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How does a lower predictability of lane changes affect performance in the Lane Change Task?

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Abstract

The Lane Change Task (LCT) is an established method to assess driver distraction caused by secondary tasks. In the LCT ISO standard, "course following and maneuvering" and "event detection" are mentioned as central task properties. Especially event detection seems to be a reasonable feature, as research suggests that distraction has profound effects on drivers' reactions to sudden, unexpected events. However, closer inspection of the LCT reveals that the events to be detected (lane change signs) and the required response are highly predictable. To investigate how the LCT's distraction assessment of secondary tasks might change if lane change events and responses were less predictable, we implemented three different versions of the LCT – an "original" one, a second one with lowered predictability of event position, and a third one with lowered predictability of event position and response. We tested each of these implementations with the same set of visual and cognitive secondary tasks of varying demand. The results showed that a decrease in predictability resulted in overall degraded performance in the LCT when using the basic lane change model for analysis. However, all secondary task conditions suffered equally. No differential effects were found. We conclude that although an ISO conforming implementation of the LCT might not be excessively valid regarding its depiction of safety relevant events, the results obtained are nevertheless comparable to what would be found in settings of higher validity.

Keywords: *Inattention; In-vehicle information systems; Evaluation methods*

1. Introduction

In-vehicle information systems (IVIS) and other electronic devices than can be used while driving have seen an immense increase in popularity in recent years (Janitzek et al., 2010), and their prevalence is expected to grow even further (Buettner, 2009). The operation of such systems requires manual, visual, cognitive and auditory resources to varying degrees. The quantification of this resource demand is a vital aspect of IVIS interface design. Consequently, the assessment of their potential to distract drivers has become an important issue. Several easy-to-use methods have been developed to investigate the level of distraction associated with IVIS use already in the early stages of product development. One of these tools is the Lane Change Task (LCT; Mattes, 2003). The LCT is a simple and inexpensive dual task method which is specified by an ISO standard (ISO/DIS 26022, 2010).

The task employs the look and feel of a simple driving simulation, which mainly consists of a three-lane road, with no other traffic present, and a set of signs appearing on both sides of that road which instruct the participants to change lanes. Participants are required to control a simulated vehicle and change lanes according to the information on the signs while maintaining a constant speed of 60 km/h which cannot be exceeded. The signs appear around every 150 m; time between lane changes is around 9 s. Recommended performance measure is the mean deviation (MDEV) from an ideal lane keeping and changing trajectory that is based on the participants' own baseline drive, which is called the adaptive model. Optional is the calculation of an MDEV value based on a normative lane change model (basic model), which is the same for all participants.

One of the task's assets is the fact that it bears some obvious similarities to real world driving (while researchers are, of course, quick to point out that the LCT is not really a driving task, e.g. Mattes and Hallén, 2009). The LCT ISO standard states that the task is supposed to "contain elements important to the driving task", namely "course following and maneuvering" and "event detection" (p. 21). In terms of safety relevance, especially the inclusion of event detection seems crucial. Victor et al. (2009) state that results obtained from object and event detection methods "have direct links to driving safety" (p. 145), whereas "the safety relevance of longitudinal and lateral control metrics [...] is less direct"(p. 146). As Sheridan (2004) points out, "whether a particular distraction actually diminishes safety to any measurable extent clearly depends [...] on unexpected events that occur when attention is not on driving." (p. 593). Numerous studies have shown that different forms of distraction can impact negatively on event detection.

In their meta-analysis of effects of cell phone use on driver performance, Caird et al. (2008) found that amongst various variables, reaction time to events and stimuli was affected most. Such events can be suddenly braking lead vehicles (e.g. Alm and Nilsson, 1995; Lamble et al., 1999), a pedestrian stepping onto the driver's lane (Laberge et al., 2004) or changing traffic signals (Hancock et al., 2003). Others have used artificial tasks like the peripheral detection task (PDT, now detection response task, DRT; e.g. Patten et al., 2004) to present stimuli to the driver that require a response (usually a button press). But cell phone usage is far from being the only secondary task that has an effect on event detection. Speech based e-mail systems (Lee et al., 2001), visually demanding in-car tasks (Lamble et al., 1999b) and even climate control adjustment (Greenberg et al., 2003) were found to have an influence on event detection metrics.

