EDA Scale – Assessing Awareness for Energy Dynamics

Markus Gödker, Markus Dresel, Thomas Franke

Institute for Multimedia and Interactive Systems,
Engineering Psychology and Cognitive Ergonomics, ***University of Lübeck***

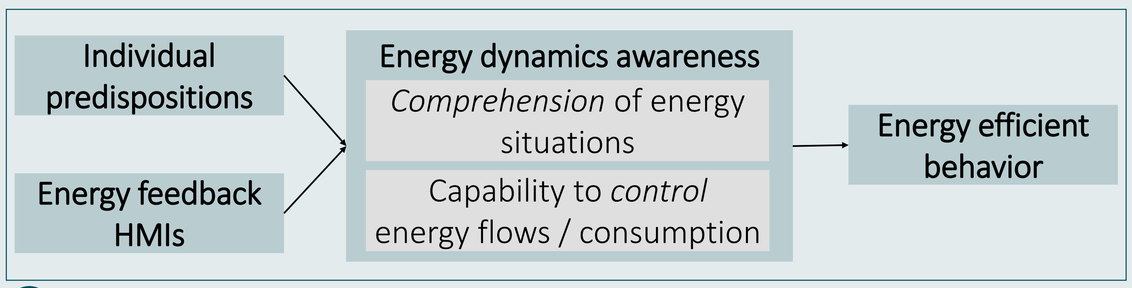
MENSCH UND COMPUTER 2019

Energy Dynamics Awareness (EDA)

- In **resource dependent systems** (house, electric vehicle, ships) **users' behavior** is an important factor for **actual energy efficiency** [1].

  Energy Efficiency = Technical Potential x User Behavior

- Even energy-literate [5] people show inefficient behavior in **dynamic energy situations** [2]. Here, individual predispositions alone are insufficient to explain energy efficient behavior.
- **Situation awareness (SA)** [6] could help to better understand user-energy interactions – more precisely, a context specific SA we call **energy dynamics awareness (EDA)**.
- **User-centered HMIs** providing energy feedback can support EDA [4].



ⓘ Possible relationships to EDA in energy efficient behavior in dynamic situations.

Research Gap To **develop HMIs** supporting EDA, an **assessment methodology** is mandatory but non-existent.

EDA Scale

Developed by a focus group consisting of 4 researchers (including 2 of the authors) with a psychological background following this procedure:

1. **Introduction** to SA, energy efficient behavior and energy feedback HMIs.
2. **Brainwriting** task to generate possible items.
3. Editing, **selection** and exclusion of items (e.g. redundancy, precision).

	How do you rate the display … ? Please indicate your level of agreement with the following statements.	completely disagree	largely disagree	slightly disagree	slightly agree	largely agree	completely agree
i1	*The display gives me a very good overview of the energy dynamics of the system.*	☐	☐	☐	☐	☐	☐
i2	*This display allows me to precisely estimate the influence of various factors on energy consumption.*	☐	☐	☐	☐	☐	☐
i3	*This display allows me to correctly predict energy consumption in future situations.*	☐	☐	☐	☐	☐	☐
i4	*The display tells me when energy is lost unnecessarily.*	☐	☐	☐	☐	☐	☐
i5	*The information on the display is designed so that I know exactly how to increase energy efficiency.*	☐	☐	☐	☐	☐	☐
i6	*By using this display, it is comprehensible for me by which actions I can influence the energy dynamics.*	☐	☐	☐	☐	☐	☐
i7	*With this display, I feel that I am better able to influence the energy dynamics in new situations according to my will.*	☐	☐	☐	☐	☐	☐

ⓘ Items i1 – i4 pertain to the *comprehension* aspect and items i5 – i7 to the *control* aspect.

ⓘ This is an English translation, the original scale is in German. Both can be downloaded here:

kurzelinks.de/edascale

Conclusions + Next Steps

- Based on these preliminary results, the **energy dynamics awareness** (EDA) **scale** can be expected to be a **reliable method** to assess the EDA support of **energy feedback HMIs**.
- This study suggests a **single-factor structure**. A **two-factor structure** with a *comprehension* and a *control* aspect might be possible and should be further examined.
- In this study, the two HMIs where **rather similar** and did not include a systematic variation to manipulate EDA. In future studies, **explicit manipulation of EDA** should be tested in order to examine how well the **scale discriminates** between interface variants.
- Further examinations of the **criterion and construct validity** are necessary.

First Scale Evaluation

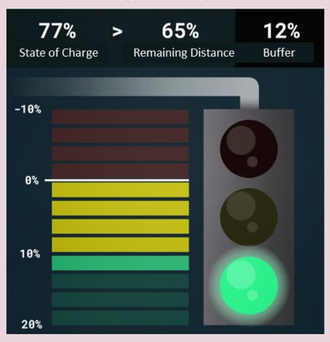
First scale evaluation as part of a study on **range interfaces for electric vehicles**.

