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Learning effects in the lane change task (LCT) - Realistic secondary tasks and transfer of learning

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Abstract

Driver distraction is a factor that is heavily involved in traffic crashes. With in-vehicle devices like navigation systems or mobile phones on the rise, the assessment of their potential to distract the driver has become a pressing issue. Several easy-to-use methods have been developed in recent years to allow for such an assessment in the early stages of product development. One of these methods is the lane change task (LCT), a simple driving simulation in which the driver has to change lanes as indicated by different signs along the road. Although the LCT is an ISO sanctioned procedure, there are still open questions. One issue are learning effects which have been found in previous studies and which have the potential to compromise the comparability of test results. In this paper, we present results on two experiments that further explored the effect of previous experience on LCT and secondary task performance. The results confirm that learning effects occur when combining the LCT with a realistic secondary task. Also, we found evidence for the transfer of learning from one secondary task to another to some degree, provided that the two tasks are sufficiently similar.

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

1. Introduction

In recent years, the investigation of driver distraction has become a highly important issue in road safety. Driver distraction has detrimental effects on a variety of driving-related variables (see Regan et al., 2009 for an overview), and has been reported to play an important role in traffic crashes (Stutts et al., 2001). While activities like smoking or eating while driving have been common for decades, so called "technology-based distraction" (Young et al., 2003) has come into focus only since navigation systems, mobile phones and related devices have entered daily life, and consequently, our vehicles. Given that in-vehicle information systems (IVIS) and other related devices have become increasingly popular (Buettner, 2009), and that they are reported to be used frequently while driving (Pickrell and Ye, 2011), it is not surprising that researchers have started to develop easy-to-use methods to investigate the extent to which the operation of a certain device is distracting.

One of these easy-to-use tools is the lane change task (LCT; Mattes, 2003). The LCT is a simple and inexpensive dual task method which is used in a laboratory setting to estimate secondary task demand on a driver as a result of the operation of an in-vehicle device. The task employs the look and feel of a simple driving simulation (Figure 1), which mainly consists of a three-lane road, with no other traffic present, and a set of signs appearing on both sides of this 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; duration between lane changes is around 9 s. Main performance measures are the mean deviation (MDEV) from a normative lane change model, or the MDEV from an adaptive model which is based on the participants' own baseline drive. The LCT has been investigated quite thoroughly already (e.g. Bruyas et al., 2008; Engstrom and Markkula, 2007; Harbluk et al., 2009, 2007; Huemer and Vollrath, 2010; Petzoldt et al., 2009), and has subsequently become an ISO standardised procedure (ISO/DIS 26022, 2010). Still, there are open questions like which metrics are most appropriate for which kind of distraction, or how to instruct participants properly to generate reliable and valid data (Young et al., 2011).

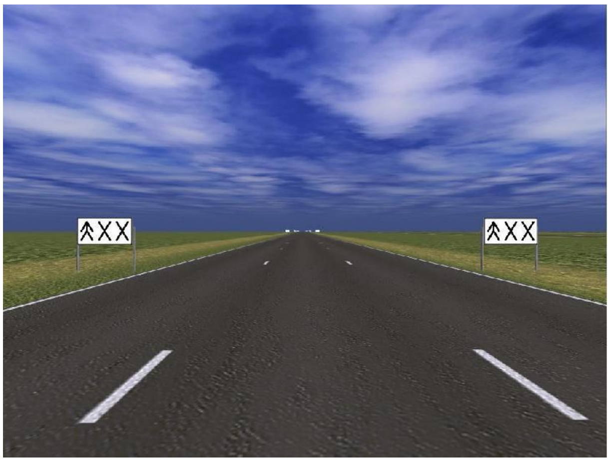

Figure 1. Lane change task (LCT); example screen.

