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Does technology always make a farmer's life easier? Perceived usability of a technologically developed tractor cab: a comparison between novice and expert users

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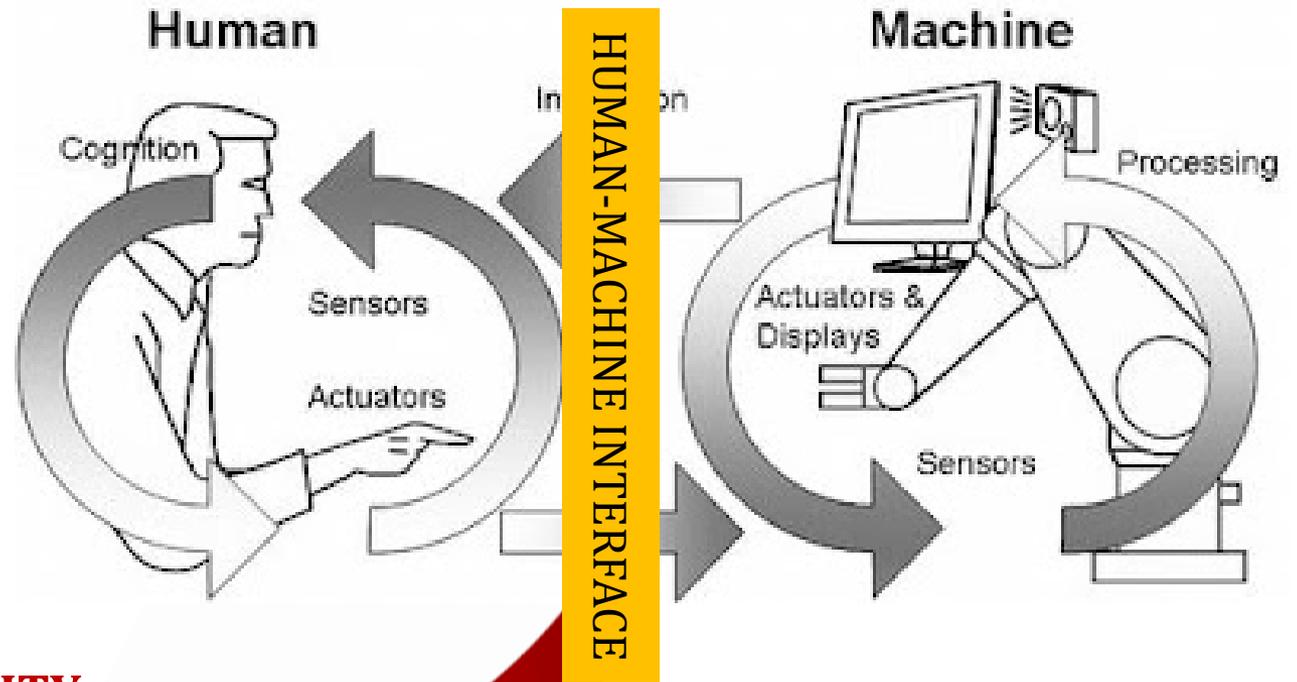
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Human-Computer interaction

HCI research focuses on understanding users' usage behaviors when interacting with the Human-Machine Interface (HMI) of a technological system, to influence the technology design and implementation processes and minimize user' resistance (Preece, 1994).





PERCEIVED USABILITY

"...the degree to which a person believes that using a particular system would be free of effort"

(Davis, 1989, p. 82)

6 components (Davis, 1989):

- Clearness
- Flexibility
- Controllability
- Ease of learn
- Ease of becoming skillful
- Ease of use



Technologically advanced HMIs provide the operator with a **large amount of information** and functionality which **may exceed** user's **cognitive resources**
(Besnard and Cacitti, 2005)



- Operating errors
- Increased mental strain
- User frustration



Ergonomic approach

Direct **involvement of the users** in the evaluation of a HMI (Karwowski, 2006):

- Experts** to obtain a more complete list of problems,
- Novices** to identify the most severe issues (Sauer et al., 2010)

