



“I’M SAD WHEN YOU’RE DISTRACTED” – EFFECTIVENESS AND USER EXPERIENCE OF AN INNOVATIVE DRIVER MONITORING SYSTEM FOR PARTIAL AUTOMATED DRIVING

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INTRODUCTION

PARTIAL AUTOMATED DRIVING (LEVEL 2 (L2) SAE, 2021)

- ▶ Driver is still responsible to monitor the roadway and to be ready to react to a system limit or error at any time.
- ▶ Driver monitoring systems (DMS) assure that drivers keep their hands on the steering wheel and their eyes on the road, and warn if drivers do not fulfill their responsibilities.

CURRENT IMPLEMENTATIONS OF DMS SYSTEMS

- ▶ Hands-on detection and warning according to UN ECE regulation R79 (2017).
- ▶ Visual attention detection and warnings: new regulations, e.g. from Euro NCAP (2022): Both long distraction > 3 s and short, cumulated distraction (10 s within a 30 s time window) result in an attention warning

NEED FOR/EFFECTIVENESS OF DMS SYSTEMS

- ▶ Morando et al. (2020; on-road study): With active Tesla Autopilot (hands-on requirement), drivers have taken their hands off the wheel more frequently than during manual driving
- ▶ Blanco et al. (2015; simulator study): Visual inattention warnings encouraged drivers to monitor the road. Over the course of the study, some drivers became habituated and ignored the warnings to complete a non-driving related task.



RESEARCH QUESTION

HOW TO DESIGN THE HMI OF AN EFFECTIVE DMS WHICH

- ▶ supports drivers' understanding of the responsibility for a continuous monitoring
- ▶ is comprehensive and user friendly
- ▶ is accepted without being perceived as paternalism?



DEVELOPMENT OF AN INNOVATIVE DMS-HMI CALLED “JEANNIE” (EMOJI-LIKE AVATAR)

- ▶ Jeannie provides continuous visual emotional feedback to the driver dependent on driver's behavior (changing emotional expression)
- ▶ and issues concrete speech-based warnings in response to prolonging hands-off or eyes-off behavior



METHOD

TEST SETTING

DRIVING SIMULATOR STUDY

- ▶ Static driving simulator at WIVW GmbH
- ▶ Implementation of L2 system: allowing both hands-on and hands-off driving (speed-dependent)
- ▶ Implementation of a DMS system (hands-on detection in steering wheel and eyes-off detection via SmartEye eye tracking system)



STUDY DESIGN

- ▶ Study sample: n=30 participants (from test driver panel)
- ▶ Between-factor: conventional vs. innovative DMS (“Jeannie”)
- ▶ Driving on the highway, mainly with active L2 system



L2 HMI

- ▶ In cluster display: L2 status icon, separate icon for hands-on vs. hands-off driving requirement („hands“), separate icon for requirement to monitor the road („eye“)
- ▶ Text with system name and explanation of responsibilities in L2 (monitoring + hands-on or off the wheel)



METHOD

DMS VARIANTS



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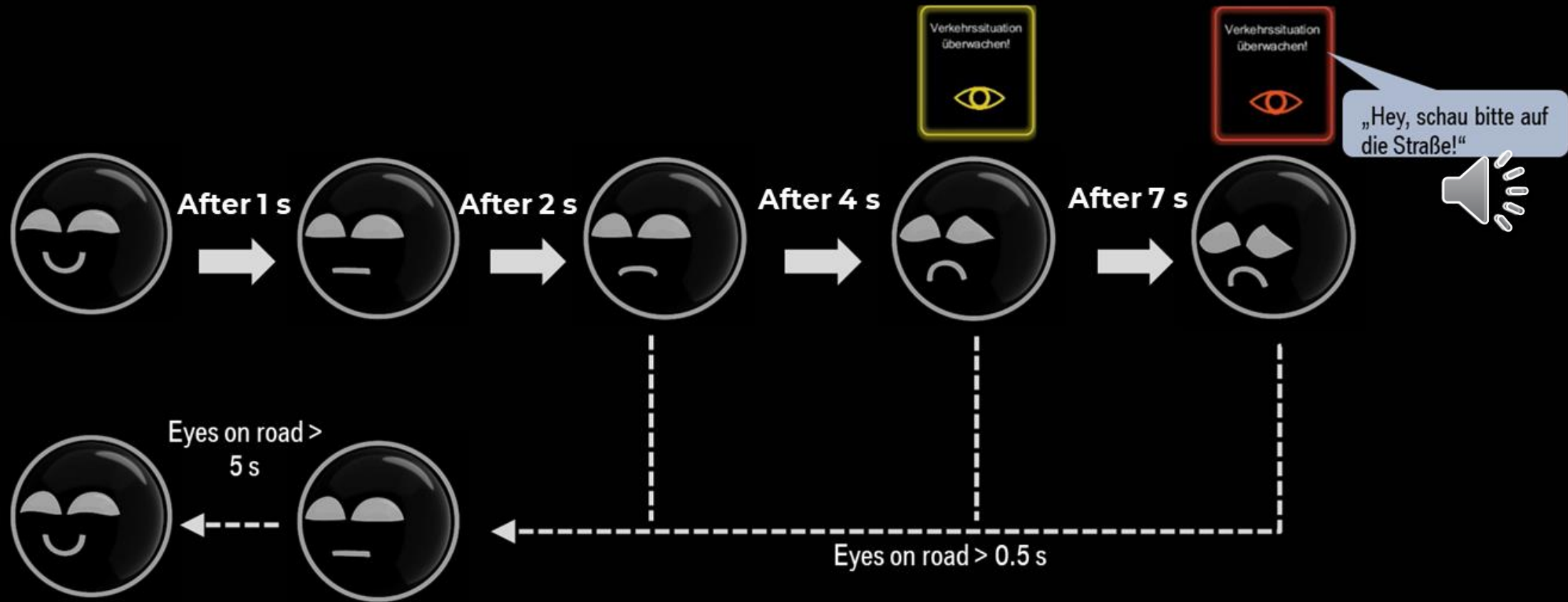


