

Attachment 5

## **Presentation virtual exterior mirrors (VAS)**

Spiegel Institut Mannheim für I/EE-71, Mannheim, 07.07.2017

## Management Summary (I/III)

- › Concept-test of the virtual exterior mirrors in a test vehicle. Implementation of use cases with 51 participants. All participants perform a testdrive with both virtual and conventional exterior mirrors. Objective (gaze data and observation) and subjective data (interrogation) were collected.
- › Initial reactions to virtual mirrors are mixed: While some participants initially like the concept, especially the field of view and image quality, the larger proportion is rather sceptical. The image size and the smaller field of view were initially criticized in comparison to the KAS. The adjustment range (ange of the VAS) could also offer more scope. Especially the 1-second delay, when switching between driver and passenger side, leads to irritation.
- › A quick learning effect can be observed when adjusting the virtual mirrors when stationary. While there were still relatively many operating difficulties with the first use case, these have decreased considerably in the course of time.
- › There is potential for optimization with the „Auto“ setting, wich is not clearly recognized as the default setting. In addition, the delay in switching between the two mirrors is too long and the display area than can be used for adjustment is not clearly visible as such.
- › The Zoom function was hardly ever used (due to the already small image detail). A „further-zoom-out“ would be more desirable

## Management Summary (II/III)

- › Clear learning effects can also be observed in the test during real driving (lane changes left/right and overtaking processes on the highway). While significant differences (both in the subjective evaluation as well as in the gaze data) often become apparent during the first execution of the tasks, these can no longer be recognized during the second run.
- › The participants perceive the virtual mirrors safe and reliable while the most tasks. Confidence in the passenger mirror is significantly lower when overtaking than with conventional mirror, but still at a very high level. Some participants wish for a blind spot assistant which should be integrated in the VAS (together with the indicator)
- › In parallel parking, there are only minor differences between the two concepts. However, parking backwards into a parking bay is perceived as more difficult with the virtual mirrors and the participants do not feel as safe with conventional mirrors, because the image section is perceived to be small and the field of vision downwards is not optimal. Automatic tilting of the mirrors would be desirable in both concepts.

## Management Summary (III/III)

- › In Conclusion the concept evaluated rather well, but is polarizing when the participants have to decide. However, More than the half would decide to opt for a VAS (if you ignore any surcharge). Arguments for the conventional concept are the familiarity, the larger image section and a higher reliability / lower error susceptibility. („What if the VAS ever fails?“)
- › The image quality of the VAS is most pleasing and the reduced head movements while driving are perceived as pleasant. Only a small percentage of participants feel the VAS is more distracting than the KAS (largely due to their unfamiliarity with the concept)
- › Greatest potential for optimization: The display and especially the image section should be larger and provide a larger field of view. Furthermore, a good integration into the interior is important so that the position is not perceived as unsettling.
- › Whether it is more pleasant / unpleasant to look in the VAS is somewhat polarizing, but overall it tends to be perceived as more pleasant to look in the VAS. The image quality and optimised viewing direction (less head movements required) are pleasing.
- › On the system usability scale, the virtual exterior mirrors achieve a total score of 76, which conforms to good usability.
- › The display size and the setting options polarize in the evaluation of the VAS. When it comes to operability, adjusting the passenger mirror is the worst overall. The feeling of safety is predominantly judged well.