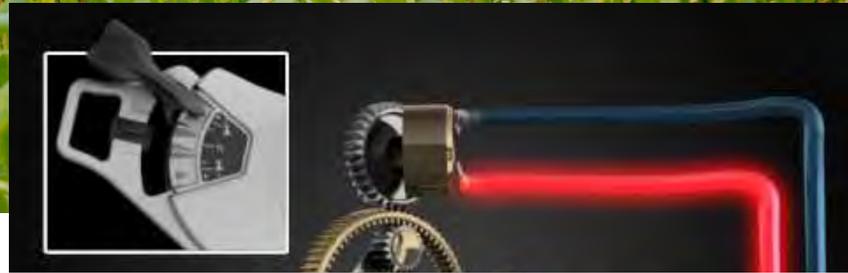
>PRODUCTIVITY

>ENERGY SAVING

>WORKING CONDITIONS

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TECHNOLOGY



Continuously Variable Transmission





The introduction of **CVTs** has deeply affected the **HMI** of the tractor cab.

- **Changes** in the **layout** of the **controls**.
- Hand-acted levers replaced by **buttons** and **potentiometers**, and **monitors**.



HMI: Perceived usability???



The present study aimed at **evaluating the HMI** of a **CVT tractor cab** in terms of **perceived usability** in a group of **novice** and **expert users**.

The investigation dealt with the **subjective responses** about the **ease of locating, interpreting** and **operating** some controls and the **accuracy of the information** given by the displays, during both the first interaction with the machine and after performing a series of specific tasks with it.

Understanding how real users interact with the machine helps in making recommendations for product improvement and for training actions development.



Participants

16 tractor drivers:

8 experts, at least 5 years driving experience on CVT (Kumar et al., 2001) ;

8 novices , never owned nor operated a CVT tractor

Experts: $M_{age} = 35.25$ yrs ($SD = 11.65$); $M_{driving\ experience} = 20.00$ yrs ($SD = 10.35$)

Novices had $M_{age} = 38.75$ yrs ($SD = 13.91$); $M_{driving\ experience} = 26.13$ yrs ($SD = 13.92$)

The tractors



TRACTOR 1: transmission articulated in gears and ranges (High-Low, Rabbit-Snail).

Controls: levers at the right side of the operator located on the cab floor. The remaining controls are levers placed on the right side console.

TRACTOR 2: Clutch, brake and throttle pedals and reverse lever close to the steering wheel.

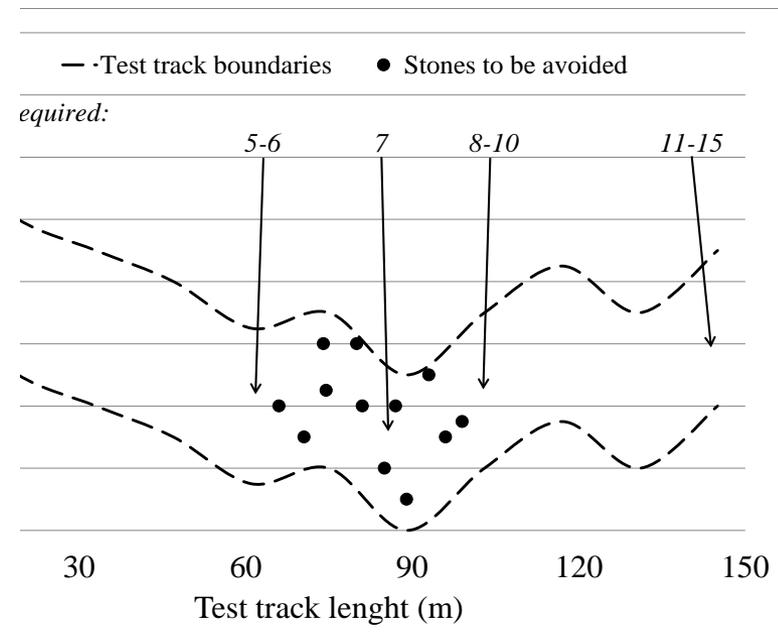
Remaining controls on the driver's seat armrest and the right side console. A display on the right side console.