CONVENTIONAL DMS

- ▶ Visual + acoustic speech-based warnings based on DMS output:
- ▶ In case of hands-off driving (according to UN ECE R79) or too long distraction (self-defined threshold: > 4s glances off the road)
- ▶ Displayed inside L2 HMI cluster display

INNOVATIVE DMS („JEANNIE“)

- ▶ Discrete warnings based on DMS output (Displayed inside L2 HMI cluster display)
- ▶ + Avatar Jeannie at separate display in the CID
- ▶ Continuous visual emotional feedback on the degree of fulfillment of monitoring tasks (hands-on and eyes-on)
- ▶ + Addressing driver needs with support services
- ▶ More human-like voice for warnings and support compared to conventional HMI



JEANNIE OUTPUT IN CASE OF EYES-OFF THE ROAD*

*Sequence and outputs comparable for hands-off the wheel (but more extended in time)





METHOD

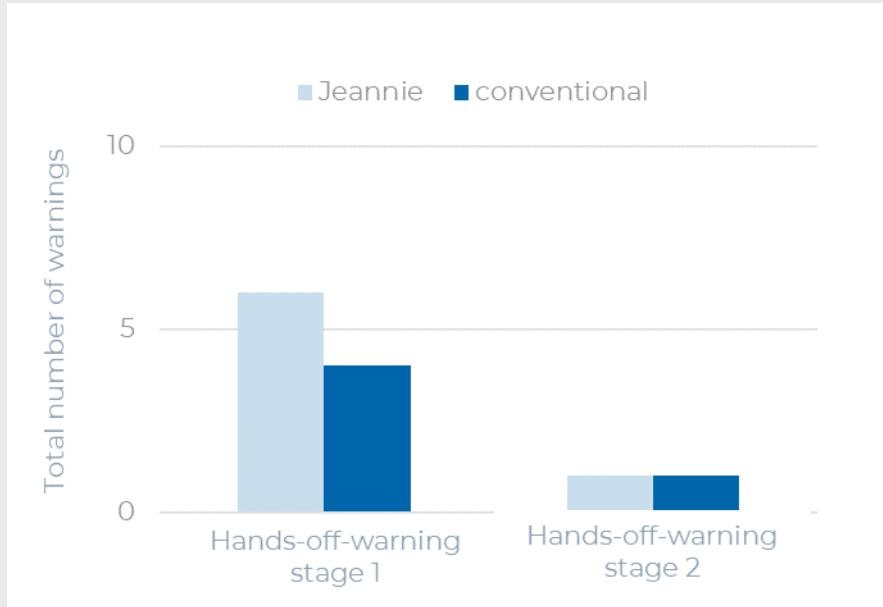
TEST PROCEDURE

Part	content	Duration [min]
Introduction	Welcome, corona test, informed consent, privacy policy	10
Practice drive	Short manual drive to get used to simulator	5
Drive A (free drive)	Driving on highway, experiencing DMS-variant according to test plan, intuitive drive without explanations/support	20
Survey after drive A	Self description of experienced system, open questions about Jeannie (what did she do? And why? System Usability Scale SUS, User Experience Questionnaire UEQ)	10
Drive B (including „supporting“ use cases)	Driving on highway, experience of DMS-variant according to test plan; additional “supporting” use cases e.g. text messaging on smartphone: Jeannie group is supported with speech-to-text function vs. conventional group has to type in the message	15
Survey after drive B	Subjective perception of support by Jeannie, SUS, UEQ	10
Drive C (instructed DMS-warnings)	DMS-warnings are deliberately triggered, driver is directly asked about warnings/behavior of Jeannie	10
Drive D (alternative DMS-concept)	Alternative DMS-condition, DMS-warnings are deliberately triggered in order to allow a direct comparison between the two DMS variants	5
Final survey	Preference of HMI variants	10

