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Investigation of Frustration

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Background and Motivation

To design a quick and fluently process and also comfortable human-machine interaction, it is important to examine the underlying influence of emotions, like **frustration**, and their impact on different interaction parameters. Frustration arises when expectations of achieving a goal after repetitive attempts due to obstacles such as unexpected reactions like negative feedback or error messages from a system are not fulfilled [3, 8, 9]. Previous work has shown that the frustration often occur during human-machine interaction (e.g. [1, 6]) and not only involving changes in facial expression, but also in posture, physiology, or behavior [9]. Lower task productivity [7], slight improve in arousal, decreased motivation, user satisfaction, and lacking trust [4,6] are evoked by frustration. This have an influence on acceptance and the quality of interaction with a technical device and leads the user to exert alternative systems [4].
This study is a step towards determining the appropriate **multi-measurement methods to identify frustration** triggered by an emotion induction task and its influence on user state factors using **subjective** (questionnaires) and **objective methods** (physiological methods) for a **better human-machine interaction**.

Research questions

- How is frustration measurable with subjective and objective methods?
- Which correlation exist between frustration and other user state factors in the emotion induction task?

Results

Subjective methods could identify frustration

- *analysis: the difference between the questionnaire responds at the time points T1 and T3 for each scale was calculated (Fig. 2)*
- Frustration scale difference was in FRUST-group higher (Fig. 3)

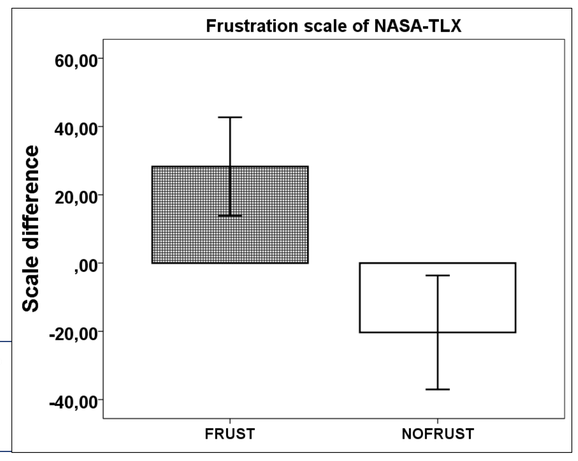

Figure 3: Results of frustration scale difference (T3-T1) of the NASA-TLX questionnaire, means and 95% confidence intervals.

Objective methods could not determine frustration

- *analysis: psychophysiological data were divided into 15s-sections after receiving each feedback in the emotion induction blocks*
- difference between the heart rate (*beats per minutes*) in the task and the rest condition was in average higher in the NOFRUST-group
- Heart rate fluctuations (*differences between the heart rates within a 15s-section*) were in average higher in the FRUST-group than in the NOFRUST-group
- Heart rate variability (*frequencies of the distances between two heartbeats*) in the FRUST-group was usually higher in the individual distances
- EMG: The average number of local maxima was greater in the NOFRUST-group, but the amplitude was higher in the FRUST-group

Frustration showed negative correlation with dominance and self-reported performance and positive correlation with arousal

- all subtractions (T3-T1) of the scale data of SAM questionnaire (valence, arousal, and dominance) showed differences between the groups (Fig. 4)
- FRUST-group rated their task performance worse than the NOFRUST-group
- frustration subtraction scale showed negative correlations with the self-performance
- valence, dominance, and self-confidence indicated a negative correlation with frustration score of NASA-TLX

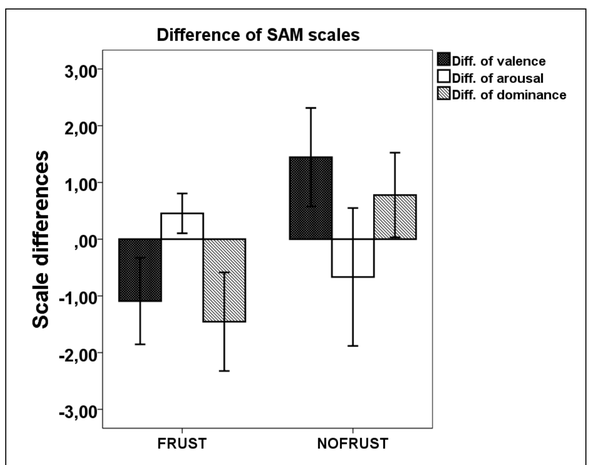

Figure 4: Results of the differences (T3-T1) of all 3 scales of SAM questionnaire, means and 95% confidence intervals.

Conclusion and Outlook

In this study, the results suggest an increase in the frustration during the task, which was indicated by the questionnaires (like in [5, 7, 10]), but not by psychophysiological methods.
The higher the frustration was perceived, the worse the subjects assessed their performance in the task. Dominance, valence and self-confidence are negatively correlated with frustration. A possible reason for the missing differences between the condition groups detected in the psychophysiological methods is the large variance within the condition group. Therefore, the sample size should be increased in future studies to investigate frustration with psychophysiological methods.
Since dominance, self-confidence and self-performance decrease with perceived frustration, it is important to minimize frustration. To have the ability to deal with a situation and hence decrease frustration levels is important in the interaction with a technical system and has a direct influence on the acceptance and assessment of the interaction. More research about relevant factors leading to the feeling of frustration in human-machine interaction should be done to design better collaborative interaction especially with semi autonomy systems.