- ✓ Participants completed a series of tasks with both Tractor 1 and 2.
- ✓ Tasks: driving on the road, and harrowing while maneuvering on farm road.
- ✓ All the participants performed the simulation harrowing task with each tractor 4 times, for a total time of about 10 minutes.

Table 1. List of sub-tasks participants had to perform with the 2 tractors.

Sub-tasks	Tractor 1	Tractor 2
Operate the auxiliary service coupling to open the harrow to be ready for working	Move a lever forward	Press a button on an handler
Operate the rear 3-point hitch lift to lower the harrow (without touching the test track)	Move a lever forward or backward	Rotate a small wheel or press a button
Switching the PTO on	Move a lever forward	Press a button
Forwarding the tractor at 10 km/h and following a fixed and bounded path	Look a table and choice the gear by levers and press the accelerator pedal	Press the accelerator pedal or move the handler till 10 km h ⁻¹
Arrived near the bumps (simulating stones), operating the rear 3-point hitch lift to raise the harrow	Move a lever forward	Rotate a small wheel or press a button
Slow down till 7 km/h	Release the accelerator pedal	Release the accelerator pedal or move the handler till 7 km h ⁻¹
Avoid to pass over the bumps	Moving the flywheel	Moving the flywheel
Operating the rear 3-point hitch lift to lower the harrow	Move a lever forward or backward	Rotate a small wheel or press a button
To bring again the forwarding speed at 10 km/h	Press the accelerator pedal	Press the accelerator pedal or move the handler till 10 km h ⁻¹
Follow the path till the end	Moving the flywheel	Moving the flywheel
Stop the tractor	Press the clutch pedal and acting on the gear levers	Release the accelerator pedal or push a button
Operating the rear 3-point hitch lift to raise the harrow	Move a lever forward or backward	Rotate a small wheel or press a button
Switching the PTO off	Move a lever backward	Press a button
To operate the auxiliary service coupling to close the harrow as for road transfer	Move a lever backward	Press a button on an handler
Carry out a sharp tum as at the end of the field in a bounded space	Move the flywheel and operating with gear levers	Move the flywheel and the handler





- 1. Perceived usability** of the HMI during the **first contact** with the cab:
Locating controls (e.g. PTO, hydraulic system, lighting).
- 2. Perceived usability** of the HMI **after** having performed the **tasks**:
Ease to operate the control devices, clearness and understandability of the levers/knobs, buttons, warning lights and accuracy of the information given by the display.
- 3. General evaluation** of the tractor:
Learnability, safety, quality, and solidity.
- 4. Open-ended questions**:
difficulties in accomplishing the tasks, additional feedback on the arrangement and operation of the controls.

