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Communication of Intent Among Drivers: Does It Deteriorate With Age?

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ABSTRACT

Interactions among drivers of neighbouring vehicles, aiming to communicate intent and agree on a safe motion plan, are a crucial component of driving activity. Empirical evidence from on-road, video-assisted observations and analysis of parallel commentaries by twenty-two experienced drivers show that the performance of older drivers (mean age 72.8 years) as regards interactions relevant to lane changes was similar to that of younger drivers (mean age 36.3 years). No difference was found in trip duration, number of lane changes, frequency and type of cues signifying intent to change lane and frequency of perceiving such cues. This may be an indication that the interpretation of traffic events, once acquired, does not loose in significance with age. Still, older drivers reacted less often after a cue signifying lane change intent although there was no difference in the perception of cues. Older drivers may adopt a more defensive driving strategy so that they do not need to adjust their driving, having found ways to compensate for their possible performance deterioration due to age.

Keywords: Drivers' interactions, Drivers' intent, Older drivers

INTRODUCTION

Interactions among other drivers are an essential component of driving activity (Portouli et al., 2014). In several cases, for example before starting a left turn with oncoming traffic or before a lane change, drivers anticipate the surrounding drivers' intent and communicate their own intent before starting the manoeuvre.

Typically, interactions among drivers require planning, decision taking, deliberate expression of intent, perception and interpretation of other drivers' intent, coordination. Perceptual and cognitive capabilities deteriorate with age (Ortiz et al., 2013; Charlton, 2006; Gabaude, 2003; Charness & Bosman, 1992; Gogging & Stelmach, 1990) and this deterioration may interfere with the capacity for safe driving, including interactions with other drivers.

Older drivers reported having difficulties extracting the most relevant traffic sign and making decisions under time pressure (Musselwhite and Haddad, 2010) and that their reactions are slower than they used to be (Karali et al., 2016). On-spot investigations in intersections have shown that older drivers

experience problems estimating safe gaps between own and approaching cars (Oxley et al., 2006). Older drivers often fail to yield to the right-of-way according to accident analyses of crashes by McGwin and Gerald Brown (1999). In a driving simulator experiment, older drivers exhibited greater inconsistency in maintaining a constant speed following a vehicle and keeping in the lane (Bunce et al., 2012).

Since interactions among drivers are frequent and necessary for smooth and safe driving and considering the possible deterioration of perceptual and cognitive capabilities with age, the present paper studied whether there are differences between drivers older than 65 years and younger drivers as regards their involvement in such interactions.

METHOD

An on-road, video-assisted observational study with parallel running commentary by participating drivers was designed and conducted so as to obtain empirical evidence for interactions among drivers relevant to lane changes. Lane changes were chosen as the most prevalent, relevant and objectively identifiable type of manoeuvre in the specific traffic environment, namely they are clearly observable and frequently involve interactions among drivers.

The study was conducted on a peri-urban road with right-hand traffic, at least two lanes per direction and a central barrier. The traffic flow in this artery is dense enough, so frequent lane changes along with accompanying interactions were expected to occur. The route, 15 km in length, was identical for all runs. Along the route there are several traffic lights, the speed limit is 70 km/h, however higher speeds are frequent. For the environmental and traffic conditions to be comparable among runs, all observations took place around mid-day, off-peak hours, between 10:00 and 15:00, in good ambient light and good weather conditions.

Two smartphones with a CMOS (metal–oxide–semiconductor), 13 megapixel camera with a 1080p video resolution were used to record the traffic scene and the driver's commentary. One was mounted on the front dashboard recording the scene in front of the vehicle, the second on the back dashboard recording the scene behind the vehicle. The voice recordings were used to synchronise the front and rear scene recordings. An observer-researcher accompanied the participants during the ride, as a natural recipient of the running commentary.

Watching off-line the video recordings of the traffic scene, three independent analysts annotated the lane changes by the participants and by other drivers in close distance, in front of the participants' vehicle and the cues signifying intent to change lane, based on the typology by Portouli et al (2014).

