures have elicited medium effects on intentions (*d* = 0.35 - 0.58; Webb & Sheeran, 2006). Researchers studying driver comprehension of Virginia bicycle laws have found large effects (*d* = 1.682; Still & Still, 2019). The power analysis indicated that a total of 126 participants would be required (31 in each of the four groups) to observe a significant interaction effect.

Participants were recruited from a convenience sample of Old Dominion University (ODU) undergraduate students through the SONA Research Participation System, an online recruitment service used by the ODU Psychology department. Participants were required to self-report that they had a current Virginia motor vehicle's driver's permit or license and were at least 18 years old. Participants were eligible to receive credits that could be applied toward course credit at an instructors' discretion. In total, 200 students responded to the online study. After data cleaning procedures, 144 participants (111 female, 30 male, and 3 nonbinary) ranging from 18 to 53 years old (*M* = 21.73, *SD* = 5.842) were retained for final analyses.

Informed consent was obtained from all participants, and ethical guidelines were observed throughout the study's administration. ODU's College of Science Institutional Review Board (IRB) approved the application for Exempt Research describing how the research protocol was designed to account for or limit any potential risks to human participants (Appendix B).

Design

This study employed a 2 (educational material: revised handbook, redesigned brochure) x 2 (perspective: first-person, third-person) between-subjects design. The independent variable, driver perspective, included two levels. The material was presented from two perspectives: (1) First-person (i.e., *I*), and (2) third-person (i.e., *the driver*). The independent variable, educational material, included two levels: (1) a *revised* version of the existing handbook, and (2) *redesigned* brochure applying evidence-based design elements. Dependent variables included in this study were drivers' knowledge of road-sharing, judgments of knowledge about road-sharing, attitudes toward cyclists, and intentions to safely road share.

Stimuli

The experimental manipulations were based on the 6th edition of the *Share Virginia Roads* handbook published in 2018. The handbook provides a review of safety procedures and traffic regulations for all road users in Virginia. The Northern Virginia Regional Commission (NVRC) prepared the handbook through a Federal Highway Safety Grant from the Virginia DMV with oversight from a Technical Advisory Committee.

Two versions of the existing handbook were developed. First, incremental changes were made to the design and organization of sections within the existing *Sharing Virginia Roads* handbook. These changes were needed to ensure a valid and fair comparison with the existing handbook before applying the perspective manipulation. For example, 57 references to

pedestrians were removed so the content targeted cyclist and driver interactions across both versions. Therefore, this *revised handbook* was one version of educational material used in this study (Figures 1 – 2). Second, additional changes were made to develop a *redesigned brochure* by applying visual and organizational design principles (see Appendix A for detailed review of the visual redesign process). Both versions of the educational material were then depicted from a first-person or third-person perspective from the role of a *driver* sharing the road with a cyclist to evaluate the main independent variable (Figures 3 – 4). Participants were assigned to one of the four groups associated with the experimental manipulations through blocked randomization to maintain equal sample sizes across groups during data collection.

Figure 1

Revised Handbook with Content Rewritten from a First-person Perspective (i.e., I)

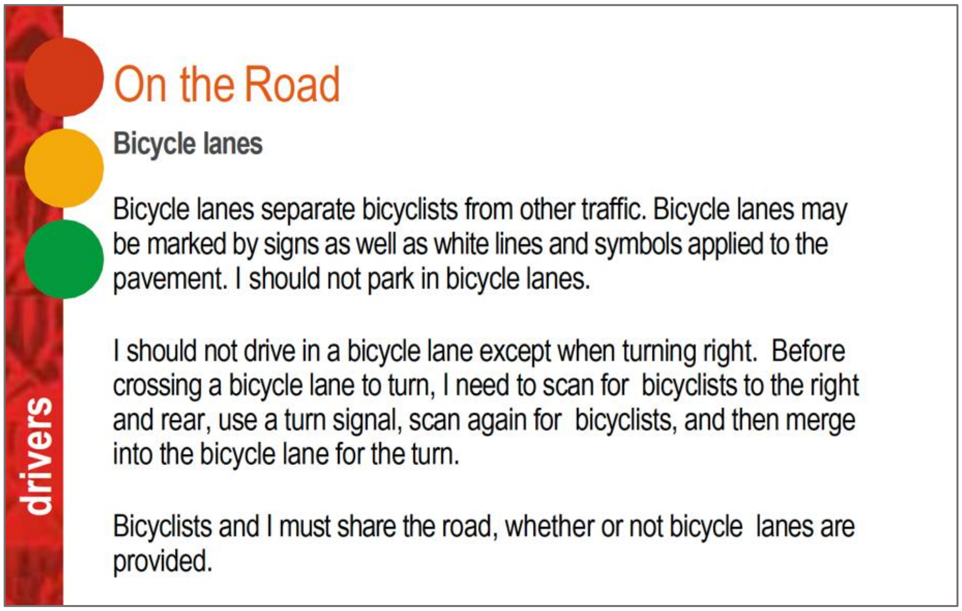


Figure 2

Revised handbook with content rewritten from a third-person perspective (i.e., driver)

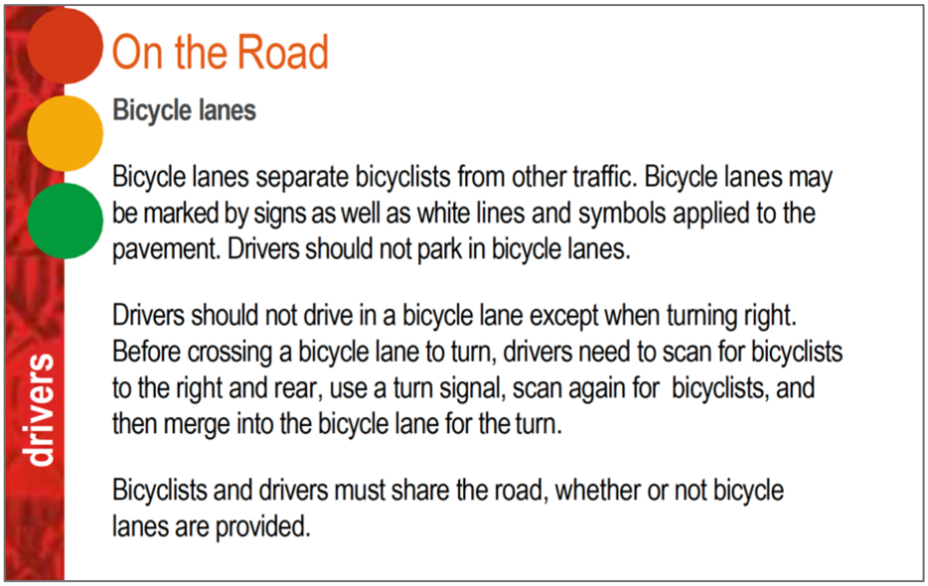


Figure 3

Redesigned Brochure with Content Rewritten from a First-person Perspective

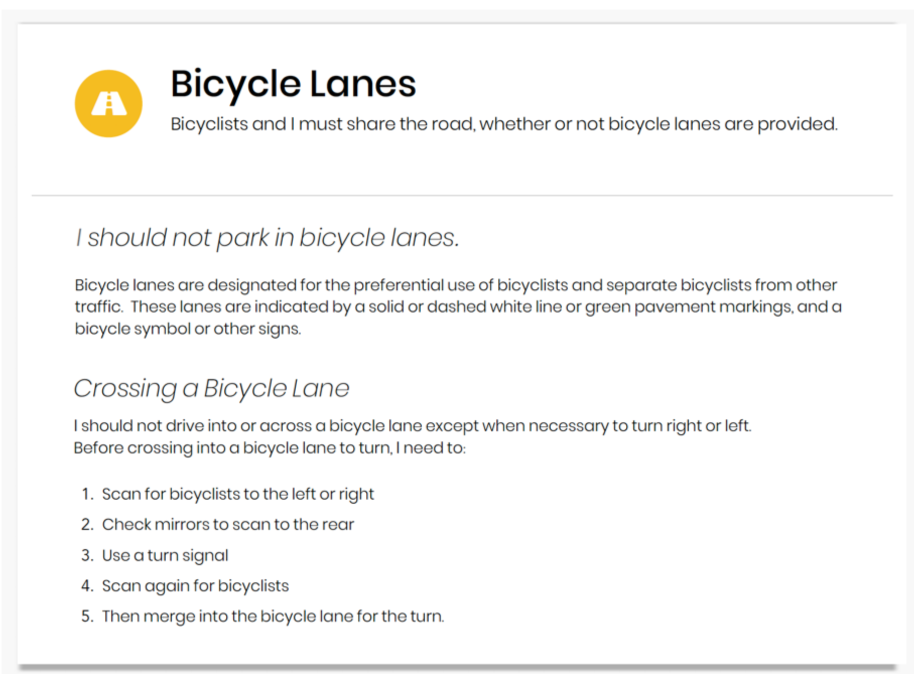
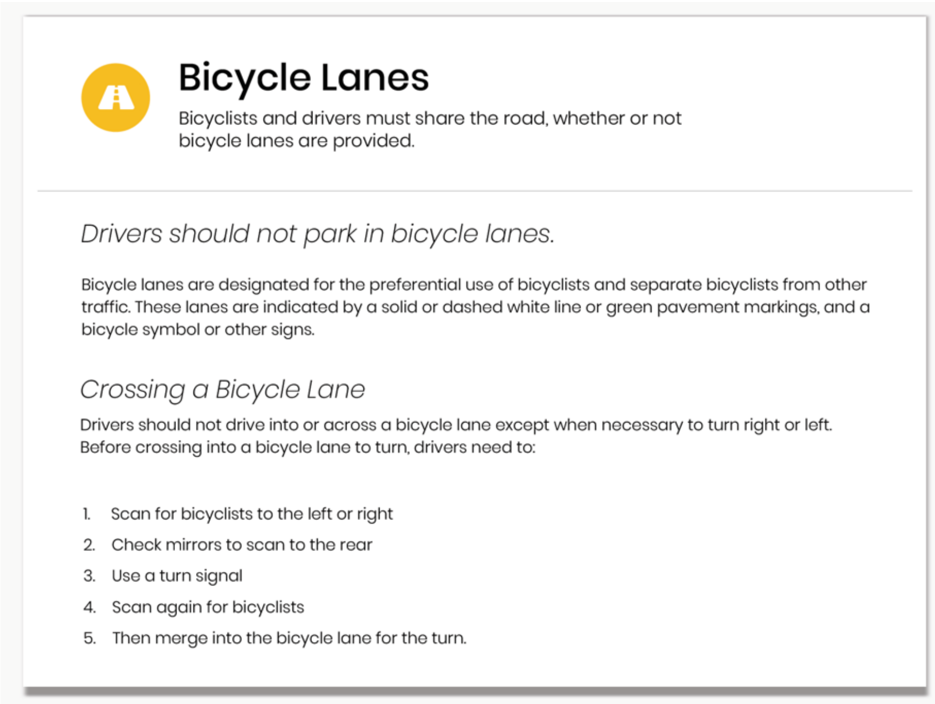


Figure 4

Redesigned Brochure with Content Rewritten from a Third-person Perspective


Bicycle Lanes

Bicyclists and drivers must share the road, whether or not bicycle lanes are provided.

Drivers should not park in bicycle lanes.

Bicycle lanes are designated for the preferential use of bicyclists and separate bicyclists from other traffic. These lanes are indicated by a solid or dashed white line or green pavement markings, and a bicycle symbol or other signs.

Crossing a Bicycle Lane

Drivers should not drive into or across a bicycle lane except when necessary to turn right or left. Before crossing into a bicycle lane to turn, drivers need to:

1. Scan for bicyclists to the left or right
2. Check mirrors to scan to the rear
3. Use a turn signal
4. Scan again for bicyclists
5. Then merge into the bicycle lane for the turn.

Measures

Demographics

The target audience of the proposed education countermeasure were drivers familiar with Virginia traffic laws and regulations. Therefore, the study was open to participants who drove a vehicle in Virginia. To qualify for participation in the study, participants answered a question to indicate that they held a Virginia learner's permit or driver's license (Appendix D). Still and Still's (2019) Virginia cycling and driving experience questionnaire was also included to gather more detailed information about participants' cycling and driving experience (Appendix D).

Data about years and annual mileage driving and riding on the road were used to operationalize cycling expertise and expertise for analyses. Participants were asked about the

frequency of using each mode of transportation, and frequency of seeing cyclists, experiencing frustration with cyclists, and experiencing close calls with cyclists while driving. No apriori predictions were associated with these questions, but data were collected to aid in the interpretation of findings. If participants qualified for the full study, they answered more background questions like age and gender. Data were collected about individual characteristics for potential exploratory analyses.

Judgments of Knowledge

Participants rated their agreement with three statements using a five-point rating scale (1 = strongly disagree, 5 = strongly agree) such as “I know the laws that govern bicycle riding in Virginia” (Appendix E). The selected scale aligned with a classic approach established in the 1960s in which participants provide a rating using a five-point Likert scale (Arbuckle & Cuddy, 1969). The advantage of measuring these types of metacognitive experiences after the learning process, rather than during it, is that learning outcomes reveal long-term memory (Rhodes, 2016). Two items were included based on those developed by Still and Still (2019) to assess participants’ judgment of knowledge about the general laws governing bicycle riding and interactions with bicyclists. According to psychometric recommendations, a minimum of three items in a single sub-scale should achieve convergent validity through a confirmatory factor analysis beyond a simple correlation (Armitage & Conner, 2001; Marsh et al., 1998). Therefore, a third item was added to assess participant’s judgment of knowledge about the legal passing distance. A unit weighted average composite score was calculated for all items. Internal consistency (IC) was measured with Cronbach’s alpha and was high for this measure ($\alpha = .866$), indicating a high degree of consistency.

Comprehension Test

The comprehension test contained 20 questions about how cyclists should use the road and what road rules drivers should follow when they encounter cyclists on the road (Appendix F). There was at least one question related to information from each section of the handbook and revised brochure. Some true or false items were adapted from the knowledge assessment Still and Still (2019) administered to drivers and cyclists to assess road-sharing laws and responsibilities. They developed their assessment using current Virginia law and related recommendations publicly available from VDOT. For example, 55% of drivers correctly answered the following item: “If no bike lanes or shared lane markings are present the motorist has complete right-of-way” (Still & Still, 2019). Other items were revised from the July 2020 VA DMV Driver Manual Knowledge Practice Exam, such as the multiple-choice questions about the correct hand signal for turning right. Questions were either true/false or four multiple-choice items. Internal consistency was moderately high ($\alpha = .710$).

When redesigning the handbook, content was categorized by three types of knowledge to ensure representation of each type within the comprehension test. Procedural knowledge included information related to a driver or cyclist behavior involving a sequence of steps (e.g., driver allowing space for a cyclist to merge into a lane). Questions also related to general declarative knowledge (e.g., definition of a sharrow), and laws/legal requirements (e.g., specific reference in the item to VA vehicle code’s legal passing distance). There were ten declarative knowledge items and ten procedural knowledge items. The comprehension test included eight items related to the cost of noncompliance, specifying laws and legal recommendations for driver or bicyclist behavior. The law category includes a mix of four declarative and four procedural

items. A composite score of correct items within each of these three categories was created for further exploratory analysis.

Attention Check

Participants were presented with four attention check questions at specific points during the post-experimental questionnaires to increase the quality of the data and honest responding, and to reduce inattentive or random responding (Oppenheimer et al., 2009; Appendix F).

Intentions

While no direct measure of driver behavior was used in this study, a measure of behavioral intention was employed based on its association with behavioral outcomes (Webb & Sheeran, 2006). Items were like those selected by Elliott et al. (2003) in their application of TPB to investigate drivers' intentions to comply with speed limits. They applied Ajzen's (2005, 2010) recommendations to develop a measure of participants' self-reported intention to engage in safe driving. References to speeding were replaced with references to how drivers intend to safely share the road with cyclists and maintain at least a three-foot distance to pass cyclists (Elliott et al., 2003). The questionnaire included a total of nine items, with three items related to each of the three beliefs described by Ajzen (1991, 2013): behavioral, normative, and control beliefs (Appendix G). A unit weighted average composite score was calculated for the full scale including nine items (some reverse scored) and for each of the three factors. Internal consistency was moderately high for the full scale ($\alpha = .742$).

Attitudes Toward Cyclists

A scale developed by Rissel et al. (2002) was used to measure attitudes toward cyclists (Appendix H). Participants were asked to rate their degree of agreement with 12 statements (e.g., "It is very frustrating sharing the road with cyclists") using a five-point Likert-type scale (1 =

strongly disagree to 5 = strongly agree). Some items are reverse scored items to reflect when agreement with that item would indicate a positive attitude toward cyclists. A unit weighted average composite score was calculated for all items. Higher scores represent more *negative* attitudes towards cyclists. Cronbach's alpha was calculated to assess the measure's internal consistency (high IC; $\alpha = .80$). Recent research investigating driver attitudes toward cyclists has found moderate ($\alpha = .70$; DeAngelis et al., 2017) to high ($\alpha = .83$; Fruhen & Flin, 2015) degrees of consistency for this measure. In this study, internal consistency fell well below a recommended 0.6 alpha level ($\alpha = .382$).

Procedure

All experimental materials were administered with Qualtrics as an unmoderated survey. When participants opened the study link, they reviewed two demographics items. These items were used to screen out participants who did not meet the exclusion criteria of being at least 18 years old and holding a current Virginia driver's license or learner's permit. If participants qualified, they moved on to the next screen with an Informed Consent document (Appendix C) outlining the risks and benefits of participation and describing that participation was voluntary. After reviewing the Informed Consent, participants were prompted to check a box to indicate their consent to participate in the study before moving on to the study.

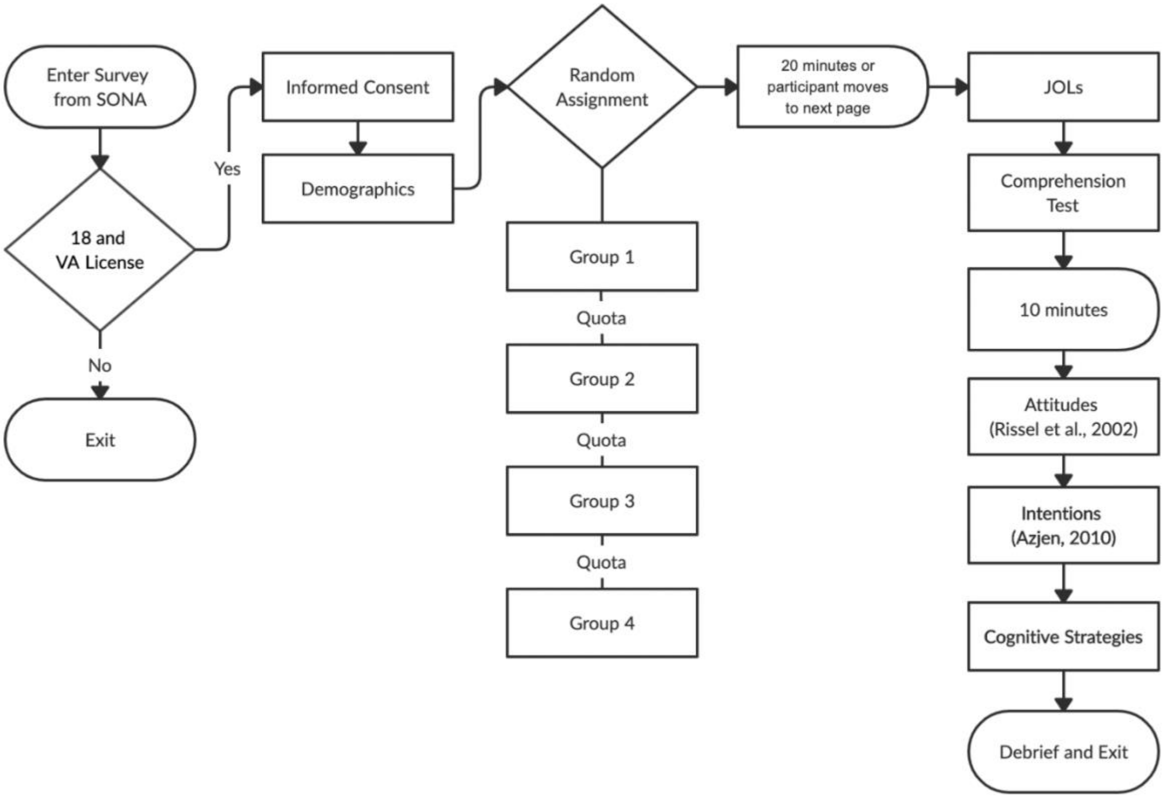
Participants then completed the full demographics questionnaire before receiving detailed instructions about the study. Participants were randomly assigned to one of the four conditions to review the educational materials. They were instructed to exit the screen when they were ready to continue, or the window would close once twenty minutes elapsed. This amount of time was selected before pilot testing to balance multiple methodological concerns. First, it enhanced ecological validity of the task to align with self-paced learning of DMV material before

completing a permit or licensing exam. It provided participants with adequate time to review the material while reducing the likelihood of fatigue while completing the online unmoderated research study. Finally, allowing sufficient time to review the material reduced time-pressure related stress which can have detrimental effects on learning and decisions (Edland & Svenson, 1993).

Following the presentation of the education material, all participants received the same comprehension test. Participants had another twenty minutes to complete the comprehension test. In addition to the justification for the learning time limit, online instructors may recommend allocating 30 seconds per true-false item and 60 seconds per multiple-choice item for assessments to reduce unproctored cheating (Cluskey et al., 2011). Participants were presented with the final post-experimental questionnaires. Finally, participants reviewed a screen with debrief information about the purpose of the experiment (Appendix L). The session took less than one hour to complete. Participants were awarded their corresponding SONA participation credit within ten days of completing the study illustrates the experimental procedure (Figure 5).

Figure 5

Experimental Procedure for the First Study



CHAPTER IV

STUDY 1 RESULTS

In the following sections, details are presented about data cleaning procedures, statistical analyses associated with the hypothesized effects, and observed effects from follow-up analyses.

Data Cleaning Procedures

Missing Values

All measures underwent pilot testing and quality assurance testing to reduce the likelihood of missing data (i.e., nonresponse due to poorly designed questions or partial nonresponse due to participant fatigue). Data were assessed during pilot testing to ensure missing values fell below 20%. During experimental administration of the surveys, no responses were mandatory. Before participants moved to the next page, they received a response request prompt before moving on to the next page to reduce the likelihood of nonresponses.