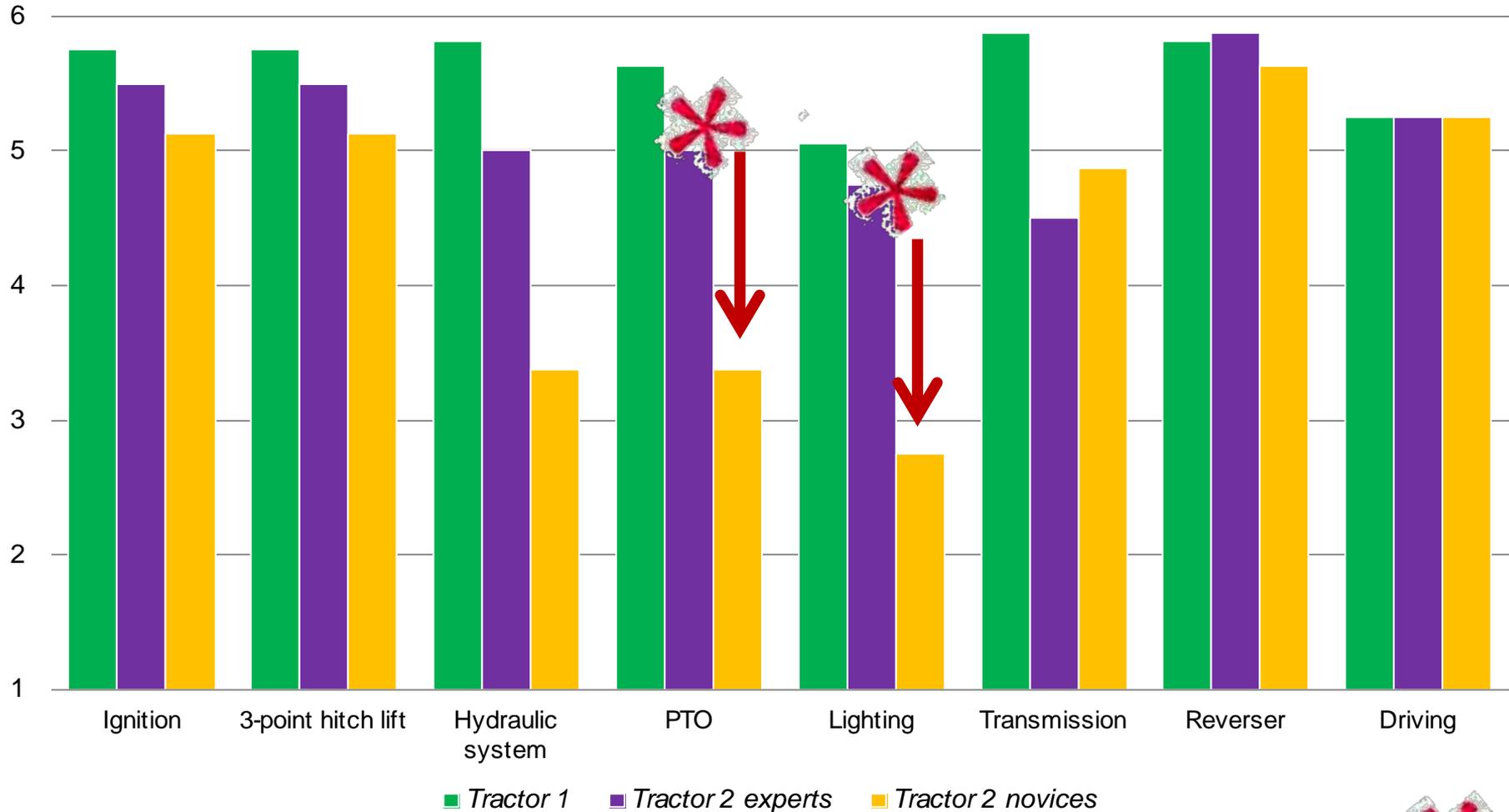
The observation



While participants were driving the tractors, a trained research assistant reported whether the users achieved or failed each sub-task in an observational grid.