Given the profound effects distraction has on the detection of events and the driver's response to them, including elements of event detection in a task that is supposed to assess the effects of driver distraction is fairly reasonable. But are the events and the way they are presented in the LCT really safety relevant? The event detection element that the ISO standard refers to is the perception of and proper response to the lane change signs. While those signs are not evenly spaced, the standard states that "the mean distance from sign to sign is 150 m (a minimum of 140 m plus an exponentially distributed random variable with a mean of 10 m)" (p. 7). In practice, that means that none of the distances is shorter than 140 m, and that in more than 85% of all cases, the distance from sign to sign is between 140 and 160 m. Lane change intervals are between 8.4 and 11.4 s (Mattes and Hallén, 2009). Therefore, after passing a sign, participants can allocate at least 8 s to the secondary task without risk to miss the next one, and can be pretty sure this next one will appear not much later than 9-10 s after the previous. Even more problematic is the fact that "the lane change signs are always visible", although they remain "blank until the lane indications on the signs appear (i.e., pop up) at a distance of 40 m before the signs" (p.7). So, the position of the event to detect is known well in advance, just as when the event will occur. Consequently, others have found before that the LCT runs into problems when it is supposed to assess secondary tasks that allow for "tactical" behaviour, i.e. timing secondary task operation according to the occurrence of lane change signs (Bengler et al., 2010; Petzoldt et al., 2011). The term "temporal uncertainty", ascribed to Hick (1952) and Hyman (1953), is used to describe this aspect of response selection (usually summarised under the label "Hick's law" or "Hick-Hyman law"), which is "the degree of predictability of when the stimulus will occur" (Wickens and Hollands, 2000). If temporal uncertainty is low, reaction times are short. It appears that the LCT with its relatively regular, easily predictable events is hardly a reflection of a suddenly braking lead vehicle, much less a pedestrian stepping onto the street unexpectedly.

However, the issues go even beyond the detection of events. Once an unexpected event is detected, a driver usually has to decide among a set of different behavioural options to respond. Depending on the distance to the hazard, he might brake, accelerate, steer to the left or right, or combine some of these manoeuvres. While this is still a fairly constrained response set, it is certainly richer in options than the LCT. Even without consideration of other context factors (Is the adjacent lane empty? Does the height of the kerb allow for a swerve to the right? etc.), a certain amount of processing is required to select an appropriate response. In the LCT, for two out of three possible lane positions (left and right), no information processing or decision making is required to initiate a response. When travelling in one of the outer lanes, the only behavioural option when arriving at a lane change sign is to steer towards the other side of the road. As Boff and Lincoln (1988) highlight, response time is affected by the "uncertainty about which stimulus will appear and/or which response will be required" (p. 1860). The signs might give information on how far to travel across (either the centre or the other outer lane), but initially, there is only one valid motor response, which is known before. As soon as the information pops up on the sign (or even before – however, participants are instructed "to begin a lane change as soon as the symbols appear on a sign, but not before", ISO/DIS 26022, 2010, p. 17), participants can begin to steer. Processing of the information presented on the sign can be done while steering. Some researchers have already tried to avoid that issue, e.g. by introducing an unlimited number of lanes on their track, so that every time a lane change is required, it could be either to the left or the right (Hofmann and Rinkenauer, 2013). Although not directly an element of event detection, the fact that responses can be selected without or before processing information is another indicator for a certain disparity between actual safety critical events while driving and events as defined in the LCT.