Another issue that has been raised is the potential influence of previous LCT experience (Huemer and Vollrath, 2012; Petzoldt et al., 2011). During the early stage evaluation of in-vehicle information systems, it would not be uncommon that participants are drawn from a pool of people that is regularly recruited for similar studies, and thus might be repeatedly assigned to LCT experiments. The question then is if previous experience leads to effects that alter LCT performance in a way that makes it incomparable to results obtained elsewhere. Evidence from various studies supports this assumption. In a simulator experiment, Shinar et al. (2005) found that after a sufficient amount of practice in using a mobile phone while driving, learning effects led to a decrease in driving impairment. Chisholm et al. (2008) investigated the effects of practice in using an IPod while driving on driving performance. They found that over the course of six sessions, event detection improved considerably, although not to a safe level. Also secondary task performance benefits from repeated practice, as Jahn et al. (2009) reported in their study on skill acquisition in operating navigation systems. An early study by Brown and Poulton (1961) showed that driver performance on an auditory secondary task while driving improved remarkably over the course of several dual task trials. It has generally been argued that such improvements can be the result of improved single task performance ("intratask automaticity"), but also optimised resource allocation between the tasks ("intertask resource deployment strategies", Brown and Carr, 1989). Brown (1998) emphasised that dual task practice promotes time sharing. Damos and Wickens (1980) confirmed that such learning effects occur, and that they even might transfer to other task combinations. But, while gaining experience and learning to allocate resources in an optimal way are good for road safety in general, for the assessment of the distraction potential of in-vehicle information systems, this is somewhat problematic.

Huemer and Vollrath (2012) addressed the issue of learning effects in the LCT in three experiments. In the first experiment, they investigated the development of LCT single task performance as a function of training. Although participants appeared to reach their optimum level of performance rather fast, a significant increase in performance was observed especially from the first to the second trial. Experiment II addressed different training regimes and their effects on dual task performance. Using the so called surrogate reference task (SuRT; Mattes and Hallén, 2009), a self paced visual secondary task, they tested effects of blocked single task, alternating single task and dual task training. Again, they found performance improvements over time, for both the LCT and the secondary task. Interestingly, the different training regimes resulted in different patterns of performance development. More important, however, was that, again, effects occurred. In their final experiment, they substituted the SuRT for another secondary task, the critical tracking task (CTT; Jex et al., 1966). Different from the SuRT, which only requires intermittent monitoring, the CTT requires a more or less continuous devotion of attention. With an experimental setup comparable to the previous experiment, no improvements in LCT performance were found. However, for the CTT, substantial performance increments in the dual task training were observed. Petzoldt et al. (2011) addressed potential learning effects in two similar studies. In their first experiment, they tested the effects of single task and dual task training on LCT and secondary task performance. Participants either received i) no training, ii) a single task LCT training, or iii) a dual task training with LCT + SuRT and LCT + CTT. In a test phase one week after the initial training, all three groups completed several dual task trials of LCT + SuRT and LCT + CTT with various levels of secondary task difficulty (identical to the training phase for the dual task training group). Overall, the results supported the view that both primary and secondary task performance improve with training, with stronger effects for the dual task training. In the second experiment, the period between training and test phase was extended to 4-7 months. The procedure remained largely unchanged, except for the fact that only the CTT was used as a secondary task. Again, performance improvements were found for both LCT and secondary task, which indicates that the training effects found previously are rather stable.

While the results in general indicate that previous LCT exposure might be an issue, the described experiments have certain shortcomings that limit the extent to which these results can be generalised. One problem is the use of artificial secondary tasks, although they arguably have their advantages. They are overall quite standardised, and the level of difficulty is easy to manipulate. However, the fact that they are only artificial gives rise to the question of whether the results obtained are applicable to realistic secondary tasks as well. While the components of demand (usually visual and motor interaction with the task) are similar, complexity might be higher for realistic tasks, which certainly would result in different patterns at least for the learning curve, if not for learning effects in general. Also, the fact that the same secondary tasks are employed repeatedly appears to be somewhat unrealistic. While it is true that subjects are repeatedly drawn out of the same pools of potential participants, it is unlikely that they will be used to test the same systems over and over again. Hence, it is necessary not only to assess if there is any learning effect for LCT use in conjunction with a realistic secondary task, but also whether there is transfer of learning from one secondary task to another. To address these issues, two experiments were conducted.

2. Experiment I

In a first experiment, we sought to find evidence that the learning effects found in previous studies also occur when combining the LCT with a realistic secondary task. Considering the impressive sales figures for both portable (GfK Retail and Technology, 2009) and factory (J.D. Power and Associates, 2010) installed navigation devices, entering destinations into a navigation system was chosen as the secondary task. We decided to use a simple repeated measures design, as this most closely resembled the described problem of repeated use of the same participants when testing in-vehicle information systems.