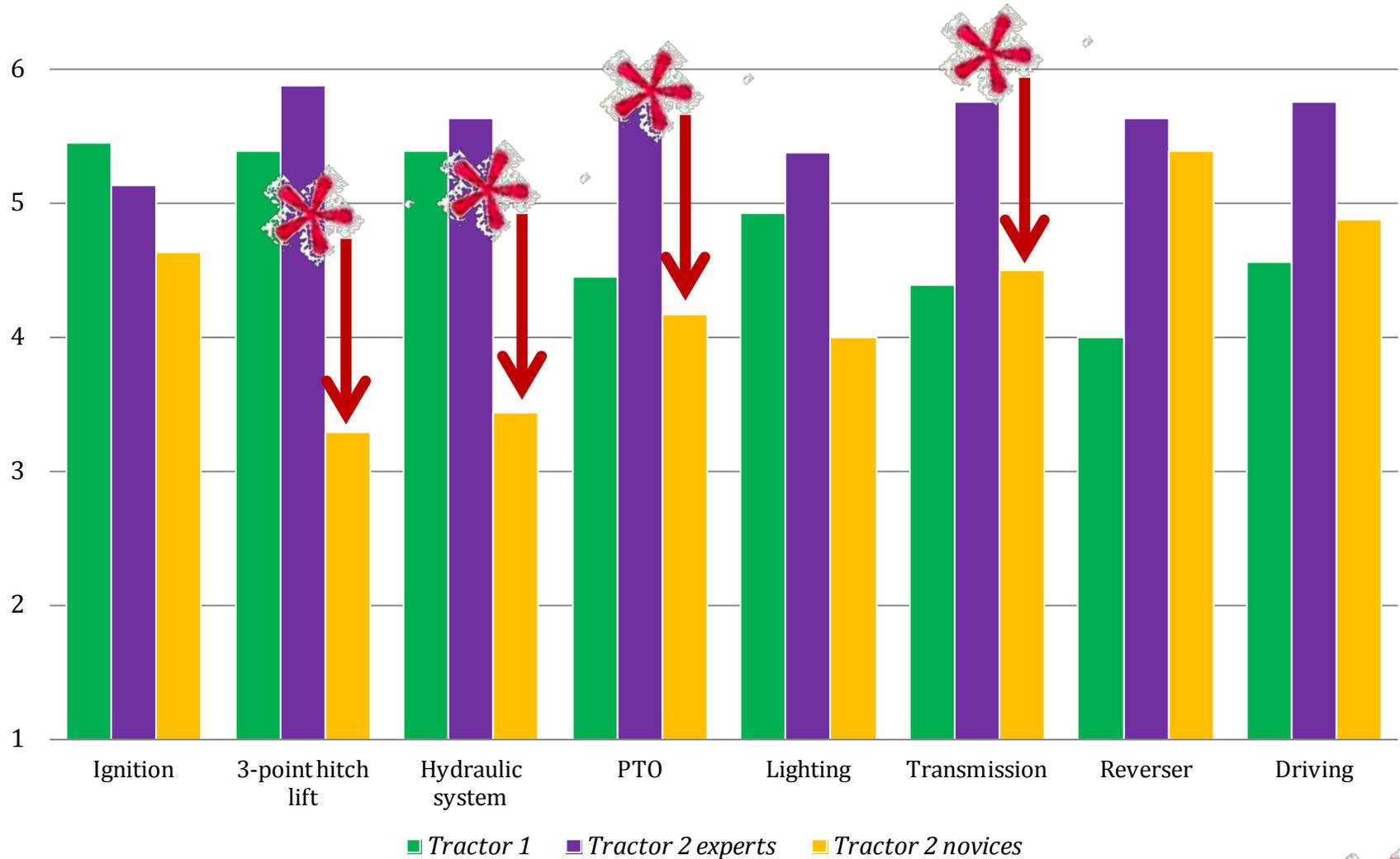


Perceived ease of locating controls



- ➡ Controls placed in an unexpected area of the working station.
- ➡ PTO speed setting control isolated from the PTO engaging/disengaging control





- ➡ From the observation: all the participants managed to accomplish the tasks
- ➡ Open-ended questions: three novices reported difficulties in operating the PTO and the 3-point hitch lift controls when operating the harrow.