N = **40** bus drivers (2 female)
Self-reported electric bus **experience**:
***M* = 26.0 h** (*SD* = 21.8 h)

Procedure:
1. Thematic Introduction
2. **1st HMI presentation** and **EDA Scale** questionnaire (among others)
3. **2nd HMI presentation** and **EDA Scale** questionnaire (among others)
4. General Questions and Demographics

The study was conducted in **German.**

"Traffic Lights"

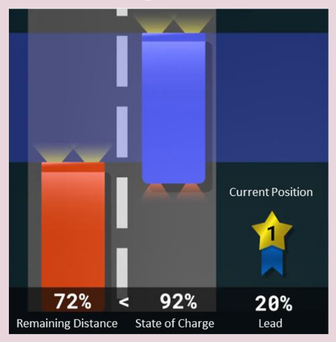


The Range Indication HMIs

Two range HMIs indicating the ***range buffer*** *by comparing the* ***remaining distance*** *and the* ***state of charge*** *in order to support a* ***heuristic range evaluation****.*

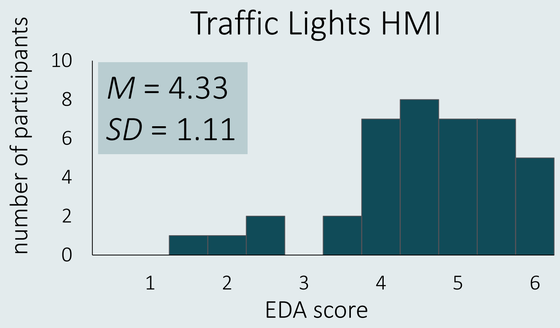
See the ***videos*** *from the study here:*
kurzelinks.de/trafficlights
kurzelinks.de/rangerace

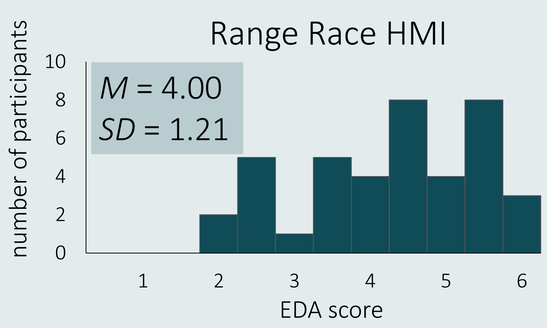
"Range Race"



Scale Analysis

Descriptive Statistics





Mean difference not significant: $t(39) = 1.55$, $p = .129$, $d = 0.25$

Scale Statistics

	Traffic Lights HMI	Range Race HMI
Cronbach's α	**.92**	**.93**
Range α if item dropped	**.89** (i5) – **.92** (i1)	**.91** (i2) – **.93** (i6, i7)
Range item-rest correlation	**.58** (i1) – **.89** (i5)	**.71** (i7) – **.90** (i2)

Exploratory Factor Analysis

Both parallel analyses [7] and scree-plots indicated a single factor structure.

	Traffic Lights HMI			Range Race HMI		
	PAF1	PAF2		PAF1	PAF2	
	1	1	2	1	1	2
% expl. Var.	61.8	31.0	38.9	67.8	40.3	37.6
i1	.61	.83		.75	.98	
i2	.87	.77		.93	.57	.44
i3	.68	.64		.92	.56	.44
i4	.76	.32	.49	.82	.84	
i5	.93		.70	.85	.33	.61
i6	.80	.94		.74		.96
i7	.81	.88		.72		.72

ⓘ Factor loadings below 0.3 are not displayed; PAF1 = Factor loadings in the principal axis factoring (PAF) [3] with one factor; PAF2 = Factor loadings in a PAF with two fixed factors (oblimin rotated).

Acknowledgments

This research is funded by the EKSH GmbH as project "NuR.E" (project no. 8/12-31). We would like to thank the project partner Stadtverkehr Lübeck GmbH for the support.

References

[1] Chris Bingham, Chris Walsh, and Steve Carroll. 2012. Impact of driving characteristics on electric vehicle energy consumption and range. IET Intelligent Transport Systems 6, 1 (2012), 29–35. https://doi.org/10.1049/iet-its.2010.0137

[2] Dirk Brounen, Nils Kok, and John M. Quigley. 2013. Energy literacy, awareness, and conservation behavior of residential households. Energy Economics 38 (2013), 42–50. https://doi.org/10.1016/j.eneco.2013.02.008

[3] Anna B. Costello and Jason W. Osborne. 2005. Best practices in exploratory factor analysis: four recommendations for getting the most from your analysis. Practical Assessment Research & Evaluation 10 (2005). Issue 7. http://pareonline.net/getvn.asp?v=10&n=7

[4] Sarah Darby. 2006. The effectiveness of feedback on energy consumption. A Review for DEFRA of the Literature on Metering, Billing and direct Displays 486, 2006 (2006), 26.

[5] Jan E. De Waters and Susan E. Powers. 2011. Energy literacy of secondary students in New York State (USA): A measure of knowledge, affect, and behavior. Energy policy 39, 3 (2011), 1699–1710. https://doi.org/10.1016/j.enpol.2010.12.049

[6] Mica R. Endsley. 1995. Toward a theory of situation awareness in dynamic systems. Human factors 37, 1 (1995), 32–64. https://doi.org/10.4324/9781315087924

[7] John L. Horn. 1965. A rationale and test for the number of factors in factor analysis. *Psychometrika* 30, 2 (1965), 179–185. https://doi.org/10.1007/BF02289447

Poster as PDF