All data were assessed for quality, nonresponses, missing values, and outliers before conducting statistical analyses. Ten participants who started the study who did not meet inclusion criteria were screened out before beginning the study (i.e., eight tried to use a mobile device, one was not 18 years old, and one did not hold a permit/license). Data were removed for four participants who did not answer correctly at least three out of the four attention check items that were distributed throughout the scale items. Of the remaining participants, 22 were removed through listwise deletion from the full data set due to nonresponse within or following the demographics questionnaire (i.e., 10% of participants and 8% of total items removed).

Out of the 200 participants who started the study, 168 participants were retained. These participants completed all or some demographics, reviewed the experimental material, and completed all or some of the post-experimental items. Two participants each skipped one item in

the comprehension test. Due to the item-level data being missing at random (MAR), mean substitution was applied across items within each individual's construct-level measure (i.e., mean-person imputation for those two participants' comprehension scores) (Newman, 2014).

Annual Cycling Mileage

Participants reported cycling an average of 161.06 miles per year (*Min* = 0; *Max* = 10,000; *SD* = 84.645). Hoaglin and Iglewicz's (1987) recommended outlier labeling rule was used to calculate the extreme values in cycling mileage by multiplying the Interquartile Range (IQR) (20 - 0 = 20) by a factor of 2.2 to calculate *g* (44) and adding *g* to the 75th percentile (20 + 44 = 64). A total of 24 (16 male, 8 female) participants reported cycling more than 64 miles per year and were removed from the final sample.

Removing these extreme values controls for effects of expertise on the outcome measures and ensures the experimental design and educational material would be sensitive to the targeted audience of the proposed countermeasure (i.e., drivers who are inexperienced cyclists). The final 144 participants retained for the final analyses reported cycling an average of 7.43 miles per year (*Min* = 0; *Max* = 59; *SD* = 13.15) and riding a bicycle on the road for an average of 3.17 years overall (*Min* = 0; *Max* = 20; *SD* = 5.34).

Assumption Checks

To address the hypotheses directly, data were analyzed together using a factorial multivariate analysis of variance (MANOVA). All assumptions for MANOVA were assessed before completing full analyses associated with each hypothesis. Histograms were inspected to ensure a normal data distribution for each dependent variable. Skewness and kurtosis values fell within an acceptable range of +/-2 for all values (George & Mallery, 2016). All data skewed positive, except attitude scores which skewed negative (but higher scores indicate *less positive*

attitudes) and comprehension score which had a bimodal distribution. Shapiro-Wilk tests of normality indicated some data were not normally distributed based on a conventional, conservative significance level of $\alpha = .01$ (Tabachnick & Fidell, 2019). For example, JOL scores were not normally distributed for both levels of text perspective and educational material ($p < .001$).

Q-Q-plots of the residuals were examined to ensure normal distributions. Levene's test of equal variances was nonsignificant (*p* values ranged from .03 to.983) for all dependent variables based on a conservative significance level of $\alpha = .025$ (Wickens & Keppel, 2004). Studies applying Ajzen's Theory of Planned Behavior indicate a moderate relationship among the chosen dependent variables. Correlations among the dependent variables fell within a moderate range, indicating an absence of multicollinearity (i.e., $r = .20 - .60$; Tabachnick & Fidell, 2019) (Table 1). Box's M value of 32.747 ($p = .413$) was non-significant (Huberty & Petoskey, 2000). The covariance matrices between the groups were assumed to be equal when conducting the MANOVA.

Statistical Analyses

First, analyses were conducted to understand differences in all dependent measures as a function of cycling mileage during data cleaning procedures. Second, the data addressing the hypotheses were analyzed with a 2 (educational material: revised handbook, redesigned brochure) x 2 (perspective: first-person, third-person) between-subjects Multivariate Analysis of Variance (MANOVA) to test for main effects and interactions for the combined dependent variables. The multivariate analysis has lower power than the univariate analysis, but a MANOVA reduces the likelihood of Type I error compared to a series of ANOVAs. An alpha level of $p < .05$ was established to minimize the chance of a Type I error. Effect sizes are

presented as partial eta squared (η^2_p = small: .01; medium: .09; large: .25) or Cohen's *d (d* = small = 0.2, medium: 0.5; large: 0.8) (Cohen, 1988; Maxwell et al., 2017). Third, exploratory 2 x 2 factorial ANOVAs were conducted for some item- and factor-level data to understand if any specific learning or attitudinal outcomes were sensitive to the experimental manipulation. No apriori predictions were made for these follow-up analyses.

Table 1

Correlations Among Dependent Variables in the First Study

	M	1	2	3
1. Comprehension [a]	.68	-		
2. Intentions [b]	3.86	.432** (<.001)		
3. JOLs [c]	3.94	.466* (.003)	.424** (<.001)	
4. Attitudes [d]	2.70	-.244* (.003)	-.383** (< .001)	-.233 (.005)

Note. N = 144; M represents grand mean across conditions.

* p = .0031 level (Bonferroni familywise correction) (two-tailed). ** p < .001 level.

[a] Proportion of correct answers out of 20 items. [b] Unit weighted average of nine items on a five-point scale. [c] Unit weighted average of three items on a five-point scale. [d] Unit weighted average of 12 items on a five-point scale; higher scores representing more negative attitudes towards cyclists.

Cycling Mileage

Participants reported a wide range of annual cycling miles. An additional analysis was conducted, which included the 24 participants removed for final analysis due to extremes in self-reported annual cycling mileage (n = 160). A 2 x 2 between-subjects Multivariate Analysis of

Covariance (MANCOVA) was carried out to test for main effects and interactions for the combined dependent variables after controlling for self-reported annual cycling mileage. Box's M value of 32.151 (p = .228) was non-significant based on Huberty and Petoskey's (2000) guideline (i.e., p < .005). The MANCOVA revealed no significant interaction or main effects of text perspective and educational material on the combined dependent variables after controlling for cycling mileage (p > .05). Cycling mileage was associated with the combined dependent variables (p = .012, η^2_p = .065). When re-conducting the MANCOVA with the final sample, there was no significant association between the dependent variables and cycling mileage (p = .102).

Hypothesis Testing

The MANOVA revealed no predicted significant interaction or main effects of text perspective and educational material on the combined dependent variables (p > .05). Therefore, no hypotheses were supported (Table 2). Appendix M includes additional tables with means and standard deviations for all dependent variables as a function of text perspective and educational material.

Table 2

Results of Perspective x Educational Material MANOVA

Effect	Wilk's Λ	F	Hypothesis df	Error df	p	η^2_p	power
Intercept	.009	3856.078	4	137	0	.991	1
Perspective	.952	1.712	4	137	.151	.048	.514
Material	.999	.046	4	137	.996	.001	.059
Perspective * Material	.996	.147	4	137	.964	.004	.080

Comprehension Scores

Across conditions, participants answered an average of 13.5 out of 20 questions correctly (i.e., with an average proportion of correct responses = .675). Scores ranged from five to 20 and scores on nine items surpassed 70%. An item analysis revealed 80% of participants across conditions missed one item, indicating the item may have been too difficult: “A bicyclist stopped at a red light at an intersection that has both a bicycle lane and a right turn only lane, and intending to go straight should be (in the travel lane next to the right turn only lane).” This question was designed to be challenging, but the handbook specifies this scenario would be most likely for a confident, experienced cyclist. In the second study, this question was rewritten to clarify the appropriate scenario. Removal of the single item from the comprehension test when conducting the MANOVA did not impact statistical significance (e.g., p = .534 for the main effect of perspective and p = .603 for the main effect of educational material). All twenty items were included for hypothesis testing.

The first prediction was that participants reviewing material written in a first-person perspective would have higher comprehension scores across educational material than participants reviewing the material written from a third-person perspective. There was no between-subjects main effect of perspective (p = .775). Collapsing across educational material, participants reviewing material written in a first-person perspective (M = .671, SD = .168) did not score significantly higher on the comprehension test than participants reviewing the material written from a third-person perspective (M = .679, SD = .169). Therefore, Hypothesis 1 was not supported.

The second prediction was that participants reviewing the redesigned brochure would have higher comprehension scores across perspectives than participants reviewing the revised

handbook. Collapsing across text perspectives, participants in the redesigned brochure condition (*M* = .676, *SD* = .171) did not score significantly higher on the comprehension test than participants in the revised handbook condition (*M* = .673, *SD* = .167). There was no between-subjects main effect of educational material (p = .849), which did not support Hypothesis 2.

Judgments of Learning

Across conditions, participants reported moderately high average JOLs (*M* = 3.94, *SD* = 0.844). Information written in a first-person perspective in the redesigned brochure (*M* = 3.84, *SD* = 0.852) was not associated with significantly higher JOLs than information written from a first-person perspective in the revised handbook (*M* = 3.96, *SD* = 0.876), third-person perspective in the revised handbook (*M* = 3.95, *SD* = 0.891), or third-person perspective in the redesigned brochure (*M* = 4.03, *SD* = 0.764). There was no significant interaction between perspective and educational material on JOLs (p = .446) which did not support Hypothesis 3.

Attitudes Toward Cyclists

Cronbach's α for this 12-item measure was .382. Removal of the full measure from the MANOVA did not impact statistical significance (e.g., p = .547 for the main effect of perspective). Upon reviewing each item and associated responses, one specific item could have been confusing for participants after reading information about cyclists safely using the center or right of a lane: "It is safer for cyclists to keep to the left of the lane." Removing the single item increased Cronbach's α to .395, which was below a recommended degree of internal consistency. Removal of the single item from the attitudes measure for the purposes of the MANOVA did not impact statistical significance (e.g., p = .125 for the main effect of perspective).

It was hypothesized that participants in the first-person perspective condition would report lower attitude scores (i.e., less negative, or more positive attitudes) than participants in the

third-person perspective condition across educational material. Participants reported moderately low average attitude ratings across all experimental groups (*M* = 2.698, *SD* = 0.556). Collapsing across educational material, participants in the first-person perspective condition (*M* = 2.776, *SD* = 0.537) did not report more positive attitudes than participants in the third-person perspective condition (*M* = 2.614, *SD* = 0.568). There was no significant main effect of perspective across educational material on attitudes when including 12 ($p = .081$) or 11 items ($p = .071$). Taken together, Hypothesis 4 was not supported.

Intentions

Finally, it was hypothesized that participants in the first-person perspective condition would report higher intentions than the third-person condition across material. Overall, participants reported moderately high intention ratings across conditions (*M* = 3.432, *SD* = .844). Collapsing across material, participants in the first-person perspective condition (*M* = 3.788, *SD* = 0.693) did not report higher intentions to safely share the road with cyclists than participants in the third-person perspective condition (*M* = 3.844, *SD* = 0.633). There was no significant main effect of perspective across educational material on intentions ($p = .790$). Hypothesis 5 was not supported.

Exploratory Analyses

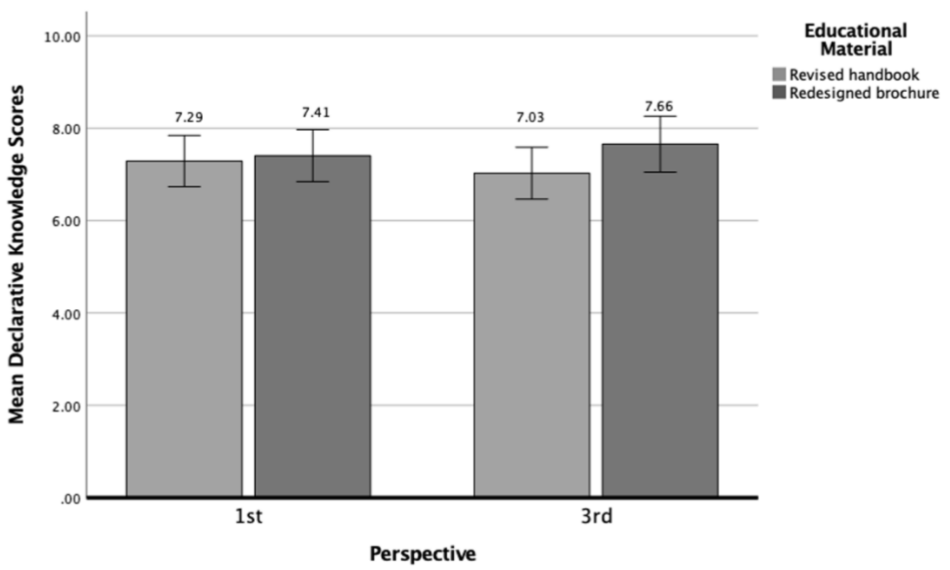
Comprehension Factor Scores

Three exploratory 2 x 2 factorial ANOVAs were conducted to compare the effects of text perspective and educational material on declarative knowledge, procedural knowledge, and law-based knowledge factor scores. For the procedural knowledge factor, there was no significant effect of educational material ($p = .640$) or perspective ($p = .465$), and no significant interaction ($p = .769$). For the law-based knowledge factor, there was no significant effect of educational

material (p = .573) or perspective (p = .687), and no significant interaction (p = .532). There was a significant effect of educational material on the declarative knowledge factor, $F(1, 4.955)$, p = .027, $\eta^2_p = .031$. Mean comparisons indicated that participants who reviewed the redesigned brochure answered more declarative knowledge questions correctly than participants who reviewed the revised handbook across text perspectives (Figure 6). This effect of the redesigned material on declarative knowledge lends support to Hypothesis 2.

Figure 6

Main Effect of Educational Material on Declarative Knowledge Scores Across Perspectives



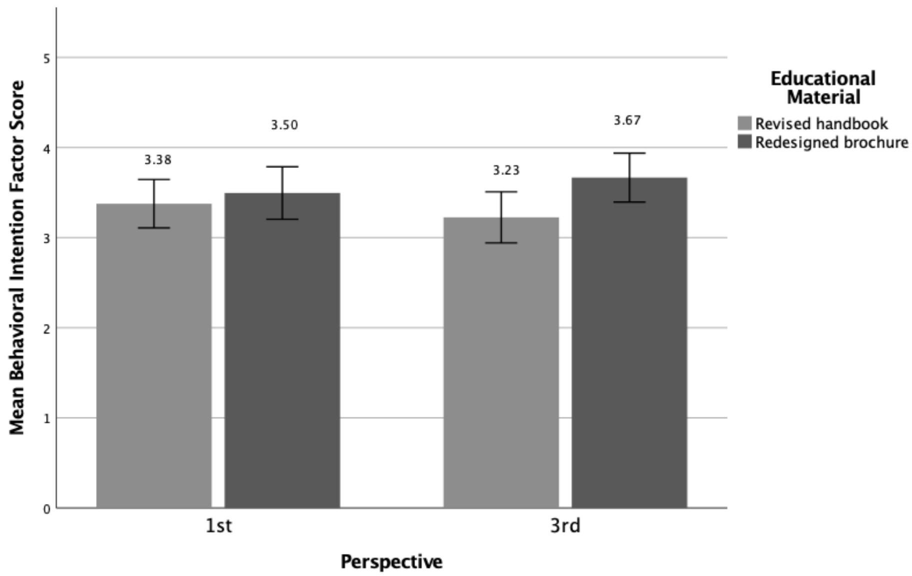
Note. Mean based on unit weighted average of 10 items; error bars represent 95% confidence intervals; p = .027.

Behavioral Intentions Factor

It was predicted that first-person perspective would elicit higher self-reported intentions to safely share the road than third-person perspective across educational material conditions (Hypothesis 5). Researchers investigating intentions based on the TPB develop measures of intentions with multiple items across three factors: perceived behavioral control, social norms, and behavioral intentions. A 2 x 2 factorial ANOVA was conducted to explore the effects of perspective and educational material on the behavioral intentions factor. There was no significant interaction (p = .244) or significant effect of perspective (p = .945). There was a significant effect of educational material on the behavioral intention factor. Participants reviewing the redesigned brochure reported higher intentions than participants reviewing the revised handbook, $F(1, 2.807)$, p = .036, η^2_p = .028 (Figure 7). These results do not lend support to Hypothesis 5. A perspective effect was predicted, not an effect of educational material.

Figure 7

Main Effect of Educational Material on Behavioral Intentions Factor Scores Across Perspectives



Note. Mean based on unit weighted average of three items; error bars represent 95% confidence intervals; participants responded on a rating scale from 1 = strongly disagree to 5 = strongly agree; p = .036.

CHAPTER V

STUDY 1 DISCUSSION

The current study aimed to translate the effectiveness of first-person perspective in health communication to a road-sharing context. Text-based content in the *Sharing the Road* in Virginia handbook (6th ed.; NVRC, 2018) was revised and presented from first-person or third-person perspectives of a driver sharing the road with a cyclist. The interaction between text and image perspective on drivers' comprehension, knowledge judgments, attitudes, and intentions were assessed. This chapter includes a discussion of findings related to the planned predictions and observations from follow-up analyses for each dependent measure are discussed. Next, the theoretical and practical implications of any observed effects are presented. Finally, some of the study's limitations and proposed future directions are described.

Comprehension Scores and Judgments of Learning

Reviewing first-person perspective (H1) or the redesigned brochure (H2) did not improve global comprehension of information about sharing the road with cyclists. Educational material and perspective had no impact on participants' law-based and procedural knowledge scores. However, participants who read the redesigned brochure scored higher on declarative knowledge questions than participants who read the revised handbook across perspectives (supporting H2). It is unclear why the redesigned material impacted declarative knowledge more than procedural knowledge.

Part two of the Virginia DMV driver licensing exam assesses drivers' general knowledge with multiple-choice questions. To pass this portion of the Virginia driver's permit or licensing exam, learners must answer at least 80% of those questions correctly (VA DMV, 2020, p. 3).

Participants' scores would not meet the threshold for passing a Virginia state licensing exam, but participants in this study had a single exposure to the material.

Perspective and educational material did not affect participants' JOLs (H3). There was a moderate positive relationship between comprehension scores and judgments of learning across conditions. A moderate positive relationship was noted between JOLs and intentions, but a weak relationship was observed with attitudes. A relationship between JOLs and comprehension scores could provide evidence of calibration between participants' actual knowledge and perceived knowledge. Health and education researchers have suggested feelings of learning and declarative knowledge may be separate constructs and require separate measures (Hansford & Hattie, 1982). One goal of a countermeasure is to transition a learner from the general awareness or familiarity stages of affective learning (Krathwohl et al., 1973) to the more complex internalized attitudes that are needed to influence intentions and, subsequently, behavior.

Specific countermeasures may need to focus on reaching individuals who exhibit a calibration bias in which their declarative knowledge and judgments of knowledge are misaligned. Knowledge judgment measures may not be sufficient on their own to evaluate the effectiveness of a countermeasure or target a specific population, such as drivers, before implementing a countermeasure, such as a safety awareness campaign. Taken together, these findings illustrate the importance of measuring multiple outcomes to understand the effects of exposure to an intervention. Regardless of the independent variables of interest, a person's perceived familiarity with information or judgments about newly acquired knowledge may relate to certain outcomes more than others. More research is needed to understand whether familiarity with or judgments of knowledge could help reduce the time and cost needed to implement and evaluate a countermeasure's effects on learning outcomes.

Attitudes and Intentions

There was a weak negative relationship between comprehension scores and attitudes. Participants who scored high on the comprehension test were more likely to report less negative attitudes toward cyclists. This small association between comprehension and attitudes could lend negligible support to the familiarity hypothesis, which argues that familiarity with a topic increases one's support of that topic (Dunlosky & Metcalfe, 2009).

Across conditions, participants reported positive attitudes toward cyclists and intentions to share the road with cyclists safety. In contrast with past research, there was no evidence that perspective influenced attitudes (H4). Multiple studies in health communications have found that a first-person perspective is associated with more positive attitudes toward a health concern than third-person perspectives (e.g., Fagerlin et al., 2005; Ubel et al., 2001; Winterbottom et al., 2008). There was a moderate positive relationship between attitudes and intentions in the current study. In a meta-analysis of 185 studies, Armitage and Conner (2001) found that TPB accounted for 39% of the variance in intentions. Attitudes was the strongest predictor of behavioral intentions followed by perceived behavioral control factors and subjective norms factors.

Zebregs and colleagues (2015) conducted a meta-analysis of statistical versus narrative evidence effects on health communications. They found that statistical evidence had a stronger influence than narrative evidence on attitudes toward health-related behaviors. However, narrative evidence had a stronger influence on intentions to engage in those behaviors. The specific narrative components were not the focus of that meta-analysis, but the findings support the need for a deeper understanding of the variance in outcomes of interventions.

On average, participants reported neutral to moderately high intentions to share the road safely with cyclists, but first-person perspective did not affect self-reported intentions with the

full three-factor scale (H5). The redesigned brochure did affect scores on the behavioral intentions factor of the intentions scale (H5). When applying TPB to develop interventions, researchers may include each of these factors as separate constructs in larger models instead of using a global score. According to Webb and Sheeran (2006), a behavioral intention mediates the influence of attitudes, subjective norms, and individual differences like demographics. Ajzen used TPB to describe how attitudes, social norms, and perceived behavioral control could predict intentions to carry out a specific behavior (Ajzen, 1991; Fishbein & Ajzen, 1977, 2010, 2018). Based on the results of this study, it may be most appropriate to measure social norms and perceived behavioral control as pre-intervention constructs and evaluate behavioral intentions as post-intervention outcomes to align with TPB.

Lack Of Perspective Effects on Outcomes

Knowledge Elicitation

This study attempted to synthesize a variety of outcome measures and methods employed by researchers in healthcare, communication, education, and psychology to understand the holistic impact of the proposed countermeasure. There are multiple ways researchers across these fields elicit knowledge and affective outcomes from participants. It is common to use a pretest and posttest method to assess intervention outcomes like retention, attitudes, and intentions (e.g., Lewis et al., 2008). Little and Bjork (2011) outline some of the benefits of pretesting. First, it can enhance active involvement in learning and increase the learner’s general interest in the topic. This aspect of involvement aligns with ELM (e.g., Petty & Cacioppo, 1986). It can help signal or cue learners about what information is relevant and important to future testing. Finally, it directs attention to information if it is encountered later which facilitates encoding. Together, pretests can lead to better recall for the previously tested information.