# Agenda

**01. Overview – Setup and Sample**

**02. Results – Use Cases Standing**

**03. Results – Use Cases while driving**

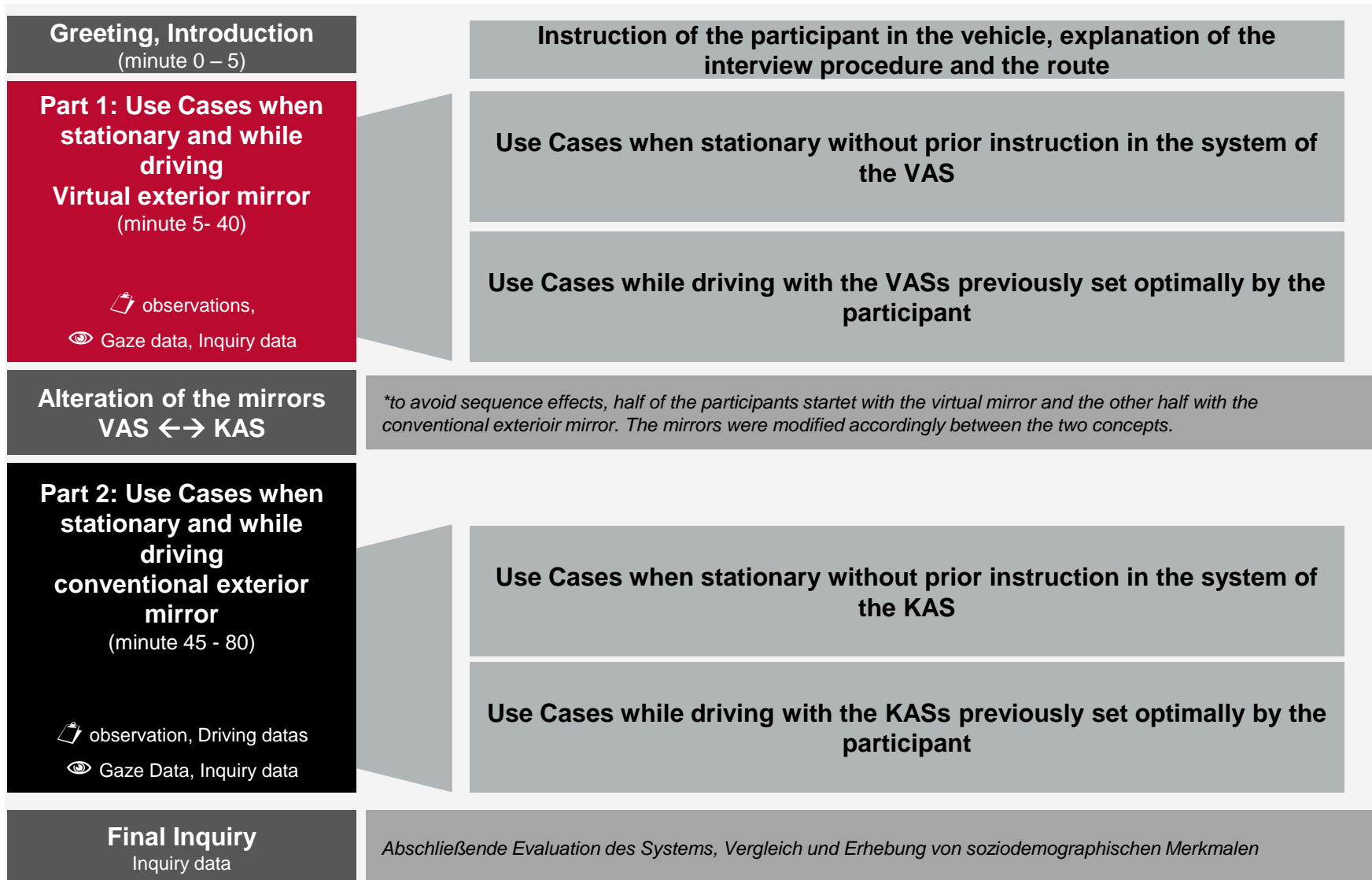
**04. Results – Final inquiry**

# Setup

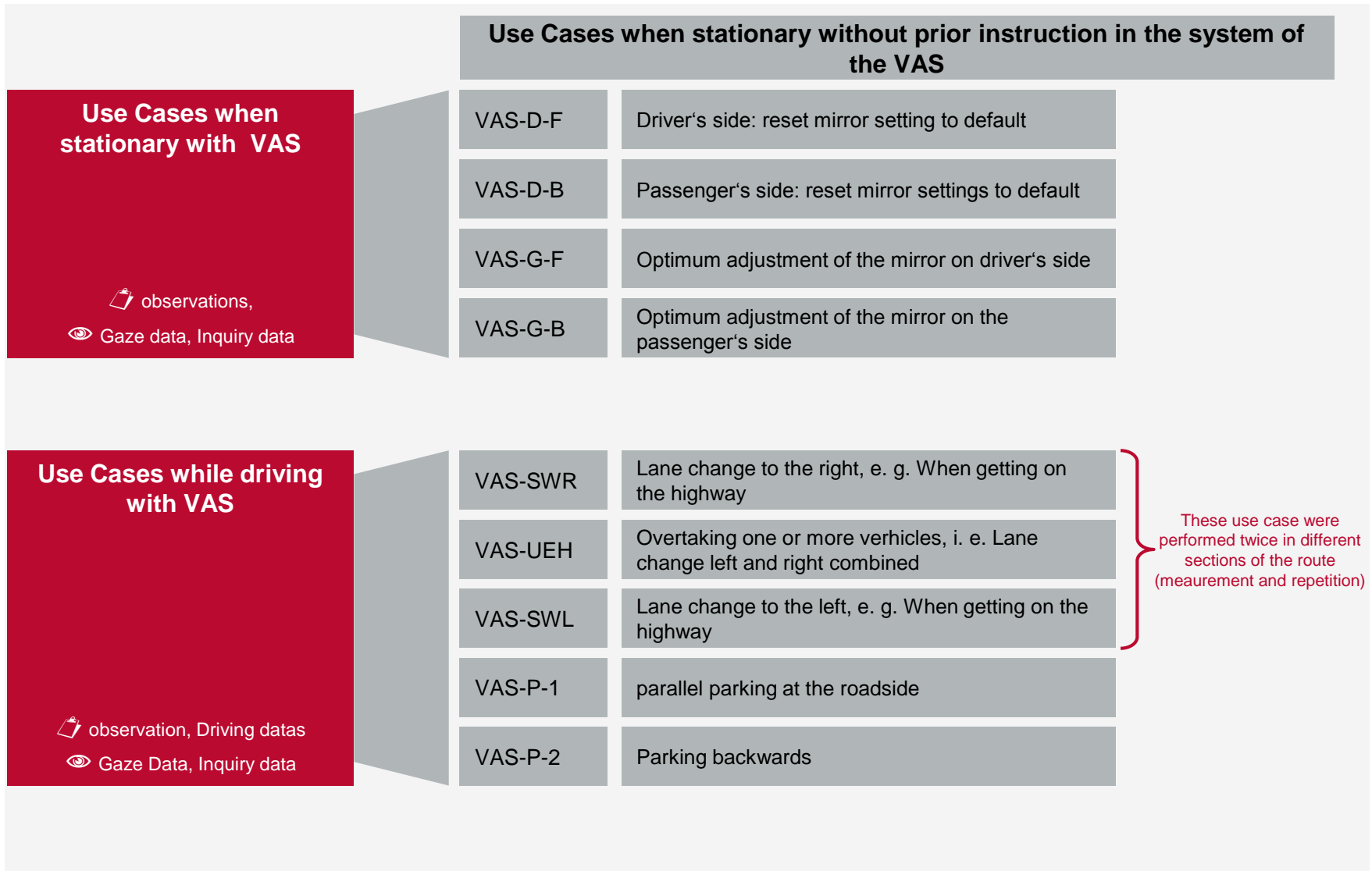


- › **Testing Virtueller Außenspiegel (VAS)**
  - › Concept test while driving in Mannheim
  - › Within-Subject-Design: VAS vs. KAS (conventional exterior mirror)
  - › N=51 à 90 minutes
  - › Implementation June 2017
  
- › **Study content**
  - › Test of Usability and distraction
  - › Inquiry and observation
  - › Gather the approval of the VAS
  - › Gaze Data recording
  - › Drive data recording