Given the aforementioned issues, it is at least debatable if the LCT is an event detection task that is really reflecting the detection of safety relevant events in real world driving. But what could be expected if LCT events were less predictable? How would results look like if signs were not visible all the time, and if the information had to be processed before a manoeuvre could be selected? It is reasonable to assume that as a result of lower predictability, performance would overall degrade (Green, 2000). That in itself is not a problem for the LCT – a simple, unspecific degradation of performance would not change the overall pattern of results and hence not change the conclusions drawn. But could the pattern of results when assessing different secondary tasks change as a consequence of increased unpredictability?

With regard to an increased difficulty in the detection of an event, there is no clear picture to allow for a specific hypothesis. There are reports of cognitive distraction having a stronger effect on performance in simple event detection tasks (decelerating / braking in response to a slowing down /

braking lead vehicle) than visual distraction (Jamson and Merat, 2005), just as there are reports of exactly the opposite (Liang and Lee, 2010). In a driving simulator study, Muhrer and Vollrath (2011) found that visual distraction negatively impacted on the perception of sudden events, however also went with compensatory behaviour (increase in distance to lead vehicle, decrease in speed), whereas under cognitive distraction, participants did not compensate. This suggests that the negative effects of visual distraction might be underestimated under the current LCT regime, which requires the perception of (and reaction to) rather predictable events which allow for compensatory strategies.

With increased difficulty in response selection, cognitive distraction could be expected to have a stronger impact on LCT performance. Engstrom and Markkula (2007) reported on an LCT experiment in which they employed visual and cognitive secondary tasks. Their analysis showed that only with a concurrent cognitive task, there were several instances of erroneous responses in which participants performed a lane change to the wrong target lane. They concluded that the cause was either recognition or response selection failure. Choice reaction time, of which response selection is a central element, has a long history as a measure reflecting the processing of information (e.g. Merkel, 1885). It is reasonable to assume that once information has been perceived (which has to be the case in order to select a response), visual resources play a secondary role at best, whereas cognitive resources are required to facilitate the decision on an appropriate response.

To investigate which consequences a reduced predictability of lane changes has on lane change performance, we created our own implementation of the LCT, to then manipulate relevant features of the task. We created our first version of the LCT according to ISO recommendations, and tried to reduce the predictability of lane change events in our second version. In the third version, we kept the reduced predictability of the events, and reduced the predictability of the required response in addition. We conducted three different experiments, all of which had exactly the same setup, the sole exception being the way the LCT was implemented. Consequently, in the analysis presented in this article, we treat the three experiments as three conditions in a between subjects design. However, we want to emphasise that the experiments were conducted one after the other, and not in parallel. The results of Experiment I were important for us to understand whether our implementation of the LCT worked or not, before we could proceed with any other experiment. Findings from Experiment II were taken into consideration when designing the LCT implementation for Experiment III.

2. Method

2.1. Participants

Seventy-two students of TU Chemnitz took part in our three experiments. Three datasets had to be excluded from the analysis for being statistical outliers. Forty-three of the remaining 69 participants were female, 26 male, with a mean age of 22.7 years (*SD* = 3.1). All possessed a valid driving licence. Once they had taken part in one of the experiments, they were not allowed to participate in another one.

2.2. Material

2.2.1. LCT

We implemented the LCT with the STISIM driving simulation environment (see Figure 1). This allowed us to manipulate the relevant environmental variables to create a higher level of unpredictability.

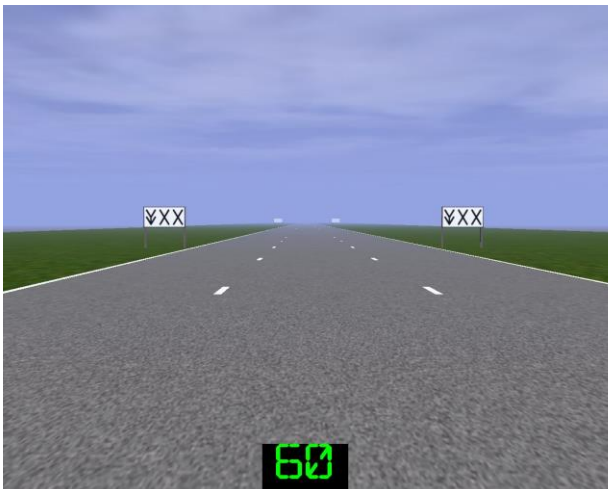

Figure 1. Lane change task (LCT); example screen.