The parallel commentary aimed at capturing the drivers' cognitive activity relevant to interactions among drivers. The three analysts analysed qualitatively the commentaries off-line, as regards the cues perceived by the older and younger drivers and used to anticipate others' intent.

Table 1. Characteristics of the two groups.

	"Older"	**"Younger"**
N	11 (*9 men, 2 women)*	11 (5 men, 6 women)
Age	72.8 years (67 – 80 years)	36.3 years (26 - 52 years)
Driver for	45.6 years	15.7 years
Average kms driven per year	≈ 15,400 km	≈ 14,500 km

The data from twenty-two (22) native drivers, 14 men and 8 women, were selected for analysis. All participants possessed a valid driving licence for at least three years. No participant reported being diagnosed with any impairment. Participants were split in two groups according to their age, the "Older" than 65 years old and the "Younger" groups. Women were underrepresented in the "Older" group, due to difficulties in recruiting participants with these specific characteristics. Table 1 presents the participants' demographic characteristics.

Before the drive, the participants were instructed to drive normally their own car and in parallel to describe aloud their observations in the surrounding traffic and their actions relevant to any such observation.

Most of the participants could effortlessly drive and comment simultaneously. Still, there were moments of increased risk –due to traffic conditions– during which even drivers who spoke fluently stopped talking, apparently to focus completely on the driving task.

The video recordings were used (i) to calculate the duration of each trip, (ii) to annotate the number of lane changes initiated by the study participants and by other drivers in front of the participants' vehicles, (iii) to annotate the cues signifying intent to change lane and (iv) to annotate the participants' reactions to such cues, if any. The reactions were either slowing down to facilitate the intended lane change or accelerating to block the intended lane change in front of the participant's vehicle.

The running commentary was digitally transcribed and was used to measure the number of words spoken by each driver and to qualitatively analyse how drivers anticipated others' intent in each group. An example of such an anticipation is: "The following driver would fall on me, he keeps on being stuck on me, he wishes to change lane".

It is evident that the above interpretative process involves some subjective judgment on the part of the analysts. To safeguard the objectivity of the process, the video annotations and the qualitative analysis of the commentaries were done by three independent analysts.

Mann-Whitney U tests were used to compare trip duration, number of words, lane changes, number of cues signifying intent and number of reactions between the two groups. The Chi-Square test of independence was used to determine if there is a significant relationship between age and type of cues referenced in the commentaries as signifying others' intent to change lane.

RESULTS

No difference in the trip duration was found between the two groups. The mean trip duration was 17.5 min for the "Older" vs 15.8 min for the "Younger" drivers. The Mann-Whitney test indicated that "Older" drivers spoke more (Mdn = 541 words) than "Younger" drivers (Mdn = 297 words), $U = 25.5$, $p < 0.05$, $r = 0.02$.

No difference was found as regards the lane changes by the participants or by other drivers close to the participant's vehicle. On average, the "Older" drivers changed lane 6.5 times per trip and the "Younger" drivers 8.1 times. Other drivers made on average 5.8 lane changes per trip close to an "Older" participant's vehicle and 6.2 lane changes close to a "Younger" participant's vehicle.

No difference was found as regards the number of cues signifying intent to change lane between the two groups, that were annotated by the video observers. The observers annotated on average 2.6 such cues per trip by "Older" drivers vs 4.1 by "Younger" drivers. No difference was found either as regards the number of annotated cues by drivers of surrounding vehicles. The observers annotated on average 5.0 such cues per trip by an "Older" participant vs 6.0 by a "Younger" participant.

The Mann-Whitney test indicated that "Older" drivers reacted less often after a cue signifying others' intent to change lane (Mdn = 1.7) than "Younger" drivers (Mdn = 4.2), $U = 30$, $p < 0.05$, $r = 0.42$. All of the 19 reactions by the "Older" drivers were meant to facilitate the other's intended lane change, i.e., the "Older" drivers slowed down their vehicles. The majority of the "Younger" drivers' reactions (42 out of 46) were also meant to facilitate the other's intended lane change, 4 reactions were meant to block the lane change by accelerating.