# Schedule – Overview

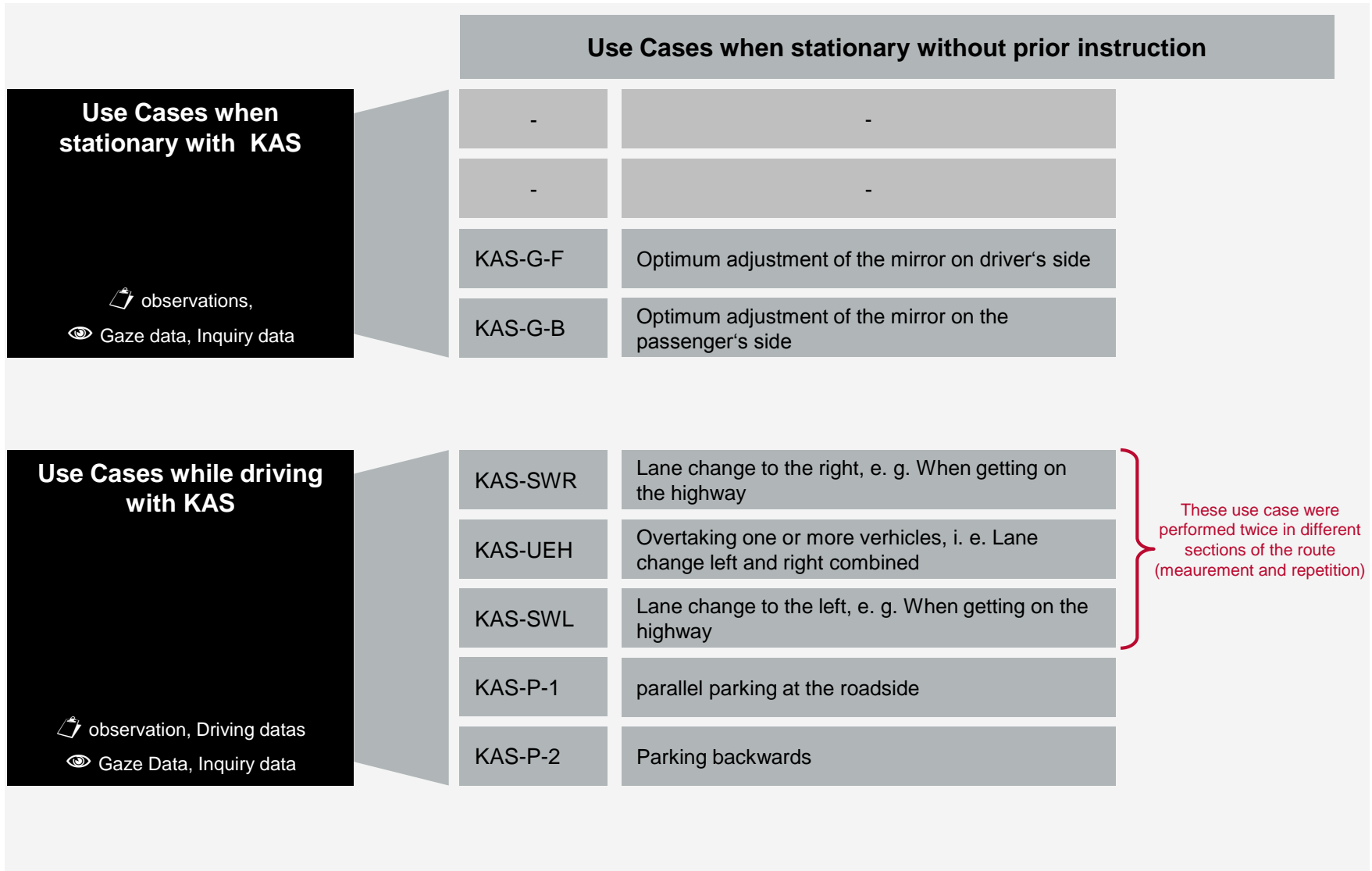


# Schedule Use Cases with virtual exterior mirrors

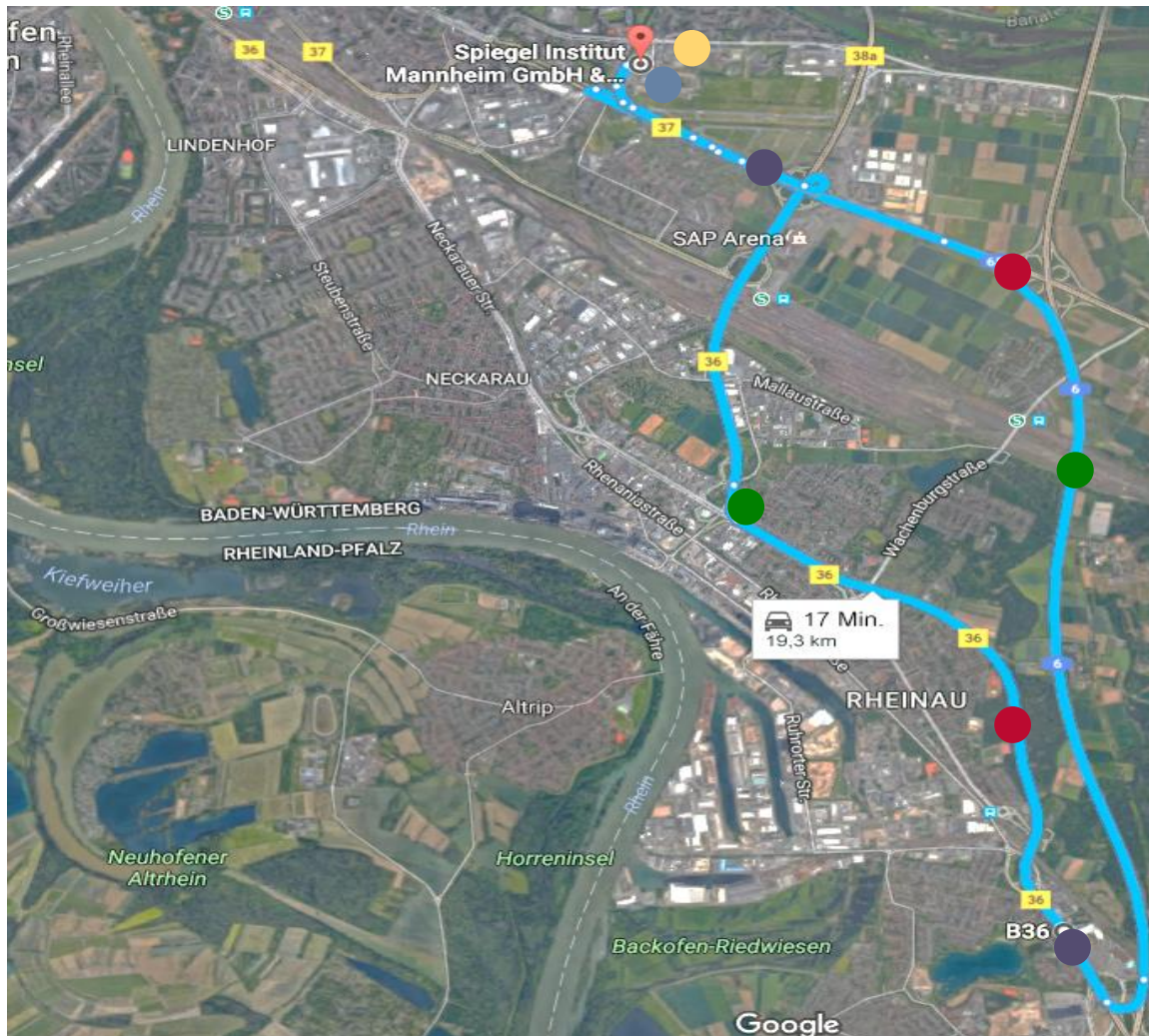









# Schedule Use Cases with conventional exterior mirrors



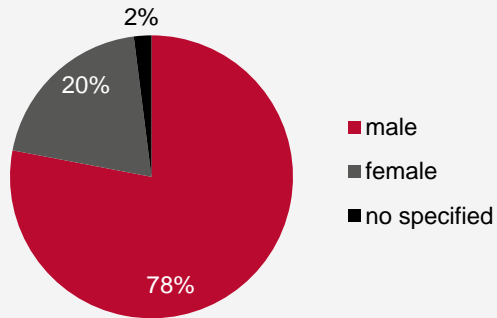
# Distance for Use Cases while driving



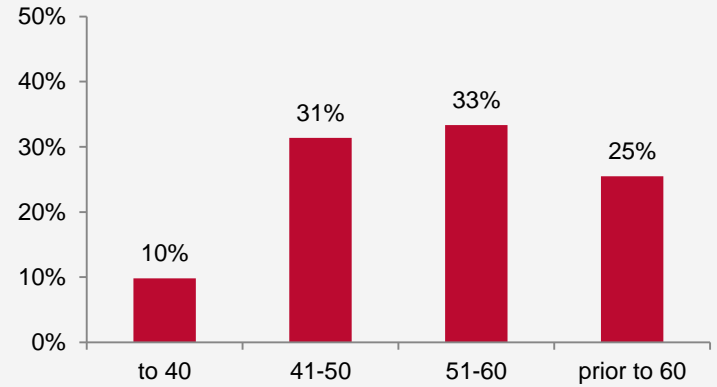
Use Cases While Driving		Location
VAS- or KAS-SWR-1 and -2	Lane change right(2x)	
VAS- or KAS-UEH-1 and -2	Overtaking (2x)	
VAS-or. KAS-SWL-1 and -2	Lane change left (2x)	
VAS-or. KAS-P-1	Parallel parking on roadside	
VAS-or. KAS-P-2	Parking backwards	

# Random sample – demographics

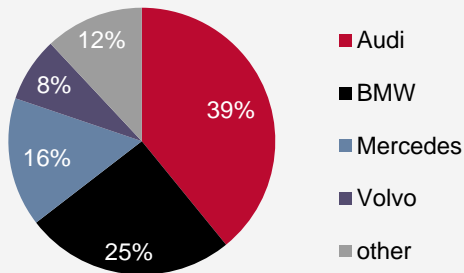
## Gender



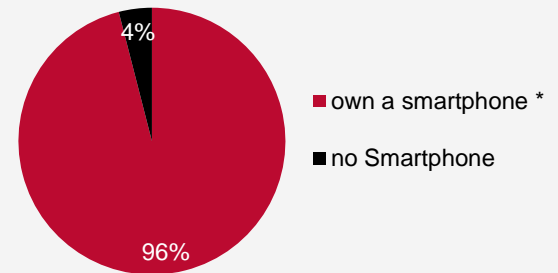
## Age



## Brand of main vehicle used



## Smartphone ownership and use



\* If a smartphone is available, it is used daily

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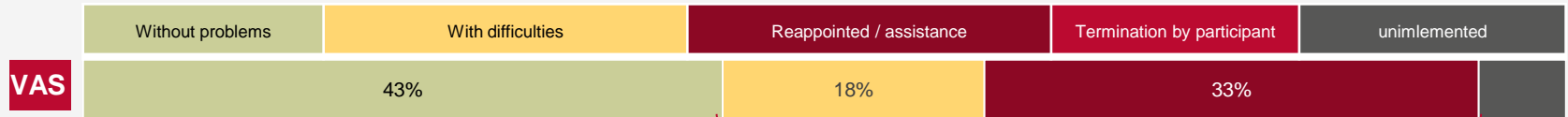
04. Results – Final inquiry