Experiment I. For Experiment I (classical LCT, conforming to ISO), we closely followed the ISO LCT guidelines (ISO/DIS 26022, 2010). We used the well known lane change signs, had them visible permanently with the lane change information popping up 40 m before passing the sign, and put them at the same positions as in Mattes' (2003) LCT implementation, with distances between two signs of about 150 m (SD = 9,6 m; range 140.05-188 m).

Experiment II. In Experiment II (sign position less predictable), we changed sign visibility and sign positions to make event detection more difficult. We completely removed the blank signs from the simulation. Instead, the whole sign (including the information) would only become visible 40 m in advance. A similar setup is mentioned by Mattes and Hallén (2009) as part of the ADAM project, however, no results of such an investigation seem to have been published. We also introduced a higher variation of sign positions compared to the ISO recommendation. Distances between two signs were still 150 m on average, however now with a much wider, random distribution (SD = 33.7 m; range 73-219 m), which resulted in intervals of 4.4 up to 13.1 s between lane changes.

Experiment III. In Experiment III (sign position + sign content less predictable), we wanted to keep event detection as difficult as possible (i.e. we kept the changes made in Experiment II) and add an element of uncertainty regarding the response that was required, to make the task a true event detection and response selection task. To accomplish this, we added signs that did not require any action on behalf of the driver. We placed signs that indicate the change to a specific lane at positions at which the driver should already be travelling on the required lane, i.e. two consecutive signs pointed to the same lane (Mattes and Hallén, 2009, use the term "catch trial"). Overall, we added six signs (two for each lane) that did not require a response to the eighteen that were already part of the track. Positions of the signs that did require a lane change remained the same as in Experiment II, so the normative lane change paths are identical.

The LCT was presented on a 23” flat screen. The vehicle was controlled with a MOMO force-feedback game steering wheel with foot pedals. The length of a single LCT trial corresponded to the length of one LCT track (1,800 m) which took roughly 3 min, provided the participants followed instructions. As performance measures, we calculated both the mean deviation (MDEV) from a normative lane change path and the MDEV from an adaptive lane change model based on a participants baseline drive, as well as lane change initiation (ISO/DIS 26022, 2010).

2.2.2. Secondary tasks

For the secondary tasks, we decided to use a cognitive and a visual task, each of them in an easy and a difficult version. We closely followed the example of Mattes and Hallén (2009) in the selection of the tasks and the levels of difficulty.

In the easy cognitive task, participants had to count forwards in steps of two from 212 on. In the difficult version, the task was to count backwards in steps of 7 from 581 on. Participants were told to keep a constant pace while counting, however without specific instruction on the actual pace.

The visual task we employed was the so-called surrogate reference task (SuRT), which required participants to scan stimulus displays for the one stimulus that differed from others surrounding it. Target and distracters were white circles in front of a black background. Participants responded by moving a vertical grey indicator bar to the position of the identified target and pressing the enter key for confirmation, followed by the next display. For the visual easy condition, distracters were 4 mm in diameter (visual angle approx. 0.46°), the target was 8 mm (visual angle approx. 0.92°), with only two indicator bar sections. In the visual difficult condition, distracters were 7 mm in diameter (visual angle approx. 0.80°), the target was again 8 mm (visual angle approx. 0.92°), with eight indicator bar sections. The task was presented on an 8.37″ screen to the right of the participant. The indicator bar was controlled by using a standard keyboard. Position of screen and keyboard matched the requirements of the LCT ISO.

