Attention, Comprehension, Execution:
Effects of Different Designs of Biofeedback Display

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Motivation

Conventional graph-style visual representations may not be the most applicable biofeedback methods for behavior monitoring and control, and this is because biosensor data is not intuitive and is hard to manipulate directly and precisely, especially in computer-mediated collaborative interactions.

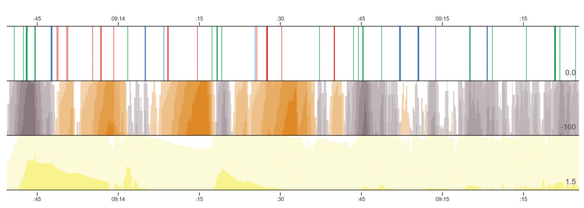
Approach

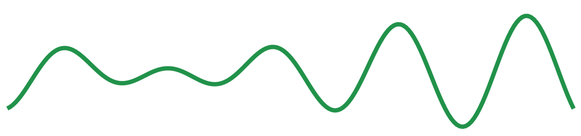
We explore four design styles by visualizing physiological data in individual settings. Following the Research through Design model, we compare these four designs regarding their abilities to facilitate biofeedback interpretation through a within-subject controlled experiment with 24 participants.

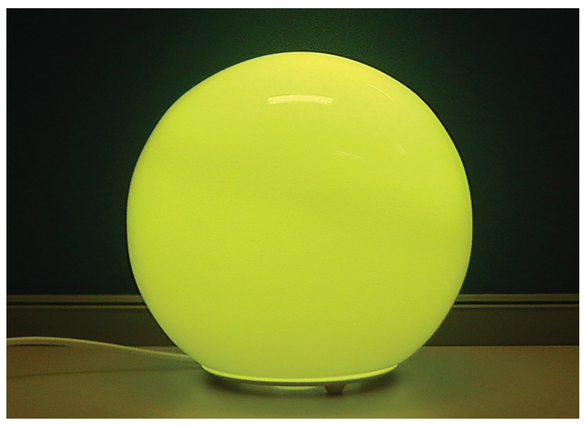
Scale	Graphical	Illustrative	Artistic	Ambient
Intuitive	***	**	*	*
Meditated	*	**	***	***
Specific	***	**	*	*
Holistic	*	**	***	***
Realistic	***	**	*	**
Imaginative	*	**	***	**
Descriptive	***	**	**	*
Experiential	*	**	**	***
Focal	***	**	**	*
Peripheral	*	**	**	***

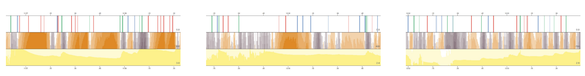
Tabel 1: Four design styles compared along with several key factors. The number of "*"(s) indicates the rating level of the corresponding scale.

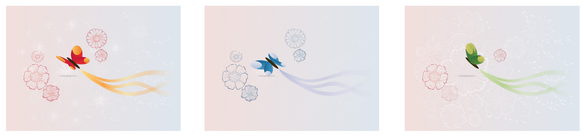
Terms and Design Details











Graphical Representation (**G**)

The overview as well as detailed descriptions to the raw data.

- Horizon graph
- Above view: the stress trend.
- Middle view: the accumulated pattern.
- Below view: the skin conductance.

Illustrative Representation (**I**)

The optical abstraction extracted from visual analogue(s).

- A dynamically waving curve
- Color: the stress trend.
- Amplitude: the accumulated pattern.
- Frequency: the skin conductance.

Artistic Representation (**A**)

The experience oriented expression of visual metaphor(s).

- A butterfly design
- Color: the stress trend.
- Flapping frequency of wings: the accumulated pattern.
- Number of ribbons: the skin conductance.

Ambient Representation (**M**)

Take attractive and tangible everyday object(s) as the media.

- Philips Hue
- Color: the stress trend.
- Saturation: the accumulated pattern.
- Brightness: the skin conductance.

Study

Hypotheses

- The effort demanded for attention allocation (***HA***), comprehension (***HB***) and execution (***HC***) is significantly different among the four visual designs.
- **I** and **M** would take significantly less effort for people to focus their attention on relevant information than **G** or **A** (***Hα***).
- **M** is significantly easier to comprehend than the other three designs (***Hb***).
- **G** is significantly harder to adjust accordingly compared to the other three representations (***Hc***).

Participants

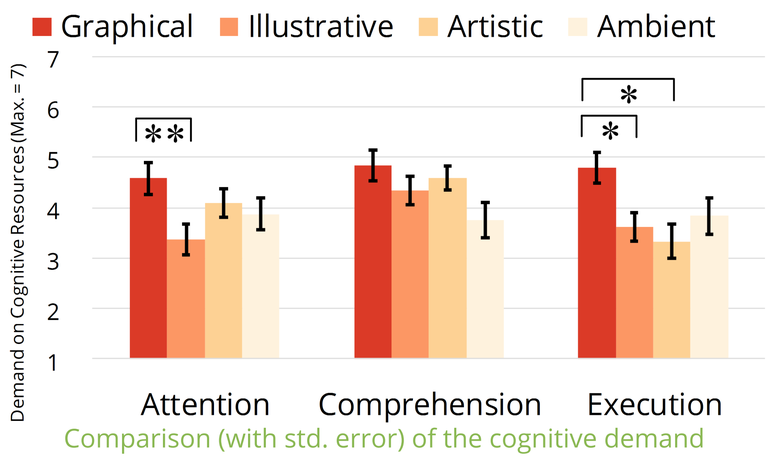
24 participants (nine females; age M = 24.88, SD = 2.47) are recruited from a local university.

Experimental Tools

- A Pip for taking the physiological measures.
- A lamp (with Philips Hue inside) for the ambient display in the left-hand corner of the table.
- A tablet computer (Microsoft Surface Pro 4) for showing the other three displays in front of the participant.

Analysis

The effort demanded of graphical design is significantly higher than the illustrative design, while there is no significant difference in comprehension across the four representations.



Comparison (with std. error) of the cognitive demand

Dimension	Measurement	*df*	*MS*	*F*	*P*	η^2	Results of Hypotheses Testing			
Cognition	Attention	3	6.01	4.09	0.01	0.15	***HA***	Accepted	***Hα***	P. Accepted
	Comprehension†	1.85	8.36	2.84	0.07	0.11	***HB***	M. Accepted	***Hb***	Rejected
	Execution	3	9.57	3.67	0.02	0.14	***HC***	Accepted	***Hc***	P. Accepted

Table 2: Repeated measures MANOVA results on different measurements of four visualization designs, † with Greenhouse-Geisser correction as the data violates the assumption of sphericity. *MS* represents *Mean Square*. M. means Marginally. P. means Partially.

Conclusion

In general, a neat, simple design with substantial, properly balanced visual cues and highlighted, critical information can effectively reduce cognitive overheads.

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