In this study, no pretest was included. Pretests could have provided additional cues to learners about which specific content to direct their attention. As summarized above, it would have made it difficult to delineate the effects of perspective on elaboration while learning. There are also concerns about using pretest-to-posttest gains because research suggests pretesting can serve as a learning event (i.e., testing effect; Brown et al., 2014). The direct effects of the experimental manipulation on cognitive and learning outcomes were of interest in this study.

Next, pre- and post-intervention measures, and recall, recognition, retention, and transfer tasks are commonly used to evaluate countermeasures outcomes and efficacy. Researchers may use open-ended or closed tests. A free recall task requires learners to actively search and retrieve relevant memories without any cues or prompts during retrieval. For example, participants may be required to "write down everything you know about (the concept)." Then two independent raters score written answers based on the number of correct main ideas (e.g., sixteen main ideas; Mayer et al., 2005). In the current study, a cued recall or recognition test was used to assess comprehension through a multiple-choice test. These types of tests provide cues that allow the learner to discriminate against alternatives. Recall tasks are more difficult than recognition tasks, pose higher cognitive demands on the learner, and require cognitive strategies that differ from those needed for a recognition test (Krathwohl, 2002; Flavell, 1979). Therefore, the lack of consensus in narrative-based countermeasures' learning effects could be due in part to the wide variety of knowledge elicitation methods.

Subjective Self-Report Measures

The lack of differences in affective learning outcomes as a function of the experimental manipulation in this study could also be related to the self-report subjective measures' susceptibility to social desirability bias. Participants may provide ratings that differ from their

actual attitudes or intentions to try to look better to others (i.e., impression management) or to feel good about themselves (i.e., self-deception) (Larson, 2019). On the other hand, this study was administered online and protected participants' anonymity, which may elicit less social desirability on standardized measures (Nederhof, 1985). Researchers examining traffic behavior self-report measures found small social desirability effects. Data collection in private settings reduced effects further (Lajunen & Summala, 2003). Dodou and de Winter (2014) also found that effects of social desirability were not significantly different between offline, online, and paper survey administration in a meta-analysis. Finally, caution is needed when interpreting the results associated with the attitudes scale because internal consistency was so low. Removal of the full measure or a single problematic item from this measure did not impact statistical significance. The attitudes scale employed in this study is the first limitation and proposed area of future work.

Limitations And Future Work

It is appropriate to recognize several potential limitations that could provide additional explanations and context beyond interpretations of the results already described. There are at least three limitations to this study that may provide additional insight into the results. Each limitation could be addressed in future research.

Attitudes Towards Cyclists Scale

The first limitation concerns the reliability of the attitudes measure used in this study. A scale developed by Rissel and colleagues (2002) was employed in the current study to measure attitudes toward cyclists. Research investigating driver attitudes toward cyclists has found moderate ($\alpha = .70$; DeAngelis et al., 2017) to high ($\alpha = .83$; Fruhen & Flin, 2015) degrees of internal consistency for this measure. Two factors could explain why the measure of attitudes

was unreliable in this study. This measure is widely used in bicycle research, particularly in Australia and the U.K. Lower reliability could be due to conducting the research in the U.S. where there are some differences in road usage (e.g., driving on the right side of the road).

One specific item could have confused participants: “It is safer for cyclists to keep to the left of the lane.” Across conditions on average, participants reported neutral to moderately strong agreement with the item. It is unclear whether high agreement with this statement would indicate positive or negative attitudes toward cyclists here in the U.S., particularly after reviewing the educational material describing cyclists safely using the center or right of a lane. This item language was changed from the left to the right side of the road to remove potential confusion for participants in the second study.

The measure is also not used consistently across studies. There is extensive variability in anchor labels (highly or strongly), anchor directionality (1 = disagree or agree), and the number of items (nine to 12 items in the scale). Composite scoring (unit-weighted average composite score or sum score) and overall interpretation of high scores (representing more negative or positive attitudes) are not constant (e.g., DeAngelis et al., 2017, $\alpha = .70$; Fruhen, et al., 2019, $\alpha = .87$; Thorp & Saxton, 2021, $\alpha = .874$). The current study employed the following anchor labels: 1 = strongly disagree to 5 = strongly agree.

Rissel et al. (2002) replicated a 12-item survey administered by an Australian company in 1995. They asked participants to rate their degree of agreement with 12 statements (e.g., “It is very frustrating sharing the road with cyclists”) using a Likert-type scale (1 = strongly agree to 5 = strongly disagree). These anchor labels do not align with best practices for survey development and administration. They developed a unit-weighted average composite score from nine of the 12

items based on their results. In the paper, Rissel's team did not discuss reverse scoring of any items but interpreted higher scores as representing more *negative* attitudes towards cyclists.

DeAngelis and colleagues (2017) reverted the original anchors, included only six items from Rissel et al.'s (2002) questionnaire, created a unit-weighted average composite score, used strongly-to-highly agree anchor labels, did not discuss reverse scoring, and reported a moderately high reliability (α = .70). Fruhen et al. (2019) used 10 of the items, computed a *sum* score across items, reported a high reliability (α = .87), and indicated a higher score represented more negative attitudes. In their preprinted article, Thorp and Saxton (2021) used the 12 original items, disagree-to-agree anchors, and a unit weighted average score. They reverse-scored items, described higher scores as indicating more positive attitudes, and achieved high reliability (α = .874).

Finally, the scale was used in this study as a dependent variable to assess the effects of the experimental manipulation on attitudes. The scale can also assess pre-intervention attitudes as a predictor variable (DeAngelis et al., 2017) or as a covariate. Variability in selecting items, scoring items, computing composite scores, and timing the administration make interpreting findings a challenge. Future work should prioritize consistency in the application of the scale within the road safety research community.

Single Exposure to Material

A second limitation of this study is that participants had a single exposure to the material instead of multiple exposures. Studies investigating the impact of narrative on individuals' comprehension, attitudes, and intentions generally rely on a single exposure for evidence of a message's impact. Education countermeasures like awareness campaigns and educational material like the handbooks in this study would provide a target audience with repetition and

multiple opportunities to engage with a message. According to ELM, a learner's motivation and ability to engage in elaborative encoding would predict attitude and behavior change (Cacioppo & Petty, 1979). Participants may not have had ample time to think about the material, make meaningful connections, or find it personally relevant with a single exposure. In a real-world situation, learners may take multiple opportunities to study and review material at their own pace before taking a licensing exam.

Affective learning outcomes such as attitudes may also play a critical role in the effectiveness of safety campaigns as evidenced earlier. They were most likely not given enough time to move beyond the earliest stages of affective learning (i.e., perception, awareness, selective attention) (Krathwohl et al., 1973). In other words, they may need more time to elaborate on the information, attach value to the information, and eventually internalize those values. This study provides evidence that road sharing safety campaigns and similar interventions may not be as effective at those early levels of learning when individuals are simply familiar with information after attending to the information. Once a learner has internalized specific values, a learner's actual reaction and behavior may be more likely to align with those values. Longitudinal investigations would be necessary to identify the impact of multiple exposures, repeated elaboration and internalization of values, and long-term knowledge, attitude, and intention changes as a function of narrative perspective. For example, future research should investigate the effectiveness of the proposed interventions by inviting participants to report whether they have engaged in the intended behaviors after the established time has elapsed.

No Direct Measures of Observable Behavior

A third limitation of the current study is the lack of a direct measure of behavioral outcomes. When developing TPB, Fishbein and Ajzen (1977) proposed that an intention was the most critical predictor of behavior. Existing studies have provided limited data about the influence of narrative perspective on actual health behaviors. There are challenges associated with measuring behavioral outcomes in the field following an intervention. Roadside observations or other observational data collection methods to detect an increase or decrease in specific behavioral outcomes can be costly and time intensive. Consequently, researchers rely heavily on self-reports of attitudes, intentions, and retrospective behavior to evaluate an intervention's effectiveness (Robertson & Pashley, 2015).

Some researchers have developed clever, inexpensive intention and behavioral measures to evaluate narrative-based healthcare interventions. For example, Lemal and Van den Bulck (2010) investigated the impact of text-based narratives on skin cancer beliefs and prevention behaviors. Four weeks after the study, participants in the narrative condition were three times more likely to report skin-checking behavior and four times more likely to report talking to a family member about cancer than those in the control group. In a study investigating narrative perspective on skin cancer prevention intentions, Houska (2010) measured behavioral intentions based on participants' likelihood of taking sunscreen coupons after the study. There were no differences in self-reported intentions to use sunscreen between second and third-person perspective conditions, but participants who reviewed a second-person perspective narrative were more likely to take sunscreen coupons than those who reviewed a third-person perspective narrative. Future work could include similar measures of direct observable behavior. For

example, whether participants click on a link to learn more about road-sharing laws and safety recommendations.

Other psychosocial theories may complement TPB when developing interventions that target specific behavioral outcomes. The Transtheoretical Model of Change (TMC) suggests behavioral modification is a fluid, five-step process (i.e., pre-contemplation, contemplation, preparation, action, and maintenance). Individuals may move forward and backward through these stages before permanent behavior change occurs. Future work could apply TMC when selecting appropriate behavioral measures to ensure they capture the various stages of behavior change. More research is needed to understand which narrative aspects could lead to the initiation of a behavior and the long-term maintenance of that behavior.

Multimedia Learning with Text and Image Perspective

When developing an education countermeasure such as the one in this first study, it is important to consider the modality or communication method used for delivery. Much of the literature on the narrative effects on knowledge, attitudes, and intentions focuses on text-based information. Text was a moderator in 22 (65%) of the studies Shen et al. (2015) reviewed in a meta-analysis investigating the impact of narrative on healthcare-related intentions and attitudes. They found small effects of narrative overall, and text-based narratives had a small, nonsignificant effect on all outcomes. Researchers have also emphasized the use of text-based narrative perspective when studying narratives' impact. De Graff et al. (2016) found that all print or text-based narratives using a first-person perspective affected story-consistent beliefs and attitudes. Nan et al. (2017) found an interaction between perspective and communication modality such that a text-based first-person perspective was more persuasive than the third-person perspective.

The first study proposed that text-based perspective would facilitate elaboration so a learner could make meaningful connections between previous knowledge and new information. Learners may also be able to make those connections through multiple representations of information, including images. Researchers have investigated the effectiveness of visual representations as an instructional tool with or without fact-based text (e.g., Glenberg & Langston, 1992; Gyselinck & Tardieu, 1999). There is extensive evidence that presenting multiple representations of information leads to higher learning outcomes than presenting only words via text or audio (e.g., Mayer, 2009). This multimedia effect, or combination of words and graphics, is also used in health education countermeasures.

Written text accompanied by pictures can increase the likelihood that someone will notice, review, and recall of health education information compared to text alone (Houts et al., 2006). It may be valuable to extend the first study by examining image-based perspective. A second study was conducted in consideration of this idea for future research. The purpose of this next study was to investigate the impact of combining text-based and visual representations of perspective on cognitive and affective learning outcomes related to safe road-sharing behavior. The remaining chapters review literature about image-based perspective and summarize the second study's methodology and overall conclusions.

CHAPTER VI

STUDY 2 BACKGROUND LITERATURE

The study and application of visual perspective has an extensive and multidisciplinary history like text-based narrative perspective. In this section, theoretical frameworks are reviewed that may account for the cognitive and affective learning outcomes facilitated by integrating text and images. Then an overview is provided about how image schemas employing self-referencing perspectives are constructed. The section closes with an emphasis on the role of perspective in influencing cognitive and affective learning outcomes through instruction that includes images and video.

Cognitive Theory of Multimedia Learning

With CTML, Mayer (1997) proposed how instruction could facilitate learning based on the dual channel model of human information processing. In general, research suggests that multiple representations of information lead to higher learning outcomes than words alone (Butcher, 2006; Mayer, 2009; Sung & Mayer, 2012). This combined benefit of text and images is known as the multimedia effect. For example, Levie and Lentz (1982) reviewed 155 experimental studies comparing text to pictures with text. They concluded that comprehension was better when pictures related to the text were included. Students who read text with pictures learned one half standard deviation more than students who did not have pictures. In their review of multimedia learning, Carney and Levin (2002) conclude research in the 1990s generally confirmed that pictures enhanced comprehension. Pictures are especially beneficial for learning complex text or to learners with low prior knowledge of a subject.

Research applying CTML also suggests that the most effective instruction employing text with illustrations can translate to other media types such as narration paired with animation.

Mayer (2003) proposes that this translation effect across media formats occurs because the human information processing system remains constant regardless of media type. There are multiple theoretical explanations behind the learning and comprehension advantage for pictures or pictures with text beyond text alone, each based on three well-established information processing constructs (Mayer & Moreno, 2003). First, there are two codes for processing words and images separately. Second, each associated channel has a limited capacity. And third, learning involves the cognitive integration of the words and images.

The multimedia effect occurs because pictorial and verbal information is processed separately before it is integrated during learning, as described by Paivio's (1979) dual coding theory. Dual coding theory describes two separate memory storage systems for visual and verbal information representations, which all share referential connections. The associated limited capacity of working memory within this dual code/channel model of information processing establishes some significant implications for multimedia instruction.

Cognitive Load Theory

Cognitive load theory (CLT; Chandler & Sweller, 1991; Sweller, 1988, 1994) is concerned with how a learner uses cognitive resources during learning and problem solving. Cognitive load has two components: mental effort and mental load. Given that working memory is limited in its capacity, Pass et al. (2003) define "mental effort" as "the cognitive capacity that is actually allocated to accommodate the demands imposed by the task; thus, it can be considered to reflect the actual cognitive load" (p. 64). Hart and Staveland (1988) describe a similar construct, mental workload, representing the mental resources used to achieve a particular level of performance. Mental load can occur when the cognitive processing required to learn designed instruction exceeds the learner's available cognitive capacity limits (Mayer & Moreno, 2003).

For instruction to be effective, it cannot overload the learner's cognitive capacity. The interactions among the task, environment, and individual create mental workload (Hart & Staveland, 1988). Instructional designers must balance three types of cognitive load: intrinsic, extraneous, and germane.

Intrinsic cognitive load is the intrinsic level of difficulty associated with any instructional topic (Chandler & Sweller, 1992). Instructional design characteristics, such as the structure of the task or sequencing of information, can also impose mental load upon a learner. These factors, under the instructor's control, are known as extraneous cognitive load. Germane cognitive load is the load associated with learning itself, like schema processing and construction (Sweller et al., 1998). Intrinsic cognitive load is a fixed, individual difference that cannot be altered by instructional design, but Sweller and colleagues explain that instructional designers can reduce extraneous load and foster germane load. One design decision an instructor can make to reduce extraneous load is to provide opportunities for learners to develop mental representations through pictorial information.

Pictures are sometimes conceptualized as external memory aids that free working memory processing resources (e.g., Hegarty & Just, 1993). External representations consist of elements and the spatial relationships among them. Graphics can help learners externalize internal knowledge (for a review of visuospatial reasoning and external representations, see Tversky, 2005). External cognitive tools such as pictures can extend a learner's cognitive capacity by "offloading" memory and other cognitive processing (Kirsch, 1995). Another benefit of external representations is their ability to provide groups with a joint understanding of the same set of ideas (Tversky et al., 2002).

Conversively, pictures may require additional capacity for readers to integrate pictures with text (e.g., Levin et al., 1987). One concern with learners combining images and verbal information is that text-based, nonauditory verbal information is recoded into a phonological format through the articulatory rehearsal process before it enters the phonological store. To reduce each type of load described in CLT and enhance learning outcomes, instructional designers should present material that aligns with the learner's prior knowledge (i.e., intrinsic load), does not contain information that is unnecessary to the learning task (i.e., extraneous load), and stimulates the cognitive processes needed to develop domain-specific conceptual knowledge structures (i.e., germane load) (De Jong, 2010).

Ultimately, Paas and Ayres (2014) suggest that the cognitive load on working memory decreases when learners make connections between verbal and nonverbal channels, which may improve learning outcomes. Transferring newly acquired knowledge to a unique context is ultimate objective of any education and training program (e.g., Halpern & Hakel, 2003). Transfer helps instructors evaluate the efficacy of the program (Wightman & Lintern, 1985). However, learners may experience high cognitive load when attempting to solve a novel scenario due to their lack of prior knowledge and schema-driven problem-solving ability. Two cognitive load measures were included to ensure the proposed education countermeasure did not contribute to the learner's experienced cognitive load while transferring newly acquired knowledge to a new road-sharing scenario.

Integration of Text and Images

Multimedia-based instruction provides opportunities for learners to build mental representations from words in printed text and pictures in the form of illustrations or animations. According to Schnotz's (2005) integrative model of text and picture comprehension (IMTPC),

the appropriate use of visualizations can offload working memory processing demands, so resources are better allocated to the learning process. Schnotz (2005) proposed an integrative model of text and picture comprehension called conjoint processing. Conjoint processing takes place through the integration of verbal (i.e., propositional) and visual mental models. Mental models are constructed through the integration of external images and internal mental models.

By conjointly processing these two types of information, learners elaborate on that information in memory to create well-developed mental models. Meaningful learning involves synthesizing the connections between pictorial and verbal representations, known as active processing. This type of elaboration (e.g., Anderson, 1993; Mayer, 1984; Pressley, 1982) or active processing has changed affective outcomes like attitudes (Petty & Cacioppo, 1986; ELM). The theory of dual coding (Clark & Paivio, 1991; Paivio, 1990) is similar to the concept of elaboration in memory. Dual coding theory proposes that learning occurs through deliberate processing of related material in both visual and verbal cognitive systems.

Instructional material targeting cognitive outcomes should not be presented to learners in a way that allows for passive review. Instead, visual and verbal representations should be actively constructed, and connections should be developed (Mayer, 2001). Mayer (1999, 2002) theorizes that active cognitive processing includes selecting, organizing, and integrating mental representations which ultimately facilitates meaningful learning outcomes. Active learning strategies might involve selective attention toward presented material, mental organization of material into meaningful structures, and integration of material with existing knowledge (Mayer, 2001). These integrative processes could support the spreading activation of memory networks. Learners can make sense of, comprehend, synthesize, and analyze visual representations (Shah & Freedman, 2011). Seeing an object's image could increase the likelihood of activation of stored

memories of that object, which then spreads to other related stored memories of images or verbal concepts (Collins & Loftus, 1975).

Image Schemas and Perspective

According to researchers Johnson (1987) and Lakoff (1987), one's understanding of objects stems from constructed image schemas or schemata. Barsalou (2008) summarizes Glenberg's view of memory as the storage of patterns that reflect how the body's goal-focused actions are integrated with specific situations. The perception of relevant objects in an environment will trigger the corresponding affordances for appropriate actions stored in memory. Schemas then, are a form of mental representation of the knowledge acquired through a person's interaction with the physical world (Johnson, 1987). One image schema may play a particularly important role in how humans make sense of their viewpoint or perspective; or how images relate to their bodies. Centre-periphery schema describes how one may organize information from the viewpoint of one's body being the center of an experience (Johnson, 1987, 1989). Centering the body then helps humans perceive other objects as near or far relative to that center. Another way of conceptualizing this schema may be egocentrism, a term often used in visuospatial learning contexts.

If a person's position in the situation is most important, a scene used in an education countermeasure should be shown from that position. Conversely, an object-centered point of view would be more appropriate when the position of the body is not as important. The next section will review how the presentation of scenes from these different viewpoints regarding the observer's body position has shown some differential improvements in learning. Three studies are explored in depth that examined educational videos and images presented from a first-person, third-person, or over the shoulder perspective. Understanding the perspective from which to

visually represent a road-sharing situation could be used to develop an effective education countermeasure.

Visual First-Person Perspective Facilitates Learning

The mirror neuron system (MNS) is said to contain a specific class of neurons in the cerebral cortex that respond to actions that one produces and observes (Rizzolatti & Craighero, 2004). In Vogeley and Fink’s (2003) MNS neuroimaging research, they found that specific brain regions were involved in assigning first-person perspective or egocentric reference frames. Therefore, the MNS may play a role in how learners actively interpret a model’s actions by constructing an internal representation of the modeled behavior. Learners must then integrate their previous knowledge with new information to construct a mental model of the behavior. The use of modeling behaviors through various forms of multimedia can influence knowledge, attitudes, perceptions, values, intentions, and behaviors (e.g., imitation or observational learning research beyond the scope of this research; Bandura, 1977, 1986; Paas & Sweller, 2012).

Garland and Sanchez (2004) investigated the impact of learner viewpoint for a knot tying task using either animated or static media. Learners viewed the knot tying procedure from two perspectives. First, they viewed a model from an over-the-shoulder (OTS) perspective, depicting how they would be completing the task. Second, the image was rotated 180° into a face-to-face (FTF) perspective so the learner could view the model. While static illustrations employing either view did not impact the speed or success with which the motor task was learned, the OTS perspective viewed as an animation produced the largest benefit to knot tying performance. The researchers suggest that animated or video-based procedural instructions should be shown from a perspective that will match the learner's final perspective (i.e., OTS), especially when a task requires high of accuracy and low error rates.

More recently, Fiorella et al. (2017) found that viewing first-person video of a model completing an assembly task promoted learning. When the model demonstrates a task from the observer's point of view, the researchers suggest it may reduce extraneous load on working memory. The researchers propose that observing a modeled behavior from a third-person perspective may require learners to transform that representation into their perspective mentally. For example, it may be more cognitively demanding to mentally switch between a model's left hand to the learner's left.

The two studies summarized above involved videos to investigate first-person perspective in multimedia learning contexts. Moreno (2007) suggests that segmenting video or animations into smaller, static images can better facilitate learning by removing any unnecessary information. Removing additional extraneous load reduces working memory processing; thereby reducing cognitive load and enhancing learning outcomes (Mayer & Chandler, 2001). Krull et al. (2004) used various points of view of a driver in a vehicle to describe the importance of applying object- and body-centered models of visual processing to instructional illustrations for procedural tasks. An object-centered point of view would depict a driver in a vehicle seat from a spectator's viewpoint looking at the driver from the front or a passenger looking at the driver from the side or over the shoulder. A body-centered viewpoint would depict the situation as the driver perceives the scene.

Krull et al. (2004) concluded that when a task requires the processing of body-centered information, images should show scenes from the point of view of a person performing the illustrated actions. However, a three-quarter view from below the camera position (i.e., canonical view) allows a learner to see multiple surfaces of the object at the same time. Therefore, that

perspective may be more beneficial when a task requires object-centered information processing of the relations among objects (e.g., Zacks et al., 2000).