2.3. Procedure

The procedure was identical for all experiments. Following ISO recommendations, participants practiced LCT driving until they achieved an MDEV < 1.2 using the basic lane change model. Then, they completed one baseline trial (LCT as a single task). The different secondary task conditions (blocked for task type, random for difficulty within task type, order balanced over participants) were explained and practiced as single tasks until participants felt comfortable (usually rather short), followed by one practice trial with both tasks in parallel, before one measurement trial was completed. At the end, participants completed a second LCT baseline trial. The experimental session took about 30 min. Overall data collection was spread over a period of six months, with around three weeks of data collection for each of the experiments.

3. Results

As one of our objectives was to assess whether the lowered predictability has an effect on LCT performance at all, we first analysed performance using the basic lane change model. In the basic model, drivers' lane keeping and changing trajectories are compared against a normative trajectory that is the same for all participants. Delayed responses to lane change signs would result in larger deviations from this normative trajectory, and would therefore be directly reflected in the performance measure. As Figure 2 shows, performance decreased as expected as a function of lowered predictability, however without any clear changes in the overall pattern of results. We calculated a two-way ANOVA for mixed designs and found a significant difference between the six task conditions, $F(5, 330) = 110.47$, $p < .001$, $\eta_p^2 = .626$. More importantly, we found a main effect of predictability, $F(2, 66) = 9.67$, $p < .001$, $\eta_p^2 = .227$. Post-hoc comparisons (Bonferroni-corrected for multiple comparisons) showed significant differences between the original LCT implementation and the two less predictable ones ($p = .027$ and $p < .001$), whereas there was no difference between the two manipulated versions (p = .356). There was no interaction between secondary task type and predictability.

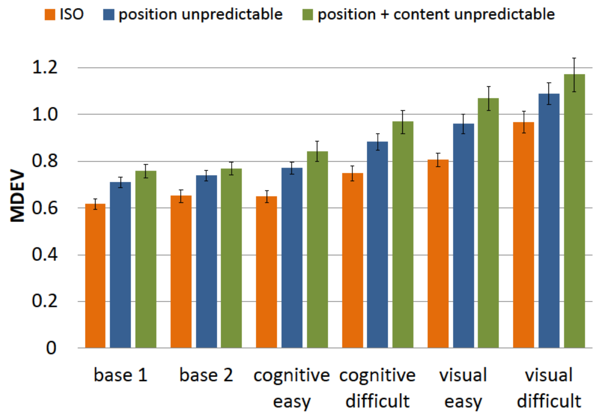

Figure 2. MDEV values (basic model) in baseline and dual task situation for the three LCT implementations (error bars indicate standard error).

We also investigated the difference between the different secondary task conditions and baseline performance, since in the assessment of the distraction potential of a certain task or system, the comparison to non-distracted performance is often of interest. To do that, we calculated the mean of the two baseline conditions, to then calculate the difference between performance in each dual task condition and the averaged baseline performance. It appears that the difference increased with growing unpredictability (Figure 3). The ANOVA showed a significant difference between the secondary task conditions, $F(3, 198) = 76.47$, $p < .001$, $\eta_p^2 = .537$, and also between the three levels of predictability, $F(2, 66) = 3.92$, $p = .025$, $\eta_p^2 = .106$. Post-hoc comparisons (Bonferroni-corrected for multiple comparisons) uncovered a significant difference between the original LCT implementation and the condition in which sign position and content were less predictable (p = .020), whereas there was no difference between the unpredictable sign condition and the other two (p = .580 and p = .466).