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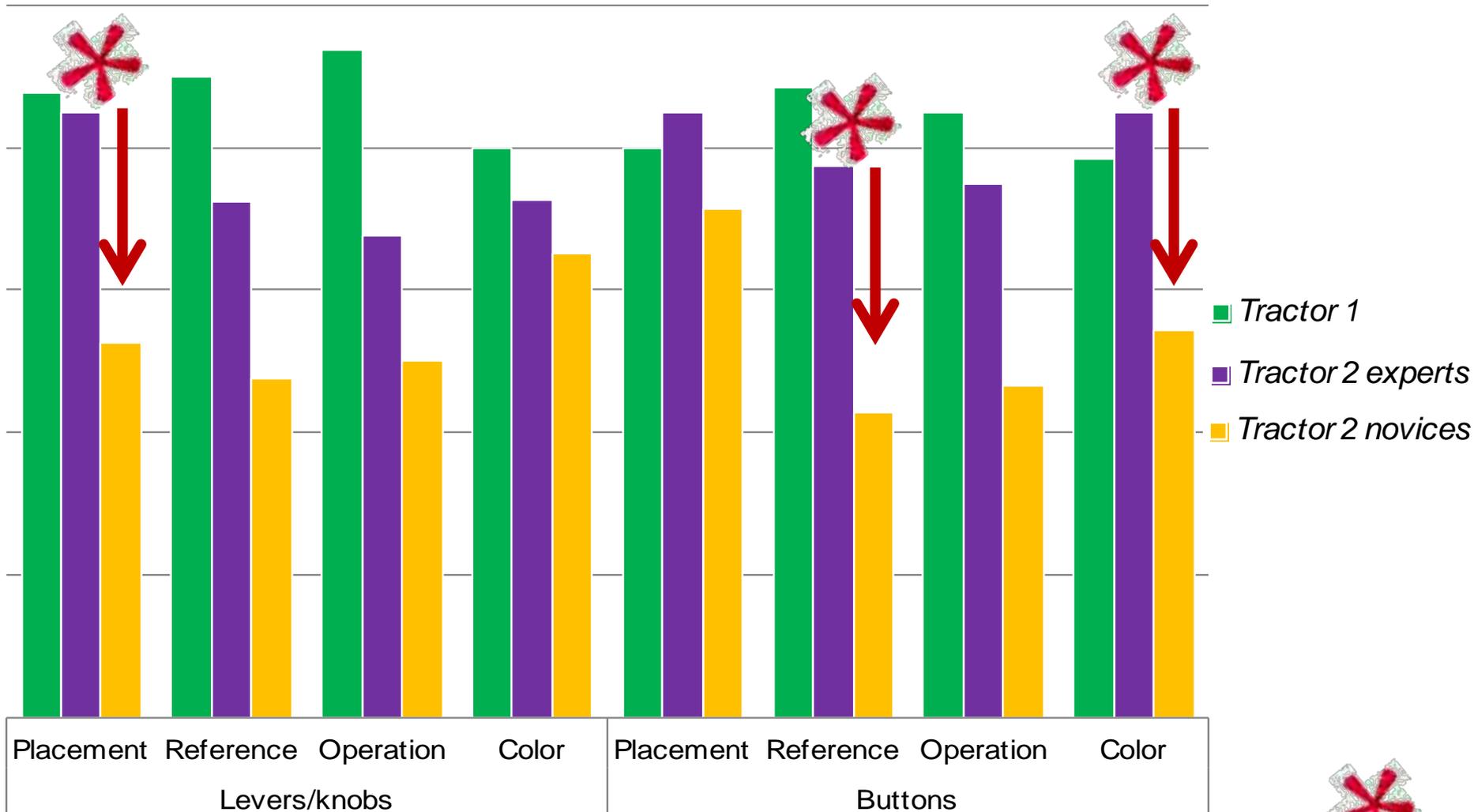
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