Goal of Second Study

Text-based road-sharing educational materials were developed to investigate the effectiveness of perspective in cognitive and affective learning outcomes in the first study. The redesigned brochure improved declarative knowledge and increased self-reporting behavioral intentions compared to the revised handbook across perspectives. The redesigned brochure was used to carry out the second study. Images were included in the brochure alongside the text. These images depicted the same road-sharing scenarios from a driver's first-person perspective or top-down view.

The goal of the second study was to understand how image-based perspective interacted with text to influence outcomes. TPB was applied again as a framework to understand the impact of the independent variables on multiple outcomes. No effect of perspective was uncovered in the first study. However, first-person perspective was predicted to improve memory and retention by increasing the likelihood of elaboration (e.g., ELM; Petty & Cacioppo, 1986) through self-referencing (Branaghan, 2010; Rogers et al., 1977). Learners are also able to make connections between visual and verbal representations (Mayer, 2001) through active processing (Clark & Paivio, 1991; Paivio, 1990). Education countermeasures directed at improving road safety should be designed so they increase the probability that active processing takes place. Active processing is thought to be more successful in facilitating learning outcomes than passive processing (e.g., Anderson, 1993). When an observer views a task from their first-person perspective, it promotes learning and may reduce extraneous load (Fiorella et al., 2017).

Active processing can also increase safe driving behaviors by influencing attitudes about the behavior (Petty & Cacioppo, 1986). Changes in attitudes can thereby impact intentions (Fishbein & Ajzen, 1977; Webb & Sheeran, 2006). An interaction between text and image perspectives was predicted on all outcomes. Pairing first-person text and image perspectives was predicted to facilitate better outcomes than pairing third-person text and image perspectives. Road-sharing scenarios visually depicted from a first-person perspective of the driver when paired with first-person text were hypothesized to facilitate better comprehension (H1), higher judgments of knowledge (H2), more positive attitudes toward cyclists (H3), and higher self-reports of intentions to share the road with cyclists (H4) than top-down images paired with third-person text.

Transfer of knowledge to a new or different context is one ultimate objective of education countermeasures (e.g., Halpern & Hakel, 2003). The multimedia effect improves performance on problem-solving transfer tests in a variety of subject areas (e.g., Mandl & Levin, 1989; Mayer, 2001; Schnotz & Kulhavy, 1994; Sweller, 1999; Van Merrienboer, 1997). Individuals presented with first-person perspective images when paired with first-person text were predicted to score accurately on the novel, hypothetical situational judgment task (i.e., transfer task) more often than the individuals presented with the top-down perspective and third-person text (H5).

It is critical to reduce extraneous load associated with instruction that combines text and images. Cognitive and perceptual workload (i.e., thinking, deciding, calculating, remembering, searching) may be highest while completing inductive reasoning tests, due to the demanding nature of problem-solving (Stanton et al., 2005). Within CLT's framework, solving new problems can impose high extraneous cognitive load for novice learners due to their lack of prior knowledge or mental model for how to solve the problem. There are no direct measures of

extraneous processing during learning beyond performance on post-training tests. Therefore, transfer test performance can be used as an indirect measure such that higher transfer test performance indicates less extraneous processing during learning a new road-sharing scenario (Stull & Mayer, 2007).

CLT was applied in the second study to ensure the mental effort or cognitive load involved in learning with images and text did not extend beyond the learner's information-processing capacity when completing a transfer task (Chandler & Sweller, 1991). Two additional predictions were made to explore the impact text- and image-based perspectives on cognitive load and workload experienced while solving a novel task. An interaction between text and image perspectives on cognitive load and mental workload was predicted. Individuals presented with first-person perspective images when paired with first-person text were predicted to report lower levels of cognitive load (H6) and mental workload (H7) after completing a novel, hypothetical situational judgment task (i.e., transfer task) than the individuals presented with the top-down perspective and third-person text.

CHAPTER VII

STUDY 2 METHOD

Participants

An estimate of adequate sample size was calculated to detect the hypothesized effects based on a small effect size (*Cohen's d* = .30) (Cohen, 1992). The power analysis indicated that a total of 126 participants would be required (i.e., 31 in each group) to observe a significant interaction. Data were collected using two sample populations. The procedures used in the first study were replicated to recruit students enrolled at ODU. Students who participated in the first study were not eligible to participate in the second study. A secondary sample was also collected using Amazon Mechanical Turk (MTurk), an online crowdsourcing marketplace that allows individuals and businesses to outsource online tasks for monetary payment. Participants were not eligible to take part in the study if they had a "response quality approval rating" within the MTurk system below 95%. Participants who completed the full study were compensated $4 for their time. Established psychology research guidelines were used to develop data collection protocols for this recruitment method (e.g., Brawley & Pury, 2016; Buhrmester et al., 2018; DeSoto, 2016; Woo et al., 2015).

Approval was obtained from ODU's College of Science IRB before data collection procedures took place (Appendix B). All participants provided informed consent before completing the study. In total, 200 participants responded to the online study. After completing data cleaning procedures and removing expert cyclists, 105 participants (71 female, 31 male, one nonbinary, and two missing data) ranging in age from 18 to 64 years old (*M* = 28.615, *SD* = 11.589) were included for the final analyses.

Design

This study employed a 2 (text perspective: first-person, third-person) x 2 (image perspective: first-person, top-down) between-subjects design. The independent variable, text perspective, was the same as the first study: (1) first-person perspective (*I*), and (2) third-person perspective (*driver*). The independent variable, image perspective, was a variable with two levels based on the graphical viewpoint presented: (1) driver's first-person perspective, and (2) top-down or bird's eye view of each road-sharing scenario. Dependent variables included in this study were the same as the first study: drivers' knowledge of road-sharing, judgments of knowledge about road-sharing, attitudes toward cyclists, and intentions to safely road-share. Three added dependent variables were measured following a situational judgment transfer task: task accuracy, subjective cognitive load scores, and global workload scores.

Stimuli

All images were based on the *Sharing Virginia Roads* handbook scenarios used in the first study. The existing handbook uses multiple types of images to convey information, including photographs that show drivers and cyclists from multiple angles and diagrams of a top-down view of intersections (Figure 8). Updated images for each scenario were developed through an iterative design process, including storyboarding scenes and collaborating with a designer to render 3D images. The designer developed and rendered virtual scenes to illustrate the corresponding intersections, including drivers and cyclists. All pedestrians visible in the current handbook were removed. Text and annotations were removed from the images. Static images of each scenario were captured with screenshots from the two viewpoints to convey the experimental manipulation by adjusting the virtual camera lens within a vehicle and from a top-down view (Figures 9 – 11).

Figure 8

Examples of Photographic and Diagrammatic Images Used in Existing Handbook

Figure 9

Diagram of a Top-Down View of an Intersection, Including Pedestrian, in Existing Handbook.

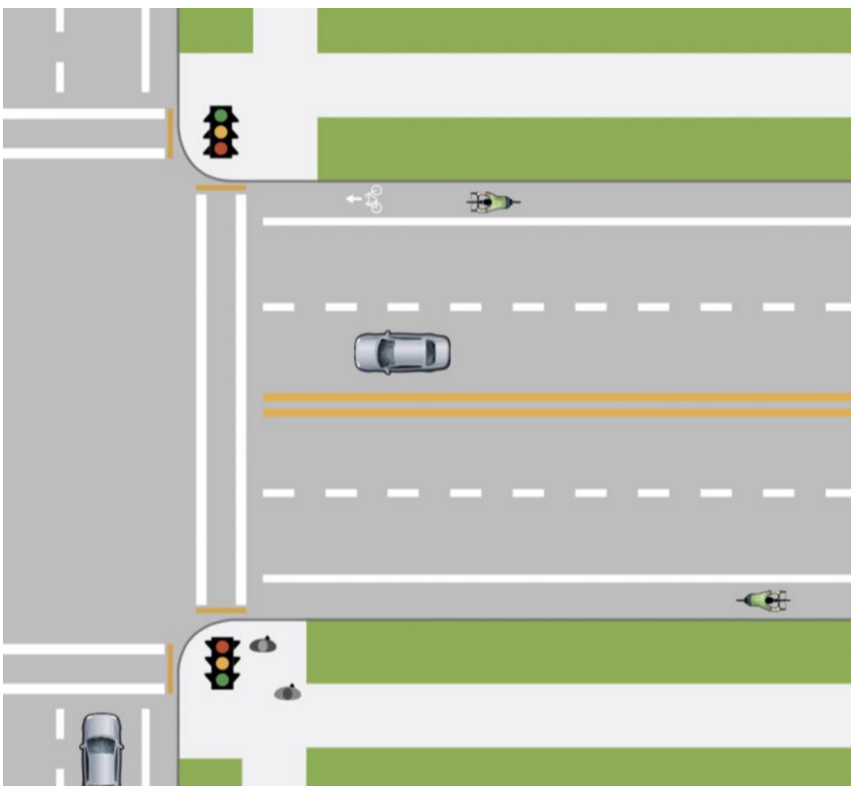


Figure 10

Redesigned Top-Down View of an Intersection with Pedestrians Removed

Figure 11

Redesigned First-Person, Driver's Perspective of an Intersection

Measures

All measures used to gather data in the first study were used in this second study (see Appendices). Pre-experimental questionnaires included the demographics questionnaire and

Virginia cycling and motor vehicle experience questionnaire. Post-experimental questionnaires included the judgment of learning (JOL) questions, comprehension test, attention check items, behavioral intentions questions (Ajzen, 2010), attitudes toward cyclists items (Rissel et al., 2002), and a cognitive strategy item. There was a moderate to high level of internal consistency for JOLs ($\alpha = .792$), comprehension test ($\alpha = .724$), attitudes scale ($\alpha = .680$) and intentions scale ($\alpha = .658$).

Situational Judgment Test

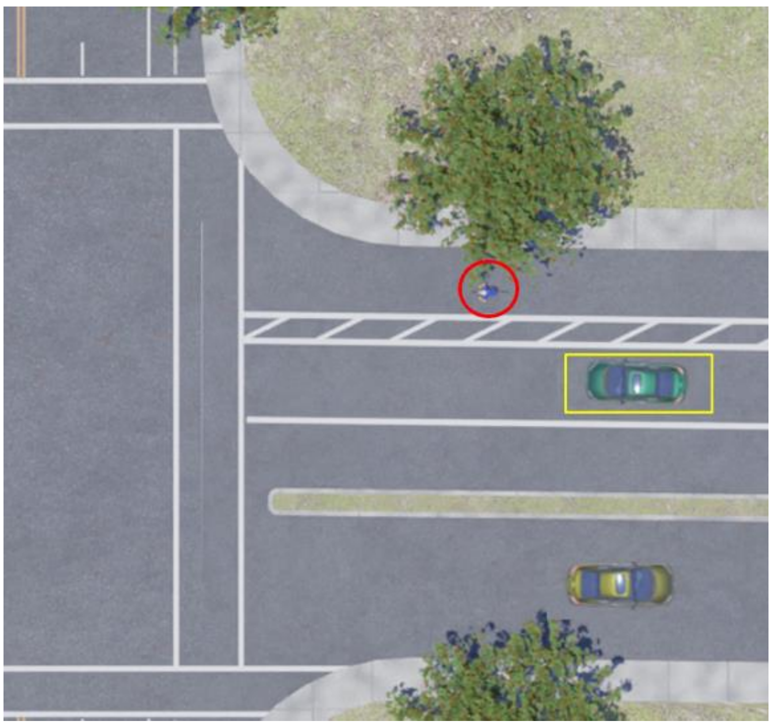
Situational judgment tests (SJTs) are used extensively for employment selection and personnel assessment. These types of tests are also used in medical education assessments. Usually, SJTs present specific scenarios or examples of effective or ineffective critical incidents in a low-fidelity, written format (Krumm et al., 2014; Lievens & Motowidlo, 2016). Closed SJTs require participants to select the correct response to the scenario from a set of alternative responses and open-ended SJTs require participants to generate their own responses (Fritzsche et al., 2006). Single response SJT development and scoring is more efficient to develop and score than multiple response SJTs (Lievens, & Motowidlo, 2016). SJTs can be used to assess a wide range of competencies, such as interpersonal skills, decision making, behavioral tendencies, and judgment skills.

A single item multiple response closed SJT was used in the current study as a transfer task to provide an opportunity for participants to apply their newly acquired knowledge to a novel scenario (i.e., a higher level of Bloom's taxonomy of cognitive learning; Krathwohl, 2002; Bloom et al., 1956). The transfer task included a text-based scenario with an annotated top-down image developed by modeling an intersection in Norfolk, Virginia. Participants reviewed the

scenario and image, and then answered a single multiple-choice question (Figure 12; Appendix J).

Figure 12

Scenario Depicted in Second Study's Situational Judgment Task



Cognitive Load

Two other measures were included in this study related to the perceived mental effort needed to solve the transfer task. First, participants answered Paas' (1992) unidimensional survey item: "How much mental effort did you invest in solving this problem?". Participants rated their effort using a nine-point semantic differential rating scale with anchor labels ranging from "very, very low mental effort" (1) to "very, very high mental effort" (9). As a

unidimensional scale, reliability and validity was not calculated. Researchers treat the data gathered from this measure as interval and report mean scores, or as nominal or ordinal. This subjective rating scale is a widely used measure of learner cognitive load (for a review, see Paas et al., 2003).

Mental Workload

The NASA-TLX (Task Load Index) is a multi-dimensional, subjective assessment of workload (Hart & Staveland, 1988) (Appendix J) is one of the most widely used, validated, and non-intrusive workload scales (Stanton et al., 2005). Respondents rated the level of mental effort required for six dimensions (or subscales): mental and perceptual demand, physical demand, time pressure, difficulty, performance, and frustration level. To assess mental and perceptual effort, respondents answered the following question: “How much mental and perceptual activity was required (e.g., thinking, deciding, calculating, remembering, looking, searching, etc.)?

According to Hart (2006), the most common NASA-TLX modification is to remove the weighting process and report raw scores for each subscale. Research suggests the unweighted scores are more sensitive to (Hendy et al., 1993) or consistently sensitive with (Byers, et al., 1989) raw scores. A weighted scale was not included in this study to improve the usability of the online testing procedure and to reduce testing time. It is a reliable and sensitive measure of perceived workload with a high test-retest reliability (r = .83; Hart & Staveland, 1988; Nygren, 1991). In this study, internal consistency was moderately high (α = .732).

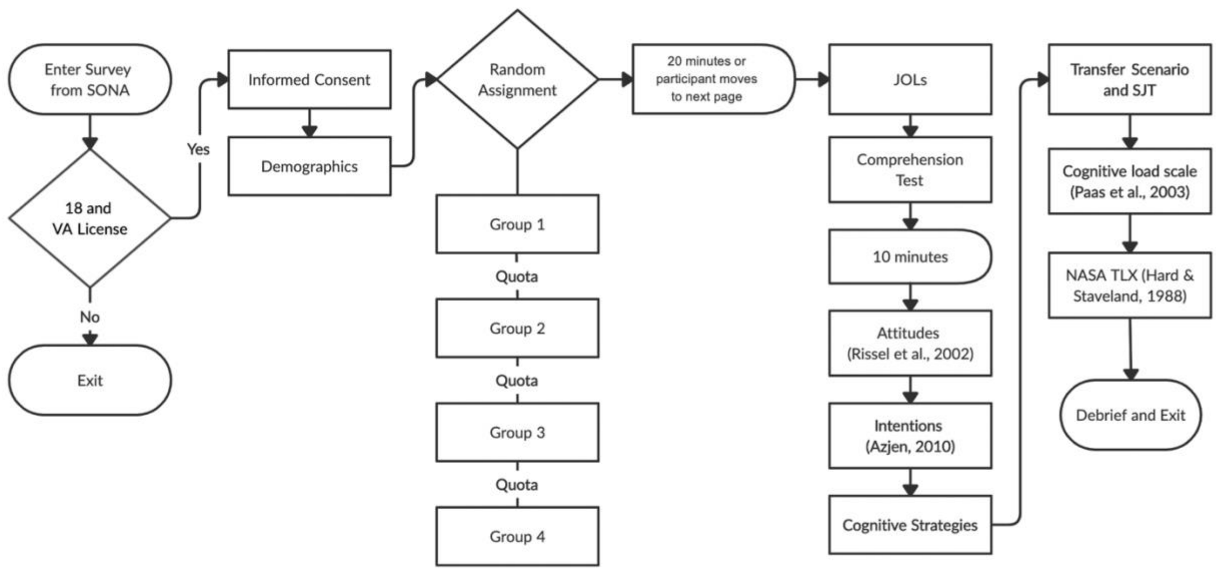
Procedure

All experimental materials were administered with Qualtrics as an unmoderated survey. Procedures replicated the first study, with the addition of a transfer task and follow-up questions (Figure 13). Participants completed the same background questions from the first study before

reviewing the experimental manipulation. Following the completion of all post-experimental questionnaires from the first study, participants reviewed a new road-sharing scenario, and completed a single item situational judgment transfer task, the cognitive load question, and workload questionnaire (Appendix J).

Figure 13

Second Study Experimental Procedure



CHAPTER VIII

STUDY 2 RESULTS

Data Cleaning Procedures

Data were assessed for quality, insufficient effort responding, extreme response durations, nonresponses, missing values, and outliers using the same procedures as Study 1. Eight participants who started the study with a mobile device were screened out of the study. Data were removed for four participants who did not answer correctly at least three out of four attention check items.

Missing Values

Nineteen MTurk workers did not review the educational material, and/or did not complete at least one of the post-experimental questionnaires. Those participants were removed through listwise deletion from the entire data set. Out of the 200 participants who started the study, 174 participants were retained who completed the experiment and at least one post-experimental questionnaires. Five students each skipped up to three post-experimental questionnaires. These data were excluded from analyses of the corresponding dependent variable.

Study Completion Duration

When visually inspecting responses to ensure data quality, some MTurk workers showed extremes in total study duration. Participants completed the full study in an average of 1406 seconds (i.e., 23.43 minutes) (*Min* = 10, *Max* = 20,861, *SD* = 1,504). Hoaglin and Iglewicz's (1987) recommended outlier labeling rule was applied. Nine participants were removed from the final analyses because they completed the study in less than 1059 seconds (17.65 minutes).

Annual Cycling Mileage

Participants reported cycling an average of 1,397.57 miles per year (*Min* = 10, *Max* = 12,907, *SD* = 1,201.87); a higher mileage than participants in the first study (*M* = 161.06, *SD* = 84.645) miles. Again, after applying Hoaglin and Iglewicz's (1987) recommended outlier labeling rule of 2.2 IQR, the cycling mileage threshold was 315.60 miles. A maximum threshold of 60 miles per year from the first study was applied again to maintain consistency across both studies and ensure the experimental design and educational material were sensitive to the targeted audience of the proposed countermeasure (i.e., drivers who are inexperienced cyclists). Nine ODU students and 50 MTurk workers (36 male, 22 female, 1 non-binary) who reported cycling more than 60 miles (*M* = 2521.61, *SD* = 13049.64) were removed from the final sample. The 105 participants included for the final analyses reported cycling an average of 10.20 miles per year (*Min* = 0; *Max* = 50; *SD* = 13.76) and riding a bicycle on the road for an average of 6.41 years overall (*Min* = 0; *Max* = 45; *SD* = 9.68).

Assumption Checks

All assumptions for MANOVA were assessed before completing the full analyses associated with each hypothesis and research question using similar procedures as the first study (e.g., normal distribution and multicollinearity). Shapiro-Wilk tests of normality indicated all dependent variables (except workload) were significantly different from a normal distribution at one or both levels of at least one independent variable based on a conventional, conservative significance level of $\alpha = .01$ (Tabachnick & Fidell, 2019). Histograms, skewness values, and kurtosis values showed attitude and workload scores skewed negative. Lower attitude scores reflect more positive attitudes and low workload scores reflect lower workload. Data skewed positive for all other dependent variables at each level of the independent variable. Skewness

values fell within an acceptable range for all variables, but kurtosis values fell outside an acceptable range for some variables (+/-2; George & Mallery, 2016).

Q-Q-plots of the residuals were examined and revealed a normal distribution for each dependent variable. Levene's homogeneity of variance test was met for all other dependent variables met the ($\alpha > .025$; Wickens & Keppel, 2004; trimmed mean, Brown & Forsythe, 1974). Correlations revealed an absence of multicollinearity among the dependent variables associated with all hypotheses (i.e., $r = .20$ - $.60$; Tabachnick & Fidell, 2019). Box's M value was nonsignificant (52.102, $p = .020$) (Huberty & Petoskey, 2000; $p < .005$). The covariance matrices among groups were assumed to be equal for the MANCOVA associated with Hypotheses 1 through 5. However, Box's M value was significant for the MANCOVA to investigate the combined effects of cognitive load and workload (24.501, $p = .005$) (Huberty & Petoskey, 2000). Therefore, separate ANOVAs were conducted to evaluate the hypotheses associated with workload and cognitive load.

Table **3** and Table 4 include correlations among the dependent variables.

Table 3

Correlations Among Dependent Variables Associated with Educational Material in Second Study

	M	1	2	3
1. Comprehension scores	.73	-		
2. Intentions	3.86	.218* (.028)		
3. JOLs	3.98	.326** (< .001)	.198* (.047)	
4. Attitudes	2.71	-.182 (.069)	-.468** (.001)	-.162 (.105)

Note. N = 105; *M* represents grand mean collapsing across conditions

* Correlation is significant at the *p* = .05 level (uncorrected). ** Correlation is significant at the *p* = .003 level (Bonferonni familywise correction).

Table 4

Correlations Among Dependent Variables Associated with the Situational Judgment Task in Second Study

	M	1	2
1. SJT score [a]	.87	-	
2. Workload [b]	19.72	-.473** (.001)[d]	-
3. Cognitive load [c]	5.65	.425[e]	.573** (< .001)[f]

Note. N = 105; M represents grand mean collapsing across conditions

* Correlation is significant at the *p* = .05 level. ** Correlation is significant at the *p* = .0056 level (Bonferonni familywise correction).

[a] Correct or incorrect response to single item (0 = incorrect; 1 = correct). [b] Sum of six items on a seven-point scale. [c] Unidimensional nine-point scale. [d] Point-biserial. [e] Eta (significant value). [f] Kendall's tau-b.