# Use Case when stationary– „Default“ driver’s side (VAS)

The setting of the basic setting („Auto“) was not understood by many participants. In some cases the wrong mirror was adjusted. A third of all participants had to prepare several times or needed assistance by the test leader



## Task Solving



n=26



Need help with the use case	17
Participant sets the wrong mirror to default setting	12
Participant adjust the mirror instead to resetting it	2
Participant zooms instead of resetting mirrors	1
<b>Other:</b> Function not found; not sure if default worked; mirror did not react	



## Pro- and Con-nominations expressed



	Numbers of Entries
Intuitive operation	2
Better Optic than KAS	1
Less aversion of vision with a mirror view	1
Sharper image, especially in rain	1

	Numbers of Entries
Adjusting the angle of inclination does not work	2
Basi setting bad – not suitable for everyone	1
No confirmation from system during setting	1
Mirror inside is against habit at mirror view to look outside	1
Too much technology in the vehicle	1

# Use Case when stationary „Default“ passenger’s side(VAS)

After examining the functionality of the VAS when adjusting the driver’s side, the majority of participants have no problem adjusting the passenger side. The 1-second delay irritates and in some cases leads to the need for help



## Task Solving



Need help with the use case	5
Participant sets the wrong mirror to default setting	2
Participant adjust the mirror instead to resetting it	1
Participant zooms instead of resetting mirrors	1
<b>Other:</b> Function not found; not sure if default worked; mirror did not react	



## Pro- and Con-nominations expressed



	Numbers of Entries
<b>VAS</b> Good functionality, if you know the operation path	1

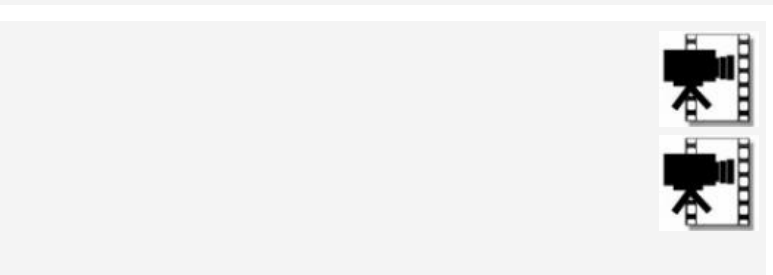
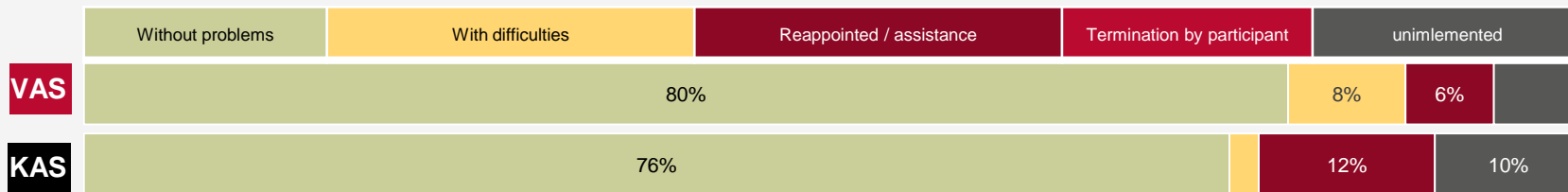
	Numbers of Entries
<b>VAS</b> Operation via touch difficult / comprehensive	3
Touch display reacts too slowly	1
No confirmation from the system during setting	1
Mirror gets dirty during operation	1

# Use Case when stationary– default settings driver’s side

Overall, both VAS and KAS had few operating errors, most often participants had problems with the exact operating surface of the touch screen. The knob of the KAS was occasionally not found or not understood



## Task Solving



n=14

Assistance needed	3	6
Participant sets the wrong mirror	2	2
<b>VAS: Participant hit / attempted to zoom control icons during adjustment</b>		
<b>KAS: adjustment knob was not found</b>		



## Pros and Cons Explained



		Numbers of Entried
<b>VAS</b>	Car adjustment suitable and reliable	2
	Good body view: not too much / little car in the picture	1
	Cool setting options	1
<b>KAS</b>	Familiar and lighter than with VAS	2

		Numbers of Entried
<b>VAS</b>	You can't adjust much	2
	Mirror does not react according to any scheme	2
	Zoom good, but suddenly the setting is gone	1
	Field of view smaller than normal mirror	1
	Not sure what i can really see	1
<b>KAS</b>	Way too hard to adjust	1

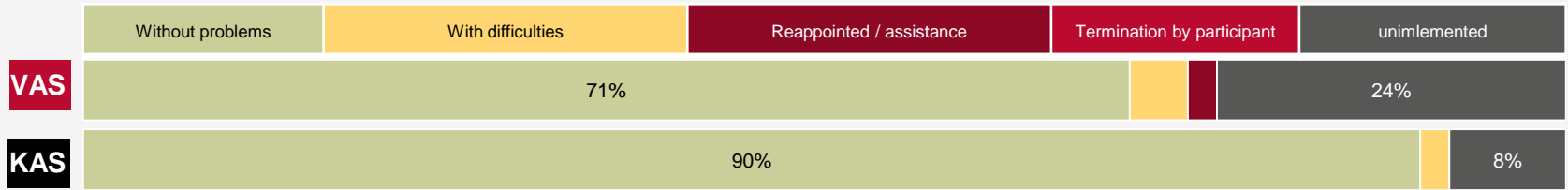
Correct operating path for use case: Tap on the driver’s mirror set by touch

# Use Case when stationary – default settings passenger’s side

All in all only isolated operating errors when setting the passenger side



## Task Solving



n=4

Assistend needed	1	
Participant sets the wrong mirror	2	1



## Pros and Cons Explained



		Numbers of Entried
VAS	Car adjustment suitable and reliable	4
	Good body view: not too miuch / little car in the picture	1
KAS	Familiar and lighter than with VAS	1

		Numbers of Entried
VAS	Mirror adjustment complicated & time – delayed	3
	Image section could be more flexible / allow larger angles	1
	A little ro bright	1
KAS	Way too hard to adjust	1

Correct operating path for use case: Tap on driver’s mirror → tap Icon for passenger’s → mirror set by touch



# Agenda

01. Overview – Setup and Sample

02. Results – Use Cases Standing

**03. Results – Use Cases while driving**

04. Results – Final inquiry

# Use Case while driving– Lane Change to the right

At the first lane change (right) significant differences between VAS and KAS are recognizable (gaze data and subjective evaluation). Already at the second lane change a familiarization effect seems to have occurred.