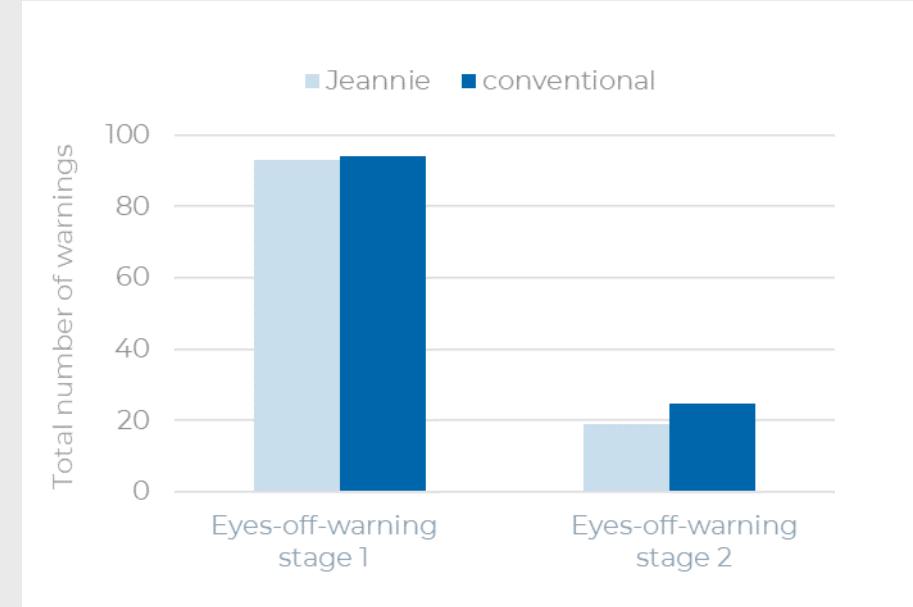


RESULTS

NUMBER OF RECEIVED WARNINGS AND UNDERSTANDING OF THEIR REASONS



Hands-Off warnings



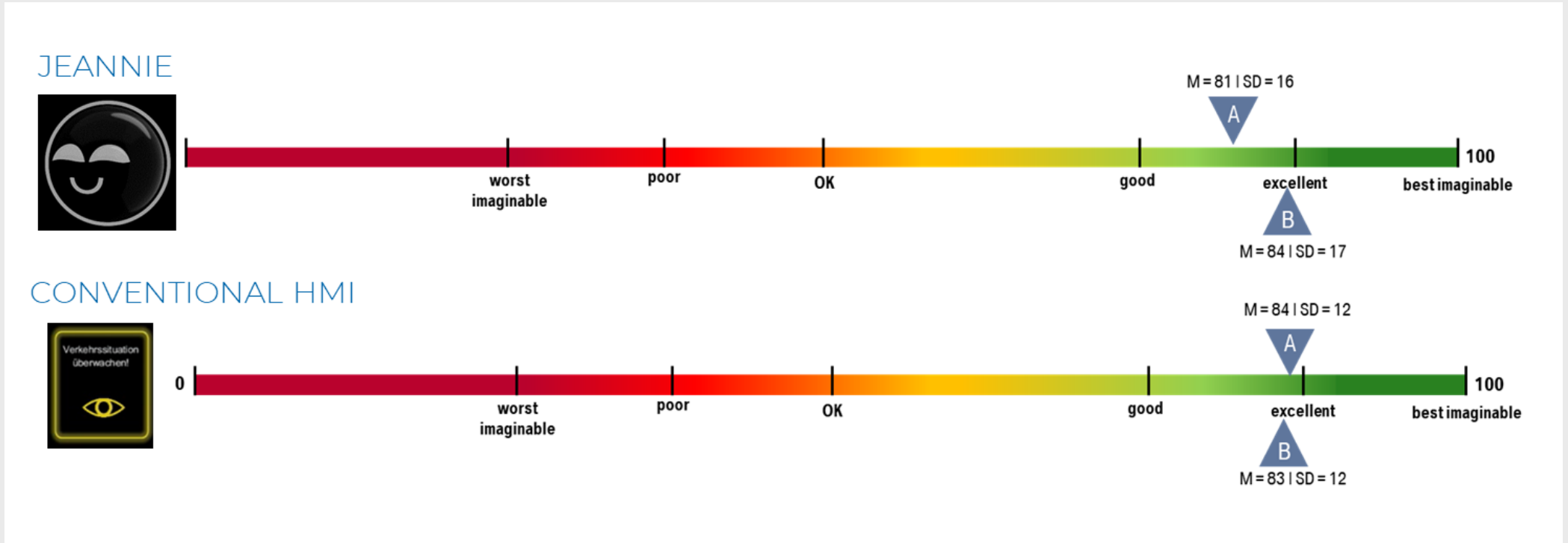
Eyes-Off warnings

- ▶ Number of received warnings did not differ between the two DMS-concepts - both concepts are equally effective
- ▶ Result from post-survey: All drivers (except one each) understand the reason for the hands-off warnings and the eyes-off warnings



