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Live Traffic Camera Content in the Connected Car:

Experiences from Motorway Experiments

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***Abstract*— Today's in-car driver information systems are offering a wealth of multimedia presentation features, which are relying on increasing amounts of available real-time traffic information. Such systems need to efficiently deliver safety-relevant information, but they should not overstrain the driver with too much detail.**

We present two user studies on the motorway to explore the impact of using live traffic content as a preview of the traffic situation ahead on the motorway. Our study showed that neither drivers did not look more often on the Human-Machine Interface (HMI) screen, nor did they display significantly less safe driving behaviors. In fact, drivers did not take too much notice of the in-car traffic content, as they tended to focus on the driving task. Our results also indicate that the impact of traffic pictures is partly mediated by the presence or absence of auditory instructions. When audio instructions were available, subjective comprehensibility did not differ between recommendations with or without traffic pictures. By contrast, when audio instructions were not presented, comprehensibility was rated lower for messages with traffic pictures than without.

A further finding is that drivers recognized the displayed traffic situation better in the smartphone than in the large-screen setup. This was probably due to the fact that the multimedia contents were shown in full-screen mode on the smartphone. Regarding subjective preference, users had moderate interest for using traffic camera content while driving. A specific comparison with regard to the preference of traffic formats showed that abstract animations tended to be perceived as less distracting, but realistic contents such as videos were perceived as slightly more attractive with regard to hedonistic aspects of user experience. Implications for design and further research are discussed.

Keywords*— User studies, Traffic Telematics, Multimedia, Traffic camera, Automotive User Interfaces.

I. Introduction (*Heading 1*)

Information technology is increasingly ported into the car, encompassing various hardware devices and appliances, information services for various purposes and increasingly sophisticated media formats. These provide growing amounts of data about traffic states and incidents in real-time via various channels (audio, text, pictures and even videos) from road operators, radio stations, and other organizations

One of the most often used types of information services is currently to check live traffic camera content directly before starting a trip. As such services are increasingly migrating to mobile platforms, drivers are taking such services into the car with their devices. Thus, although primarily designed for pre-trip situations, such multimedia content may also be used even while driving.

While many car-passengers may acknowledge such increased information and entertainment value, on-trip display of multimedia also bears critical safety risks. There is a large body of empirical evidence showing that visual distraction is responsible for many car accidents. Current and upcoming guidelines, such as the NHTSA human factors guidelines [13], therefore seek to limit sources of visual distraction, such as videos and games. Also the European statement of principles (ESOP) issued guidelines and design goals, which also point to the necessity "not to distract or visually entertain the driver" [4].

However, in the special case of live traffic content, which is related to safety rather than entertainment, we are confronted with two contradictory safety-related considerations. On the one hand, drivers might benefit from a better foresight of the traffic situation ahead, but on the other hand more information should not lead to an increased visual or cognitive load.

This paper presents two user studies which were conducted in real traffic conditions on the motorway. The main goal was to explore potential benefits and risks of using traffic camera content while driving. We were interested in understanding whether on-trip traffic content consumption can provide an opportunity for enhancing the driver's capabilities to understand the traffic situation. At the same time, we wanted to get a first estimate on the expectable safety risks by adding this type of visual information.

As of now, no rigorous empirical evidence on the recommendability of such tailored traffic-related multimedia in the car is available. Results from experiments on visual distraction are not necessarily valid, as these are usually focused on abstracted conventional maps (e.g. [9]) or more recently augmented reality ([6], [11]). It may make a difference whether drivers are watching media for entertainment purposes or whether they are provided with simple pictures or short video snippets that are tailored to support their understanding of the road situation ahead. If presented in small, easily comprehensible portions it may have a clear benefit for the driver. For instance, the information about a traffic congestion further ahead might be enriched with a picture of that exact location, to give drivers a more immediate and concrete notion of the situation than a simple text message.

In order to have a complete picture on the type and size of effects by traffic camera content, it is important to also control for other important impact factors. Experience from past studies has shown that the presence or absence of audio typically has a strong influence on how drivers react to visual information on the HMI. A system that provides all necessary information by audio and that adds additional information, such as traffic-related multimedia, may have better effects than visual-only presentations. However, such assumptions have not been backed up by empirical research so far.

Apart from questions about overall recommendability of traffic-camera content, the exact way how to present it in the interface has not been investigated so far. The suitability of traffic camera content in the car might differ depending on the device on which it is shown. While large screens such as tablets or built-in Original Equipment Manufacturer (OEM) consoles may show the content in an acceptable size, it might be hardly viewable on small-screen devices such as smartphones or personal navigation devices. But even with large screen devices, the question arises whether the presentation of traffic information should necessarily be full screen or whether it can also be shown as a part of the screen.