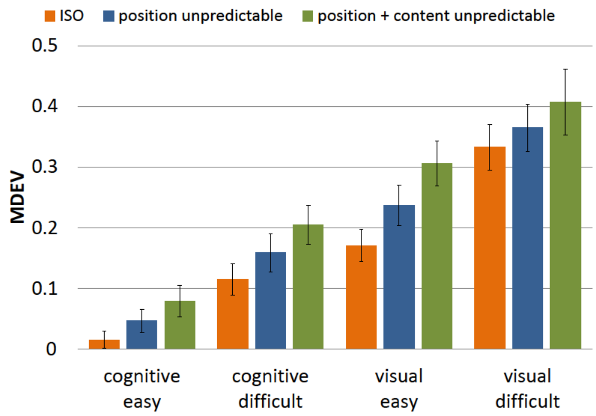

Figure 3. Difference from average baseline for the three LCT implementations (MDEV, basic model, error bars indicate standard error).

In a second step, we analysed performance using the adaptive lane change model, which is the method recommend by the ISO standard (the basic model is described as "optional"). Here, the trajectory against which performance is tested is created using a participants own baseline drive. This method can serve to minimise inter-individual differences in recorded performance. Whereas in the basic model a slow responder would produce overall high MDEV values because his slow responding creates generally large differences to the normative trajectory, the adaptive model accounts for that, as the trajectory against which is tested would expect a later response to the sign from this particular participant. So, if a higher unpredictability of the lane change signs would result in an unspecific delay in lane change initiation across all conditions (including the baselines) the adaptive method would practically filter that effect out.

As can be seen in Figure 4, this appears to be more or less the case. Although a minor decrease in performance seems to occur, the differences are hardly substantial. The ANOVA confirmed this impression, with no significant effect of predictability, $F(2, 66) = .46$, $p = .637$, $\eta_p^2 = .014$. Task condition again had a significant influence on performance, $F(5, 330) = 77.99$, $p < .001$, $\eta_p^2 = .542$. There was no interaction between predictability and task condition.

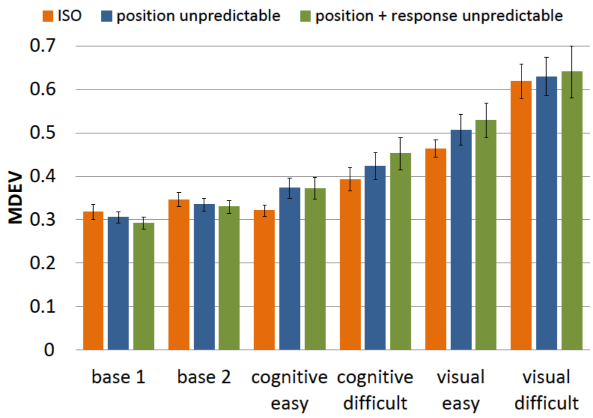

Figure 4. MDEV values (adaptive model) in baseline and dual task situation for the three LCT implementations (error bars indicate standard error).

We also assessed lane change initiation directly. This was done by identifying local minima/maxima of steering wheel angle preceding a lane change. The delay in lane change initiation was then calculated as the time difference between that local minimum/maximum and the appearance of the lane change sign. As displayed in Figure 5, predictability had the expected effect on lane change initiation delay, which was confirmed by the statistical analysis, $F(2, 66) = 43.13$, $p < .001$, $\eta_p^2 = .568$. Post-hoc comparisons (Bonferroni-corrected for multiple comparisons) uncovered significant differences between all three LCT implementations ($p < .001$ for ISO version vs. both less predictable implementations, $p = .023$ for comparison between the two less predictable versions). Task condition also impacted significantly on performance, $F(5, 330) = 159.95$, $p < .001$, $\eta_p^2 = .708$. In addition, we found a significant interaction between predictability and task condition, $F(6, 330) = 4.60$, $p < .001$, $\eta_p^2 = .122$. It appears that while the decrement in performance as a result of lowered predictability is clearly visible throughout, it seems to be especially pronounced in the two visual conditions, where the difference between performance with any of the two less predictable versions and the ISO conforming one is higher than for other task conditions.