RESULTS

SYSTEM USABILITY SCALE (SUS)

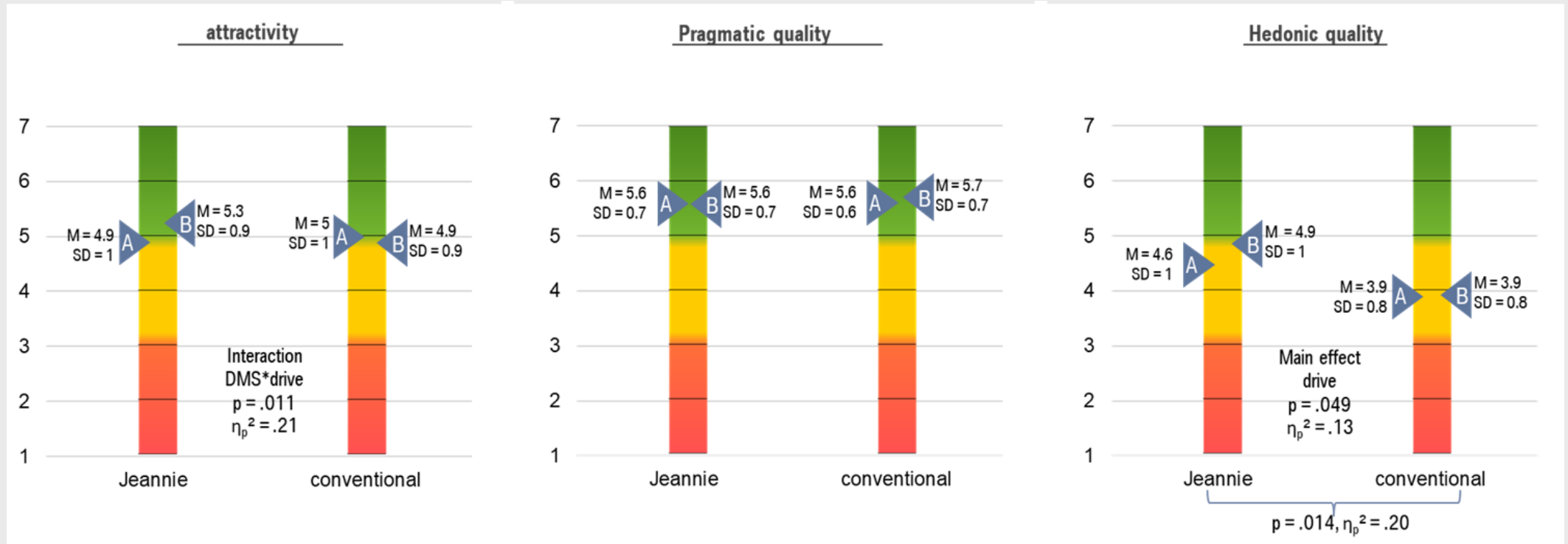


- ▶ The L2 system achieved good to almost excellent usability ratings with both DMS concepts
- ▶ No difference in SUS scores between the DMS-variants and between drive A and B (B: with additional support in Jeannie condition)



RESULTS

USER EXPERIENCE QUESTIONNAIRE (UEQ)