2.1. Method

2.1.1. Participants

Twenty students from Chemnitz University of Technology took part in this experiment. Sixteen participants were female and 4 were male, with a mean age of 21.6 years (*SD* = 2.7). All possessed a valid driving licence.

2.1.2. Material

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. Any secondary task was stopped as soon as the end of the track was reached. The main performance measure used in this experiment was mean deviation (MDEV) from an adaptive lane change model based on a participants baseline drive (as recommended by ISO/DIS 26022, 2010).

For the navigation system destination entry task, a “Navigon 20 Easy” system was used. Participants had to enter different addresses (city, street, and number) using the system’s touch screen. The addresses were presented in written form before the beginning of a trial, and stayed visible once the trial started. Addresses had to be entered character by character. Once the required destination appeared on the screen, participants were allowed to select it without adding further characters. Addresses were designed in a way that the entry could be completed using 9-11 characters.

As an instrument to assess the load subjectively experienced by the participants, the DALI (Pauzie and Pachiaudi, 1997) was used. This questionnaire is derived from the NASA-TLX (Hart and Staveland, 1988) and is specifically designed to capture the workload experienced while driving with an additional task. Five of the questionnaire’s seven scales that were suitable were selected: global attention demand, visual demand, stress, temporal demand, and interference. The auditory demand and tactile demand subscales (specific constraints induced by vibrations during the test) were omitted, as they were irrelevant in the chosen experimental setup (no auditory or tactile demand present).

2.1.3. Procedure

Participants completed two identical testing sessions which were one week apart. In each session, they started with practice trials of the LCT. In accordance to ISO (ISO/DIS 26022, 2010) recommendations, participants practiced LCT driving until they achieved an MDEV < 0.7 using the adaptive model. The navigation system destination entry was practiced as a single task until participants felt comfortable, followed by one practice trial with both tasks in parallel. Then, they completed one baseline trial (LCT as a single task) and three trials of the dual task situation. After that, they answered the DALI questionnaire and provided demographic information. Overall, one session took about 30 min.

2.2. Results

In Figure 2, MDEV values (adaptive model) are displayed for the baseline and the dual task trials (a mean value was computed for the three trials) for the two test sessions. Adaptive MDEV was calculated using the respective baselines of each individual session (i.e. session one baseline for first session data, session two baseline for second session data). As the focus of this experiment was learning effects, we compared the MDEV values of the first and the second session for both baseline and the dual task situation with t-tests for dependent measures. As Figure 2 indicates, there was a highly significant difference between session one and session two for the trials in which the secondary task had to be operated, $t(19) = 5.30$, $p < .001$, $d = 1.19$. Also baseline performance differed significantly between sessions, $t(19) = 2.74$, $p = .013$, $d = .61$.

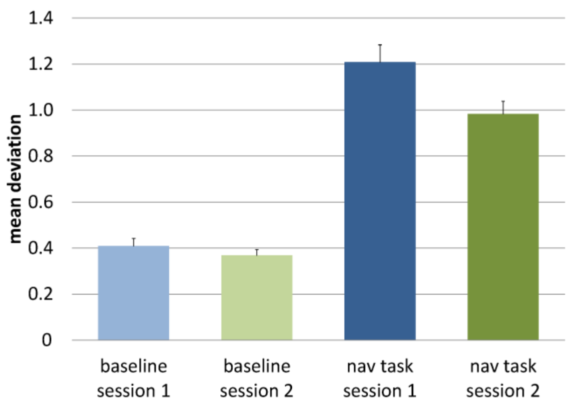

Figure 2. MDEV values in baseline and dual task situation for both sessions (error bars indicate standard error).

Interestingly, when looking at the three dual task trials separately for each session (see Figure 3), there appears to be no positive development during the sessions. Only in the first session, performance seems to improve slightly in the third trial, however far from statistical relevance. For the second session, no improvement is visible at all.

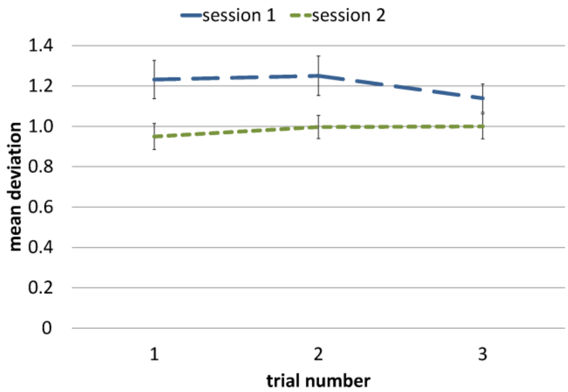

Figure 3. MDEV values in the three dual task trials for both sessions (error bars indicate standard error).