A further important question with regard to usability but also feasibility and implementation costs is whether presenting a still picture is actually enough for being able to get a grasp of the traffic flow at the shown location, or whether a short video snippet might be more suitable. Also, the minimum necessary picture or video quality (in terms of resolution and framerate) would be required in order to get an understanding for cost-benefit considerations related to a possible service rollout. Furthermore, it might well be that the traffic flow might be more efficiently communicated by means of abstracted animations.

Adding such novel visual features to an in-car user interface may have its greatest benefits in an enhanced user experience. In this regard, we were mainly interested in exploring a potential differential impact on perceived driving support, readability of screen contents attractiveness ("coolness"), but also negative feelings like perceived distraction.

Section 2 describes the method of these two studies and section 3 provides their results. In section 4, we conclude with a summary of main findings, a critical reflection and an outlook on further necessary research.

II. METHOD

To answer the questions above, we designed two studies. Study 1 was a road experiment that systematically assessed the suitability of traffic pictures for on-trip realtime traffic information services, and Study 2 was a road-based inquiry that aimed to compare in more detail possible traffic content presentation formats for such on-trip scenarios. In the following, these two studies are described separately, with regard to participant composition, experimental design, procedure and experimental measures.

A. Study 1: Impact of Traffic Pictures

The study was completed by 25 persons, who had been invited by means of public announcements and the research institution's test participants database. They received a voucher from a consumer electronics store as a remuneration for their participation. The participants' age averaged to 33.6 years. In order to diminish the likelihood of accidents, only experienced drivers were admitted to the sample who had a driver's license for a minimum of two years (i.e. 20 years old) and who drove for a minimum of two hours a week and several times per month on a highway.

The drivers' maximum age was restricted to 65 years. 16 of the participants were male and 9 female - a gender ratio which can be still regarded typical for motorway usage in the investigated region [2]. Experience with navigation devices was varied within the test sample: 11 participants stated to have no prior experience with navigation devices. 8 were regular and 6 sporadic users of navigation devices.

1) Real-time safety scenarios

As application scenarios to evaluate on-trip multimedia use, we oriented ourselves to Vehicle-to-Infrastructure (V2I) services that will be rolled out in the near future on European motorways [8]. In order to get a profound understanding of the various requirements of such services we selected a set of application scenarios that had already been used in preceding road experiments ([6], [7]). As Tab. 1 indicates, these strongly vary with regards to the demands they impose on the user. Compared to normal route following situations, in which drivers actually can fully concentrate on driving, real-time driving recommendations can be quite unconventional and require fast reactions. Examples for such situations are unexpected changes of the recommended route or even emergency stops on the emergency lane.

TABLE I. SAFETY SERVICES ADDRESSED IN THIS STUDY

Recommendation type	Demand	Description
Normal route following ("Normal")	Low	Following the directions on the HMI.
Speed limitation ("Speed")	Low	A new speed limitation is recommended.
Lane utilization ("Lane")	Medium	The system instructs the driver to use a specific lane.
Unexpected route change ("Route")	Medium	A new route is recommended, requiring the driver to react and leave the highway.
Emergency stop ("Emergency")	High	Due to an urgent safety hazard, the system instructs the driver to stop on the emergency lane at a certain position.

In order to convey the realtime character of a future V2I system, the necessary time to react to the provided HMI instruction was dedicatedly very short: drivers had to change the lane within the next 200 meters, to change the route in the next 300 meters, and to make an emergency stop within the next 500 meters. The lane utilization scenario actually included two subsequent lane change recommendations, in order to result in at least one lane change in case the participant is already driving in the recommended lane.

2) *Presentation modality*

We used a PC-based platform for the development of our multimodal in-car application (see also a description of the system and its underlying prototyping platform in [1]). There were two versions with regard to presentation modality: one audiovisual version that presented the safety messages both on the screen and via audio, and a visual-only version in which the audio was turned off.

In each safety instruction, the following information was subsequently provided via audio (speech in quotes, translated from German, example for unexpected route change): (1) an alert by a well-audible non-speech sound and verbally by "Attention!", (2) a distance indication "in 300m", (3) the driving recommendation "Turn right", and (4) the underlying safety information "due to a congestion". Such an audio message had a duration of about 4 – 5 seconds. The key information (2) and (3) was then repeated after 2 seconds.