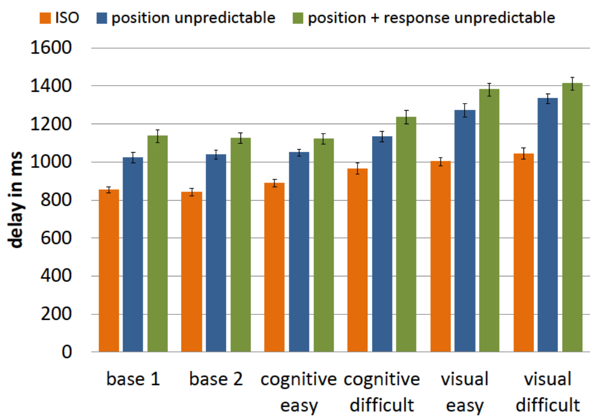

Figure 5. Delay in lane change initiation for the three LCT implementations (error bars indicate standard error).

Finally, we analysed performance in the secondary tasks (see Figure 6). Performance in the visual task was measured as the number of SuRT trials finished. For the cognitive task, the number of counts made during the run of a trial was used as a performance measure. Accuracy (correctly identified target stimuli in the SuRT, correct counts in the cognitive task) was high throughout (group means between 88% for SuRT difficult with ISO LCT and 100% for SuRT easy with position unpredictable LCT), so it can be assumed that participants devoted sufficient attentional resources to the operation of secondary tasks. As would have been expected, task condition had a major influence on performance, $F(3, 198) = 570.54$, $p < .001$, $\eta_p^2 = .896$. Predictability, in contrast, had no main effect, $F(2, 66) = 3.08$, $p = .053$, $\eta_p^2 = .085$. However, we found a significant interaction between task condition and predictability, $F(6, 198) = 4.42$, $p < .001$, $\eta_p^2 = .118$. It appears that the group that was tested on the LCT with reduced predictability of the sign position completed more secondary task trials across all conditions compared to the group that was tested on the ISO conforming implementation. The group for which both sign position and content were less predictable completed fewer secondary task trials than the other two in three of the four conditions. In the cognitive easy condition, however, this group completed a considerable number of trials more than the group that was tested on the ISO conforming implementation.

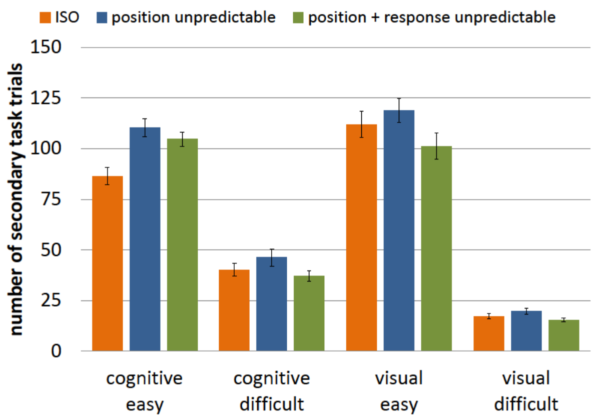

Figure 6. Secondary task performance (as number of secondary task trials completed) in the different experimental conditions (error bars indicate standard error).

4. Discussion

Goal of our experiments was to investigate which effects a decrease in predictability of lane changes in the Lane Change Task (LCT) would have on LCT performance with different concurrent tasks. The results showed that when performance was calculated as the deviation from a normative lane change trajectory, a decrease in predictability lead to degradations in performance. This effect was stronger for the LCT that included both lowered predictability of sign position and required response compared to the LCT in which only sign positions were less predictable. The analysis of lane change initiation delay provided similar results. This is hardly surprising. Green (2000) noted that "time increases with [...] uncertainty (signal location, time or form), and surprise", just as "response selection slows under choice RT when there are multiple possible responses" (p. 200). However, none of the changes to the LCT seemed to produce specific effects in certain dual task combinations. LCT performance in cognitive and visual, easy and difficult dual task situations suffered equally. And when the adaptive MDEV, the recommended performance measure, was calculated, even the main effect of predictability disappeared. Despite the reasonable expectation that a higher temporal uncertainty or a decreased predictability of the required response might affect different dual task combinations in a different way, differences between the dual task combinations remained surprisingly stable.