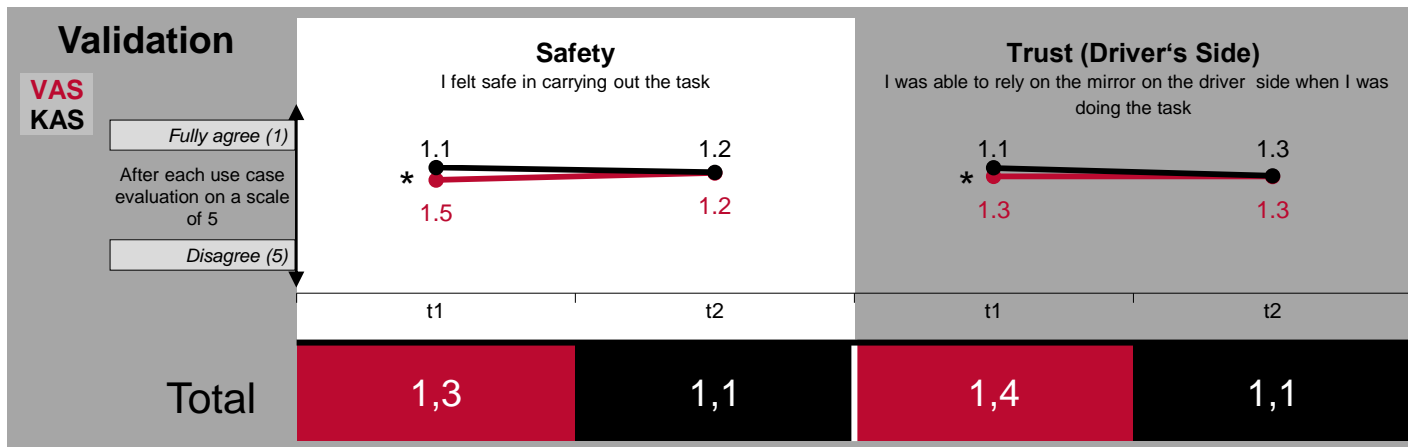
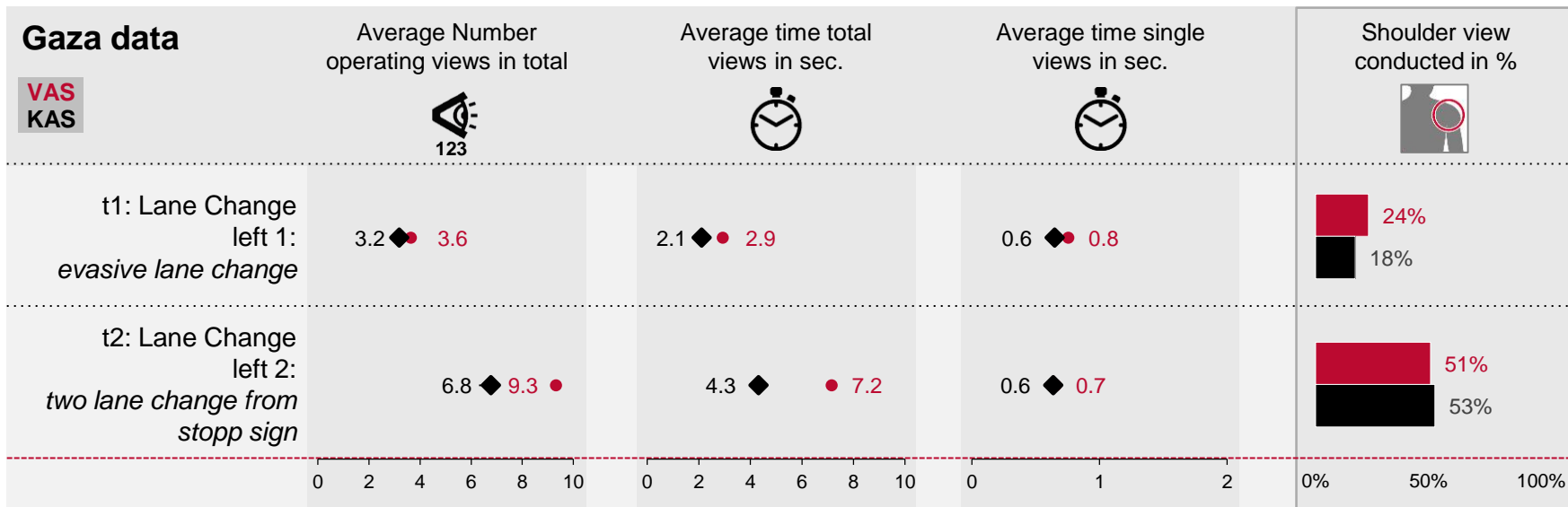


N=51; Frequency and mean values are shown; \* = significant differences with p < 0,05 (t-test)

Gaze Data (n=31): varying sample size, since exclusion of outlier values.

# Use Case while Driving – Lane Change to the left

At the first lane change (left) significant differences between VAS and KAS are recognizable (gaze data and subjective evaluation). Already at the second lane change an familiarization effect seems to have occurred.



Difficulties	Numbers of
	Entries
Mirror too small	3
Distances are unclear	2
Position not optimal	2
contrast / brightness	2
Image section too small	2
Warnings unclear	1
<b>Total</b>	<b>12</b>

N=51; Frequency and mean values are shown; \* = significant differences with p < 0,05 (t-test)

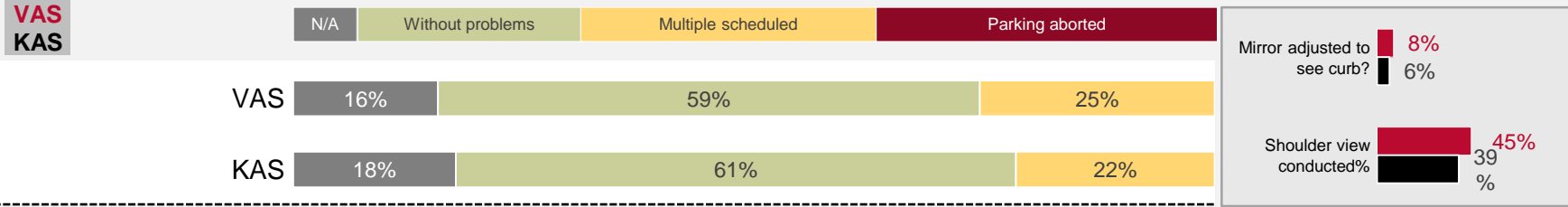
Gaza Data (n=31): varying sample size, since exclusion of outlier values.

# Use Case while driving – parking (parallel)

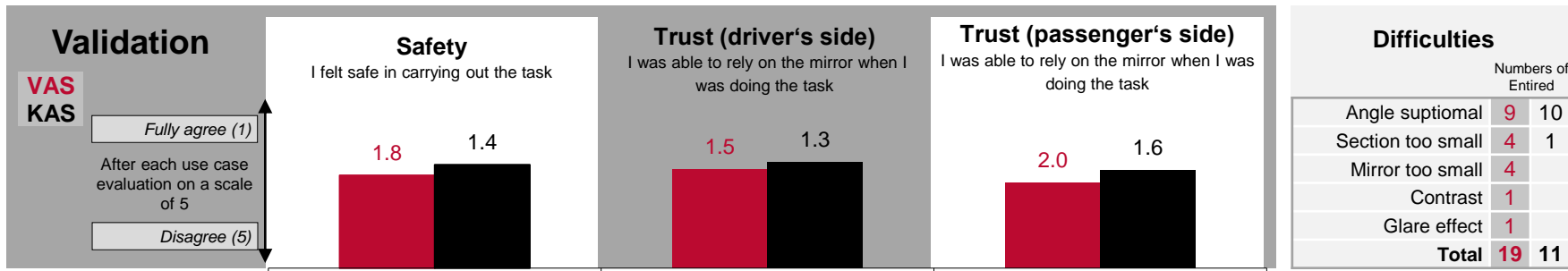
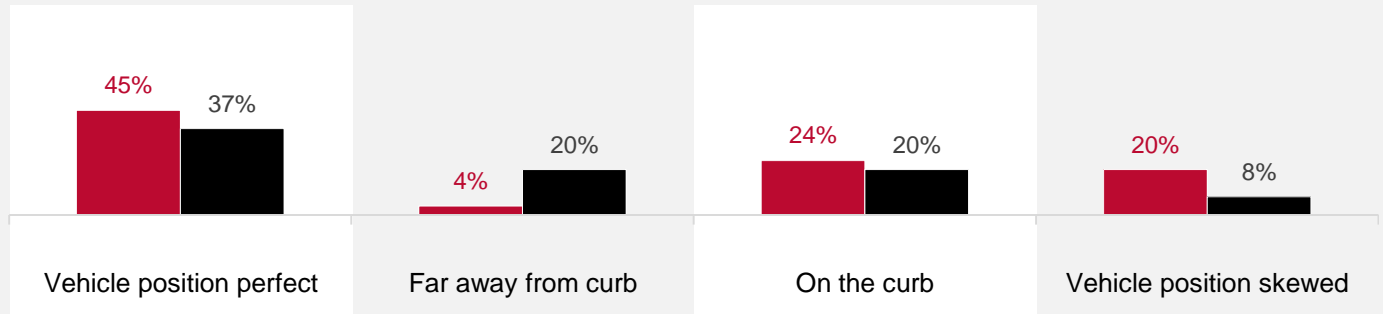
Overall, only minor differences between VAS and KAS. For both concepts, the angle was occasionally perceived as sub-optimal. Some participants consider the size of the mirror and image section (VAS) to be too small.