3) *Traffic camera content*

The visual conceptual design was consistent to prototypes that had been successfully evaluated in previous studies (see more detailed information in [5]). It was a split-screen design, featuring a bird's eye view map of the outside world on the left side and messages boxes on the right side (see Fig. 1).

The visual prototype came in two versions: the 'No picture' (serving as the control condition) and the 'Picture' condition. The 'No Picture' design (see Fig. 1, top) displayed 1-3 message boxes with currently valid safety information and warnings at the bottom, and the resulting driving recommendations on the top (including icon and distance indications). In the 'Picture' design (Fig. 1, bottom), the traffic camera image was placed at the bottom right, instead of the safety information and warnings. The images had been gathered and pre-recorded from traffic cameras next to the test route.

4) *Procedure and Test Route*

The experiment comprised four phases: a briefing phase in which participants were informed about the test and provided demographic data, the training phase for getting accustomed with the car and the driving tasks, the test phase (described below), and a final interview.

The procedure and test route was congruent with that of previous road experiments on safety-related traffic telematics that investigated other aspects, such as realistic visualization and screen size (see also [6] and [7]). In the test phase, participants were accompanied by two researchers: an experimenter, who provided instructions and observed driving behavior, and an operator in the backseat who managed the test instrumentation. Participants drove along a pre-defined route, which was a roundtrip along several highways in the Vienna metropolitan area (Fig. 2). The route had a length of about 55 km, with an averaged test driving time of 45 – 60 minutes.

Fig. 1. : Screen without traffic picture (recommending an emergency stop) and screen with traffic picture (showing a situation on the road ahead necessitating utilization of the left lane)

The main experiment was composed of three phases where each of the four safety recommendations was presented once by the HMI. By allocating the scenario types over these three phases, presentation of each scenario type was stretched over the whole length of the test drive (Tab. 1), thereby preventing systematic experimental order biases.

Furthermore, the order of the safety scenarios was varied throughout the phases, to avoid systematic experimental biases.

There was always a "normal" driving situation of approximately 4.5 km on average before a critical moment, in which a safety recommendation was presented. With this setup, we aimed to simulate normal driving and avoid the pure succession of unusual critical situations: the driver could "fall back" into a typical driving situation, and would then be confronted with a special situation. Furthermore, this setup should help the driver to reserve sufficient mental resources for the safety-critical moments.

Fig. 2. Test route for Study 1

5) *Experimental Design and Measures*

The experiment was a mixed design with 2 between-subject factors (traffic camera content, presentation modality) and 2 within subjects factors (scenario and phase). Participants were randomly assigned to the two traffic camera content setups, that is, 13 persons were confronted with traffic camera content and 12 persons without. Each of these two groups was split into an audiovisual and a visual-only presentation sub-group.

During the drive, the following measures were obtained:

- Safe driving: Directly after each critical situation, the experimenter examined on a rating on a 7-point scale the safety of the driving behavior (no abrupt braking maneuvers, no drastic tempo changes, distance keeping). The experimenter had been thoroughly trained during several test drives, in order to ensure reliability of test results.
- Visual distraction: Long glances to the HMI, defined as lasting more than 2 seconds, were counted. These have been found to be sources of incidents, compare [10].
- Comprehensibility: Participants were asked directly after the respective situation how comprehensible the presentation was to fulfill the HMI recommendations during the drive.

B. *Study 2: Multimedia Format Comparison*

The second study aimed at getting more differentiated insights on how to integrate traffic camera content into on-trip traffic information services. As outlined in section 1, we were interested in whether it makes a difference to use a small or large screen, to present moving or still traffic images, whether the picture quality is important, and whether abstract indications are a valuable alternative to camera pictures.

52 persons participated in this study. The same guidelines with regard to age range and driving experience were followed. Mean age was 35, gender distribution was 30 (56.6%) males vs. 23 (43.4%) females. Experience with navigation devices was distributed to 32 (60%) persons owning vs. 21 (40%) not owning a navigation system. 17 (53.1%) of the navigation system owners used navigation devices regularly and 15 (46.9%) sporadically.

1) *Content Formats*

The same in-car UI setup as described above was used, especially we adopted the same conceptual design and system message flows. However, instead of having only one version with a still picture, we presented five different content formats, in order to gain indications with regard to our research questions (fps = frames per second; kbps = kilobits per second): (1) a high quality video (lossless compression), (2) a compressed video (5 fps / 80 kbps), (3) a sequence of pictures (0,5 fps), (4) a still picture, and (5) an abstract animation (moving or not moving still squares along a road, see Fig. 3 for an illustration).