The only change in the pattern of results that was observed was a growing difference between performance in dual task conditions and the baseline conditions. This might be an issue when inferences are drawn from a direct comparison of dual task conditions with baseline driving, especially when no or only small differences between baseline and dual task performance are found. Minin et al. (2012) reported on an experiment with six experimental conditions, including two single task and four dual task trials. Based on the results of their analysis, they discussed why the basic lane change model was not able to capture performance degradation on the primary task (although they failed to report descriptive statistics on that fact). Mitsopoulos-Rubens et al. (2010) described experiments from which they concluded that the LCT was overall effective in assessing distraction however also discussed why LCT performance was not always significantly affected by cognitive distraction. Considering our results, one might wonder if the same non-effects would have occurred if the LCT would have been less predictable.

One reason why the LCT is appealing as a tool is that although the simulation-like look gives the impression of real-world driving, it is an extremely simple task. We did not want to create a task that is much more complex, but rather tried to stay as close as possible to the original one, only introducing minor changes that would not alter its underlying nature. Our aim was to meddle only as little as possible with the ISO standard. However, it certainly would be possible to push the task further, to make lane changes even less predictable and response selection even more difficult. An example of that would be the integration of a more demanding choice reaction task. Instead of requiring only the processing of one single aspect of information (the lane indicated on the lane change sign), a combination of information might have to be assessed in order to select an appropriate response. One simple variant might be to introduce colour as an additional layer of information on the signs. The combination of a certain sign with a certain colour might have a specific meaning, the combination with a different colour another one. Given the complexity of many driving situations, and given the fact that especially in such complex situations driver distraction appears to produce the largest effects (e.g. Jamson and Merat, 2005), it would be highly interesting to see if results would still be comparable to our findings.

Overall, the results of the experiments reported in this paper support the validity of the LCT. Despite the fact that the ISO standard's claim that the LCT has elements of an event detection task is questionable (especially when thinking not only of events, but safety relevant events), a lower level of event predictability did not produce fundamentally different results. Although LCT requirements were manipulated, the patterns of results obtained with the different LCT implementations were strikingly similar. The ISO conforming version of the task would have come to the same conclusions about the secondary tasks as the less predictable ones. Still, from a theoretical point of view, a lower predictability of lane changes is certainly of higher external validity than the current ISO recommendation. In future revisions of the standard, this might be an aspect that should be considered, given especially its ease of implementation.

In general, the question of external validity is worth asking, not only regarding the requirements of the task, but also regarding the measures that are obtained. Is it realistic to assume that real world drivers aim for "perfect" lateral control (i.e. no variance at all), or does good performance in a regular traffic environment just mean "safe" lane keeping within certain boundaries? Usually, it is fairly easy to come up with examples of bad performance (i.e. crossing the lane boundaries), whereas non-safety critical performance, or different levels thereof are often not straightforward to define. Consequently, absolute criteria for what is acceptable and what is not do not exist. However, this is not necessarily a shortcoming of this specific assessment method. Rather, it appears that the correlation between surrogate measures of safety and actual safety is not perfect, and as of now, only partially understood. In the assessment of driver distraction, however, there is a clear need for absolute criteria to compare against. The current practice of using performance while engaged in an acceptable secondary task (e.g. tuning the radio) as a surrogate for such a threshold is far from being satisfactory. The development of valid thresholds seems to be an important next step, not only for the LCT, but for most measures of driver distraction.

But, it appears that even a definition of driver distraction and a clear statement on its consequences for real world driving are difficult (Regan et al., 2011). So, the "reality" against which simple methods have to be compared is only poorly defined. But only when there is a full, integrated picture of what the driving task is, and how a potential source of distraction is expected to disrupt that task, can definitive statements about the (in)validity of simple assessment methods of driver distraction be made.

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