## Observation data – parallel parking process



## Quality of the maneuver



N=51; Frequency and mean values are shown; \* = significant differences with p < 0,05 (t-test)

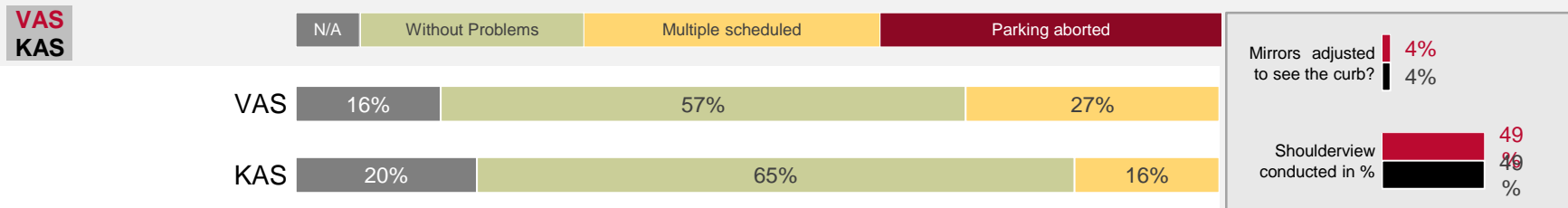
Gaza Data (n=31): varying sample size, since exclusion of outlier values.

# Use Case While Driving – Parking (Backwards)

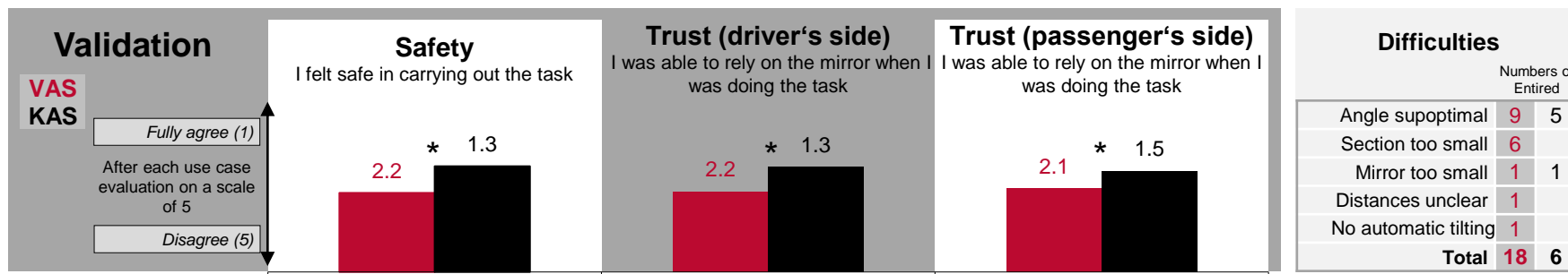
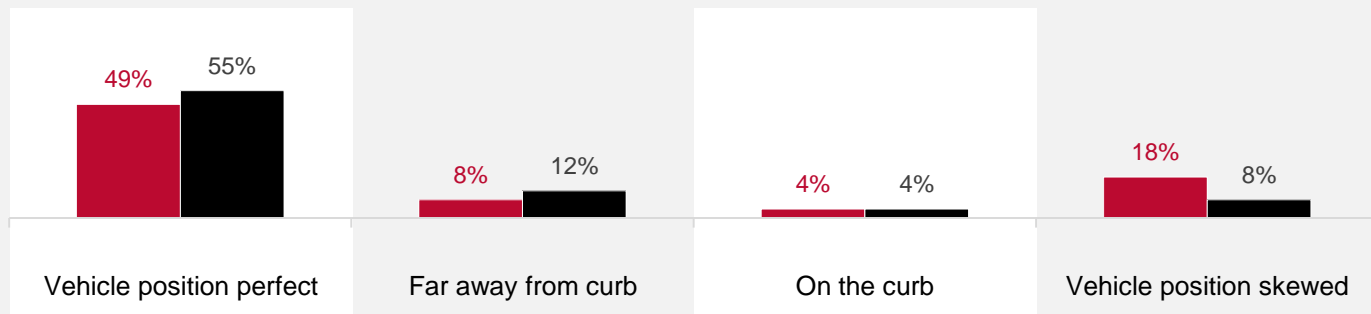
When parking backwards into a parking bay, the VAS is rated significantly worse than the KAS. The angle (downward view) and the size of the screen section offer potential for optimization. Automatic downward tilting angle of view would be desirable



## Observation Data– Parking backwards



## Quality of the maneuver



N=51; Frequency and mean values are shown; \* = significant differences with p < 0,05 (t-test)

Gaza Data (n=31): varying sample size, since exclusion of outlier values.