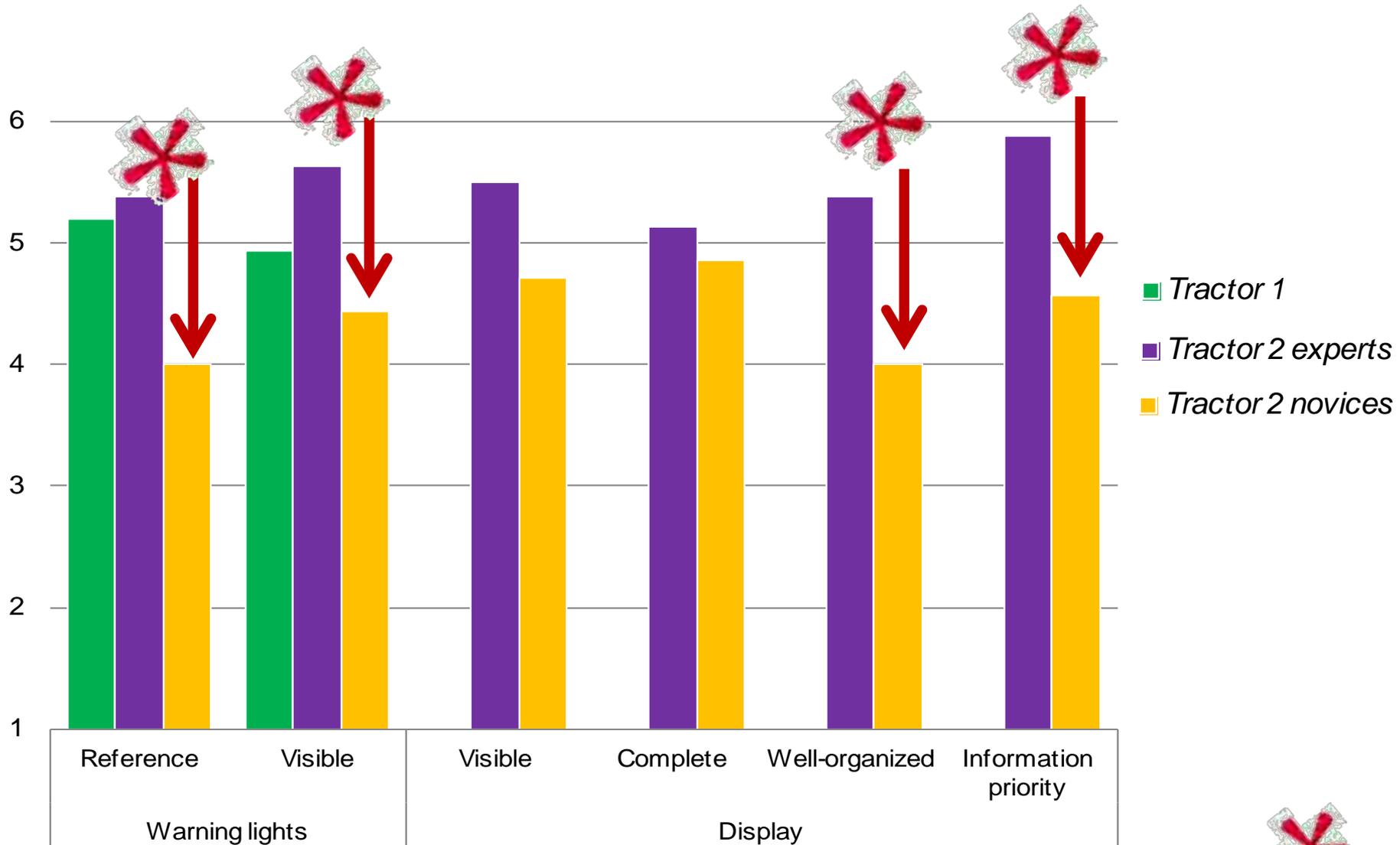
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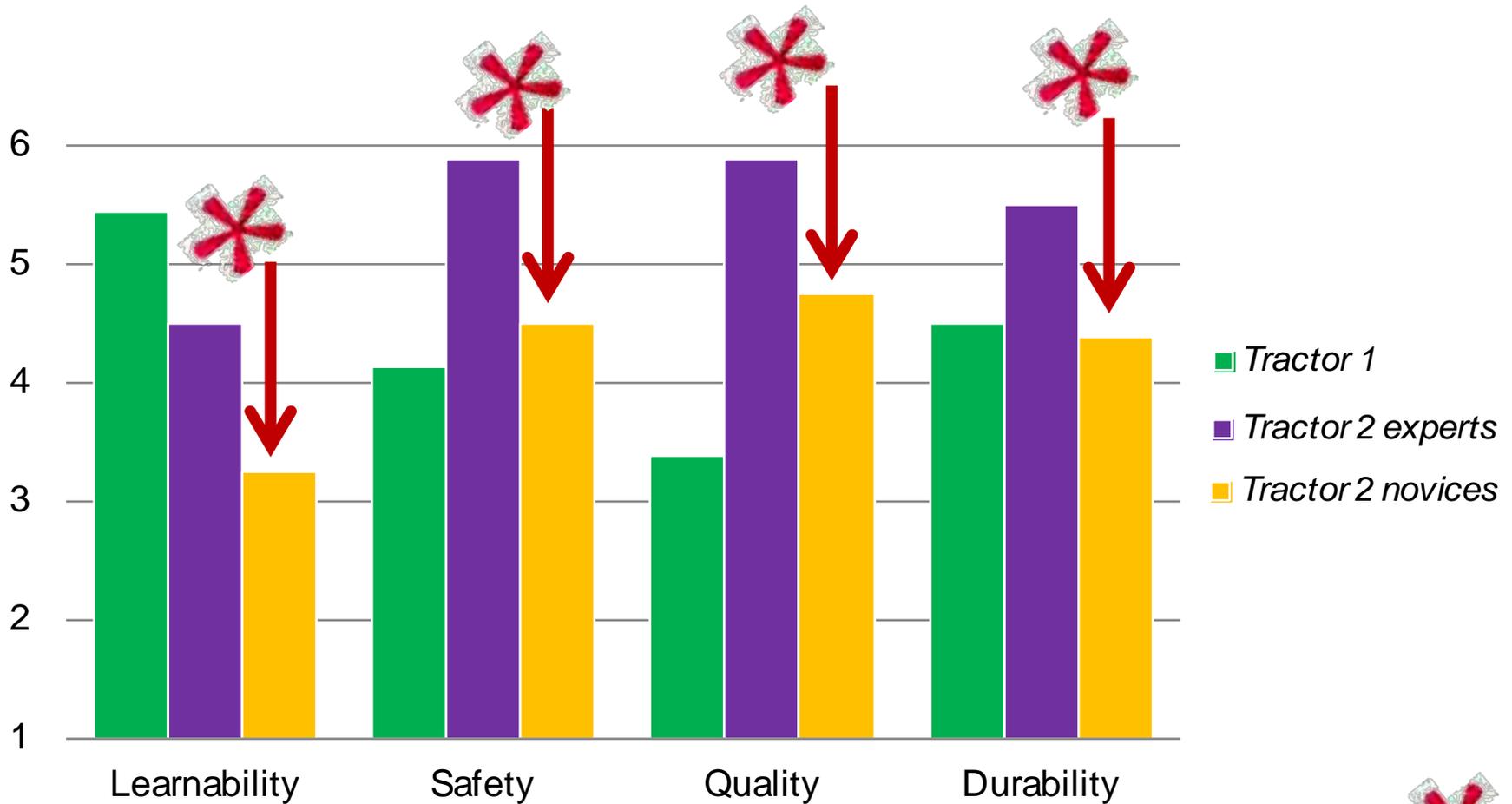