Secondary task performance was measured as the average number of navigation system entries completed per trial. In the first session, participants completed 2.2 entries (SD = 0.54) on average. During session two, they completed about 2.7 entries (SD = 0.73), significantly more than during session one, $t(19) = -2.86$, $p = .010$, $d = .64$.

Figure 4 shows the results for the subjective assessment of the dual task situation (LCT + navigation system entry) for both phases. There appears to be no clear pattern. A t-test for dependent measures uncovered only a significant difference for the scale “interference”, $t(19) = 2.35$, $p = .030$, $d = .53$.

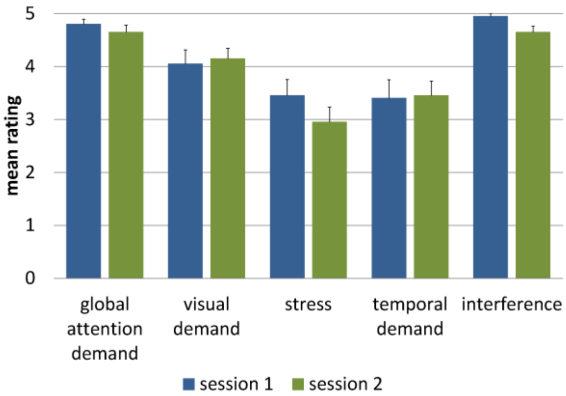

Figure 4. Subjective assessment of dual task situation (error bars indicate standard error).

2.3. Discussion

Our first experiment provided further evidence for the assumption that previous LCT experience might facilitate performance in the LCT as well as a given secondary task. Although the initial exposure to the dual task situation encompassed only few trials, we found substantial learning effects both for the LCT as a single task, and for the LCT in the dual task situation. Moreover, secondary task performance also benefitted from the previous experience. Interestingly, these improvements are hardly reflected in the participants' subjective assessments of the dual task situation. Only the scale "interference" showed a reduction of perceived demand. The fact that perceived interference decreased, however, strengthens the claim that previous dual task experience is not only relevant for the performance in the respective tasks, but also for the optimal allocation of attention between them.

3. Experiment II

Based on the finding that dual task experience with artificial (Petzoldt et al., 2011) and realistic (Experiment I) secondary tasks positively affects performance in subsequent encounters with the same dual task situation, in our second experiment, we focussed on the potential transfer of learning effects from one secondary task to another. Similar to Experiment I, participants should be exposed twice to the LCT and a secondary task, with the first session serving as a learning phase for the second session (test session). However, while the secondary task in the second session was the same for all participants, the secondary tasks for the learning phase differed one from another, and, more importantly, also differed from the secondary task in the test session. To find out whether transfer occurs, we chose secondary tasks that shared aspects with the secondary task of the test session to a varying degree. We called them "near transfer" (for a secondary task very similar to the task in the test phase) and "far transfer" (for a secondary task of limited similarity to the task in the test phase) tasks. Different from Experiment I, we used a between subjects design (control group, far transfer, near transfer).

3.1. Method

3.1.1. Participants

Fifty-nine students from Chemnitz University of Technology took part in the second experiment. Forty-eight participants were female and 11 were male, with a mean age of 22.7 years (*SD* = 3.5). Again, all of them possessed a valid driving licence.

3.1.2. Material

The LCT and its setup employed for this experiment were identical to the previous experiment (see 2.1.2.). Also the navigation system destination entry task was directly taken from Experiment I. The DALI was again used to assess ratings of subjective work load.

As one of the secondary tasks for the learning phase, the surrogate reference task (SuRT; Mattes and Hallén, 2009) was employed. It is rather artificial, and considered a "far transfer" task in relation to real life navigation systems tasks. It requires the participants to scan stimulus displays for the one stimulus that differs from the others surrounding it. Target and distracters are white circles in front of a black background (Figure 5). Participants respond 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 this experiment, we used a rather simple version of the task. 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. The task was presented on an 8.37" screen to the right of the participants, in a position where an aftermarket navigation system would typically be put.