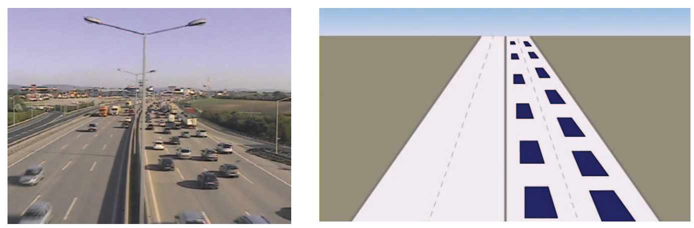

Fig. 3. Multimedia content snapshots of the conditions ‘photo’, ‘photo sequence’, ‘compressed video’ and high-quality video (left side) and the abstract animation (right side)

2) *Screen Size*

We had a ‘large screen’ and a ‘small screen’ setup. The ‘large screen’ setup consisted of a 12” screen, thereby representing a built-in driver information system (see screenshots of this design in Fig. 2). The ‘small screen’ setup was a smartphone that was attached to the PC-based prototyping platform, using a custom video streaming module (compare Fig. 4, left). Thus, we were able to display on the smartphone visualizations by the same rendering engine, conveying the impression of a fully functional smartphone application for the test driver. For both screen sizes the same visual conceptual design was applied (see description above).

The conceptual design of the screen differed between the two screen setups. The large screen was similar to that in Study 1, but due to readability reasons the multimedia content had to be presented on the small screen in fullscreen mode.

3) *Procedure, Test Route and Measures*

Participants drove along a test route of 20 km on a motorway. The test route was subdivided into five phases of about four kilometers, to each of which one of the five above defined formats was allocated (order was varied systematically throughout participants). They were confronted in each phase with two driving recommendations, one speed limitation and one unexpected route change that were enhanced with the respective traffic camera content.

Fig. 4. Small screen test prototype (screenshot)

The study was based on a mixed design with Screen Size as a between-subjects factor and Content Format as a within subjects factor. Participants were randomly assigned to the screen size and to a specific order of multimedia content formats. We used the following measures:

- Safe driving: The same measure for observing driving safety as in Study 1 was applied.
- Description of screen contents: After having experienced the safety recommendations in each phase, participants were asked: "What did you see on the screen?" This was to find our whether a multimedia item had been noticed, and if yes, whether the shown traffic situation had been recognized (e.g. a congestion).
- Quality of Experience rating: We then asked the participants to rate the quality of the presentation on a five-point rating scale, similar to a Mean-Opinion Score in multimedia Quality of Experience studies.
- User experience: After each drive, we conducted an Interview, in which the participants were asked to provide ratings for the five investigated video formats, with regard to perceived support (the extent to which they felt supported for the driving recommendation), distraction, and readability. Furthermore, we were interested in gathering some more user experience aspects beyond the prevailing notion of safety and efficiency in driving studies. For this purpose, we simply asked the following question: "Do you think this presentation is cool?" After each rating, the participants provided short qualitative explanations for their ratings.

III. Results

In this section the results for the two studies are presented: the performed experimental assessment of the use of traffic camera pictures in on-trip situations, the comparison of different traffic picture formats, and the pre-trip exploration.

A. *On-trip use of traffic pictures*

Statistical analysis was done by ANOVAs with Audio, Multimedia, Scenario, and Phase as independent factors and driving safety, comprehension and visual distraction as dependent factors. Although not perfectly suited for handling missing data, we used this approach due to its capabilities of deriving interaction effects of the independent variables. For pairwise comparisons, Bonferroni corrections were applied, in order to account for potential α-level inflations.

1) *Safe driving*

Within the 375 test situations, very few unsafe driving situations were observed by the test facilitators, resulting in a very high mean score of 6.77 (SD=0.54), compare also Fig. 5. No significant main effect was found with regard to our main experimental variables "Traffic Picture", $F_{1,314}=0.28$, $p=0.60$, and "Audio", $F_{1,314}=3.17$, $p=0.76$. There was also not a significant difference between the three different phases, $F_{2,314}=1.85$, $p=0.16$. However, we found a highly significant effect of the driving scenario, $F_{4,314}=8.53$, $p<0.001$. As can be seen in Fig. 5, pairwise comparisons showed that driving behavior was rated significantly less safe in emergency scenarios than in all other scenarios (no other significant difference).