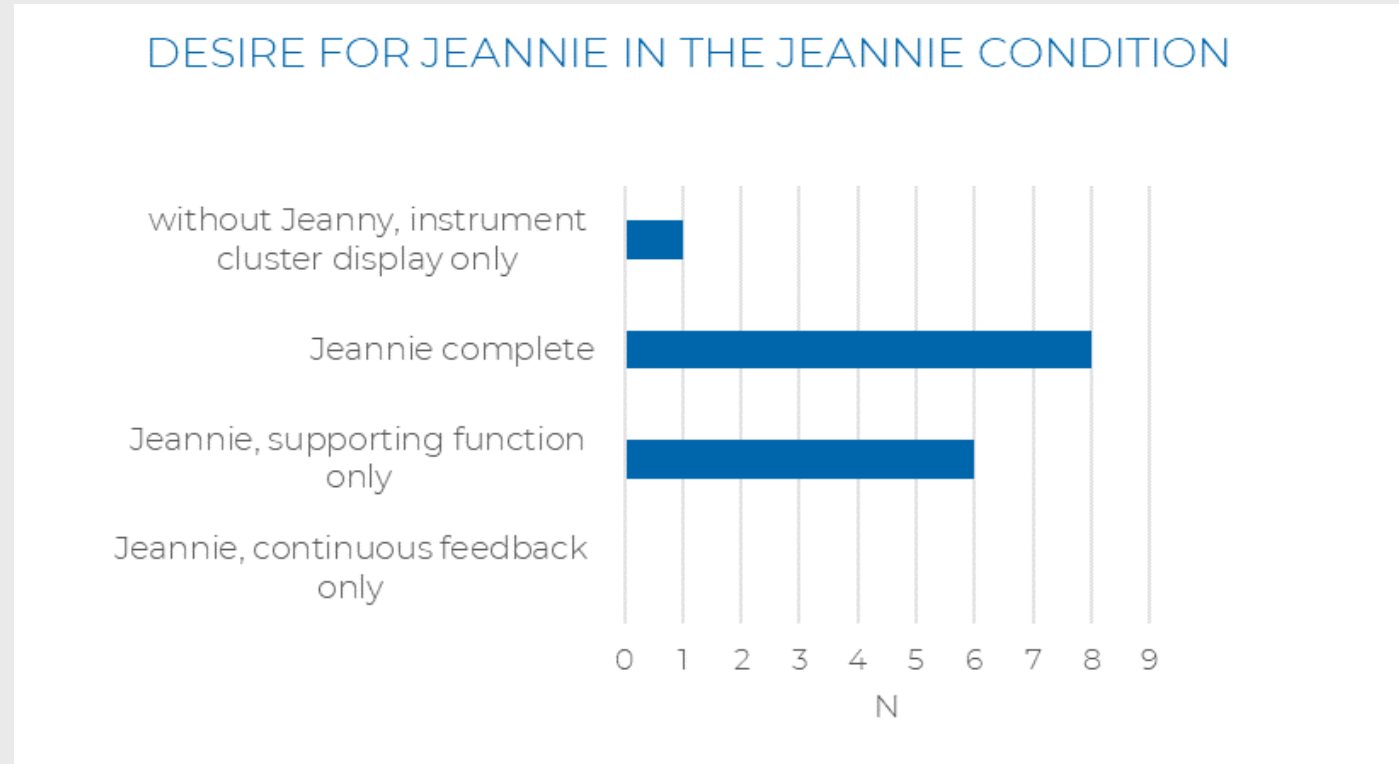


- ▶ Jeannie achieved higher User Experience values compared to the conventional DMS. Mainly due to the higher hedonic quality of the concept
- ▶ Hedonic quality increased from drive A to B. Attractivity for Jeannie increased from drive A to B, but decreased for the conventional DMS.



RESULTS

DESIRE FOR JEANNIE



- ▶ Half of Jeannie users wanted to have the complete system, n=6 subjects wanted only the supporting function
- ▶ More negative comments about the continuous feedback of Jeannie: perceived as additional distracting factor, feedback is too ambiguous, visualization is too dynamic



SUMMARY AND CONCLUSIONS

COMPARABLE EFFECTS FOR BOTH DMS CONCEPT:

- ▶ Both concepts are comparably effective in creating an understanding of DMS warnings
- ▶ Both concepts require only moderate visual demands (not shown here)
- ▶ System usability of the L2 system achieves comparable, almost excellent values with both DMS systems.

BENEFITS FOR THE JEANNIE CONCEPT:

- ▶ Higher perceived user experience, especially higher hedonic quality for Jeannie
- ▶ Supporting function of Jeannie experienced in drive B increased attractiveness and hedonic quality
- ▶ Drivers especially liked the supporting function of Jeannie and the more human-like interaction with the system

DISADVANTAGES FOR THE JEANNIE CONCEPT:

- ▶ Drivers do not wish to have the continuous visual emotional feedback



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THANK YOU VERY MUCH FOR
YOUR ATTENTION

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