Statistical Analyses

First, analyses were conducted to assess any differences in dependent measures due to cycling mileage and sample population. Second, the data addressing the hypotheses associated with the educational material were analyzed with a 2 (text perspective: first-person, third-person) x 2 (image perspective: first-person, top-down) between-subjects Multivariate Analysis of Covariance (MANCOVA) to test for main effects and interactions for the combined dependent variables after controlling for sample population (i.e., MTurk or ODU).

Third, analyses were conducted to understand potential workload and cognitive load associated with the situational judgment transfer task. Three separate 2 (text perspective: first-person, third-person) x 2 (image perspective: first-person, top-down) between-subjects ANOVAs were carried out to test for main effects and interaction for SJT performance, cognitive load scores, and global workload scores. Finally, exploratory analyses were conducted for some item- and factor-level data to understand if any specific learning, attitudinal, or workload outcomes were sensitive to the experimental manipulation. No apriori predictions were made for these follow-up analyses. Further details about all exploratory analyses are provided later in this chapter.

Effects Of Sample Population and Cycling Mileage

To explore potential differences in demographics and cycling experience between MTurk workers and ODU students, descriptive statistics were calculated, and exploratory independent *t*-tests were conducted. MTurk workers ranging in age from 18 to 64 (M = 36.305, SD = 10.845). were significantly older than ODU students ranging in age from 18 to 47 years old (M = 22.37, SD = 5.915), $t(151.247) = -10.651$, $p < .001$, $d = 1.613$. Levene’s test indicated unequal variances for age ($F = 37.873$, $p < .001$), so degrees of freedom were adjusted. MTurk workers reported

cycling an average of 1479.76 miles per year (*SD* = 10,309), compared to ODU students who reported cycling an average of 148.35 miles per year (*SD* = 927.57). This difference in cycling mileage was not statistically significant ($p = .313$).

As part of the data cleaning procedures, additional analyses were conducted to include the 59 participants removed for final analysis due to extremes in self-reported annual cycling mileage. A 2 (text perspective: first-person, third-person) x 2 (visual perspective: first-person, top-down) between-subjects MANCOVA was conducted using annual cycling mileage and sample population (dummy coded: 0 = ODU, 1 = MTurk) as covariates. Box's M value of 89.631 ($p = .083$) was non-significant (Huberty & Petoskey, 2000; $p < .005$). The MANCOVA revealed no significant interaction or main effects of text perspective and educational material on the combined dependent variables after controlling for both cycling mileage and sample population ($p > .575$). The covariates, sample population ($p = .006$, $\eta^2_p = .190$) and cycling mileage ($p = .001$) each revealed a significant association with the combined dependent variables. After removing experienced cyclists from the sample and re-running the MANCOVA with the remaining 105 participants, cycling mileage was not significantly associated with the combined dependent variables ($p = .112$). However, sample population was significantly associated with the combined dependent variables when conducting the MANCOVA with the remaining 105 participants ($p = .006$). Therefore, sample population was included as a covariate for the analyses associated with Hypotheses 1 through 5.

A second 2 x 2 MANCOVA was conducted to determine any effects of cycling mileage and sample population on the combined dependent variables associated with the situational judgment task (SJT): SJT performance, cognitive load ratings, and workload ratings. Box's M value of 23.292 ($p = .236$) was non-significant (Huberty & Petoskey, 2000; $p < .005$). Cycling

mileage (p = .284) and sample population (p = .884) were not significantly associated with the combined dependent variables. Controlling for cycling mileage and sample population, the MANCOVA revealed no significant interaction or main effects of text perspective and educational material on the combined dependent variables (p > .143).

Educational Material Hypotheses

The MANCOVA revealed no predicted significant interaction or main effects of text perspective and image perspective on the combined dependent variables, after controlling for the sample population (p > .05). Therefore, Hypotheses 1 through 5 were not supported (Table 5).

Table 5

Results of Text x Image Perspective MANCOVA for the Combined Dependent Variables

Effect	Wilk's Λ	*F*	Hypothesis df	Error df	*p*	η2p	power
Intercept	.005	4327.22	4	93	.000	.991	1.000
Sample	.811	5.402	4	93	.0006*	.189	.968
Text	.969	.711	4	93	.587	.030	.222
Image	.987	.420	4	93	.794	.018	.144
Text * Image	.990	.410	4	93	.801	.017	.141

* Covariate significantly associated with the combined dependent variables at the p < .001 level.

Comprehension Scores

Across conditions, participants answered an average of 14.53 out of 20 questions correctly with a range from seven to nineteen (i.e., average proportion of correct responses = .727). First, an interaction between text perspective and image perspective on comprehension

scores was predicted. Road-sharing scenarios visually depicted from a first-person perspective of the driver when paired with first-person text (M = .767, SD = .110) did not facilitate significantly higher comprehension scores than top-down images with first-person text (M = .729, SD = .162), first-person images with third-person text (M = .703, SD = .190), or top-down images with third-person text (M = .719, SD = .172). There was no significant interaction between text and image perspectives on comprehension scores (p = .775). Hypothesis 1 was not supported.

Judgments of Learning

Across conditions, participants reported moderately high average JOLs (M = 3.98, SD = .795). An interaction between text perspective and image perspective on JOLs was predicted. There was no significant interaction between text and image perspectives on JOLs (p = .501). Participants in the first-person text with first-person images condition (M = 3.91, SD = .788) did not self-report higher judgments of knowledge than participants in the other conditions, including first-person text with top-down images (M = 3.92, SD =.881), third-person text with top-down images (M = 4.16, SD = .663), and third-person text with first-person images (M = 3.94, SD = .747). Hypothesis 2 was not supported.

Attitudes Toward Cyclists

Road-sharing scenarios visually depicted from a first-person perspective were predicted to facilitate more positive attitudes toward cyclists than the top-down perspective across first- and third-person perspective text presentations. Participants reported moderately low (i.e., positive) average attitude ratings across conditions (M = 2.82, SD = 0.351). There was no significant interaction between text and image perspectives on attitudes (p = .887). Participants in the condition viewing first-person text and images (M = 2.76, SD = 0.588) did not report significantly less negative (lower) attitude scores than participants in the condition reviewing

first-person text with top-down images (M = 2.67, SD = 0.475), third-person text with first-person images (M = 2.66, SD = 0.316), and third-person text with top-down perspective images (M = 2.71, SD = 0.580). Hypothesis 3 was not supported.

Intentions

Overall, participants reported moderately high intention ratings across conditions (M = 3.60, SD = 0.382). Road-sharing scenarios visually depicted from a first-person perspective were predicted to facilitate higher intentions to share the road with cyclists than the top-eye perspective across both text presentations. There was no significant between-subjects interaction between text and image perspectives on intentions (p = .981). Participants in the first-person text with first-person perspective images condition did not report significantly higher intention scores (M = 3.86, SD = 0.479) than participants in the first-person text with top-down images condition (M = 3.89, SD = 0.554), the third-person text with first-person images condition (M = 3.83, SD = 0.474), or the third-person text and top-person images condition (M = 3.86, SD = 0.534). Hypothesis 4 was not supported.

Transfer Task Hypotheses

Situational Judgment Task

Across all conditions, 86% of the participants answered the SJT correctly. Across text perspectives, individuals presented with the first-person perspective imagery were predicted to score more accurately on the novel, hypothetical situational judgment than the individuals presented with the top-down perspective. The 2 (text perspective: first-person, third-person) x 2 (image perspective: first-person, top-down) between-subjects ANOVA revealed there was a significant interaction between text and image perspectives, F(1, 5.563), p = .022, η^2_p = .104. A significantly higher proportion of participants in the condition with first-person text and top-

down images answered the single-item SJT correctly (95.50%) compared to the conditions with first-person text and images (84.6%), third-person text and first-person images (85.7%), and third-person text and top-down images (81.80%). This finding was not in line with the predicted outcomes, so Hypothesis 5 was not supported.

Cognitive Load

Overall, participants reported average cognitive load ratings of 5.65 (SD = 1.647) on a nine-point scale across conditions. Across text perspectives, participants presented with the first-person perspective imagery were predicted to report lower levels of cognitive load after completing the situational judgment task than the participants presented with the top-down perspective, across text-based perspectives. The 2 (text perspective: first-person, third-person) x 2 (image perspective: first-person, top-down) between-subjects ANOVA did not yield a significant interaction between text and image perspectives (p = .619), a main effect of text perspective (p = .274), or a main effect of image perspective (p = .529) on cognitive load. Participants did not report lower cognitive load first-person perspective imagery condition (M = 5.56, SD = 1.888) than participants in the top-down perspective condition (M = 5.79, SD = 1.242) across text perspectives. Hypothesis 6 was not supported.

Workload

The current study's scores were compared to Grier's (2015) percentile scores to enhance the interpretation of workload scores. Grier (2015) conducted a meta-analysis of NASA-TLX global workload scores within 20 task categories and found unweighted workload scores ranged from 14.08 to 88.50 (M = 45.29, SD = 14.99). Participants reported average unweighted global workload ratings ranging from 19.17 to 20.96 (M = 19.72, SD = 3.519) across conditions. These mean workload scores fell between the minimum (13.08) and 25th percentile (38.00) for

cognitive and memory tasks analyzed in Grier's meta-analysis. Therefore, workload scores in this study were interpreted to be on the low end of the continuum (Grier, 2015).

Across text perspectives, individuals presented with the first-person perspective images were predicted to report lower levels of mental workload after completing a novel, hypothetical situational judgment transfer task than the individuals presented with the top-down perspective. The 2 (text perspective: first-person, third-person) x 2 (image perspective: first-person, top-down) between-subjects ANOVA revealed no significant interaction between text and image perspectives (p = .220), effect of image perspective (p = .410), or effect of text perspective (p = .21) on workload. Collapsing across text perspectives, participants did not report significantly lower workload in the first-person perspective imagery condition (M = 19.48, SD = 3.841) compared to participants in the top-down perspective condition (M = 20.06, SD = 3.019). Hypothesis 7 was not supported.

Exploratory Analyses

Comprehension Factor Scores

Three exploratory 2 x 2 factorial ANCOVAs were conducted to compare the effects of text and image perspective on declarative knowledge, procedural knowledge, and law-based knowledge factor scores, after controlling for sample population. Sample population was significantly associated with the three knowledge factors: declarative knowledge, F(1, 17.018), p < .001, η^2_p = .151; procedural knowledge, F(1, 7.938), p = .006, η^2_p = .076; and law-based knowledge, F(1,7.239), p = .008, η^2_p = .070. The ANCOVAs revealed no significant interaction (p = .148) or main effects of text (p = .944) or image (p = .906) perspective on the procedural knowledge factor, and no significant interaction (p = .676) or main effects of text (p = .727) and image (p = .564) perspective for the law-based knowledge factor. The ANCOVA revealed a

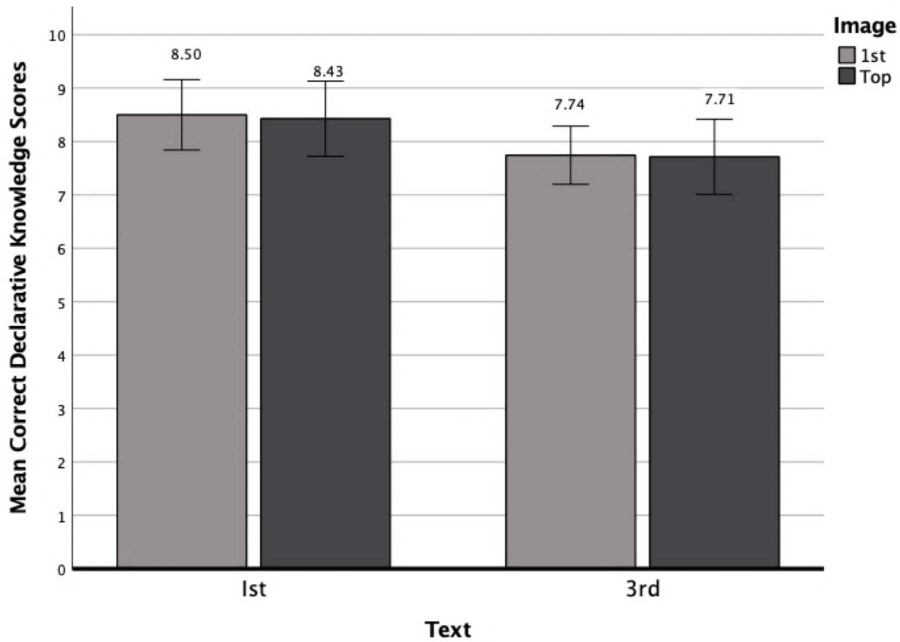
significant main effect of text perspective for the declarative knowledge factor, $F(1, 4.997)$, p = .028, η^2_p = .049 (Figure 14). Controlling for the sample population, participants presented with first-person text (M = 8.47, SD = 1.342) correctly answered more declarative knowledge items than participants presented with third-person text (M = 7.73, SD = 1.794) across image perspectives. Additional item-level analyses were conducted to better understand how comprehension of specific questions differed across groups.

Comprehension Item Analysis

First, exploratory 2 x 2 factorial ANCOVAs were conducted to understand the association of the covariate, sample population, with any items in the comprehension test. Appendix M includes proportions of correct responses for all twenty items across conditions. Sample population was significantly associated with seven items, but the individual 2 x 2 ANCOVAs revealed no significant item-level interactions or main effects (p > .05). Next, individual exploratory 2 x 2 ANOVAs were conducted to compare the effects of text perspective and educational material on the items in the comprehension test not associated with sample population. The item analysis revealed a significant difference among conditions for three items.

Figure 14

Significant Effect of Text-Based Perspective on Declarative Knowledge Factor Scores Across Image Perspectives



Note. Mean based on sum of 10 items. Main effect is significant when controlling for sample population. Error bars represent 95% confidence intervals. $p = .028$.

Overall, 28.70% of participants across conditions correctly answered the item: "A confident, experienced bicyclist stopped at a red light at an intersection that has both a bicycle lane and a right turn only lane and intending to go straight should be (in the travel lane next to the right turn only lane)." There was a significant main effect of text perspective: $F(1, 6.286)$, $p = .014$, $\eta^2_p = .061$. Across image perspectives, a smaller proportion of participants who were presented with first-person text ($M = .16$, $SD = .367$) correctly answered this item than participants presented with third-person text ($M = .39$, $SD = .493$). Within the first-person image conditions, 8.30% of participants in the first-person text condition answered the question

correctly (M = .08, SD = .282), compared to 40% in the third-person text condition (M = .40, SD = .497); but there was no significant interaction (p = .337).

Across conditions, 68% of participants correctly answered the next item: "Bicyclists signal a left turn when they look over their shoulder and then (hold the left arm out straight)." There was a significant main effect of text perspective: $F(1, 0.652)$, p = .086, η^2_p = .030. Across image perspectives, a larger proportion of participants who were presented with first-person text (M = .73, SD = .447) correctly answered this item than participants presented with third-person text (M = .59, SD = .496). Within the first-person image conditions, more participants in the first-person text condition answered the question correctly (M = .75, SD = .442) compared to the third-person text condition (M = .54, SD = .505); but there was no significant interaction (p = .414).

Finally, across conditions 70% of participants correctly answered the item: "The Dutch Reach refers to (opening the car door using the right hand to allow the body to pivot to look behind you)." There was a significant interaction between text and image perspective, $F(1, 7.447)$, p = .008, η^2_p = .072. A higher proportion of the participants in the first-person text and image condition (M = .92, SD = .282) correctly answered this item compared to participants in the third-person text and top-down image condition (M = .542, SD = .505), first-person text and top-down image condition (M = .67, SD = .483), and third-person text and first-person image condition (M = .76 SD = .436). A significant interaction between text and image perspective was predicted, but these specific item-level effects did not directly support to Hypothesis 1.

Behavioral Intentions

Across both text presentations, there were no predicted differences in intention scores between participants who reviewed first-person perspective images compared to participants who

reviewed images from the top-down perspective. Three separate analyses were conducted to explore potential effects of text and image perspective on each of the factors of the intentions scale. Sample population was not significantly associated with the social norms factor (p = .164) or the overall behavioral intentions factor (p = .054), so it was not included in those analyses as a covariate.

A 2 x 2 factorial ANOVA yielded no significant effect of image perspective (p = .537) and no significant interaction effect (p = .077) for social norms factor. A 2 x 2 factorial ANOVA yielded no significant effect of perspective (p = .222) and no significant interaction effect (p = .646) for the behavioral intentions factor. A 2 x 2 factorial ANCOVA yielded no significant effect of image perspective (p = .896) and no significant interaction effect (p = .218) for the behavioral control factor. Sample population was significantly associated with the perceived behavioral control factor, F(1, 21.792), p < .001, η^2_p = .185. Collapsing across conditions, MTurk workers (M = 4.16, SD = .654) reported higher perceived behavioral control over their safe road-sharing actions than ODU students (M = 3.57, SD = .569), t(99) = -4.844, p < .001, d = 0.968. Overall, these results did not provide support for Hypothesis 4.

Workload Subscales

There were no significant effects of text and image perspective on learners' global workload scores. Correlations did reveal a significant moderate negative association between SJT accuracy and global workload (

Table **4**). Participants provided ratings on a seven-point rating scale to each of the six unidimensional subscales. According to Hart (2006), researchers customarily analyze the six subscale ratings individually or in conjunction with an overall composite rating of workload.

Analyzing item ratings allows designers and researchers to isolate specific sources of problematic workload.

Data skewed negative (i.e., low scores indicate lower workload) based on histograms, skewness values, and kurtosis values. Two exceptions were that the effort and performance subscales appeared normally distributed. Skewness and kurtosis values for the effort subscale approached 0, but fell outside an acceptable range for all other subscales (+/-2; George & Mallery, 2016). Shapiro-Wilk tests of normality was significant for all subscales of the workload scale ($p < .001$; Tabachnick & Fidell, 2019). A significant Levene's test statistic based on the trimmed mean indicated unequal variances for the effort subscale ($p = .021$), but the assumption of equal variances was met for all other subscales.

Correlations yielded no significant associations between any workload subscales and SJT scores ($p > .05$). Cognitive load had a moderate positive association with the mental demand subscale ($r = .545$, $p < .001$) and effort subscale ($r = .635$, $p < .001$) of the workload questionnaire. Data did not meet the multicollinearity assumption for MANCOVA (Box M's value = 312.825, $p < .001$). Therefore, separate exploratory 2 x 2 factorial ANOVAs were conducted to compare the effects of text and image perspective on each of the six subscales. The ANOVAs for mental ($M = 4.26$, $SD = 1.263$), physical ($M = 1.26$, $SD = 0.486$), temporal ($M = 2.18$, $SD = 1.129$), performance ($M = 2.86$, $SD = 1.039$), and effort ($M = 4.68$, $SD = 1.360$) subscales revealed no significant effects for any condition ($p > .10$). The ANOVA on the frustration subscale revealed a significant interaction, $F(1, 6.058)$, $p = .041$, $\eta^2_p = .042$. Participants overall provided low ratings of frustration ($M = 2.20$ $SD = 1.217$). Participants in the condition with third-person text and top-down images ($M = 2.85$, $SD = 1.491$) reported significantly higher frustration than participants in the condition with first-person text and top-

down images (M = 1.97, SD = 0.668). Standard errors and the distribution of responses was greater among participants who reviewed third-person text with top-down images than those who viewed the first-person text with top-down images.

CHAPTER IX

STUDY 2 DISCUSSION

The purpose of the second study was to investigate the impact of combined text and visual perspectives on drivers' comprehension, knowledge judgments, attitudes, and intentions. The second study replicated the first study and employed two additional measures of perceived mental effort that participants experienced when solving a novel transfer task. These measures were included to ensure the combination of text and images did not increase extraneous cognitive load experienced by participants. In this chapter, an overview of the findings associated with the hypothesized outcomes and follow-up observations is provided. Next, theoretical and practical implications of the observed effects are shared. Finally, the study's limitations and proposed future directions are outlined.

Comprehension

It was predicted that pairing first-person text with first-person images would improve global comprehension scores, but this was not the case (H1). First-person text perspective did affect declarative knowledge scores across image perspectives. The redesigned brochure influenced declarative knowledge scores, but text-based perspective had no effect in the first study. The use of pictures is thought to benefit learners as they move from declarative to procedural knowledge (Gyselinck & Tardieu, 1999). Pictures used in health education can improve comprehension if they illustrate spatial relationships (Houts et al., 2006; Levie & Lentz, 1982). However, there was no differential effect of an image-based perspective on procedural knowledge in the current study. Declarative knowledge may have been more sensitive to the effects of text-based first-person perspective content once the material included images. That said, the item-level differences found as a function of the interaction between text and image

perspectives are difficult to interpret because they elicited different types of knowledge. No direct comparison was made to stimuli without images.

Finally, the goal of this research was to evaluate the comprehension of the existing road-sharing handbook in Virginia. Beyond the SJT to assess transfer of knowledge, participants were not behind the wheel of a vehicle or simulator, so they did not need to make rapid, critical decisions while perform complex psychomotor skills necessary to operate a vehicle. Future work should investigate whether the current findings also apply to actual performance through direct behavioral outcomes. Therefore, conclusions about the impact of combining text and image perspectives on different types of knowledge comprehension are tentative.

Judgments of Learning

Across conditions, text and image perspectives did not impact JOLs (H2). There was a moderate positive relationship between comprehension scores and judgments of learning across conditions. Like the first study, this result could indicate some calibration between drivers' judgments and actual knowledge. In contrast, these results could suggest the need for multiple measures to understand the effectiveness of similar countermeasures. Measures of knowledge judgments may not be sufficient in evaluating the effectiveness of a countermeasure. More information may be necessary to target a specific population like drivers before implementing a road safety campaign.

Attitudes and Intentions

Text and image perspectives did not differentially influence participants' attitudes toward cyclists (H3). There was a weak positive relationship between comprehension scores and intentions and no relationship between comprehension and attitudes. These results do not align with Rissel et al.'s (2002) finding that drivers showing more negative attitudes about cyclists

were those who were less knowledgeable about road rules. Internal consistency for the attitudes scale in the second study increased twofold from the first study. Based on the first study's results, one item was altered. "Left" was changed to "right" in the statement "It is safer for cyclists to keep to the left of the lane." This single update to the scale may not be the only explanation for an increase in internal consistency, but it would be a recommended adjustment for future studies in the United States to aid interpretability.