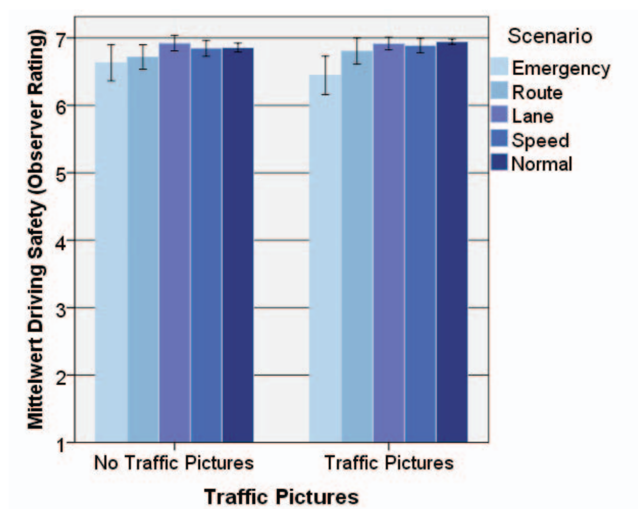

Fig. 5. Mean observer ratings on safety of driving situations with vs. without traffic pictures, grouped by audio vs. no audio.

2) *Comprehension*

Fig. 6 shows the results of the subjects' ratings of comprehensibility directly after having been confronted with the safety message. Note that due to operational reasons, we could only analyze the data of 21 subjects, i.e. 250 test situations (25 subjects x 4 safety scenarios x phases).

Regarding the perceived comprehensibility of the communicated driving task, we did not find a significant difference with regard to Audio, F 1,246=2.25, p=0.14. Situations with traffic pictures were perceived as less comprehensible than those without, F 1,246=5.56, P=0.19. When taking a look at Fig. 6, the version with traffic pictures received similar ratings to those without traffic pictures in visual-only situations, but got lower ratings when audio was present. This interaction between Audio and Traffic Picture was statistically supported, F 1,246=4.60, p=0.33. We did not find a statistical effect of Scenario, F 4,246=0.60, p=0.66.

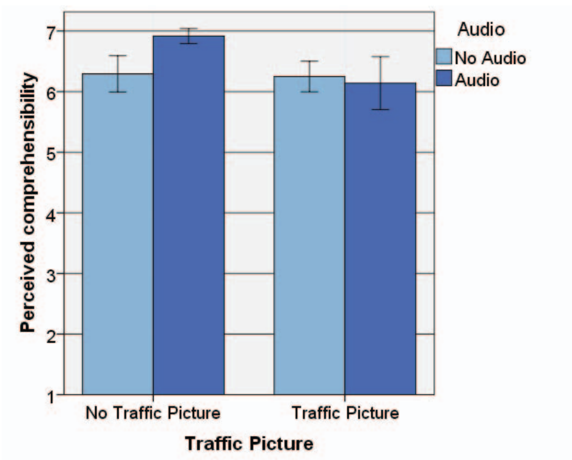

Fig. 6. Comparison of mean user ratings on perceived comprehension with regard to the presence or absence of Traffic Pictures and Audio

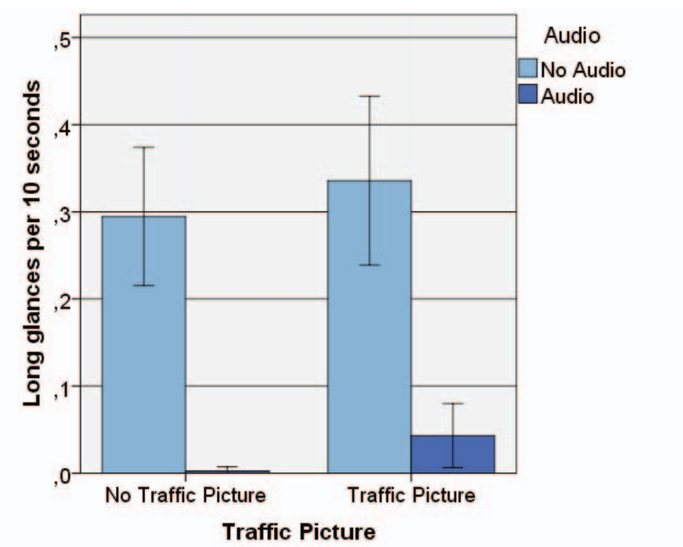

Fig. 7. Comparison of number of glances per second on with regard to the presence or absence of Traffic Pictures and Audio

3) Glances towards the HMI

Fig. 7 shows that the presence of audio made a big difference: with audio users took a long glance on the display for 0.02 times per 10 seconds, but without audio it was 0.31 times per 10 seconds. This effect was highly significant, F 1.278=84.69, p<0.001. In contrast to that, we did neither find a main effect of Traffic Picture, F 1,278=1.51, p=0.22, nor an interaction effect with Audio, F 1,278=0.004, p=0.95, or with Scenario, F 3,222. We found a significant effect of scenario, F 3,222=4.21, p=0.01, but there was no interaction effect of Scenario with the other variables Audio and Traffic Picture.