- ➡ Buttons: too small to be immediately visible and recognizable.
- ➡ Icons referring to the buttons unclear.
- ➡ Buttons placed very near to each other on the dashboard on the right side of the seat, nothing apart from the color distinguished between them.





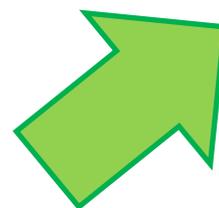
 Many novices but also one expert reported that there was too much information to be monitored on screen



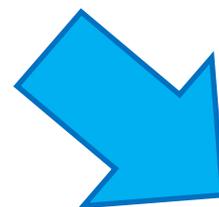
- ➔ Tractor 1 was rated higher with regard to its learnability but lower than Tractor 2 on all the other aspects.
- ➔ Overall the participants found the technological machine to be useful in performing farm activities.

- The introduction of electronics in tractors has led to a reduction in terms of physical effort to operate the controls.
- Nevertheless, the wider range of warnings, the multifunctionality of the controls and the possibility/need to set them represent a critical issue for an effective and satisfying human-tractor interaction, especially for novice users.

Need to improve system usability

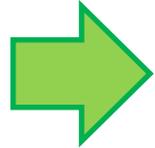


Training actions



Design solutions





Focused training sessions adopting **behavioral modeling techniques** —as hands-on demonstrations and behavioral simulations (Burke *et al.*, 2006) — could be provided when buying a new machine, with some **periodical refreshes** in case of new technological releases.



A solution could be to offer the possibility of **choosing simplified set up** already **customized for each level of operators' skill** or for the different operators' needs.



In general there is a **lack of** agreement and **shared design criteria** on tractor cab HMIs, leading to principles of design driven by the brand feeling rather than the driver feeling.

Standardization could be a good approach to reduce the negative impact of the new technologies on the confidence of the users (e.g. virtual monitor of the Isobus system).

On this issue, some manufacturers are oriented to provide basic design on the electronic commands, reserving the possibility to upgrade the final design following the requirements or the abilities of every client.



THANK YOU FOR YOUR ATTENTION

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