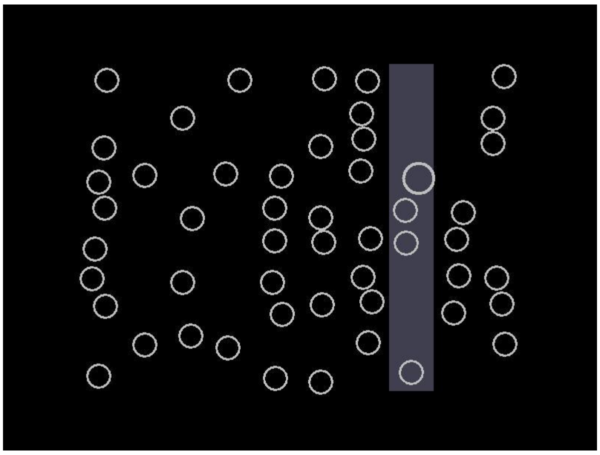

Figure 5. Surrogate reference task (SuRT); example screen.

As a “near transfer” task, we employed a destination entry task on a mobile phone navigation system (To avoid confusion, we will use the term “mobile phone task” from here on. Still, we want to emphasise that the mobile phone task is essentially a destination entry task, similar to the destination entry on the navigations system, only on a different device.). The phone used was a Nokia N70 with navigation software. Just like for the navigation system destination entry task, participants had to enter different addresses (city, street, and number) with the phone. The menu structure was similar to the portable navigation system. However, due to the fact that the phone we used did not have a touch screen, destination entry had to be completed using the phone’s keys. Therefore, while the destination entry tasks on the navigation system and the mobile phone shared several key components, they were not identical.

3.1.3. Procedure

The near and far transfer groups participated in a learning phase that was completed one week before actual testing. We tried to keep the amount of practice similar to the first session of Experiment I, and therefore followed the same procedure. Participants started with practice trials of the LCT (again until adaptive MDEV < 0.7) and the respective secondary task (SuRT or mobile phone task) as single tasks, followed by a practice trial with both tasks in parallel. Then, they completed another single task trial (as a baseline trial) of the LCT and three trials of the dual task situation. The test session was identical for all three groups and followed Experiment I (2.1.3.), using the navigation system destination entry as a secondary task. Again, there was a short practice phase for the single tasks (LCT until performance threshold was reached, secondary task until participants felt comfortable) and the dual task situation (one trial), before one baseline trial and three dual task trials were recorded and the questionnaires (DALI and demographics) administered. Learning phase and test session took about 30 min each.

3.2. Results

In Figure 6, MDEV values (adaptive model) in the test session are displayed for the baseline and the navigation system task for the three groups. As in Experiment I, the goal was not to compare the baseline to the navigation system task, but rather study the effect that experience has on these experimental conditions. Therefore, we compared the MDEV values of the three groups for both baseline and the navigation system task in two separate between-subjects ANOVAs. The analysis showed no significant differences between the three baselines, $F(2, 56) = 1.13$, $p = .330$, $\eta^2 = .04$. Similarly, the MDEV values in the navigation system task did not differ significantly, $F(2, 56) = .56$, $p = .574$, $\eta^2 = .02$.

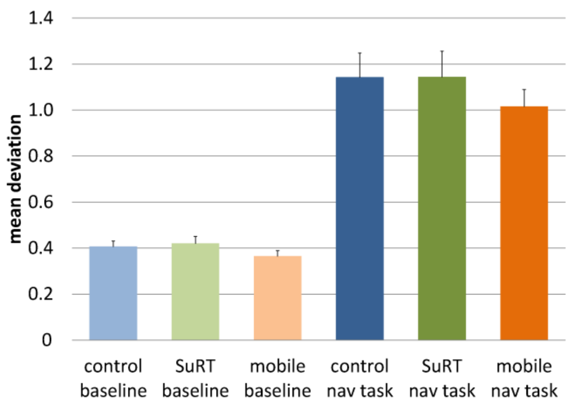

Figure 6. MDEV values in baseline and dual task situation for the different experimental conditions (error bars indicate standard error).

We also looked into the performance in the three dual task trials separately (see Figure 7). Again, there is no clear evidence for learning effects during testing. Similar to the first session in Experiment I, untrained participants' performance seemed to improve slightly, whereas for the two other groups, performance appeared to get even worse in the final trial. However, none of these impressions could be confirmed in a statistical analysis.