B. *Traffic Content Format Comparison*

As described in section 2, each of the 52 drivers was allocated to 5 test situations in each of which one of the five multimedia formats could be evaluated. From these 260 test situations, 14 could not be analyzed due to technical issues. For statistical comparisons we used non-parametric tests (Kruskal-Wallis and Mann-Whitney-U) instead of GLM, as these are more flexible in handling missing data.

In only 188 (76%) of these 246 analyzed test situations, participants noticed the multimodal content on the screen. Often people were too busy with driving, such that they could not look at all on the screen. As Fig. 9 indicates, the presented content was recognized significantly less often with the animation than with all other four content formats (65% vs 95% of the noticed multimedia items, all pairwise comparisons p<0.05).

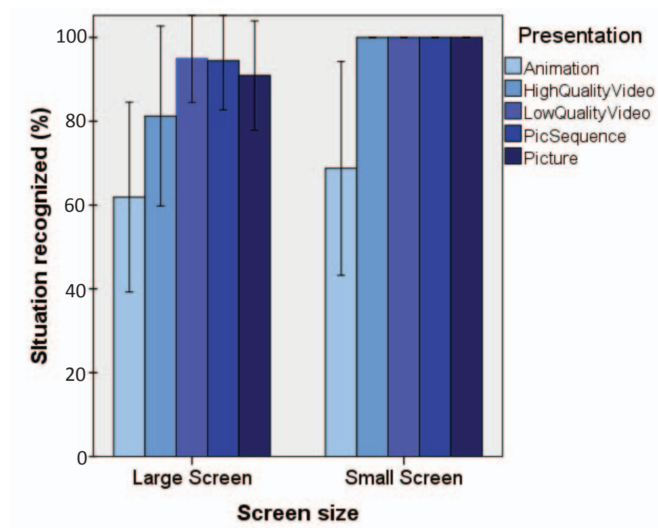

Fig. 8. Percentage of correctly recognized traffic situation

Screen size did not have an effect on the drivers' noticing the contents on the screen (73% vs. 80%, F 1,244=2.05, p=0.15). Interestingly however, participants noticing the multimedia items recognized the presented contents with the (full screen) smartphone presentation more often than with the (partial screen) large display (94% vs. 85%, F=4.87, p=0.029).

1) Interview

The 52 participants who took part in the multimedia formats comparison study were invited to an interview after their test drive. For statistical analysis, we again used non-parametric tests (Friedman and Wilcoxon).

Overall, the perceived quality of the provided multimedia presentation did not differ significantly between the different formats, χ^2=7.7, p=0.10.

In the interview after the test drives, the mean rating scores on the 7-point scales for perceived support of the figures was 3.825 (SD=2.34). No significant differences have been found between the formats (χ^2=5.08, p=0.28). Pure readability appeared to be a little less problematic to participants (Mean for all formats = 5.2), also here the five formats did not differ significantly from each other, χ^2=8.10, p=0.09.

Generally, adding traffic-related multimedia to the in-car interface while driving appeared to be moderately distractive to many participants. This is shown by the moderate mean rating score of 3.8 (where 1 means low distraction and 7 high distraction, SD=2.0), and also participants gave critical comments in this regard.

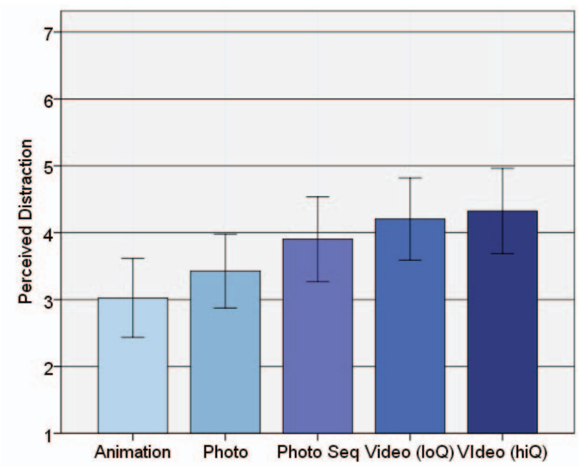

Fig. 9. Mean ratings for perceived distraction (1=very low distraction, 7=very high distraction)

Also the participants' comments related to distraction were mixed: those participants who had often not noticed the screen contents due to focus on driving consequently stated that these were not distractive. Others said that in general multimedia information does not provide enough added value in comparison to their demanded attention.