Participants who reported more positive attitudes toward cyclists also reported moderately higher intentions. This is in line with TPB, which proposes that people's intentions about any behavior can be modified by changing their attitudes (Ajzen, 1991). There were no differences in intention ratings across conditions for the global intention measure, or the three intention factors, as a function of text or image perspectives (H4). These results do not support the proposed hypotheses, but they are consistent with some previous research that did not find an effect of perspective on intentions. For example, Nan et al. (2015) found that first-person perspectives did not affect participants' intentions to get an HPV vaccine even though it did affect their perceptions of risk. Meadows (2012) found no effect of perspective on behavioral intentions for those exposed to audio-based narratives in the contexts of texting while driving, binge drinking, smoking, and HIV prevention.

At present, there is no validated, standard measure of drivers' intentions specifically associated with safely sharing the road with cyclists. Researchers apply Ajzen's recommendations to develop scales to measure intentions depending on the study's context and target of the countermeasure. Nemme and White (2010) developed a set of questions to measure young people's subjective norms, perceived behavioral control, and behavioral intentions relating to four health issues, including texting while driving. Behavioral intent for texting while

driving was measured with items on a seven-point Likert-type scale: (1) “I plan to send [read] SMS messages while driving in the next week,” (2) “I intend to send [read] SMS messages while driving in the next week,” and (3) “It is likely that I will send [read] SMS messages while driving in the next week.” Similarly, Elliot and colleague’s (2003) investigated drivers’ intentions to comply with speed limits using TPB as a framework. The current study used Elliot et al.’s (2003) measures of intentions as a model. Unique self-report measures of intentions could also add to the complexity in interpreting insights about the impact of specific interventions on intentions. Finally, these results support Nemme and White’s (2010) suggestion to apply a multi-strategy approach in reducing the incidence of risky driving behaviors.

Transfer, Cognitive Load, and Workload

Results did not support the prediction that first-person text matched with first-person imaged would facilitate more accurate SJT scores (H5). However, there was a large effect of text perspective on SJTs. More participants in the condition with first-person text and top-down images answered the SJT correctly than all other conditions. The current study employed a combination of a transfer task and two subjective scales, including Paas’ cognitive load scale and the NASA-TLX global workload questionnaire. After participants completed the situational judgment transfer task, text and image perspectives had no effect on their cognitive load (H6) and global workload scores (H7). Cognitive load and workload were moderately positively associated. Correlations also revealed that participants who scored correctly on the SJT reported moderately lower workload scores than those who scored incorrectly.

Interpreting Cognitive Load

Workload scores can be interpreted across a variety of task domains (Grier, 2015), but it is challenging to interpret the cognitive load scale despite it being a well-established ubiquitous

scale. There are inconsistencies in the range of units used (e.g., seven or nine), the anchor labels applied (i.e., "very very high mental effort" in the original scale or "extremely easy" in others), and the timing of administration (i.e., during or post-learning) of this scale (de Jong, 2010; van Gog & Paas, 2008). There is also some inconsistency in how the outcomes of this measure are interpreted. There is no agreed-upon interpretation of the scale, so the self-reported values for the single-item scale vary widely in their meaning across studies. De Jong (2010) discussed examples of how the same values for level of effort or difficulty have been interpreted as the lowest (most beneficial) in one study and highest (most detrimental) in another.

A fundamental challenge in interpreting cognitive load measures is the lack of evidence that the three types of load can be separated through measurement techniques (De Jong, 2010). Kirschner et al. (2011) describe how researchers may use problematic circular arguments to explain the relationships among knowledge, mental effort, task difficulty, and the various types of load. For example, suppose learners perform poorly on a knowledge test but provide low mental effort ratings. Researchers could interpret the findings to (1) mean intrinsic load was high due to task difficulty or (2) the extraneous load was too high due to poorly designed instruction based solely on comprehension test performance. In another scenario, Paas and colleagues (2005) suggested low mental effort combined with low test performance can signal low task involvement. Learners could perform well on a knowledge test and rate their mental effort as high because they put forth high effort to process information and construct schemas (Paas & Van Merrienboer, 1993). Therefore, the instrument captured germane load but not the extraneous load imposed by the task difficulty (intrinsic load) or instructional characteristics (extraneous load). Using a workload measure alongside a measure of cognitive load may help with interpretation.

Workload

Workload's six subscales offer additional context and insight into aspects of a task's or a learner's potential contribution to subjective cognitive load. Correlations revealed that participants who reported higher cognitive load scores also reported moderately higher scores on the mental demand subscale and effort subscales of the NASA-TLX. Such a relationship provides evidence of the construct validity of the cognitive load scale used in this study. Paas' scale is intended to measure the participants' mental effort required to complete a task, but it is still unclear which type of load influenced mental effort. Reviewing third-person text and top-down images led participants to feel more frustrated when completing the transfer task than reviewing first-person text with top-down images. Additionally, pairing first-person text and top-down images increased SJT performance.

Participants scored low overall on the mental workload scale and answered the transfer task correctly. One goal of the design of this proposed intervention was to ensure the mental effort needed to complete a transfer task did not exceed a learner's resources. In other words, instructional material design, organization, and presentation should reduce extraneous load (Gerjets et al., 2009); while fostering schema construction and elaboration through germane load. This goal was achieved across all conditions as evidenced by the low workload scores, posing a challenge in differentiating specific perspective effects.

In a recent mixed methods study, Naismith et al. (2015) suggested that Paas' scale, the NASA-TLX Scale, and their own Cognitive Load Component Measure did not fully capture extraneous load and cannot be used to measure overall cognitive load. Thus, the results of the current study suggest that the cognitive load scale and NASA-TLX cannot be used interchangeably to measure the overall cognitive load learners experience when encountering a

transfer task. When used together, they provide additional insight into whether cognitive load is caused by internal, task, or instruction factors.

Lack of Text and Visual Perspective Effects on Outcomes

Complexity

In their review of multimedia learning, Carney and Levin (2002) found that pictures enhanced comprehension, especially when combined with complex text. Fiorella and colleagues (2017) noted that the first-person perspective effect was stronger for a complex assembly task than a simple task. Potentially, they suggested, low-complexity tasks do not overload the learners' limited working memory resources, so learners can better engage in mental transformations. Houts and colleagues (2006) reviewed research about the role of pictures in health communication in improving attention, comprehension, recall, and adherence. They suggested that pictures are successful in health communication contexts because patients may struggle to understand healthcare-related information, which is often unfamiliar, involves complex concepts and words, and is presented with technical terminology and phrasing. Most information presented in the current study was not highly complex, except for few specific topics and scenarios participants struggled to understand based on low item-level comprehension scores. Participants were also not required to perform a physical task like drive a simulator or make a difficult decision about a medical procedure. Certain types of knowledge or situations like the one presented in the current study may not be as sensitive to perspective.

Prior Knowledge

If a reader adopts a particular perspective before being exposed to text, they interpret certain information in the text as more important or relevant to the reader (e.g., Baillet & Keenan, 1986; Pichert & Anderson, 1978). After reading, learners can better recall perspective-

relevant than perspective-irrelevant text information (e.g., Baillet & Keenan, 1986). Previous studies have suggested the degree to which adopting a perspective impacts comprehension depends on a learner's prior knowledge about a text (Kaakinen & Hyona, 2008, 2011).

Mayer (2009) proposed an overarching individual differences principle across instructional design principles aligned with the cognitive theory of multimedia learning. Mayer claimed that "prior knowledge is the single most important individual difference dimension in instructional design. If you could know just one thing about a learner, you would want to know the learner's prior knowledge in the domain" (p. 193). Ultimately, instructional methods designed to reduce cognitive load may aid low-experience learners more than high-experience learners.

For example, Carney and Levin (2002) found that learners with low prior knowledge benefited most from pictures with regard to comprehension. Researchers have also described an expertise reversal effect in which images such as diagrams interfere with learning. Experts must integrate the existing schemas and knowledge they possess with graphical representations. Synthesizing redundant material in the form of images paired with text may interfere with learning due to the excessive cognitive load imposed on an expert, which reduces learning outcomes (Kalyuga & Sweller, 2005).

In the current study, participants were removed who reported high annual cycling mileage to target the intended audience of the intervention and control for discrepancies between novice and expert cyclists in (a) their risk perception and knowledge of laws guiding road-sharing behavior (Still & Still, 2019) and (b) outcomes based on the combination of images and text. All participants were required to have a driver's permit or license, and most reported seeing

a cyclist on the road; therefore, they had some prior knowledge of road-sharing with cyclists. Thus, the facts and scenarios presented to them were not entirely novel.

Although beyond the scope of the current study, it would be interesting to explore the effects of image perspective across a mix of various skill levels (e.g., novice, moderate, expert), as some research has suggested that prior knowledge can alter the advantage of animations and other visualizations (Hegarty & Kriz, 2008). Conversely, Schnotz and Wagner (2018) found the initial construction of learners' mental models was more text-based than picture-based: text provided learners with more conceptual guidance for understanding new information than pictures. When learners were required to perform a task following initial comprehension, students relied more on pictures as external tools. Instructional designers could apply these results through scaffolding and differentiating instruction. Offering an effective strategy for countermeasures to target specific audiences, text-based material could serve as a conceptual guide for initial comprehension. Learners should be provided with text, followed by sketches or low-fidelity imagery, full diagrams and pictures, and then integrated video clips as a learner's mental model develops and transitions through levels of learning.

Self-paced Learning

Within multimedia learning contexts, learner-controlled, self-pacing, or interactive learning environments allow participants to have control over the instructional content's pace, sequence, or presentation. Self-pacing is one method instructors can use when administering video, animated, and narrated instruction. Furthermore, it is relevant to written text and static images in instruction. In this study, a 20-minute limit was set; however, the overall presentation of educational materials was not system-paced. The material was shown as a single-page, endless-scroll format, and information was not presented in segmented screens. Participants were

able to control the overall pace of learning. Providing control over learning can positively influence learning and motivation (for a review, see Kinzie, 1990).

Tabbers and colleagues (2002) discussed how the simultaneous presentation of related text and graphics can reduce issues of splitting learner attention. When applying the recommendations posed within the context of multimedia theory, instructional designers need to balance the advantage of using system-paced auditory narration in reducing the split attention effect (i.e., modality) with the advantage of self-paced written text. Under self-paced presentation conditions, students are not exposed to the high extraneous cognitive load involved in searching for and matching related elements of information. In comparison, students presented with system-paced graphics and printed text must integrate spatially and temporally separated verbal and pictorial elements (Ginns, 2005; Mayer & Anderson, 1991). Visually presented text may be more effective during self-paced learning because students pay more or less attention to different elements of information according to their current knowledge levels. As Schnotz (2005) recommended for an integrated model of text and picture comprehension, written rather than spoken text may be ideal when picture complexity is low and learning time is unlimited.

Self-paced learning with static images and text may have reduced the sensitivity of the perspective effect on this study's outcomes. It gave participants adequate time to elaborate on the material, and it may have facilitated motivation and elaboration across conditions. However, the use of self-paced learning an intentional experimental design decision. The procedure employed in the study enhanced the ecological validity of the task to align with self-paced learning of DMV material while balancing fatigue and time-pressure induced stress on learning.

Effects of Sample Population on Outcomes

The covariate—the sample population—was significantly associated with some of the global and factor-level dependent measures. For example, MTurk workers did report higher perceived behavioral control over their safe road-sharing actions than ODU students. TPB posits that perceived behavioral control involves one's perceptions about how easy or difficult it is to perform a target behavior (Ajzen, 1991). Perhaps older participants who self-selected to take part in a study about cycling reported feeling more in control of their behavior and were more involved in learning the content than younger drivers who were less invested in the topic.

This finding aligns with Elliot and colleagues' (2003) investigation of drivers' compliance with speed limits. They found perceived control was a statistically significant independent predictor of intention. Age shared a statistically significant association with perceived control, indicating older drivers had greater perceived control than younger drivers in their study. Interestingly, they also found that drivers were more likely to base compliance intentions on their control perceptions if they complied with speed limits less often in the past. Again, if a countermeasure targets a diverse audience, a variety of strategies may be needed to produce effects, and multiple outcome measures may be needed to evaluate its effectiveness.

ELM proposes that interventions produce attitude changes through one of two processing routes: central or peripheral (Petty & Cacioppo, 1986). An individual's ability or motivation mediates the extent to which elaboration occurs (Petty & Cacioppo, 1986; Petty & Wegener, 1999). When motivation or ability levels are high, elaboration is also high, and the message is processed centrally. Conversely, when motivation/ability levels are low, elaboration is also low, and the message is likely processed peripherally. Peripheral cues facilitate a message's impact on attitudes (e.g., the number of arguments presented instead of the quality of the content; Petty &

Cacioppo, 1984). Central processing may also produce longer-lasting attitudes than peripheral processing (Petty & Cacioppo, 1986; Petty et al., 1995).

An individual's level of involvement with information has been shown to influence their level of motivation and ability to elaborate (Chaiken, 1987; Grunig & Grunig, 1989; Krugman, 1965; Petty & Cacioppo, 1986). An individual is highly involved with an issue if they perceive it has some direct impact on their life (Perloff, 1993). If a message is important to a reader, they will pay more attention to it than if it had no personal impact (Petty & Cacioppo, 1986). If a learner is willing to invest the mental effort needed to learn, they may have improved learning outcomes (Paas et al., 2005).

Limitations and Future Work

There are several limitations of this study that could be addressed in future research.

Situational Judgment Transfer Task

The transfer task in this study may have approached a ceiling effect. Across experimental conditions, most participants (86%) chose the correct response to the closed SJT. Using a closed, single-item SJT with image-based cues may have been too easy for participants and less sensitive to the experimental manipulations of perspective. Knowledge-elicitation methods using an open-ended question requiring free recall may be a better measure of transfer in this context to ensure participants have authentically learned, retained, and applied the new information (Bloom et al., 1956).

Pairing first-person text and top-down images increased SJT performance. The images in the transfer task were presented only from the top-down, so it is unclear why learning the material with first-person text and top-down images may have reduced frustration during a transfer task when these images were also shown from the top-down. Including the top-down

images in the instructional material may have enhanced the participants' cognitive capacity by "offloading" the cognitive processing needed to interpret the images (Schnotz, 2005). However, this phenomenon does not fully explain how a first-person perspective would also facilitate reduced load when paired with top-down images.

Sample Size and Statistical Power

A second potential limitation of the study is there may be insufficient power to detect the hypothesized small effects due to an inadequate sample size. While 126 participants (or 31 in each experimental group) were recommended based on the *a priori* power analysis, 105 participants were included in the final analysis after data cleaning. Most analyses did include fewer than 25 participants in some groups, which could increase Type 2 error rates. When examining means, significance levels, and effect sizes, null effects are less likely to be attributed to a low sample size. Controlling for individual differences like cycling mileage and sample population reduced the sample included in analyses. However, doing so increased the validity and rigor of the overall design, method, and statistical analyses. The body of literature about first-person perspectives would benefit from additional research to determine more conclusively whether the current results are replicable in other contexts, with larger samples, and for different learners.

No Direct Comparisons with Full Original Handbook

In the first study, the original handbook was not compared with the redesigned brochure or the re-organized version of the handbook. Changes were made to the existing handbook and brochure to design a valid experiment (see Appendix A). No direct comparison was made between the experimental manipulations and the full 55-page handbook that includes references to pedestrians. More research is needed to compare the original, unrevised handbook to the

versions developed for the current studies. In the second study, text perspectives and visual perspectives were combined but not compared directly with the images used in the original handbook. Of particular interest is whether removing extraneous information—like text and image references to pedestrians—across all material facilitated better comprehension or impacted intentions. As per cognitive load theory, the coherence principle refers to the “weeding” of text, audio, and graphics that do not support the goals and objectives of instruction (Clark & Mayer, 2016; Mayer & Moreno, 2003).

Such comparisons against existing educational countermeasures would uncover the specific design elements in the redesigned materials that would be most effective in improving cognitive and affective learning outcomes. More research is necessary overall to understand how best to apply both text and visual perspective components to multiple outcome measures. Until this is accomplished, it is unclear whether first-person text and image perspectives could be leveraged with uniform success in countermeasures targeting safe road-sharing behaviors.

CHAPTER X

CONCLUSION

A variety of countermeasures are implemented to tackle the problem of unsafe road-sharing behaviors, such as law enforcement, road signage and lane markings, and education programs. Unfortunately, driver education programs are not broadly effective in reducing crash rates with road users (Venkatraman et al., 2021). Drivers and cyclists lack an alignment of road-sharing knowledge and attitudes, which results in hundreds of unnecessary cyclist fatalities each year in Virginia. Hoekstar and Wegman (2011) suggest that the first step in developing a potential education countermeasure like a road safety training program or awareness campaign is to pretest the material through experimental methods to determine the strength of the planned effects. Those recommendations were applied through two small-scale experimental studies designed as a starting point of investigation into a potential theory-driven education countermeasure targeting safe road-sharing behaviors between cyclists and drivers. The current research sought to translate widely used health communication methods, psychosocial behavior theory, and instructional design theory to redesign educational material intended to foster Virginia drivers' knowledge of road rules described in a Virginia road-sharing handbook, self-evaluations of that knowledge, attitudes toward cyclists, and behavioral intentions to have safe future interactions with cyclists.

Based on the Elaboration Likelihood Model (ELM; Petty & Cacioppo, 1986), educational countermeasures must present information that captures drivers' interest by being personally relevant and facilitating elaboration and synthesis of new information with their existing knowledge (Slater, 2002; Wundersitz et al., 2010). Health-related education and communication designers incorporate first-person narrative perspective to achieve these instructional goals. First-

person perspective, through elaboration, also influences affective learning outcomes like attitudes (De Graff et al., 2016; Winterbottom et al., 2008). According to the Theory of Planned Behavior framework (TPB; Ajzen, 1991), positive attitudes about a behavior increase the likelihood of behavioral intentions, which are then associated with behavior outcomes (Webb & Sheeran, 2006).

The first study investigated first- and third-person perspective text information, and the second study employed the Cognitive Theory of Multimedia Learning (CTML; Mayer, 1997) to text and image perspectives on cognitive and affective learning outcomes related to safe road-sharing behavior. Cognitive load, multiple knowledge types, and individual comprehension test items were considered when evaluating the efficacy of incorporating first-person perspective text and images into educational material. The current research also controlled for individual differences that can impact the efficacy and strength of interventions. Across both studies, the first-person perspective effect found in the health education and communication domains did not translate broadly across outcomes to this specific road-sharing context. Narrative instruction is used across disciplines under the assertion that it provides effective instructional outcomes. Given the diversity of narrative characteristics and effects found across disciplines, continued research is warranted to understand which narrative components facilitate specific outcomes and whether those components translate to other domains. By targeting the perspective of the narrator or audience, the current work contributed to the theoretical understanding of this specific narrative instruction component which is thought to facilitate a variety of learning outcomes.

The overall practical contribution of the current research was the redesigned brochure version of an existing Virginia road-sharing handbook. Well-established principles of instructional, organizational, and visual design were applied to create the new material. For

example, signaling and cueing strategies (e.g., headings and color blocking) were used to attract the learner's interest to relevant parts of the instruction and to improve learning by reducing extraneous cognitive load (Schneider et al., 2018). While the proposed experimental manipulations of first-person perspective had limited effects on outcomes, the redesigned brochure did improve declarative knowledge and behavioral intentions. In the context of cognitive load theory (CLT; Chandler & Sweller, 1991), poor quality instructional material design, organization, and presentation can impose extraneous load on learners (Cierniak et al., 2009). Small, evidence-based design changes like the ones applied in these studies could facilitate early cognitive learning levels, such as general declarative knowledge, and affective learning levels, like awareness of the road-sharing problem (Bloom et al., 1956; Krathwohl et al., 1973). Additional research is needed to evaluate the efficacy of translating these design decisions to other transportation scenarios. The lack of evidence for first-person perspective and the efficacy of small design changes may help researchers, policymakers, and instructors prioritize approaches to developing countermeasures to improve safety on the road (Brookshire et al., 2016).

The current research applied a multiple discourse approach by integrating multiple literatures. Sleet et al. (2007, 2011) calls on experts working in the road safety domain to adopt an interdisciplinary perspective, integrating expertise from transportation, traffic psychology, health psychology, environmental psychology, engineering, medicine, political science, and public health. Ultimately, a combination of road safety countermeasures will be needed to address the complex ways in which human, engineering and technology, and environmental factors interact. A collaborative translational research approach is needed to bring together strengths, perspectives, and weaknesses across disciplines (Parrott, 2008).

Future education countermeasures intended to improve road-sharing safety outcomes with cyclists must, at a minimum, incorporate instructional design principles, apply theory-driven approaches that enable drivers to connect new information to their existing knowledge, and target a combination of cognitive and learning outcomes. While more research is needed in this area, the goal must be to apply evidence-based practices to increase the likelihood that drivers will learn how to share the road safely with cyclists but also modify their behaviors. Doing so has the potential to keep cyclists safe on the road and save lives.

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APPENDIX A

HANDBOOK REDESIGN

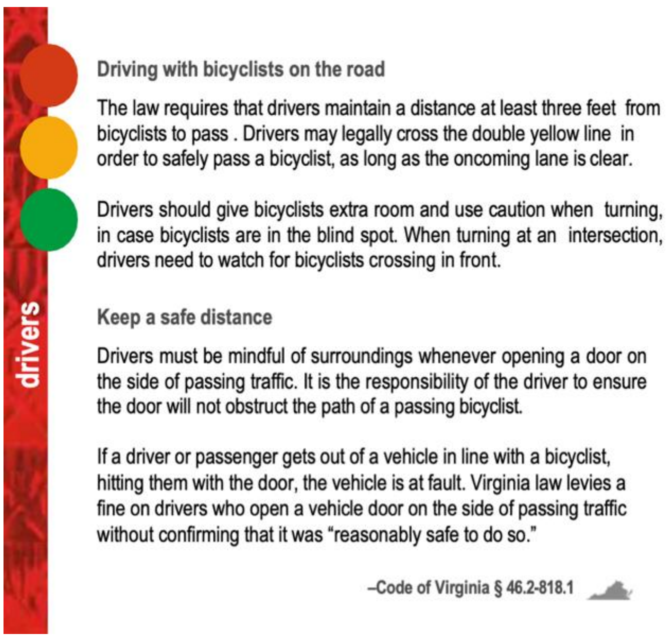
My overall practical contribution to this is work is a revision of an existing Virginia road-sharing handbook Figure 15). In this appendix, I provide an overview of all design changes made to develop the stimuli for the current research. Overall improvements were made across all material, and additional visual and organizational improvements were made to create a second redesigned brochure.