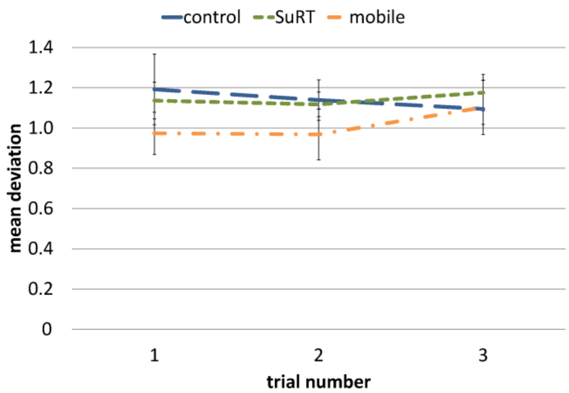

Figure 7. MDEV values in the three dual task trials for the different experimental conditions (error bars indicate standard error).

As can be seen in Figure 8, previous practice did, however, impact on secondary task performance, measured as the average number of navigation system entries completed per trial, $F(2, 56) = 3.94$, $p = .025$, $\eta^2 = .12$. Post-hoc comparisons (Bonferroni-corrected) showed a significant difference between the control group and the group that completed the mobile phone task during the learning phase ($p = .030$, $d = .78$), with no significant difference but a medium size effect for the comparison of the two groups that completed a learning phase ($p = .129$, $d = .64$).

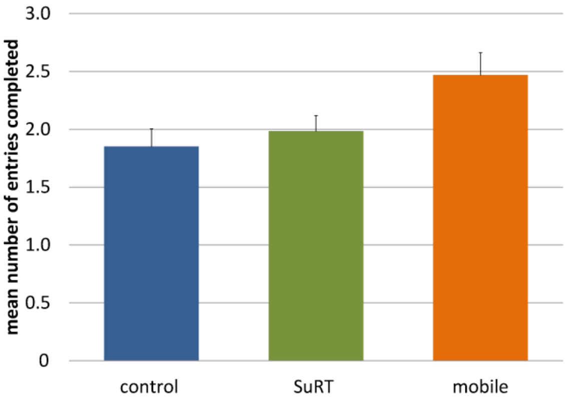

Figure 8. Secondary task performance in the different experimental conditions (error bars indicate standard error).

Figure 9 shows the results for the subjective assessment of the dual task situation (LCT + navigation system entry) for all three groups. As expected, the group that completed the mobile phone task during the learning phase scored lowest throughout. Interestingly, though, the group that learned with the SuRT produced rather high ratings on several scales. Between subjects ANOVAs uncovered significant differences for the scales "global attention demand" $F(2, 56) = 5.74$, $p = .005$, $\eta^2 = .17$, and "visual demand", $F(2, 56) = 5.169$, $p = .009$, $\eta^2 = .16$. Post-hoc comparisons (Bonferroni-corrected) showed a significant difference between the SuRT group and the mobile phone task group for both scales ($p = .004$, $d = 1.10$ and $p = 0.010$, $d = 1.10$).

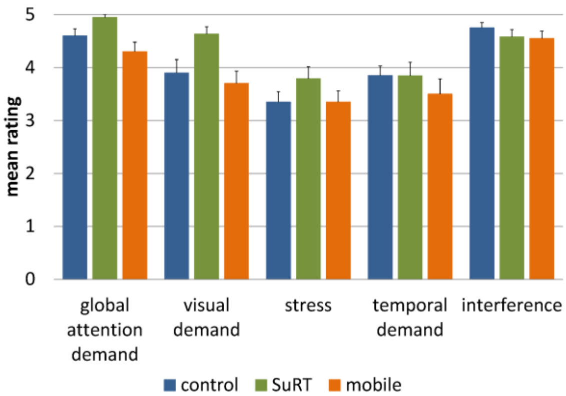

Figure 9. Subjective assessment of dual task situation (error bars indicate standard error).