Interestingly, as can also be seen in Fig. 9, the abstract animation received the lowest distraction score (M=3.02, SD=1.88), which was significantly lower than for the moving camera images (i.e., the photo sequences, the low-quality and the high-quality videos, for all these pairwise comparisons $p<0.05$). Reasons that participants mentioned for their ratings were that abstract animations were easier and faster recognizable, especially compared to video. Also, several participants missed the movement information in the photo and the photo sequence.

Consistent to the above presented results, also our user experience measure of "coolness" was relatively moderate, with a mean score of 3.32 (SD=2.26). As Fig. 10 shows, the coolness ratings show a trend of increasing along the realism of media formats: They were highest with the two videos (M=4.44, SD=2.44; M=4.05, SD=2.45), significantly higher than the still image and the image sequence (M=3.74, SD=2.19; M=3.61, SD=2.01), $p<0.05$.

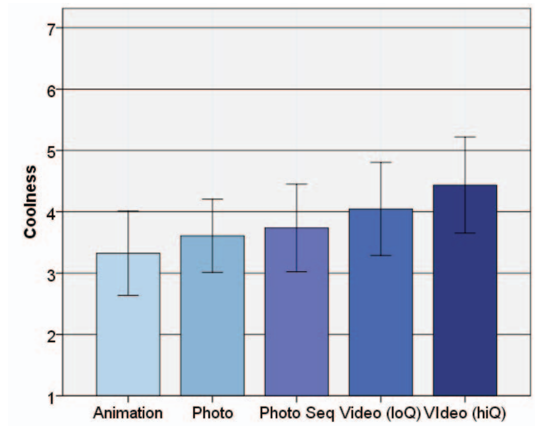

Fig. 10. Mean rating scores for 'coolness' (1=not at all cool, 7=very cool)

IV. Conclusions

We conducted a motorway user study in order to get first indications of the safety and user experience related to using live traffic-related multimedia while driving a car.

A. Main Findings

Other than might have been expected, we did not find indications on potential safety threats by the employment of traffic pictures within car information systems. Neither did drivers look more often on the HMI screen, nor did they show particularly less safe driving behaviors. By contrast, eye glance behavior (Study 1) and driver inquiry (Study 2) suggests that drivers did not take overly much notice of the in-car traffic content. They tended to focus more on the driving task.

A possible way to interpret this finding is that people tend to pay attention to areas that are of most particular value for them, which was in this case not primarily the traffic multimedia content. To this end, follow-up studies should explore whether models such as SEEV (salience-effort-expectancy-value) by Wickens et al. [14] can be used to predict users' tendencies to pay attention towards novel visual features such as traffic previews.

We generally also reconfirmed previous findings that auditory information has strong merits for in-car usage (compare e.g. [11], [3], [9]). This may even to a stronger extent apply to the real-time safety scenarios investigated in this study (compare similar results in [7]).

More specifically, our results also indicate that the impact of traffic pictures is partly mediated by the presence or absence of auditory instructions. When audio instructions were available, subjective comprehensibility did not differ between recommendations with or without traffic pictures. By contrast, when audio instructions were not presented, comprehensibility was rated lower for messages with traffic pictures than without. This finding may have implications on application design, for example by making the display of traffic camera content conditional to the presence of audio instructions.

Furthermore, we found that there was no strong overall preference as concerns different traffic content formats. Basically, in terms of perceived support in the investigated situations, it did not matter too much whether a video or photo was presented. While there was no strong "consensus", we could see that abstract animations tended to be perceived as less distracting, but realistic contents such as videos were perceived as slightly more attractive with regard to hedonistic aspects of user experience ("coolness").

An interesting result is also that people recognized the displayed traffic situation better in the smartphone than in the large-screen setup. This is probably due to the fact that the multimedia contents were shown in full-screen mode on the smartphone. Users could probably more efficiently focus on the shown situation than with the large screen which featured multimedia only as a sub-part.

B. Limitations and Further Work

Much more research is needed in order to facilitate truly valid recommendations on the design of safety-related multimedia services for the connected car. The following critical reflections on the limitations of the research questions and methodology of this first study shall help guide future research activities in this field.