Drivers in the "Older" group described 29 of the 55 cues (52.7%) annotated by the observers, and drivers in the "Younger" group described 36 out of the 66 annotated cues (54.5%). The qualitative analysis of the commentaries is shown in Table 2. Explicit communication cues were the use of direction lights, the flashing of headlights and hand and head movements. As regards the behaviour of other vehicles, the participants focused on vehicles moving differently than the surrounding vehicles and anticipated intent based on this motion that was different than the traffic flow. Examples of such references are: "(s)he is in a hurry", "(s)he is stuck behind me", "(s)he drives a bit slower", "(s)he drives on the lane marking", "(s)he accelerates", "(s)he slowed down", "(s)he approaches with high speed", "(s)he is not steady on the lane", "(s)he brakes abruptly", "(s)he drives aggressively", "(s)he keeps on doing strange manoeuvres". Additionally, the participants formed expectations about the future motion of other vehicles based on their knowledge of the road topology ahead. For example, drivers anticipated that another vehicle would change lane because they knew that the specific lane would end. Finally, anticipation of others' intent was based on stereotypes. For example, specific aggressive behaviour was expected based only on the colour or model of a car or in case of motorcycle rider or truck driver. The chi-square test of independence did not reveal a significant relation between age and type of cues described by the participants.

Table 2. Type of cues used to anticipate the other drivers' intent to change lane.

Type of cues	"Older"	"Younger"
Explicit communication signals by other drivers	5 times	6 times
Observed vehicle behaviour different than the flow	16 times	19 times
Expectations based on prior knowledge of the road topology ahead	-	6 times
Expectations due to stereotypes	1 time	3 times

DISCUSSION

Interactions among drivers are common and form a significant part of the driving activity. The main aim of this work was to investigate whether older drivers are as interactive as younger ones with other drivers and whether they can anticipate other drivers' intent and react similarly to younger drivers.

No difference was found between the "Older" and "Younger" groups as regards trip duration and lane changes, either by the participants or by drivers of surrounding vehicles. This may be an indication that the driving performance of older drivers is similar to that of younger drivers and that surrounding drivers drive in a similar way around older drivers as around younger ones, perceiving no difference.

This is further supported by other findings of the present study. Specifically, no difference was found as regards the frequency and type of cues signifying lane change intent by the participants and by other drivers and no difference as regards the cues perceived and used by the participants in the two groups. This may be an indication that the interpretation of traffic events once acquired, does not loose in significance with age. Older drivers anticipate the traffic scene evolution, by observing and interpreting behaviour of other drivers at a similar manner as younger drivers. It should be noted that older drivers spoke more words, so the running commentary should not have affected their driving performance.

The "Older" participants reacted less often after a cue signifying another driver's lane change intent, although there was no difference in their describing, and therefore perceiving, the cues. This may be an indication that older drivers adopt a more defensive driving strategy as reported by previous studies (Musselwhite and Haddad, 2010; Broberg and Willstrand, 2014), driving effectively while having found ways to compensate for their possible performance deterioration (Winter et al., 2015).

It is worth mentioning that the most frequent cues used to anticipate intent were not formal communication signals, but mainly the variation in the motion of surrounding vehicles compared to the traffic flow, for example a vehicle driving faster or slower than other vehicles or a vehicle that was closer to the lane marking than in the centre of the lance. Six times the anticipation was made without any observable difference or change in the other vehicle behaviour or without any explicit communication by the other driver, only based on the participant's prior knowledge about the road topology ahead.

The present study was based on observations of interactions relevant to lane changes in the specific traffic environment. The findings should be verified by more empirical evidence from other locations. Future studies should also focus on interactions relevant to other manoeuvres in more traffic environments and cultural contexts. Still, the findings of this study support the idea that trajectory prediction algorithms should take into account the variation of other vehicles dynamics compared to the traffic flow and the road topology ahead.

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