# Agenda

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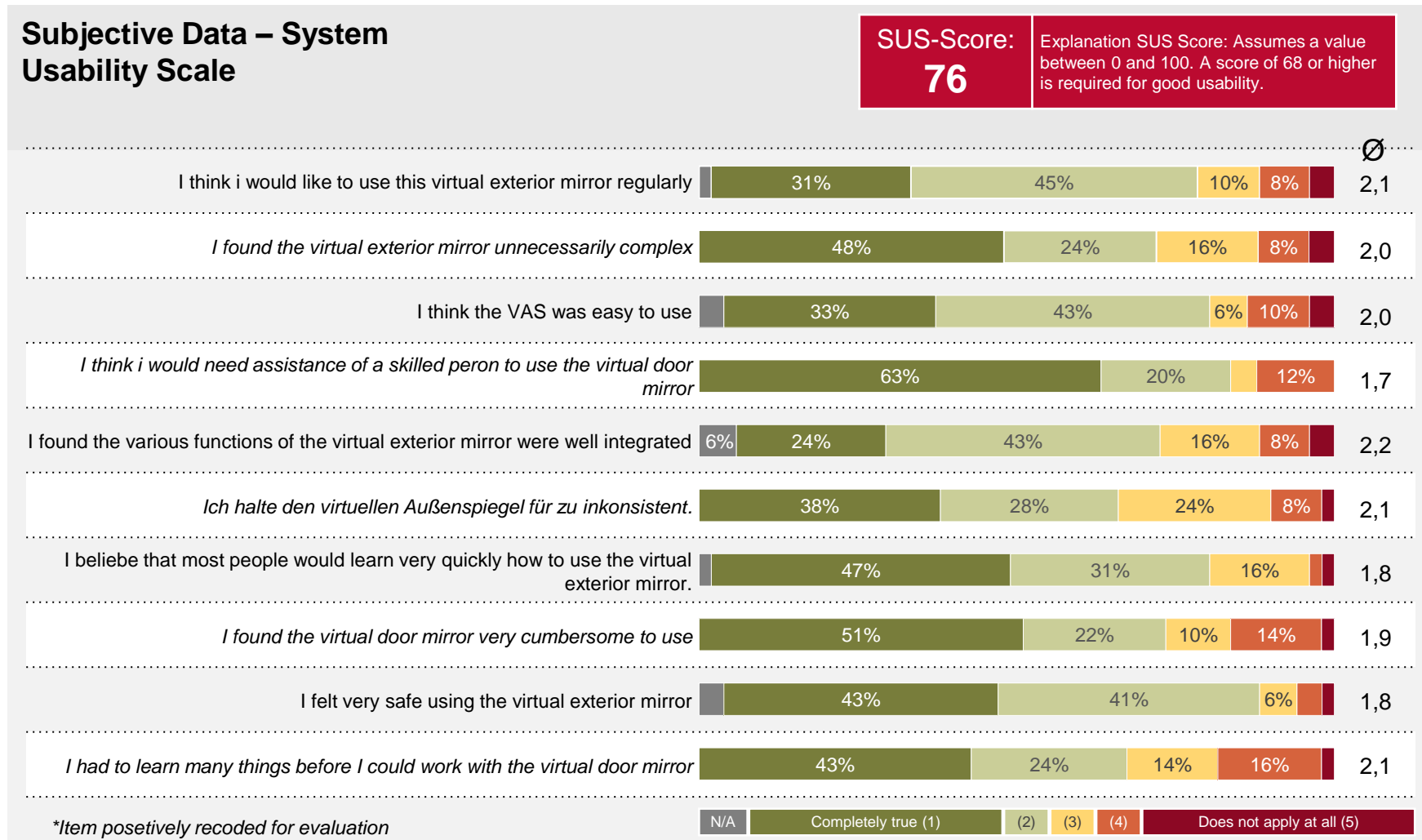
**02. Results – Use Cases Standing**

**03. Results – Use Cases while driving**

**04. Results – Final inquiry**

# Final inquiry – System Usability Scale (only VAS)

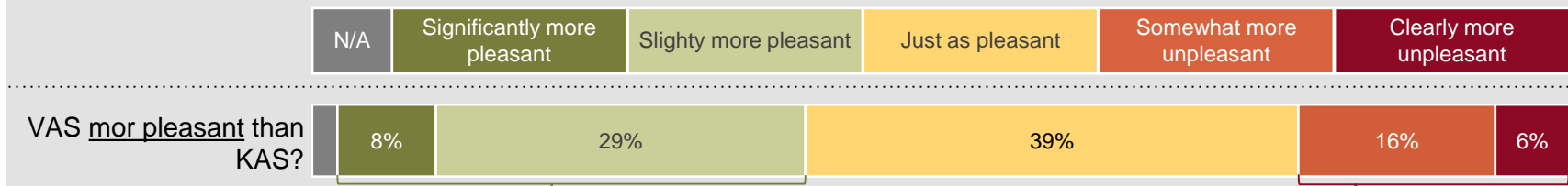
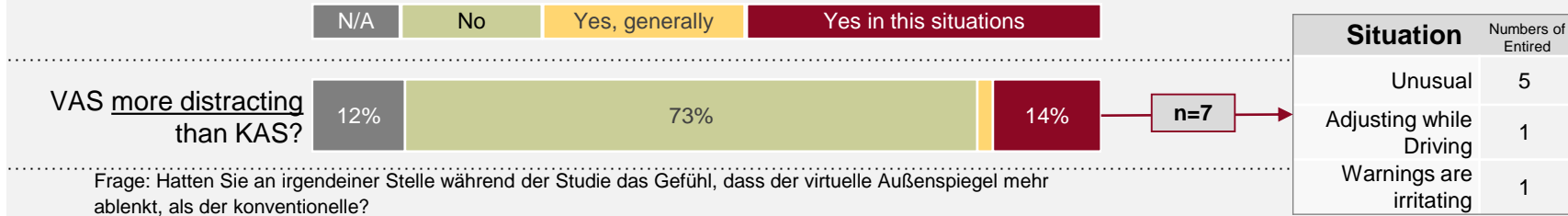
The total score of the system usability scale of 76 corresponds to a value that speaks for a good usability of the virtual exterior mirrors



# Final Inquiry

Only a small percentage of participants feel that VAS more distracting than the KAS (especially because it is unusual). Whether it is more pleasant / unpleasant to look into the VAS polarizes something. Image Quality and the less head movements are pleasing.

## Comparison VAS vs. KAS



**n=19**

Reasons	Numbers of Entired
Good picture quality	8
Better viewing direction	6
No weather influences	2
Realistic portrayal	2
No glare effects	1

**n=11**

Reasons	Numbers of Entired
unusual	3
Unsettling glare effects of the display	3
Picture quality not sufficient	2
Image is saller than KAS	2
Safety concern (e.g. Failure)	2
KAS image more real	1

Question: Compared to the conventional door mirror: How pleasant is to look into the virtual exterior mirror? Why?



# Final Inquiry

The best thing about it is the image quality and the reduced head movements while driving. Greatest optimization potential: The Display and especially the image section should be larger and offer a larger field of view. Good integration into the interior is important.

## Likes

What do you like about the new concept of the VAS



First impressions	Numbers of Entired
Concept appealing in general	12
Field of vision, viewing angle	5
operation	2
Good picture quality	2
<b>Single:</b> different settings, fits to virtual cockpit, familiar through iPad	

Final Inquiry	Numbers of Entired
Good picture Quality	16
Positioning, requires less head movement	13
Warnings in mirror	11
Good picture size	9
Integration of the blind sport monitor	6
General	5
Zoom function	5
Supports modern exterior design of the vehicle	5
Vehicle narrower without mirror	4
aerodynamically	4
No weather influences, pollution	3
No mirror loss possible (shut down, vandalism)	2
<b>Single:</b> less wind noise, operation; setting range	

## Dislikes

Was do you like less about the new concept of the VAS?