Overall Improvements

In an effort to design a valid and fair comparison between the revised handbook and redesigned brochure conditions, incremental design changes were made to all stimuli before adjusting the first-person and third-person perspective. For example, the existing 55-page version was reduced to 14 pages to mitigate potential participant fatigue when reviewing material in a single experimental session and to ensure only the most relevant information was included across conditions. To design a controlled experimental manipulation, a total of 57 references to pedestrians were removed to target cyclist and driver interactions (Figure 16). Both design changes align with recommendations to remove or "weed" extraneous details like words or that are irrelevant to the instructional goals (i.e., coherence principle; Mayer & Moreno, 2003). Participants were assessed specifically on their knowledge of sharing the road with cyclists, which was the study's focus.

Figure 15

Sample of Existing Share VA Roads Handbook



To maintain consistent terminology across all stimuli, "motorists" was replaced with "drivers," "bikes" was replaced with "bicycles," and any references to second-person perspective ("You") was replaced with the corresponding perspective for the perspective-based independent variable. There were also no images in the revised handbook or redesigned brochure versions of the educational material. Overall, all stimuli included the same text-based content, but the redesigned brochure was more organized, visually appealing, readable, and usable.

Figure 7

Example of Information About Pedestrians in the Existing Handbook

Pedestrians' Side of the Road

Pedestrians must walk facing traffic

Walk LEFT
When there is no sidewalk or shoulder, PEDESTRIANS may walk as near as practicable to an outside edge of the roadway. It is safest to walk facing traffic.

Ride RIGHT
MOTORISTS and BICYCLISTS use the right side of a two-way road.

Turning Vehicles

Pedestrian crossing

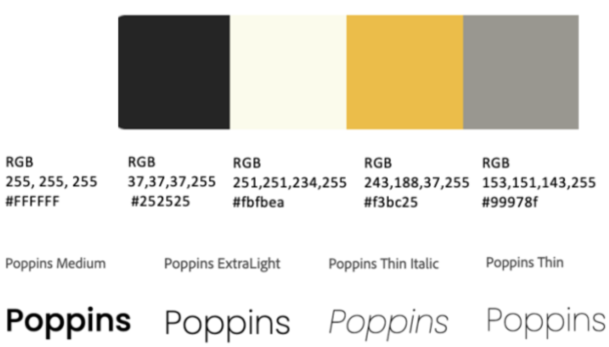
To make sure they are seen, pedestrians should make eye contact with drivers, particularly those turning right.

Redesigned Brochure

Collaborating with a User Experience Designer, the revised handbook was updated further as a redesigned brochure by applying human-centered design (HCD) or user-centered design (UCD) principles. Numerous visual design principles can be carefully balanced to ensure that information was visually appealing, understandable, and usable. These principles help inform the process of applying specific elements such as line, scale, alignment, contrast, shape, color, grid, or space (Poulin, 2018). Designers also apply well-researched Gestalt principles based on how humans perceive and organize visual information (Pomerantz & Portillo, 2012). Similarity, continuation, color, closure, proximity, figure/ground, and symmetry help ensure information is appealing and usable. Icons from Font Awesome, an open-source iconography project, were used for each major section of the brochure.

Designers can also ensure text-based information is presented concisely, legibly, consistently, in proper sequence, and with clear typography and color. Within Edward Tufte's information design work, he proposes four essential guidelines for telling compelling stories through visual information representation: Graphical excellence, visual integrity, maximizing the data-ink ratio, and aesthetic elegance (e.g., Tufte et al., 1998). Poulin (2018) also describes how crucial it is for instructional designers to apply these visual design principles and help reduce distractions, increase learnability, and allow learners to devote their cognitive effort to learning the educational material at hand.

Design guide for redesigned brochure:

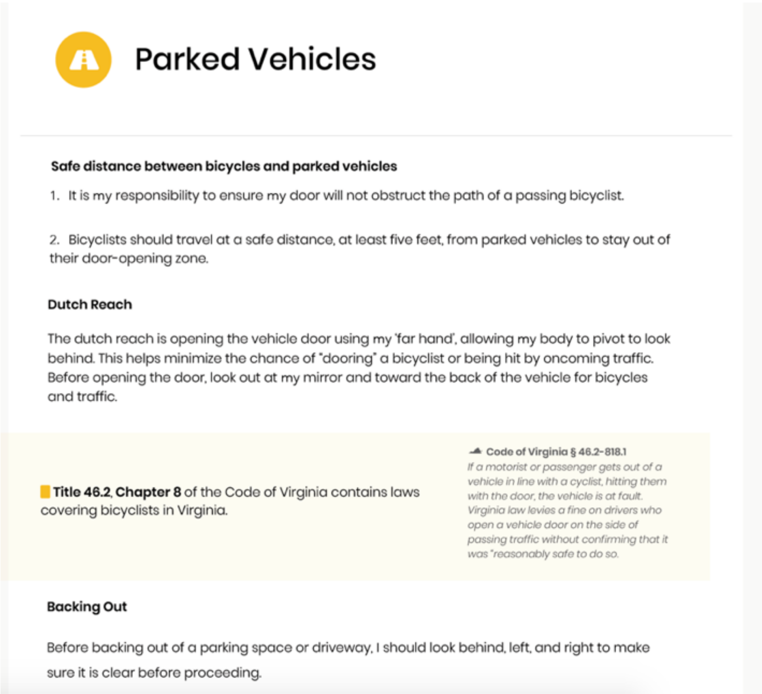


Next, the major headings of the content were organized to align with the location of road-sharing activities. The content is currently organized into three sections based on the road user: Cyclists, drivers, and pedestrians. The re-organization of material by location reduces redundancies across each section and ensures the information is presented with a shared understanding of laws and best practices. For example, 22 references to sidewalks were condensed and how each entity on the road accesses them across multiple sections in the handbook. The design, organization, and categorization of information also plays a role in the perception and memorability of that information (e.g., memory consolidation). Related information is better remembered than unrelated facts or uncategorized items. Participants tend to remember categorized lists better than uncategorized lists in recall tests (Bousfield, 1953; Bower et al., 1969).

Finally, the existing handbook is presented in two formats: (1) A downloadable PDF that is paginated on the longest side of the page like a print booklet, and (2) a website with discreet sections for motorists, bicyclists, and pedestrians. The brochure was redesigned to better facilitate reading online: (1) A downloadable PDF with an endless scroll style of pagination (Figure 17) and (2) a sidebar navigated webpage. For the current studies, participants were exposed only to PDF versions of stimuli within a survey. All stimuli were presented in an endless scroll format embedded within Qualtrics.

Figure 8

Sample of Redesigned Brochure



APPENDIX B

COLLEGE OF SCIENCE EXEMPT FROM IRB STATUS LETTER

OLD DOMINION UNIVERSITY

aaalac INTERNATIONAL PROUDLY, AN AAALAC ACCREDITED PROGRAM

OFFICE OF THE VICE PRESIDENT FOR RESEARCH

Physical Address
4111 Monarch Way, Suite 203
Norfolk, Virginia 23508
Mailing Address
Office of Research
1 Old Dominion University
Norfolk, Virginia 23529
Phone(757) 683-3460
Fax(757) 683-5902

DATE:	April 6, 2020
TO:	Jeremiah Still, PhD
FROM:	Old Dominion University Sciences Human Subjects Review Committee
PROJECT TITLE:	[1586493-2] Improving road-sharing knowledge and attitudes with an educational campaign
REFERENCE #:	
SUBMISSION TYPE:	Revision
ACTION:	DETERMINATION OF EXEMPT STATUS
DECISION DATE:	April 6, 2020
REVIEW CATEGORY:	Exemption category # *[enter category]*

Thank you for your submission of Revision materials for this project. The Old Dominion University Sciences Human Subjects Review Committee has determined this project is EXEMPT FROM IRB REVIEW according to federal regulations.

We will retain a copy of this correspondence within our records.

If you have any questions, please contact Chris Osgood at 757-683-6778 or cosgood@odu.edu. Please include your project title and reference number in all correspondence with this committee.

This letter has been electronically signed in accordance with all applicable regulations, and a copy is retained within Old Dominion University Sciences Human Subjects Review Committee's records.

APPENDIX C

INFORMED CONSENT FORM

Improving road-sharing knowledge and attitudes with an educational campaign

You are invited to participate in research study that examines the potential impact of an educational campaign on road users' knowledge and attitudes about sharing roadways in Virginia. This study is being conducted by researchers at Old Dominion University in Norfolk, Virginia.

The purposes of this page are to give you information that may affect your decision to say YES or NO to participation in this research, and to record the consent of those who say YES. This is an online study consisting of several tasks requiring you to review educational material and respond to a series of survey questions.

Please read this form and contact the researcher or responsible principal investigator with any questions you may have before agreeing to be in the study.

Road users (drivers and cyclists) may have different expectations and knowledge about the rules or laws governing safe road-sharing behavior. State driver manuals and licensing exams address how different road users can safely share the road, but many states do not emphasize relevant state laws or safety recommendations. Education and awareness campaigns are designed to improve road safety using different methods, but there are inconsistencies in their effectiveness.

The overall aim of the current research is to advance the scientific understanding of how to improve the safety of road users' interactions on roadways through educational campaigns.

Procedures:
If you agree to be in this study, you were asked to complete an online study consisting of several tasks requiring you to respond to survey questions. First, we will gather some information about your general road use experience (for example, how many years have you been driving a motor vehicle or riding a bicycle?) and other general information about yourself. Next, you will review text-based and/or image-based information and scenarios related to using Virginia roadways. In the final part of the study, you will complete a survey that includes some questions about your knowledge, opinions, and attitudes, and the mental effort required to complete the study. The study consists only of online information for you to review and the online survey questions. Most of the survey items described above are answered by selecting an option or using a rating scale, but some survey items do require short, open-ended responses.

Exclusionary Criteria:
To participate, you must be age 18 and over. You must have passed a Virginia driver's licensing or learner's permit exam to participate. You must have normal or corrected-to-normal vision. Therefore, if you normally wear eyeglasses or contact lenses you will need to wear them to participate.

Risks and Benefits of being in the Study

ODU: There are no direct risks to participants in this study. There are not direct benefits to participants in this study. The main indirect benefit to you for participating in this study is the research credit, extra credit or course credit points you will earn for your class. You will also be helping scientists improve road safety educational campaigns in Virginia.

MTurk: There are no direct risks to participants in this study. There will be no costs for participating. Benefits of participating include payment from Amazon and helping scientists improve road safety educational campaigns in Virginia.

Compensation

ODU: The researchers want your decision about participating in this study to be absolutely voluntary. Although they are unable to give you payment for participating in this study, if you decide to participate in this study, you will receive 1.0 Psychology Department SONA research credits (1 OFF Study), which may be applied to course requirements or extra credit in certain Psychology courses. Equivalent credits may be obtained in other ways. You do not have to participate in this study, or any Psychology Department study, to obtain this credit.

***MTurk*:** The researchers want your decision about participating in this study to be absolutely voluntary. For completing the full HIT, participants will receive a payment from Amazon in the amount of $1-5.

Confidentiality

ODU: The individual results of this study were kept private. In any sort of report that might be published, no information that could be used to identify an individual participant were included. Research records were stored securely and only the researcher will have access to the records.

MTurk: The individual results of this study will be kept private. In any sort of report that might be published, no information that could be used to identify an individual participant will be included. Research records will be stored securely and only the researchers will have access to the records. Researchers will have access to your MTurk worker ID which may be able to link to your personal information on your Amazon public profile page, depending on your settings you have on your Amazon profile. The study will not be created with Amazon's survey software, so the company will not have access to this data.

Voluntary Nature of the Study:
Participation in this study is voluntary. Your decision to participate or not participate will have no impact on your current or future relations with Old Dominion University. If you decide to participate, you are free to not answer any question or withdraw at any time without affecting those relationships.

Contacts and Questions:
The researcher for this study is Alex Proaps. If you have questions before beginning the study or while completing the study, **you may reach her at aproa001@odu.edu**. The responsible project investigator for this study is Dr. Jeremiah Still. If you have any questions, **you are encouraged** to contact him at jstill@odu.edu or at 757-683-6426.

If at any time you feel pressured to participate, or if you have any questions about your rights or this form, then you should call Dr. Tancy Vandecar-Burdin, the current IRB chair, at 757-683-3802, or the Old Dominion University Office of Research, at 757-683-3460.

Please print a copy of this information to keep for your records.

Statement of Consent:
I have read the above information. I have asked questions and have received answers. By checking the box below, I am indicating my consent to participate.

- ☐ I consent to participate in this study

APPENDIX D

DRIVING/CYCLING EXPERIENCE QUESTIONNAIRE (STILL & STILL, 2019)

1. Do you have a current Virginia-issued driver's license or learner's permit to operate a motor vehicle?
    a. Yes / No >> *Screenout if No*

2. Have you ever driven a motor vehicle? Yes / No >> *Screenout if No*

3. Age >> *Screenout if under 18*

4. Gender: *M / F / Other / Prefer not to answer*

5. What is the highest level of education you have completed?
    a. *MCSR Rating Scale:* Some high school; GED; Some college; Associate degree; Bachelor's degree; Graduate degree (e.g., MD, Master's)

6. What is your average household income? *Textbox*

7. How long have you lived in Virginia? *Textbox*

8. How many years have you driven a motor vehicle? *Textbox*

9. How often do you drive a motor vehicle?
    a. *MCSR Rating Scale:* Less than once a month, Once every couple of weeks, 1-4 days a week, 5 or more days a week

10. Approximately how many miles do you drive each year? *Textbox*

11. Do you have any specific expertise in driving (e.g., chauffer's license, racing)? *Yes / No*
    a. *Textbox:* If so, briefly describe:

12. Have you ever ridden a bicycle? *Yes / No*

13. How many years have you been riding bikes on the road? *Textbox*

14. How often do you ride a bicycle?
    a. *MCSR Rating Scale:* Less than once a month, Once every couple of weeks, 1-4 days a week, 5 or more days a week

15. Approximately how many miles do you ride each year? *Textbox*

16. Do you have any specific expertise in cycling (e.g., mountain bike or road racing, cycling tour guide)?
    a. *Textbox:* If so, briefly describe:

17. When you are driving your motor vehicle, approximately how often do you see cyclists along the route?
    a. *MCSR Rating Scale*: Every drive, Daily, a few times a week, a few times a month, a few times a year

18. When you are driving your motor vehicle, approximately how often do you experience frustration related to cyclists on the road?
    a. *MCSR Rating Scale:* Every drive, Daily, a few times a week, a few times a month, a few times a year

19. When you are driving your motor vehicle, approximately how often have you had what you consider to be a close call with a cyclist?
    a. *MCSR Rating Scale:* Every drive, Daily, a few times a week, a few times a month, a few times a year

APPENDIX E

JUDGMENT OF LEARNING QUESTIONNAIRE

Instructions: Please rate your level of confidence about the following statements.

Rating scale: 1 = Strongly disagree; 5 = Strongly agree

Items:

1. I know the laws that govern riding a bike in Virginia.

2. I know the laws that govern motorists' interactions with bicyclists.

3. I know how many feet is considered the legal distance in Virginia for a motorist to safely pass a bicyclist on a busy road.

APPENDIX F

COMPREHENSION TEST

Directions: Please read the instructions carefully before answering each question. Do not use any outside material, notes or websites to help you complete the questions. You will have 10 minutes to complete this page. You may exit the page by clicking Next when you are ready - if you want to move on before the 10-minute allotted time is up.

1. A bicyclist under the Virginia Vehicle Code: (*Declarative/Law*)
    a. Does not need to follow the same laws as drivers of vehicles.
    b. Has the same rights and responsibilities as drivers of vehicles.
    c. Has the same rights and responsibilities as pedestrians on highways.
    d. Must always yield to other vehicles.

2. If no bicycle lanes or shared lane markings are present a driver has complete right-of-way on the road. (*Declarative*)
    a. T/**F**

3. When it comes to driving near bicycles, it is a good habit to: (*Declarative*)
    a. Never pass the bicycle under any circumstances
    b. Be prepared to stop suddenly when approaching a bicycle
    c. Give bicycles 1 foot of space to the right when passing them
    d. Speed up to pass the bicycle to get out of their way

4. Bicyclists signal a left turn when they look over their shoulder and then: (*Procedural*)
    a. hold out the right arm with the elbow bent downward
    b. hold the left arm up with the elbow bent upward
    c. motion with the left hand by waving it
    d. hold the left arm out straight

5. A bicyclist stopped at a red light at an intersection that has both a bicycle lane and a "right turn only" lane and intending to go straight should be: (*Procedural*)
    a. in the bicycle lane.
    b. in the "right turn only" lane.
    c. in the travel lane next to the "right turn only" lane.
    d. on the sidewalk.

    - Addition to Study 2: An experienced, confident bicyclist stopped at a red light

6. Which of the following statements is true of bicycle lanes? (*Declarative)*
    a. Drivers do not need to check mirrors to scan to the rear and sides for bicyclists before turning
    b. These lanes are marked with red dotted lines
    c. These are lanes designated for the preferential use of bicyclists
    d. Drivers can park in a bicycle lane when traffic is not busy

7. Bicyclists are required by law to ride on the sidewalk when a sidewalk is available. (*Declarative/Law*)
    a. T/**F**

8. At an intersection without a separate right-turn and bicycle lane, (*Procedural*)
    a. Drivers should provide space for bicyclists to merge into a single-file line among cars
    b. Right-turning vehicles should pass a through-moving bicycle.
    c. Through-moving bicycles should use the sidewalk if there is no bicycle lane at an intersection.
    d. Bicycles making a right turn should use the sidewalk.

9. Drivers may only approach and pass bicyclists if there were a safe gap of at least ____ between the vehicle and the bicycle. (*Declarative/Law*)
    a. an arm's length
    b. 1 foot
    c. 3 feet
    d. 5 feet

10. When riding on an ordinary width lane, bicyclists should always ride near the center of the lane if the distance is safer for them between the curb and the next lane. (*Declarative*)
    a. **T**/F

11. Sharrows are (*Declarative*)
    a. sidewalks used by cyclists.
    b. bicycle lanes dedicated to bicyclists only.
    c. road lanes that encourage bicyclists to ride in the lane with vehicles.
    d. road signs with a bicycle symbol and an arrow pointing down to the road.

12. It is safe and legal for bicyclists to ride on which side of the roadway? (*Procedural/Law*)
    a. Against the traffic flow (facing traffic; left side for two-way streets).
    b. With the traffic flow (right side for two-way streets)
    c. It depends on whether it’s a one-way or two-way street
    d. A bicyclist may choose to ride either with or against the traffic flow

13. Which of the following statements is true about passing a bicycle on a two-lane road with a dashed line? (*Procedural*)
    a. If there is no oncoming traffic in the opposing lane, drivers may change lanes to maintain a safe distance from the bicycle.
    b. Drivers cannot pass the bicycle on a two-lane road
    c. The recommended safe passing distance is 5 feet.
    d. Drivers may not change lanes to maintain a safe distance from the bicycle.

14. The Dutch Reach refers to: (*Declarative*)
    a. Reaching your hand out the window to make a hand signal that you are turning.
    b. Opening the car door using the right hand to allow the body to pivot to look behind you.
    c. Unbuckling the seatbelt with the left hand to allow the body to see the right mirror.
    d. Adjusting the rearview mirror to check for bicycles.

15. If a bicyclist makes a sudden change in behavior on the road, it is most likely due to (*Procedural*)
    a. the bicyclists seeing debris in the road that is unsafe.
    b. a mechanical problem with the bicycle.
    c. the bicyclists taking a lot of risks on the road.
    d. another vehicle moving too closely to the cyclist

16. Bicyclists are not required to come to a complete stop at red traffic signals and stop signs. *(Procedural/Law)*
    a. **T**/F
    - *Note this research took place before the law changed.*

17. Code of Virginia § 46.2-839 states that any vehicle overtaking a bicycle [...] proceeding in the same direction shall: (*Procedural/Law*)
    a. pass bicycles at a reasonable speed when overtaking them
    b. overtake a bicycle on a two-lane highway when proceeding in a different direction
    c. pass one foot to the left of the overtaken bicycle
    d. yield the right of way to bicycles driving on sidewalks

18. Drivers do need to look left-right-left for bicycles before: (*Procedural*)

a. Turning right on red
b. Crossing an intersection
c. Backing out of a parking space
d. All of the above

19. If a motorist opens a parked vehicle door and hits a cyclist, the cyclist is at fault because (*Procedural/Law*)
    a. Cyclists are required to maintain at least 5 feet from parked cars
    b. Cyclists should use the sidewalk next to parked cars, not the road
    c. Both a and b are correct
    d. The driver, not the cyclist, is at fault according to Virginia law

20. It is legal in Virginia for drivers to wear headphones/earbuds in both ears while on the road. (*Declarative/Law*)
    a. **T**/F

APPENDIX G

BEHAVIORAL INTENTIONS QUESTIONNAIRE

Instructions: Please rate your agreement with the following statements

Rating scale: 1 = Strongly Disagree; 5 = Strongly Agree

Items:

1. I do not intend to learn more about how I can share the road with cyclists safely in the next 12 months. *[Behavioral intention item; reverse scored]*

2. I have decided to learn more about the laws about how drivers should share the road with cyclists in my city in the next 12 months. *[Behavioral intention item]*

3. I am determined to only pass a cyclist on a road if I can safely maintain the legal distance between myself and the cyclist in the next 12 months. *[Behavioral intention item]*

4. For me, sharing the road with cyclists in my city is not easy at all. *[Perceived control item; reverse scored]*

5. If I wanted, I could follow all the laws related to sharing the roads with cyclists in my city in the next 3 months. *[Perceived control item]*

6. If it were entirely up to me, I am confident that I would only pass a cyclist on a buy road if I could safely maintain the legal distance between myself and the cyclist in the next 3 months. *[Perceived control item]*

7. People who are important to me would not want me to know the local laws and safety recommendations related to cars and bicycles sharing the road. *[Social norm item; reverse scored]*

8. Most of the people who are important to me would recommend that I practice safe driving behaviors around bicycles on busy roads. *[Social norm item]*

9. Most of the people who are important to me do not follow the laws related to sharing the roads with cyclists. *[Social norm item]*

APPENDIX H

ATTITUDES TOWARD CYCLISTS QUESTIONNAIRE (RISSEL ET AL., 2002)

Instructions: Rate how much you agree with the following statements.