First and foremost, the overall study setup was that of a small-scale semi-naturalistic road study: participants were experiencing several versions of an in-car prototype in real driving scenarios, accompanied by researchers who captured a multitude of usage data. This methodology helps to deeply dive into new topics such as this and helps to get real-world experiences, which is probably much more externally valid than could be achieved with other paradigms, such as simulator experiments. Upcoming studies should continue this path and find ways to investigate the use of multimedia during longer usage contexts and throughout everyday procedures. This will most probably only be feasible within a larger field-operational test activity.

A second aspect that definitely necessitates further development is driving safety measurement methodology. The design of future studies on this topic should try to adopt international standards, such as the new upcoming NHTSA guidelines, in order to facilitate interpretation of their findings and influence within standards definition.

The experimental design was motivated by practical considerations. For example, we designed the display of traffic camera content differently depending on screen size: on large screens we did not devote all screen estate to multimedia in order to leave room for traffic messages, but on small screens we chose a full screen display in order to facilitate readability. The downside of this is of course that we could not assess the full design space in this first study. Especially, it is not fully possible to draw conclusions on the exact influence of screen size (smartphone vs. large display) vs. the screen coverage (full screen vs. partial screen coverage). Future studies should replicate the study with an extended and fully orthogonal experimental design.

Generally, more research is needed to fully make use of traffic-related media services and to go beyond established models of pre-trip viewing. This effort should encompass several disciplines, reaching from interaction design, media informatics, user experience, up to empirical experimental research.

ACKNOWLEDGMENT *(Heading 5)*

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REFERENCES

[1] M. Baldauf, D. Schabus, M. Fuchs, P. Fröhlich, S. Suette, "The ROADSAFE Toolkit: Rapid Prototyping for Road-Testing Novel Automotive User Interfaces." Adj. Proc. AutomotiveUI 2011.

[2] Bundesministerim für Verkehr, Innovation und Technologie (2007), "Mobilität – Verkehrsverhalten." http://www.bmvit.gv.at/verkehr/gesamtverkehr/statistik/downloads/viz07_kap6.pdf

[3] G.E. Burnett, "Usable vehicle navigation systems: are we there yet?" Proc. Vehicle Electronic Systems 2000.

[4] Commission Recommendation of 26 May 2008 on Safe and Efficient In-Vehicle Information and Communication Systems; Update of the European Statement of Principles on Human-Machine Interface.

[5] COOPERS (2010). D16-IR 8200/8500: Final report for disseminating the demonstration achievements, revised business development & roll out strategy.

[6] P. Fröhlich, M. Baldauf, M. Hagen, S. Suette, D. Schabus, A. L. Kun, "Investigating Safety Services on the Motorway: The Role of Realistic Visualization." Proc. AutomotiveUI 2011.

[7] P. Fröhlich, M. Baldauf, S. Suette, D. Schabus, M. Fuchs, "Investigating In-car Safety Services on the Motorway: the Role of Screen Size." CHI 2012 EA.

[8] European Commission. ITS Action Plan. 2010.

[9] B. S. Jensen, M. B. Skov, N. Thiruravichandran, "Studying Driver Attention and Behaviour for Three Configurations of GPS Navigation in Real Traffic Driving." Pro. CHI 2010.

[10] S. G. Klauer, T. A. Dingus, V. L. Neale, J. D. Sudweeks, & D. J. Ramsey, (2006), "The Impact of Driver Inattention on Near-Crash/Crash Risk: An Analysis Using the 100-Car Naturalistic Driving Study Data." US Department of Transportation.report No. DOT HS 810 59.

[11] A. L. Kun, T. Paek, Z. Medenica, N. Memarovic, O. Palinko, "Glancing at Personal Navigation Devices Can Affect Driving: Experimental Results and Design Implications." Proc. Automotive UI 2009.

[12] Z. Medenica, A. L. Kun, T. Paek, O. Palinko, "Augmented Reality vs. Street Views: A Driving Simulator Study Comparing Two Emerging Navigation Aids." MobileHCI 2011.

[13] National Highway Traffic Safety Administration, "Visual-Manual NHTSA Driver Distraction Guidelines for In-Vehicle Electronic Devices." National Highway Traffic Safety Administration (NHTSA), Department of Transportation (DOT), Washington, DC, 2012.

[14] C. D. Wickens, J. Helleberg, J. Goh, X. Xu & W. J. Horrey, 2001, "Pilot Task Management: Testing an Attentional Expected Value Model of Visual Scanning" (Technical Report ARL-01-14/NASA-01-7.