3.3. Discussion

In our second experiment, we tried to find evidence that the learning effects found previously transfer to other dual task combinations. The results are mixed. LCT performance in the dual task situation did not show any improvements, regardless of training type. However, the LCT ISO standard (ISO/DIS 26022, 2010) emphasises the relevance not only of LCT, but also of secondary task performance for the proper assessment of distraction. And with regard to secondary task performance, significant differences between the groups were uncovered. It appeared that especially the near transfer group benefitted from the dual task training, as it was able to complete significantly more navigation system address entries than the control group. It has been pointed out before that risk exposure is directly related to secondary task duration (Wierwille and Tijerina, 1998), and that therefore the duration of a distracting activity might be just as important as its intensity (Burns et al., 2010). In line with this argument, it can be assumed that although LCT performance did not improve, distraction nevertheless decreased as a result of previous dual task experience for the near transfer group. If distraction would be assessed strictly following the ISO protocol, which recommends the use of both LCT and secondary task data, the conclusions that would be drawn would be compromised as a result of the previous LCT experience.

The subjective assessment of perceived workload showed differences between near transfer and far transfer on two scales. The fact that the near transfer group scored global and visual attention demand considerably lower than the far transfer group indicates that the extent of transfer that occurs is indeed dependent on the similarity of the secondary tasks.

4. General discussion and conclusions

We conducted two experiments to find out if the learning effects found in previous studies also occur when combining the LCT with a realistic secondary task, and if so, if there is a transfer of learning between different dual task combinations. Our first experiment showed that there are substantial learning effects for both the LCT and the secondary task, similar to the findings of Petzoldt et al. (2011) for artificial secondary tasks. The second experiment provided evidence that some learning transfer can occur between combinations of LCT and different secondary tasks. Previous experience on a different LCT + secondary task combination appeared to affect secondary task performance, however only if the secondary tasks are sufficiently similar. Still, the fact that the rather limited exposure to the dual task combination that occurred during the training phase had a significant influence on the performance in another combination of LCT + secondary task further strengthens the claim that the amount of previous experience with the LCT and respective secondary tasks should be considered carefully when recruiting participants. As Huemer and Vollrath (2012) highlight, a substantial number of training in both the LCT and the secondary task might be necessary to reach a performance plateau, and hence eliminate effects of previous experience. However, in the assessment of the distraction potential of any device, it might as well be relevant to not only investigate the distraction it elicits once performance is stable (i.e. the driver is familiar with device and environment), but also to research how distracting the device can be in a first encounter. It can be assumed that especially in situations in which the driver is not familiar with the device he operates, the level of distraction is at its maximum. With regard to the potential road safety issues that follow, this first encounter can be highly relevant for the assessment of driver distraction. In such cases, previous LCT experience would have to be controlled in some way. Ideally, LCT single task performance would be at a stable level (through sufficient practice), while the new device should not have been operated in a dual task setup before.

The fact that performance increments were found in the operation of the secondary but not always in the primary task is further evidence for the relevance of secondary task duration. It has been argued before that especially variations in driver strategies regarding the allocation of attention between primary and secondary task (Benedict et al., 2006) necessitate the acquisition of both MDEV and secondary task measures. An interesting question here is whether the improvement of secondary task performance is the result of a more or less conscious strategic decision (i.e. any resources to spare as a result of previous experience are willingly directed towards the secondary task). While this might be just an artefact (highly motivated participants who want to perform as good as possible – which is, from the participants' perspective, much easier to quantify in "number of address entries completed" than "lane keeping/change performance"), it might as well be a consequence of the fact that in real world driving, the aim is not to eliminate lane variance completely (i.e. perfect performance), but rather to keep variance within a subjectively safe range (Godthelp et al., 1984). Only the inclusion of information on secondary task performance would therefore allow accurate statements on driver distraction and the actual improvement through practice.

It has to be acknowledged that the samples used in both experiments (university students) are not representative of the driver population. Mattes and Hallén (2009) reported that a group of younger (21-39 years) participants significantly outperformed a group of older (40-59) subjects in various dual task combinations of LCT and a secondary task. In general, age has been shown to be negatively correlated with performance on all sorts of dual task combinations (e.g. Hartley, 2001; Korteling, 1991; Salthouse et al., 1984; for an overview see Verhaeghen et al., 2003), although the specific processes underlying this decrease in performance are still debated. More important in this context, however, is the question how age and dual task practice relate to each other. It has been reported that older participants can benefit substantially from dual task training (Bherer et al., 2005; Kramer et al., 1995), often with stronger effects on performance than for younger subjects. In a study by Manes and Green (1997) who investigated driver interfaces in a simulator, a group of older (65-70) participants showed higher improvement in secondary task performance than a younger (21-27) group. As younger participants' performance was overall much better, the authors attributed the result to the fact that the older participants just had more room for improvement. Shinar et al. (2005) differentiated between three age groups: young (18-22), middle (30-33) and old (60-71).