Rating scale: 1 = Strongly Disagree; 5 = Strongly Agree

Items:

1. It is very frustrating sharing the road with cyclists.
2. Cyclists should not be able to ride on main roads (without cycle tracks) during peak hours
3. Many cyclists take no notice of road rules
4. Cyclists have just as much right to use the road as motorists *(Reverse scored)*
5. Most cyclists are aware of other road users and keep out of their way *(Reverse scored)*
6. It is safer for cyclists to keep to the left of the lane.
    - *Change for Study 2:* It is safer for cyclists to keep to the right of the lane.
7. Drivers are not trained to look out for cyclists *(Reverse scored)*
8. Cyclists are courteous on the road to motorists *(Reverse scored)*
9. Many cyclists on the road have not learned to ride properly
10. Motorists need to be educated to give cyclists a fair go on the road *(Reverse scored)*
11. If cyclists want equal rights on the road, they should pay registration fees or road taxes
12. Drivers should change lanes when overtaking cyclists rather than veering around them *(Reverse scored)*

APPENDIX I

ATTENTION CHECK AND COGNITIVE STRATEGIES

Attention Check Items

1. The color test is simple, when asked about a color, you must enter the word purple in the textbox below. Based on the text you just read above, what color have you been asked to enter in the textbox?
    a. *Textbox*

2. Which of the following activities have you done today?
    a. Flew to the moon
    b. Participated in an online research study
    c. Bought ten bicycles

3. Please select "Somewhat agree" below.
    a. Strongly agree
    b. Somewhat agree
    c. Neither agree nor disagree
    d. Somewhat disagree
    e. Strongly disagree

4. I am a student enrolled at Old Dominion University
    a. T/F

5. Note:
    a. MTurk workers will receive the following question instead of #4: I am an MTurk worker
    b. T/F

Cognitive Strategies Item

1. Did you use any strategies to efficiently and effectively learn the material you were presented with today?
    a. Yes >> *Next Question*
    b. No >> *Skip to Debrief (Study 1) or Transfer Task (Study 2)*
    c. Not Sure/Don't Know *Skip to Debrief (Study 1) or Transfer Task (Study 2)*

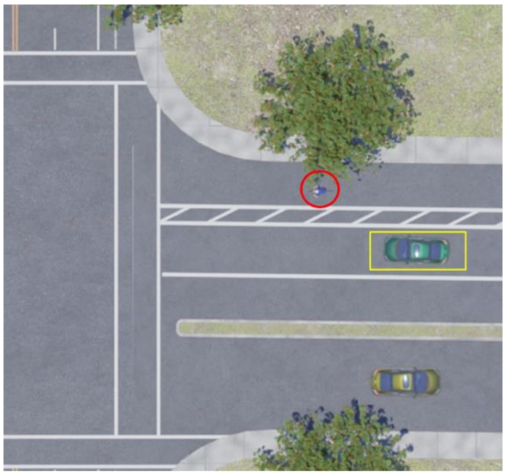
2. Tell us more about the strategies you used to more efficiently and effectively learn the material you were presented with today.
    a. *Conditional to Yes*

APPENDIX J

SITUATIONAL JUDGMENT TASK

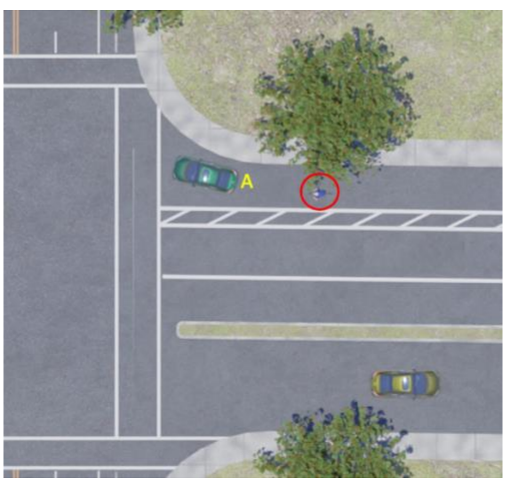
Directions: Please carefully review the following information before answering the multiple-choice question on the page.

The driver in the image is planning to turn right. The bicyclist in the image has not used a hand signal and is staying in the dedicated bicycle lane. The traffic light at the intersection has turned green signaling it is safe for the driver to turn.

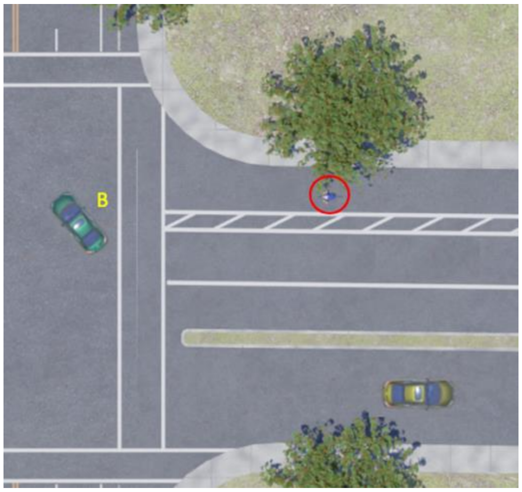


In the above scenario, what should happen next?

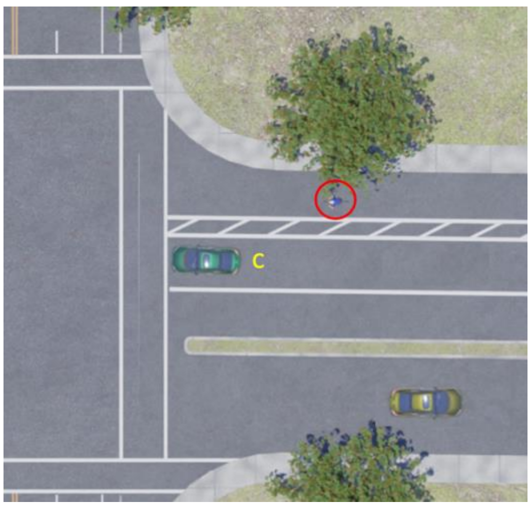
A. The driver should pass the bicyclist, merge into the bicycle lane ahead of the bicyclist, and turn right.



B. The driver should pass the bicyclist and cross the intersection, and the bicyclist should wait for the driver to turn before crossing the intersection



C. The driver should stop at the intersection, wait for the bicyclist to cross the intersection, and merge into the bicycle lane to turn right.



APPENDIX K

COGNITIVE LOAD SCALE AND NASA TASK LOAD INDEX (NASA-TLX)

Workload Questionnaire (NASA-TLX; Hart & Staveland, 1988)

Instructions: Select the location on each scale that represents the magnitude of each factor in the task you just performed.

Rating scale: 1 = Very Low; 7 = Very High

Items:

1. Mental Demand - How mentally demanding was the task?
2. Physical Demand - How physically demanding was the task?
3. Temporal Demand - How hurried or rushed was the pace of the task?
4. Performance - How successful were you in accomplishing what you were asked to do?
5. Effort - How hard did you have to work to accomplish your level of performance?
6. Frustration - How insecure, discouraged, irritated, stressed, and annoyed were you?

Cognitive Load Scale (Paas, 1992)

Rating scale: 1 = Very, very low mental effort; to 9 = Very, very high mental effort

1. How much mental effort did you invest in solving this problem?

APPENDIX L

EXPERIMENTAL DEBRIEF

Thank you for participating in our study!

Road users (drivers and cyclists) may have different expectations and knowledge about the rules or laws governing safe road-sharing behavior. The overall aim of the current research is to provide information that would advance the scientific understanding of motorists' road-sharing knowledge, attitudes, and intentions. Another goal of the current research is to provide information that could be used to improve educational and awareness campaigns. Specifically, you were a participant in one of two experimental studies to understand the effectiveness of a potential text-based and imagery-based road-sharing messaging and instructional design strategy.

Study 1:

1. **Third-person perspective group:** You reviewed sections of a Virginia handbook about how drivers and cyclists can share the road safely that the researchers rewrote into a third-person, driver's perspective. Writing information from that viewpoint sometimes helps learners better comprehend information or change their attitudes about certain information.

2. **First-person perspective group:** You reviewed sections of a Virginia handbook about how drivers and cyclists can share the road safely that the researchers rewrote into a first person, driver's perspective. Writing information from a learner's viewpoint can help learners better comprehend information because it can convey meaningful context and allows learners to make meaningful connections with their own experiences and perspective.

Study 2:

1. **Bird's eye view group:** You reviewed sections of a Virginia handbook about how drivers and cyclists can share the road safely. Researchers redesigned or added images to the handbook that showed only a top down, bird's eye view perspective.

2. **First-person perspective group:** You reviewed sections of a Virginia handbook about how drivers and cyclists can share the road safely. Researchers added images to the handbook from a first-person, driver's perspective. Presenting information from a learner's viewpoint can help learners better comprehend information because it can convey meaningful context and allows learners to make meaningful connections with their own experiences and perspective.

The results could be used to inform educational campaigns related to road-sharing activities and may also be shared with the general public (e.g., advocacy groups). If you have questions or comments, **you may reach Alex at aproa001@odu**.

APPENDIX M

ADDITIONAL DATA TABLES

Table 6

Participant Cycling and Driving Background

		Study 1		Study 2					
		Total		ODU		MTurk		Total	
Item	Frequency	*N*	%	*N*	%	*N*	%	*N*	%
Frequency of cycling per week									
	Never	9	63.00%	0	0.00%	0	0.00%	0	0.00%
	Less than once per month	121	84.00%	51	52.04%	42	42.86%	93	94.90%
	Once every couple of weeks	10	69.00%	2	2.04%	3	3.06%	5	5.10%
	1-4 days per week	4	2.80%	0	0.00%	0	0.00%	0	0.00%
	5-7 days per week	0	0.00%	0	0.00%	0	0.00%	0	0.00%
Frequency of driving per week									
	Less than once per month	12	8.30%	3	2.94%	3	2.94%	6	5.88%
	Once every couple of weeks	6	4.20%	3	2.94%	0	0.00%	3	2.94%
	1-4 days per week	41	28.50%	14	13.73%	16	15.69%	30	29.41%
	5-7 days per week	85	59.00%	36	35.29%	27	26.47%	63	61.76%
Frequency of seeing cyclists while driving									
	Every drive	7	4.90%	2	1.96%	0	0.00%	2	1.96%
	Daily	25	17.40%	11	10.78%	5	4.90%	16	15.69%
	A few times a week	48	33.30%	18	17.65%	26	25.49%	44	43.14%
	A few times a month	51	35.40%	16	15.69%	13	12.75%	29	28.43%
	A few times a year	13	9.00%	9	8.82%	2	1.96%	11	10.78%
Frequency of experiencing frustration with cyclists when driving									
	Every drive	6	4.20%	1	0.99%	2	1.98%	3	2.97%
	Daily	5	3.50%	1	0.99%	0	0.00%	1	0.99%
	A few times a week	25	17.40%	11	10.89%	7	6.93%	18	17.82%
	A few times a month	39	27.10%	15	14.85%	15	14.85%	30	29.70%
	A few times a year	69	47.90%	27	26.73%	22	21.78%	49	48.51%
Frequency of close calls with a cyclist when driving									
	Every drive	1	0.70%	0	0.00%	0	0.00%	0	0.00%
	A few times a week	4	2.80%	2	2.02%	1	1.01%	3	3.03%
	A few times a month	7	4.90%	5	5.05%	2	2.02%	7	7.07%
	A few times a year	132	91.70%	48	48.48%	41	41.41%	89	89.90%

Note. N = 98-105; descriptive statistics exclude participants who cycled more than 64 miles per year.

Table 7

Proportion of Correct Responses to Comprehension Test Items Across Studies Collapsed Across Conditions

Number	Item	Study 1		Study 2	
		N	Proportion	*N*	Proportion
1	A bicyclist under the Virginia Vehicle Code:	125	0.87	87	0.86
2	If no bicycle lanes or shared lane markings are present a driver has complete right-of-way on the road.	107	0.74	62	0.61
3	When it comes to driving near bicycles, it is a good habit to:	78	0.54	99	0.98
4	Bicyclists signal a left turn when they look over their shoulder and then	100	0.69	69	0.68
5	A bicyclist stopped at a red light at an intersection that has both a bicycle lane and a "right turn only" lane and intending to go straight should be:	31	0.22	29	0.29
6	Which of the following statements is true of bicycle lanes?	129	0.90	94	0.93
7	Bicyclists are required by law to ride on the sidewalk when a sidewalk is available.	110	0.76	87	0.86
8	At an intersection without a separate right-turn and bicycle lane,	91	0.63	75	0.74
9	Drivers may only approach and pass bicyclists if there will be a safe gap of at least ____ between the vehicle and the bicycle.	99	0.69	82	0.81
10	When riding on an ordinary width lane, bicyclists should always ride near the center of the lane if the distance is safer for them between the curb and the next lane.	95	0.66	66	0.65
11	Sharrows are	65	0.45	54	0.54
12	It is safe and legal for bicyclists to ride on which side of the roadway?	115	0.80	90	0.89
13	Which of the following statements is true about passing a bicycle on a two-lane road with a dashed line?	97	0.67	69	0.68
14	The Dutch Reach refers to	86	0.60	71	0.70
15	If a bicyclist makes a sudden change in behavior on the road in front of you, it is most likely due to	78	0.54	75	0.74
16	Bicyclists are not required to come to a complete stop at red traffic signals and stop signs.	133	0.92	88	0.87
17	Code of Virginia ¬ß 46.2-839 states that any vehicle overtaking a bicycle [...] proceeding in the same direction shall:	82	0.57	73	0.72
18	Drivers do need to look left-right-left for bicycles before:	118	0.82	87	0.86
19	If a motorist opens a parked vehicle door and hits a cyclist, the cyclist is at fault because:	72	0.50	64	0.63
20	It is illegal in Virginia for drivers to wear headphones/earbuds in both ears while on the road.	133	0.92	93	0.92
Total	Total	144			

Note. Means displayed are grand means across conditions.

Table 8

Means and Standard Deviations for Comprehension Scores as a Function of Text Perspective and Educational Material (Study 1)

	Revised handbook			Redesigned brochure			Total		
	M	*SD*	*N*	*M*	*SD*	*N*	*M*	*SD*	*N*
1st-person text	0.67	0.157	38	0.67	0.182	37	0.67	0.168	75
3rd-person text	0.67	0.179	37	0.69	0.160	32	0.68	0.169	69
Total	0.67	0.167	75	0.68	0.171	69	0.68	0.168	144

Note. Mean based on proportion of correct items out of 20 items.

Table 9

Means and Standard Deviations for Judgments Of Learning, Attitudes, and Intention Scores as a Function of Text Perspective and Educational Material (Study 1)

	Revised handbook						Redesigned brochure					
	1st-person			3rd-person			1st-person			3rd-person		
	M	*SD*	*N*	*M*	*SD*	*N*	*M*	*SD*	*N*	*M*	*SD*	*N*
JOLs $_a$	3.96	0.876	38	3.95	0.891	37	3.84	0.852	37	4.03	0.764	32
Attitudes $_b$	2.77	0.555	38	2.61	0.556	37	2.78	0.526	37	2.62	0.589	32
Intentions $_c$	3.91	0.565	38	3.83	0.689	37	3.90	0.565	37	3.81	0.687	32

Note. Participants responded on a rating scale from 1 = strongly disagree to 5 = strongly agree.

$_a$ Mean based on unit weighted average of three items. $_b$ Mean based on unit weighted average of 11 items after dropping one problematic item; four reverse scored items; lower scores represent less-negative attitudes toward cyclists. $_c$ Mean based on unit weighted average of nine items; three reverse scored items

Table 10

Means and Standard Deviations for Comprehension Scores as a Function of Text And Image Perspective (Study 2)

	1st-person text			3rd-person text			Total		
	M	*SD*	*N*	*M*	*SD*	*N*	*M*	*SD*	*N*
1st-person image	0.77	0.110	24	0.70	0.190	35	0.73	0.164	59
Top-down image	0.73	0.162	21	0.72	0.172	21	0.72	0.165	42
Total	0.75	0.137	45	0.71	0.182	56	0.73	0.164	101

Note. Mean based on proportion of correct items out of 20 items.

Table 11

Means and Standard Deviations for Judgments Of Learning, Attitudes, and Intention Scores as a Function of Text and Image Perspective (Study 2)

	1st-person text						3rd-person text					
	1st-person image			Top-down image			1st-person image			Top-down image		
	M	*SD*	*N*	*M*	*SD*	*N*	*M*	*SD*	*N*	*M*	*SD*	*N*
JOLs [a]	3.91	0.788	24	3.92	0.881	21	3.94	0.747	35	4.16	0.663	21
Attitudes [b]	2.76	0.588	24	2.67	0.475	21	2.72	0.580	35	2.66	0.316	21
Intentions [c]	3.86	0.479	24	3.89	0.554	21	3.83	0.474	35	3.86	0.534	21

Note. Participants responded on a rating scale from 1 = strongly disagree to 5 = strongly agree.

[a] Mean based on unit weighted average of three items. [b] Mean based on unit weighted average of 12 items; four reverse scored items; lower scores represent less-negative attitudes toward cyclists. [c] Mean based on unit weighted average of nine items; three reverse scored items.

Table 12

Proportion of Correct Responses to Situational Judgment Task as a Function of Text Perspective and Image Perspective

		1st-person text		3rd-person text		Total	
		N	Proportion	*N*	Proportion	*N*	Proportion
1st-person image	Incorrect	4	15.40%	5	14.30%	9	14.80%
	Correct	22	84.60%	30	85.70%	52	85.20%
Top-down image	Incorrect	1	4.50%	4	18.20%	5	11.40%
	Correct	21	95.50%*	18	81.80%	39	88.60%
Total	Incorrect	5	10.40%	9	15.80%	14	13.30%
	Correct	43	89.60%	48	84.20%	91	86.70%

* $p = .022$

Table 13

Means and Standard Deviations for Cognitive Load Scores as a Function of Text and Image Perspectives

	1st-person text			3rd-person text			Total		
	M	*SD*	*N*	*M*	*SD*	*N*	*M*	*SD*	*N*
1st-person image	5.44	1.923	24	5.64	1.88	35	5.56	1.887	59
Top-down image	5.52	1.458	21	6.05	0.939	21	5.79	1.241	42
Total	5.48	1.707	45	5.80	1.597	56	5.65	1.647	101

Note. Means based on nine-point unidimensional scale; rating scale: 1 = very very low mental effort, 9 = very very high mental effort.

Table 14

Means and Standard Deviations for Global Workload Scores as a Function of Text and Image Perspectives

	1st-person text			3rd-person text			Total		
	M	*SD*	*N*	*M*	*SD*	*N*	*M*	*SD*	*N*
1st-person image	19.47	3.671	24	19.48	4.006	35	19.48	3.841	59
Top-down image	19.17	2.080	21	20.96	3.563	21	20.07	3.019	42
Total	19.33	3.006	45	20.03	3.881	56	19.72	3.518	101

Note. Means based on sum of six items on a seven-point Likert-type scale; rating scale: 1 = very low and 7 = very high; one reverse-scored item.

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Education

Ph.D., Psychology (May 2022), Old Dominion University, Norfolk, VA
M.S., Psychology (August 2011), Old Dominion University, Norfolk, VA
B.S., Psychology and Sociology (May 2005), University of Montevallo, AL

Selected Recent Publications

Proaps, A.B, Leibner, S., & Bliss, J.P. (2019, November). Effects of transparency level and controller type on perception and performance using augmented reality and synthetic vision. In *Proceedings of the 2019 Interservice/Industry Training, Simulation, and Education Conference (I/TSEC),* Orlando, FL.

Crane, P., **Proaps, A.B.,** Bliss, J.P., & Alessi, E. (July, 2019). Augmented Reality User Interfaces for Tactical Drones (Comprehensive Scientific & Technical Report / Data Acquisition Document DI-MISC-80711A). Natick, MA. OSD/Army.

Proaps, A. B., Long, S. K., Liechty, M., & Bliss, J. P. (2017, September). Investigating the influence of agency on trust in a collaborative game-based scenario. In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting, 61 (*1). (pp. 2086-2090). Austin, TX.

Chancey, E.T., Bliss, J.P., **Proaps, A.B.** & Madhavan, P. (2015). The role of trust as a mediator between system characteristics and response behaviors. *Human Factors, 57* (6), 1–12,

Bliss, J. P., **Proaps, A.B.,** & Chancey, E. T. (September 2014). Human performance measurement in virtual environments. In K. M. Stanney, & K. S. Hale (Eds.), *Handbook of Virtual Environments: Design, Implementation, and Application* (2nd ed.) (pp.749-780). Mahwah, NJ: Lawrence Erlbaum Associates.

Proaps, A.B. & Bliss, J.P. (2014). The effects of rapid serial visual presentation of text on reading comprehension and search task performance within a virtual environment. *Computers in Human Behavior*, *36C*, 41 – 47.

Selected Recent Professional Experience

Senior User Experience Researcher (2020 – present), **User Experience Researcher** (2019 – 2020) – K12, Inc (Stride, Inc); Herndon, VA
Founder; User Experience Researcher (2014 – present) – Designology, LLC; Norfolk, VA
Instructor (2011-2016), Psychology Department, Old Dominion University, Norfolk, VA
Human Factors Scientist (2015 – 16) – Kern Technology Group, LLC; Virginia Beach, VA
Graduate Research Assistant (2012 – 2015; 2017 – 2019) – Old Dominion University Research Foundation; Norfolk, VA; Virtual Reality Rehab, Inc. (VRR)
Human Factors Engineer (Part-time; 2010 – 2011) – Naval Surface Warfare Center, Carderock det Norfolk, Combatant Craft Division, US Navy Little Creek Amphibious Base, Norfolk, VA