Experimental Setup

- between-subject design with 20 healthy participants
- two condition groups: frustration (FRUST-group) or no frustration (NOFRUST-group)

Task ([10]): *induce emotion (frustration or "satisfaction") with manipulated feedback*

- participants counted triangles in 15 different complex geometric figures & collected as many points as possible, after each entry of the counted triangles, a fixed feedback of 5 different level of points (from +3 to -3 points) was received (Fig. 1 & 2)

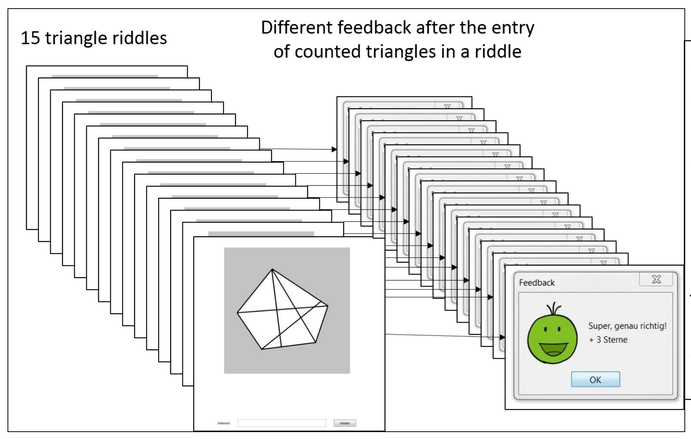

Figure 1: Schematic sequence of the emotion induction task
In 15 geometric figures (triangle riddles) the number of triangles were counted. After each entry of the counted triangles, the participants received a fixed feedback. The feedback consists of a smiley, a sentence and points. The feedback in the FRUST-group is more negative than in the NOFRUST- group, thus the collected points of the FRUST-group is lower in comparison.

Methods (Fig. 1 & 2):

- self-assessment manikin (SAM), 6-scale questionnaire about different emotions and condition of the human (EaCQ) (based on PANAS and BSKE21) & NASA's Task Load Index (NASA-TLX) → filled out before, during and after the task
- electrocardiogram (ECG) & electromyogram (EMG) with the BITalino BioMedical Development All-in-One Board, sampling frequency of 1000 Hz, rest condition recording: before and after the task

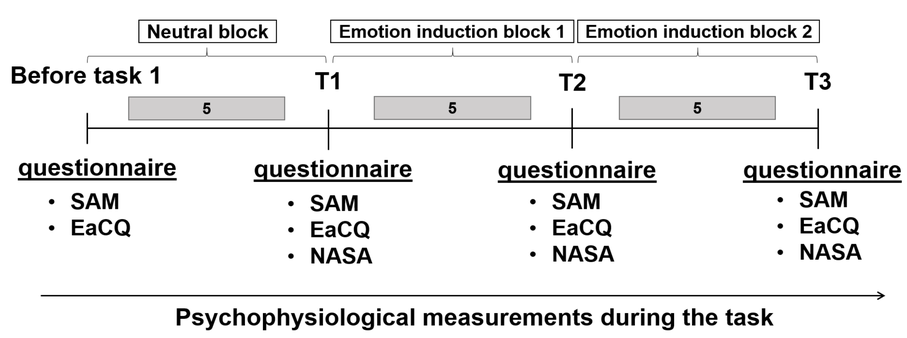

Figure 2: Structure and procedure of the emotion induction task
The task is divided into 3 blocks (1x neutral block, 2x emotion induction blocks). Each block consists of 5 triangle riddles. After each block 3 questionnaires were filled out. During the task physiological methods (ECG and EMG) were recorded.

Statistical overview of the results

Table 1: *95% confidence intervals, the lower and upper bound, as well as the effect size r of each result factor small effects: r=0.1, medium effects: r=0.3, large effects: r = 0.5 [2]*

Factor	Lower bound	Upper bound	Effect size r
Frustration scale (NASA-TLX)	28.14	69.07	0.77
Heart rate fluctuation	-0.86	1.82	0.175
Heart rate variability	-0.52	1.29	0.214
Muscle activity maxima	-0.64	0.21	0.267
Muscle activity amplitude	-0.95	1.8	0.306
Arousal	-0.11	2.36	0.553
Dominance	-3.3	-1.17	0.721
Self-confidence	-2.39	-0.72	0.684
Self-reported task performance	14.12	56.61	0.353
Frustration and self-reported task performance (correlation)	0.375	0.8741	0.678
Frustration and dominance (correlation)	-0.846	-0.503	-0.664
Frustration and self-confidence (correlation)	-0.851	-0.209	-0.577

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