Comparing the Effects of Integrated and Nomadic Navigation Systems on Road Traffic Safety: Results.

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RESULTS

The study aimed to examine the distinctions between smartphone-based car navigation systems and car-integrated navigation systems concerning their potential impact on driving performance, with a particular focus on the mediating role of distraction. Additionally, this research sought to analyze the implications of these differences for the design of car navigation systems and the formulation of regulations pertaining to their future utilization. The study consisted four data collection phases: (1) Survey, (2) expert interview, (3) observation sessions, and (4) controlled experiment.

Throughout this section, the following variable names are used.

S	Sample of smartphone navigation app users
I	Sample of integrated car navigation system users

Table 1: Variable names used throughout this section

Description of survey results

In the survey, a total of <number> participants took part. Not all participants finished the survey. Participants were disqualified from further participation when they do not own a drivers license, or never use a navigation system while driving. The mean frequency of car usage among the respondents was <number> days per week. Frequencies of types of navigation system used is displayed in table <number>. Note that the first two asterisk-marked options below (smartphone, built-in) were used to divide group *S* (smartphone) and group *I* (integrated).

Navigation app on smartphone *	28	53%
Built-in navigation system in my car *	10	19%
Streaming navigation from smartphone to board computer	13	25%
Navigation device like TomTom or Garmin	1	2%
Other system	1	2%

Table 2: Frequencies navigation system types used (n=53)

Frequencies of navigation apps used are displayed in table <number>. Alternative apps such as TomTom Go or Parkmobile were included in the question, but in no cases checked.

Google Maps	20	71%
Apple Maps	6	21%
Waze	1	4%
Other	1	4%

Table 3: Frequencies navigation apps used (n=28)

To the grouped 5-point Likert scale question “How often do the following distractions occur while using your navigation system?”, descriptive statistics are displayed in table <number>. Prior to the Likert-scale questions, participants were asked to name common distractions incurred by their navigation system. The following properties were mentioned most: <a>, <b>, <c>, <d>, <e>.

	s(*I*)	$\bar{x}$(*I*)	s(*S*)	$\bar{x}$(*S*)
1 Distracts from physical activities	0.8	0.8	0.9	0.9
2 Less aware of my environment	0.5	1.0	1.0	1.6
3 Too much time/effort to switch between driving and navigation	0.6	0.8	0.9	1.0
4 I work too hard mentally	0.5	0.5	0.9	0.7
5 Visual attention drifts too often	0.7	0.9	0.8	1.2
6 Visual attention drifts too long	0.7	1.1	0.8	1.2

Table 4: Means ($\bar{x}$) and standard deviations (s) of 5-point Likert scale frequencies of perceived distractions (n=48)

To the grouped 5-point Likert scale question “how often do you experience the following detrimental effects on your driving performance resulting from using your navigation system?”, the following descriptive statistics are identified. Prior to the Likert-scale questions, participants were asked to name common detrimental effects resulting van distractions incurred by their navigation system. The following properties were mentioned most: <a>, <b>, <c>, <d>, <e>.

	s(*I*)	$\bar{x}$(*I*)	s(*S*)	$\bar{x}$(*S*)
7 I drive faster	1.0	0.8	0.9	1.0
8 I drive slower	0.7	1.6	1.2	1.6
9 Deteriorated speed control	0.9	1.6	1.0	0.9
10 Less stable lane position	0.7	1.4	0.7	1.6
11 Lower reaction time	0.7	1.3	0.8	1.7
12 I take a wrong turn	0.7	1.7	1.3	1.8
13 I make mistakes in operating car	0.8	0.9	0.8	0.9

Table 5: Means ($\bar{x}$) and standard deviations (s) of 5-point Likert scale frequencies of perceived negative effects of distractions (n=42)

Two 5-point Likert-scale questions were asked to the occurrence of certain unhelpful properties of navigation systems. Descriptive statistics are displayed in table <number>. Participants were also asked to provide examples of both unhelpful properties. For ‘unhelpful information’ the following properties were mentioned most: <a>, <b>, <c>. For ‘interruptions’ the following properties were mentioned most: <d>, <e>, <f>.

	s(*I*)	x̄(*I*)	s(*S*)	x̄(*S*)
14 I get unhelpful information and/or instructions from the navigation	0.8	2.2	0.7	1.8
15 Navigation system is interrupted while trying to use it	0.5	1.7	0.9	2.2

Table 6: Means (x̄) and standard deviations (s) of 5-point Likert scale unhelpful properties of navigation system (n=40)

For each of the previous 17 Likert-scale questions in the previous three tables, a t-test was conducted to compare the responses between groups *S* and *I*. Given the significance level of α=0.05, significant differences between groups were found in questions “question A” (p=0.0153) and question B (p=0.0419) / no significant differences were found.

The survey resultset by itself does not seem to support a hypothesis that there is a difference in driving performance between users of a car integrated navigation system and users of a smartphone based navigation system / suggests that (drivers in group I / group S) are more often distracted by their navigation system.

Encoding the open-ended questions seems to explain why the difference between the groups is <such/so>. While group I complains mostly about <code, code and code>, group S complains about <code, code, and code>, indicating that <distraction concept from literature> applies more to <group>.

- analyse the differences between the groups by coding from text as well as from t-tests and regression analyses.
- Besides differences, also highlight patterns.
- explain how these findings relate to the RQs.

Description of interview results

Visual distraction was identified as the most significant and dangerous form of distraction while driving. The interviewee mentioned that the probability of a car accident increases substantially after just two seconds of visual inattention. To measure and analyze these distractions, the Wiener Fahr Probe was proposed as a suitable method. Despite its reliance on subjective experiences, this approach offers the advantage of flexibility in capturing and describing unforeseen situations, and less resource intensive for a small scale naturalistic driving study.

Several key measures have been identified for evaluating driving performance, including SDLP (standard deviation from lane position), steering jerk, breaking delay, abrupt breaking, time to collision, time headway, post encroachment time, and speed control. Task breakdown in driving assistant applications are more effective in safely allocating drivers’ attention compared to tasks that impose a time constraint. Attention and cognitive workload are important considerations in driving, and the concept of the "bathtub curve" has been introduced to illustrate the relationship between workload and attention. It emphasizes the need to maintain an optimal level of task difficulty and task load to ensure the driver can direct sufficient attention towards the road.

Navigation systems play a helpful role in driving performance by alleviating search behavior and allowing drivers to focus more on driving tasks as opposed to navigating. As driving assistance systems assume increasingly prominent roles, their impact on driver attention becomes a subject of investigation. This investigation includes understanding the "bathtub curve" and its implications for workload and attention. Future developments may involve navigation systems guiding drivers' roles on specific sections of the road, when driving assistants are switched on or off.