Young and middle aged drivers performed at similar levels for most of the variables (with the exception of the number of errors made in a distracting math operations task), and also exhibited similar practice effects. The older participants showed poorest performance overall, but also benefitted stronger from practice in measures like speed variance or steering variability. Based on these findings, it can be assumed that with other age groups, the effects found in our experiments would at least be the same, if not even stronger.

Although the training effects found in this and other studies are somewhat problematic for the standardised assessment of the distraction potential of a given device, they are not necessarily a shortcoming. The fact that the LCT (or rather combinations of LCT + secondary task) is sensitive to learning effects makes it an interesting tool for the assessment of skill acquisition while operating in-vehicle devices. Similar to the way Huemer and Vollrath (2012) investigated the learning process for the LCT as a single task and for combinations of LCT + artificial secondary tasks, it can be used to evaluate in-vehicle devices with regard to their "learnability". Just as Jahn et al. (2009) were able to develop learning curves for the address entry in different navigation systems as single tasks (which is rather unrealistic, given the common use of those devices while driving), it would be possible to assess the learning process for the dual task situation (assuming, again, that LCT single task performance is stable already). As Jahn et al. (2009) pointed out, process and duration of skill acquisition might differ between devices. Hence, the assessment of "how long does it take until performance is stable" might be just as relevant as "how is performance once it is stable".

If the LCT is to be used to investigate skill acquisition in detail (unlike in the experiments presented here, which were conducted to find out whether "unwanted" learning effects occur when employing the LCT to asses in-vehicle devices according to ISO recommendations) however, the measures that are employed have to be chosen with care. In Experiment I, adaptive MDEV was calculated using the baseline of session one for first session data, and the baseline of session two for second session data, as this resembles the situation in which a participant is repeatedly asked to partake in different (and separate) LCT studies. However, that might have come at the expense of uncovering improvements in lane change performance (as opposed to lane keeping performance). An overall earlier lane change initiation in the second test session would have been incorporated in the adaptive lane change path against which the actual path is tested, and would therefore not be reflected in the results. While this effect is welcome from the perspective of IVIS assessment (as it means that the assessment of the IVIS in question is independent of improvements in lane change behaviour due to exposure), it is certainly an issue if the goal is the detailed study of skill acquisition. Using only the first baseline drive to develop the adaptive path for all future drives is no solution as well. Individuals' variance in this first baseline would be minimised and subsequent improvements in lane change performance might even look like decrements in the data, as e.g. an improved (i.e. earlier) lane change initiation would lead to a higher deviation from the adaptive path. It seems that the basic MDEV, which compares the actual travel path to a normative one, although described only as "optional" in the ISO standard, is the most appropriate measure when it comes to the in-depth investigation of learning processes.

Of course, while the assessment of skill acquisition is interesting in itself, the implications of eventual findings are of even higher practical relevance. Assuming that practice effects might occur over a wide range of in-vehicle devices, training on how to use them, also in a dual task situation, is vital. In a policy paper, the Royal Society for the Prevention of Accidents (RoSPA, 2007) stated that "The issue of making sure that drivers receive appropriate training for the use on in-vehicle equipment is crucial" (p. 58). A detailed investigation of the learning curve for an individual device can provide important information on how such a training should look like. Stevens et al. (2002) provide several general recommendations, the simplest one being to simulate system use in a stationary vehicle. They also suggest an accompanied trial drive in which the system is used under supervision or the provision of a programmed tutorial as part of the system. Initial functionality could be limited according to experience or level of aptitude. A new user might be obligated to perform a navigation system task several times (error free) while the vehicle is stationary before they are able to access those functions when the vehicle is moving. Only findings on the acquisition of skills in operating the system in question can help specify the goal of a training, adjust the amount of training that is required or define a level of experience that is expected before certain functions are made accessible. If sufficient care is taken, the measures that are imposed to facilitate the safe use of in-vehicle devices can be designed in a way that makes them effective and still efficient enough so that they are acceptable to the user.

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