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Contextual Design for driving: Developing a trip-planning tool for older adults

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ABSTRACT

Independent living depends on mobility, and mobility depends on driving, particularly for people 65 years and older. The longer older adults can safely drive, the longer they can independently run errands, shop, exercise, and maintain social networks. Age-related decline of perceptual, motor, and cognitive abilities can undermine the mobility and driving safety of older drivers. Data from driving simulators, on-road tests, surveys, and crash reports describe the driving safety and mobility challenges of older adults, but these methods offer a limited view of these challenges and fail to indicate design solutions. Contextual Design—a combination of Contextual Inquiry interviews, model building, and affinity diagrams—offers a complementary approach to uncover challenges that older adult drivers' experience. For two weeks, 39 drivers age 65 and above, had their vehicles instrumented to collect driving and video data. Applying Contextual Design to these data showed that older drivers in urban and rural settings faced different mobility challenges and adopted various strategies to mitigate risk: older drivers often involved their spouse or passenger in the driving task, avoided certain driving maneuvers such as left turns, avoided unfamiliar or poorly lit roads at night, and planned trips to avoid risky driving situations. Ridesharing and trip planning emerged as important strategies to improve the safety and mobility of older drivers. Ridesharing could serve as a potential solution to prolong mobility; however, factors such as wait time, scheduling conflicts, costs, and trust were concerns for older drivers. A paper prototype was developed to validate the driving challenges faced by older drivers, and guide the development of a customized web-based trip-planning tool. The trip-planning tool could help older drivers make safer route choices by offering routes with fewer driving challenges, thereby enhancing their driving safety, mobility, and independence.

1. Introduction

From 2003 to 2013, the number of adults 65 and older in the U.S. increased from 35.9 million to 44.7 million, and is projected to more than double to 98 million by 2060 (Administration on Aging, 2014). This increase has led to a rise in the number of licensed older drivers, from 14% in 2000 to 16% in 2012 (TRIP, 2012). Along with this increase, the mobility patterns of older drivers are also shifting. From 1990 to 2009, older drivers spent more time driving, made longer trips, and made greater number of trips (Rosenbloom & Santos, 2014). This shift in driving patterns can be attributed to a number of factors such as

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older adults leading a more active lifestyle, with improved health care, education and higher income (TRIP, 2012), and an increasing number of older adults remaining in the work force well after retirement age (Rosenbloom & Santos, 2014). Ninety percent of trips taken by adults 65 and older, and 80% of trips taken by adults 85 and older are taken in the comfort of a private vehicle (Rosenbloom, 2003), and so driving continues to play an important role in maintaining the mobility and independence of older adults.

Given these trends, a major concern for the driving safety and continued mobility of older drivers is age-related decline in various abilities. Reduced visual acuity is associated with difficulty driving at night and on high traffic roads, reduced contrast sensitivity is associated with difficulty making left turns, and reduced useful field of view is associated with difficulty driving in the rain (McGwin, Chapman, & Owsley, 2000). More severely, ocular diseases such as cataract (Owsley, Stalvey, Wells, & Sloane, 1999), bilateral glaucoma, and age-related macular degeneration have been associated with the decision to cease driving (Ramulu, West, Munoz, Jampel, & Friedman, 2009). Decline in cognitive abilities, such as memory, processing speed, and verbal reasoning (Anstey, Windsor, Luszcz, & Andrews, 2006), along with cognitive impairments associated with physical decline (Marottoli et al., 1993) due to Parkinson's disease, stroke (Campbell, Bush, & Hale, 1993), and dementia (Lafont, Laumon, Helmer, Dartigues, & Fabrigoule, 2008) also result in the decision to cease driving. While these studies show that age-related decline can result in older driver's decision to cease driving; neurological disorders such as Alzheimer's disease, epilepsy, stroke, vision disorders, rheumatoid arthritis, joint and movement-related disorders, that severely impair the ability to drive safely, can result in drivers getting their license revoked (Charlton et al., 2010). Thus, when age-related decline affects older adults' ability to drive safely, they are faced with the decision to either reduce their driving exposure or cease driving, both of which undermine their mobility.

