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Farther and safer: An illusion engendered by incapability?

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ABSTRACT

Previous studies have observed that pedestrians tend to select gaps of farther distances between vehicles when crossing roads; however, the causes were unclear. Such gaps may create dangerous illusions because a farther distance for a given pedestrian crossing time implies that a vehicle is actually traveling faster. This study aimed to identify the causes of this farther-and-safer illusion, especially concerning elderly pedestrians. In particular, we examined behavioral changes after the burden of estimating the time to arrival (TTA) of an approaching vehicle has been removed through the provision of a countdown. Repeated measures collected for 82 subjects were examined using multilevel generalized linear models. The analysis results indicated that on average, the countdown effectively enhanced gap selection safety in both young (20–45 years) and elderly (60 years and older) subjects; however, its effect on reducing the illusion was heterogeneous between and within subjects. Most elderly subjects were sufferers of the farther-and-safer illusion even when their TTA estimation burden had been removed, implying that a decline in physical ability is not the primary cause of the illusion. Although the gap selection behaviors of young subjects were relatively modifiable, the behavioral changes sometimes led to a worse consequence, suggesting an incapability of properly using the countdown information. This study suggests that simply telling elderly pedestrians to recognize their age-related function changes is insufficient for improving their safety; other countermeasures are also required.

1. Introduction

Street-crossing behaviors are critical to pedestrian safety, particularly when pedestrians cross streets without the protection of traffic signals, an action for which pedestrians must rely on their cognitive, sensorial, physical, and self-perception abilities to achieve safe crossing (Tournier, Dommes, & Cavallo, 2016). Street crossing consists of various tasks such as selecting a place to cross, exploring the surrounding visual environment, selecting a time gap for crossing, and calibrating crossing speed to traffic perception. The present study focused on the task of gap selection.

Previous studies have suggested that most pedestrians tend to select gaps primarily based on distances between vehicles and neglect to consider vehicle speed to predict the arrival time of oncoming vehicles (Lobjois & Cavallo, 2007; Oxley, Charlton, & Fildes, 2005). Because a vehicle being at a farther distance does not necessarily indicate a longer time to arrival (TTA) than a vehicle being close by does, inappropriate gap selection could induce unsafe crossing decisions. The danger engendered by applying a distance-based heuristic rule to gap selection decisions is called the farther-and-safer illusion in this article.

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Oxley et al. (2005) suggested that some pedestrians ignored speed information, and simply thought that "the farther the car is away from me, the safer it is to cross." If a pedestrian has previously performed several successful street crossings, he or she may nurture a habitual street-crossing response applying this heuristic rule, despite the rule being dangerous. Another possible explanation for the farther-and-safer illusion is that pedestrians are not always able to accurately judge vehicle speed when a vehicle is far away. This is particularly salient in pedestrians with sensory or cognitive deficits such as children and older adults. Wann, Poulter, and Purcell (2011) observed that because their neural mechanisms for detecting looming objects are not fully developed, children cannot reliably detect that an approaching vehicle is traveling any faster than 20 mph, and thus, are forced to apply the farther-and-safer heuristic rule during gap selection. Elderly pedestrians may be subject to a decline in visual functions, which affects their ability to detect looming objects such as oncoming vehicles. Oxley, Fildes, Ihsen, Day, and Charlton (1995) reported that visual acuity loss in older adults causes problems in discriminating vehicles from the rest of the road environment, and declines in contrast sensitivity hinder the perception of oncoming vehicles. Previous studies have also indicated that the decline of visual motion sensitivity in older adults partially contributed to their use of distance-based heuristics (Dommes & Cavallo, 2011; Lobjois & Cavallo, 2007). Concerning cognitive deficits, Rosano et al. (2012) indicated that a decline in processing speed was associated with a low walking speed and long decision time; Dommes and Cavallo (2011) demonstrated that a decline in executive and memory functions raises the difficulty of correctly processing traffic flow information and thus predisposes pedestrians to make unsafe street-crossing decisions.

Despite the aforementioned evidence supporting the connection of sensory and cognitive deficits with the farther-and-safer illusion, the extent to which adopting the farther-and-safer heuristic rule is attributable to the decline of certain abilities in elderly pedestrians is unclear. Notably, Oxley et al. (2005) and Lobjois and Cavallo (2009) both indicated that the farther-and-safer illusion exists not only in elderly pedestrians but also in young pedestrians. Because young pedestrians normally possess well-developed neural mechanisms, the existence of the farther-and-safer illusion in young pedestrians suggests that causes other than incapability may engender adoption of the farther-and-safer rule.

Distinguishing the causes of the farther-and-safer illusion is crucial because different countermeasures are required to reduce the danger engendered by the illusion. Accordingly, this study aimed at identifying the heterogeneous reasons for adopting the farther-and-safer heuristic rule during gap selection. In particular, we compared gap selection behaviors between young (20–45 years) and elderly (60 years and older) subjects, because they have distinct cognitive and sensorial abilities. To achieve this aim, we designed an experiment where the treatment was providing subjects with a countdown of the remaining arrival time of oncoming vehicles. By offering the countdown, pedestrians were relinquished of the burden of estimating the TTA of oncoming vehicles. With the countdown, the farther-and-safer illusion should disappear if the incapability of estimating gaps is the exclusive cause of the illusion.

The remainder of this paper is structured as follows: In Section 2, we construct an analysis framework alongside a literature review of factors affecting gap selection behavior. Section 3 describes the methodology including experimental design, participant enrollment, and analysis methods. Section 4 presents the analysis results, and is followed by a discussion in Section 5. Finally, conclusions and recommendations for future studies are provided in Section 6.

2. The framework of gap selection

2.1. Estimation of TTA and the farther-and-safer illusion

Tournier et al. (2016) suggested that assessing the arrival times of approaching vehicles as well as one's own crossing time is the primary task in selecting a time gap for crossing a street. A pedestrian accepts a gap only when the estimated TTA of an oncoming vehicle is greater than his or her own estimated crossing time. In addition, a pedestrian may miss an opportunity to cross a street (i.e., reject a gap because the estimated TTA is greater than the estimated crossing time). Because gap selection largely depends on TTA estimation as well as one's own crossing time, the ability to estimate both simultaneously becomes crucial in selecting an appropriate gap for crossing a street.

The ability to estimate TTA differs from the ability to estimate one's own crossing time. According to tau theory (Lee, 1976), the ability to detect looming objects such as moving vehicles is critical for detecting vehicle speed and estimating TTA. In particular, the optical size and optical looming of a vehicle provide indications of distance and relative speed. Lee (1976) suggested that the time to passage for a vehicle traveling at a constant speed approaching a pedestrian can be perceptually detected by the ratio of the optical size to the looming rate of the subject. For a given pedestrian crossing time, vehicles traveling faster must be farther away, and therefore are smaller optically; moreover, the vehicles exhibit a lower looming rate, thereby raising the difficulty of speed detection. In addition, a threshold for looming detection exists; specifically, the neural mechanisms in charge of looming detection in children are not fully developed (Wann et al., 2011), and in elderly subjects may have already declined (Caird & Hancock, 1994; Owsley, 2011; Schieber, 2006). Therefore, detecting TTA is a more difficult task for children and elderly subjects than for young and middle-aged adults. In addition to age, Caird and Hancock (1994) identified heterogeneous imagined–actual TTA relationships in pedestrians of different genders and when oncoming vehicles were of different types.