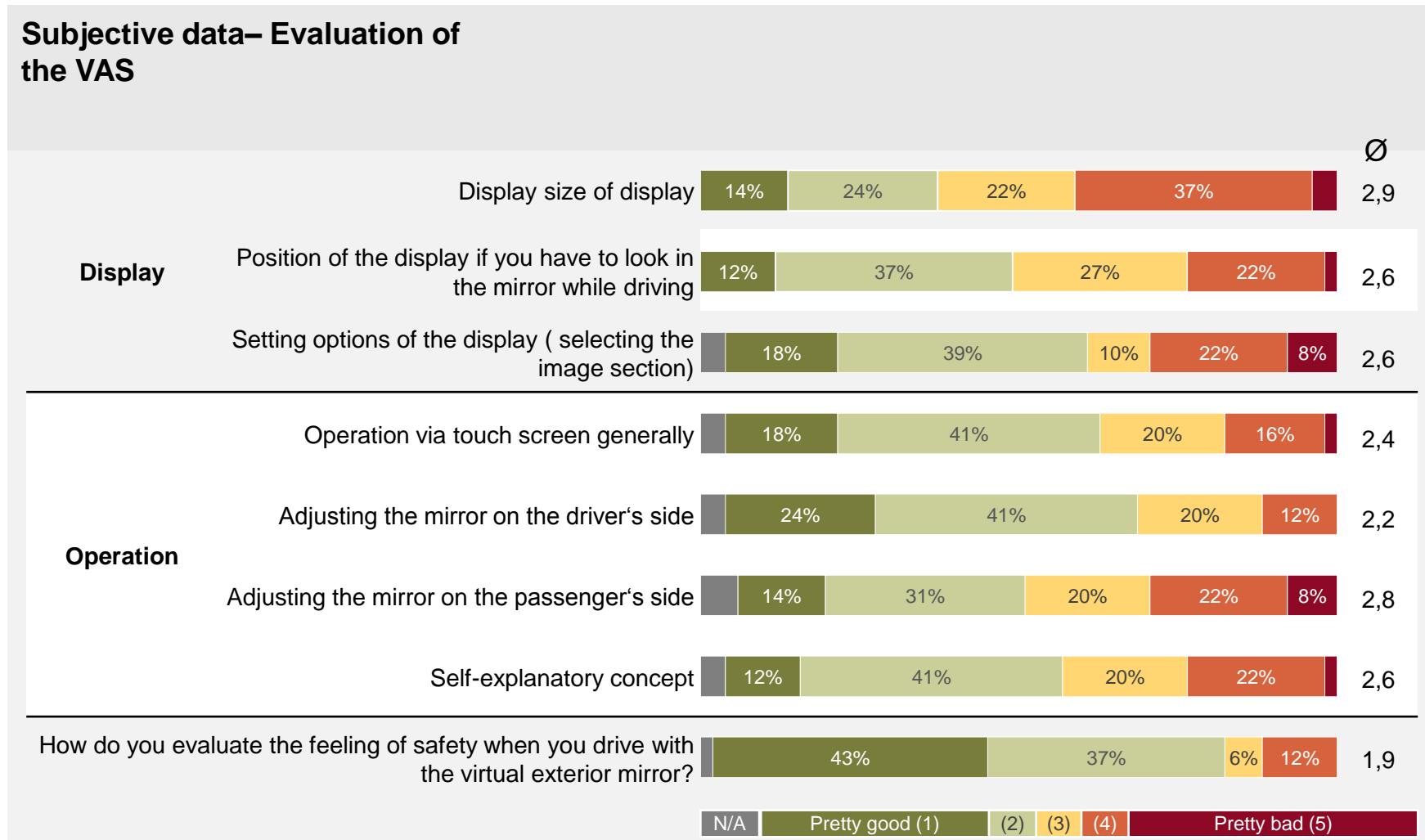


First impressions	Numbers of Entired
Image Size, field of view less than KAS	13
Operation	9
Adjustment range not sufficient	8
Unusual	6
Image quality not sufficient (colers, resolution)	4
Position in the vehicle	3
Reaktiontime too slowly	2

Final Inquiry	Numbers of Entired
Image size / image section too small	32
Position unusual, distrubing	18
operation	12
Image quality not sufficient	10
warnings (implementation)	10
Adjustment range not sufficient	8
Form, Design	6
Risk of failure, unreliable technology	6
Unusual	5
Distances difficult to estimate	4
Glare effects, influence of solar radiation	4
Weather influenced for camera	3
<b>Single:</b> No mirror when vehicle is off, fixed field of view	

## Final Inquiry

The display size and the setting options polarize in the evaluation of the VAS. When it comes to operability, adjusting the passenger mirror is the worst overall. The feeling of safety as judged by the participants is predominantly good.



N=51; Frequency and mean values are shown; \* = significant differences with  $p < 0,05$  (t-test)

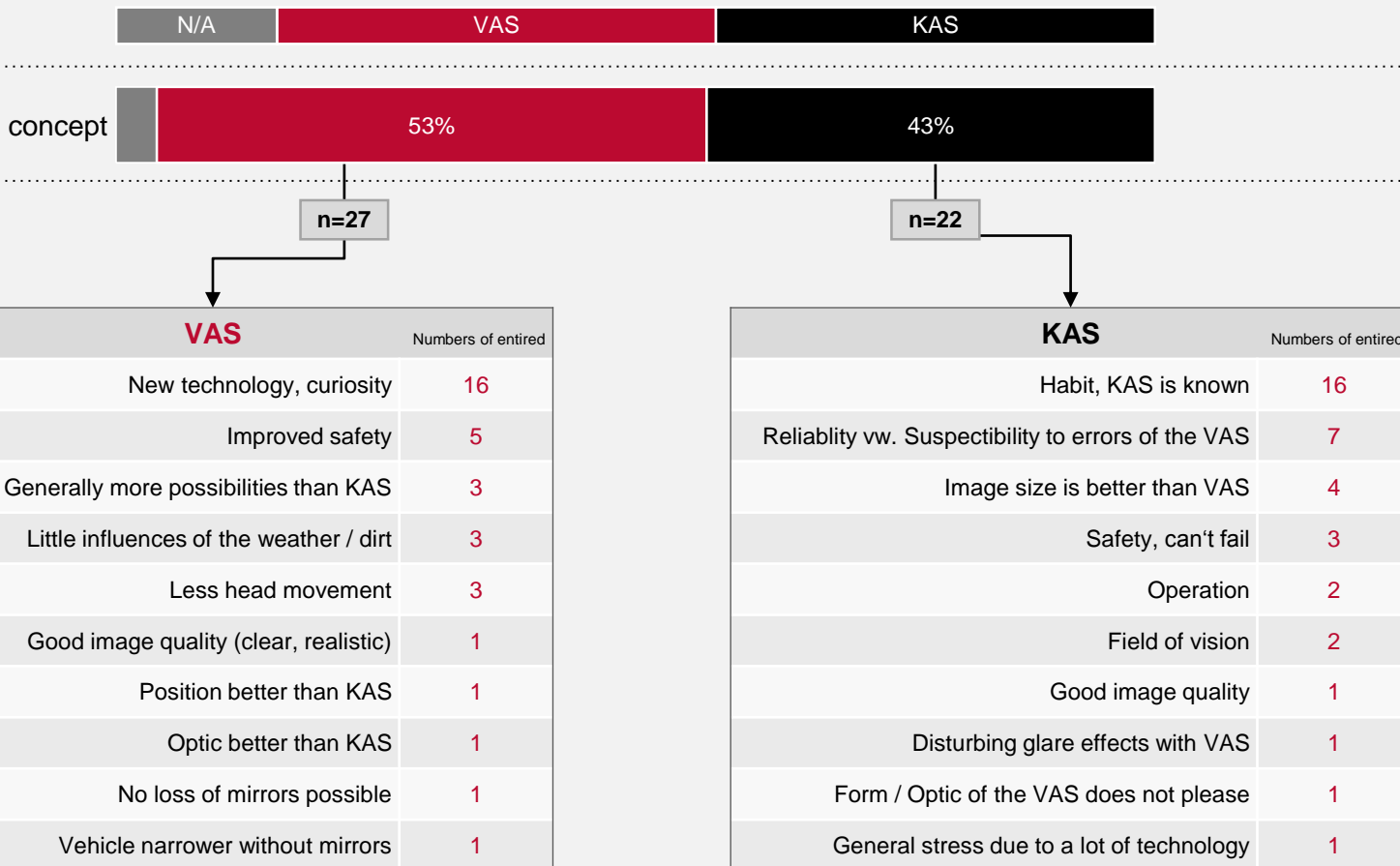
Gaza Data (n=31): varying sample size, since exclusion of outlier values.

# Final Inquiry

Just over half of the participants opt for the VAS concept. This is mainly justified by interest and curiosity of new technology. The KAS advocates name the familiarity and reliability as arguments for the KAS.

## VAS vs. KAS

Wich concept would you choose and why?





**Thank You!**