Many older drivers with age-relate cognitive and physical decline continue to drive (Stutts, 1998). These older drivers sometimes compensate by reducing their exposure to challenging driving situations (Baldock, Mathias, McLean, & Berndt, 2006). For example older adults with cataract regulate their driving exposure by driving fewer miles, at lower speeds, and taking fewer trips (Owsley, McGwin, & Ball, 1998). Despite this compensation, serious impairment in contrast sensitivity due to cataract is associated with elevated crash risk (Owsley, Stalvey, Wells, Sloane, & McGwin, 2001). Older drivers also become increasing fragile with age, which contributes to having an injury rate 8–37 times that of 30–59 year old drivers (Meuleners, Harding, Lee, & Legge, 2006), and accounts for 60–95% of the excess death rates per vehicle mile driven (Li, Braver, & Chen, 2003).

Although the risk of fragility and age-related driving impairments pose obvious risks, reduced mobility has subtler, but potentially graver consequences. Reduced mobility can increase social isolation, symptoms of depression, and healthcare costs (Windsor, Anstey, Butterworth, Luszcz, & Andrews, 2007). In one study, the inability to drive reduced the number of trips to the doctor by 15%, shopping trips by 59%, and trips to attend social, personal, and religious events by 65% (Baily, 2004). Older people who stopped driving were also three times more likely to use mental health care services than those that continued to drive (Naumann, Dellinger, Anderson, Bonomi, & Rivara, 2012), and those who stopped driving or never drove and did not have access to alternate transportation options, were also more likely to enter a long term care institution (Freeman, Gange, Muñoz, & West, 2006). According to the Genworth Cost of Care Survey (2011), the national median cost of assisted living is approximately $3450 per month ($41,400 annually) compared to $2000 per month ($24,000 annually) for an older adult living independently. These outcomes indicate the importance of understanding and addressing the mobility needs and driving challenges of older adults.

Studies have long used data from simulators, self-reports, crash reports, and on-road testing to define the driving safety challenges faced by older adults. Simulator studies are conducted in a controlled environment and provide a safe, precise, and cost-effective way of assessing the impact of age-related changes on driving performance, such as multi-tasking and divided attention (Brouwer, Waterink, Van Wolffelaar, & Rothergatter, 1991), risk perception (Pradhan, Hammel, Deramus, Pollatsek, & David, 2005), and response time to sudden driving events (Edwards & Creaser, 2003). Self-report surveys collect information on driver's crash history, attitudes, self-evaluated skills and beliefs, to examine the relationship between medical conditions and at-fault crashes (Sims, Owsley, Allman, Ball, & Smoot, 1998), the relationship between driving confidence and driving capacity (Parker, Macdonald, Sutcliffe, & Rabbitt, 2001), the association between driving cessation and depressive symptoms (Ragland, Satariano, & MacLeod, 2005), and the impact of health experience on self-regulation of driving behavior (Sargent-Cox, Windsor, Walker, & Anstey, 2011). Studies using crash data provide an objective representation of safety-critical challenges, such as the over-representation of older drivers in left-turn crashes (Reinfurt, Stewart, Stutts, & Rodgman, 2000). On-road tests have the advantage of collecting objective driving data in a representative context, and can help assess the effect of visual impairment on sign detection, peripheral reaction time, travel time (Wood, 1999), and driving safety (Wood, Anstey, Kerr, Lacherez, & Lord, 2008). As a specific example, on-road tests showed the effect of Parkinson's disease among older adults on route following tasks, navigation, and on the frequency of safety-critical errors (Uc et al., 2007).

Although simulators, self-report, crash studies, and on-road tests have provided much needed insights on driving safety, they fall short of helping design for the safety and mobility challenges of older drivers. Simulator studies use pre-specified scenarios, and hence cannot discover the challenging driving scenarios that occur during day-to-day driving. Simulator studies also fail to capture the strategies older adults develop to compensate for their impairments (Fisher, Rizzo, Caird, & Lee, 2011). Self-report studies rely on the ability of drivers to recall past events (Lajunen & Summala, 2003), and thus lack a detailed description of driving situations, and context surrounding challenging driving situations. Crash data include a standard set of descriptive variables that describe the crash such as location, crash type, road environment, vehicle information,