# Designers of Different Cognitive Styles Editing E-Learning Materials Studied by Monitoring Physiological and Other Data Simultaneously

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**Abstract.** At the Corvinus University of Budapest, a series of experiments was performed, applying the *INTERFACE* testing methodology developed by researchers of the Budapest University of Technology and Economics. This methodology is capable of recording data characterizing the user's current mental effort derived from *Heart Period Variability (HPV)* and the user's emotional state indicated by *Skin Conductance (SC)* parameters simultaneously and synchronized with other characteristics of Human-Computer Interaction (HCI). The current experiments aim to study *how the teachers (electronic curriculum designers, developers) themselves use the e-learning development tools to design and edit a new piece of e-learning material.*

**Keywords:** Cognitive styles, analytic and holistic types, e-learning, Learning Management System (LMS), Moodle, usability testing and evaluation, empirical methods, Heart Period Variability (HPV), Skin Conductance (SC).

## 1 Applying the INTERFACE Methodology

Figure 1 shows the conceptual arrangement of the *INTERFACE (INTegrated Evaluation and Research Facilities for Assessing Computer-users' Efficiency)* workstation.

The advantage of the methodology applied in our study lies in its capability of recording continuous on-line data characterizing the user's current mental effort derived from *Heart Period Variability (HPV)* and the user's emotional state indicated by *Skin Conductance (SC)* parameters simultaneously and synchronized with other characteristics of Human-Computer Interaction (HCI). This way, a very detailed picture can be obtained which serves as a reliable basis for the deeper understanding and interpretation of psychological mechanisms underlying HCI.

Elementary steps of HCI, like the different mental actions of users followed by a series of keystrokes and mouse-clicks, are the basic and usually critical components of using software. These steps can be modeled and analyzed by experts, but empirical results than expert analyses. One of the key aspects of the empirical methods is measuring

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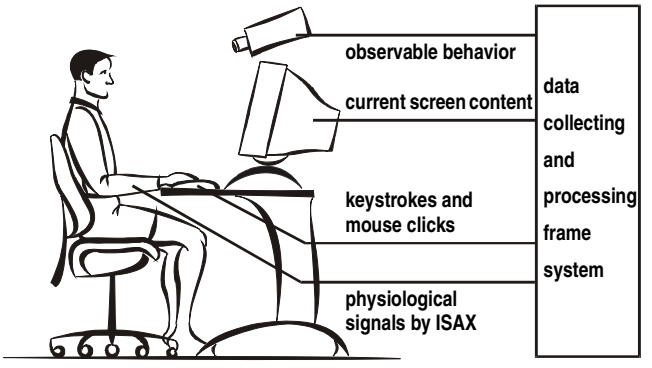


**Fig. 1.** Conceptual arrangement of the INTERFACE user interface testing workstation

*mental effort* as it is laid down e.g. in the earlier international standard of software product evaluation (ISO/IEC 9126:1991). Hence we need methods capable of monitoring users' current mental effort during these *elementary* steps.

To attain the above, a complex methodology was developed earlier at the Budapest University of Technology and Economics, by Prof. Lajos Izsó and his team [3, 4, 5, 6]. This study presents an improved methodology and a new case study.

The INTERFACE simultaneously investigates the following:

- Users' observable actions and behavior
  - keystroke and mouse events;
  - video record of the current screen content;
  - video records of users' behavior: (1) mimics, (2) posture and gestures.
- Psycho-physiological parameters
  - Power spectrum of Heart Period Variability (HPV), regarded as an objective measure of current mental effort – we apply this signal successfully since more than 15 years [3, 4, 5, 6];
  - Skin Conductance (SC) parameters, indicating mainly the emotional reactions – recently integrated into our system.

In addition to observable elements of behavior, the applied complex method also includes traditional interviews to assess mental models, subjective feelings, and the users' opinions about their perceived task difficulty and experienced fatigue.

Recording these various data simultaneously requires a more sophisticated technical background than other empirical methods based on only personal observation or simple video recording. However, multiple channels enable researchers to concentrate on the channels that highlight the importance of various parts of the current event flow.

### 1.1 Assessing Users' Performance and Behavior

*Performance* measures are useful in general and in other projects of ours, but in the current study, we will apply them only for particular aspects of the interaction.

Recording *users' behavior* has outstanding importance. The video recording of the user's face and activity is an extremely rich source of psychological information as it directly reflects the mental state (e.g. boredom, routine activity in familiar environment,

attention-demanding task, getting lost, emotions like frustration, anger, joy, etc.). To analyze this channel, we are working on integrating a new, sophisticated method into our INTERFACE methodology.

### 1.2 Assessing Mental Effort via Analyzing Users' HPV Power Spectrum

A number of studies [3, 4, 6, 11, 12, 13, 15] have shown that an increase in mental load causes a decrease in the so-called mid-frequency (MF) peak of the Heart Period Variability (HPV) power spectrum. To assess the spectral components of HPV power spectra, an integrated system called ISAX (Integrated System for Ambulatory Cardio-respiratory data acquisition and Spectral analysis) was developed and successfully used by Dr. Eszter Láng and her team. This equipment and the related method have been integrated into our INTERFACE system.

The main advantage of our method over the previously existing HPV-based methods is that the MF component of HPV shows changes in mental effort *in the time range of several seconds* (as opposed to the earlier methods with a resolution of tens of seconds at the best). This feature was achieved by an appropriate windowing data processing technique, and application of an all-pole auto-regressive model with built-in recursive Akaike's Final Prediction Error criteria and a modified Burg's algorithm. In this study, we apply a *new, further developed version of ISAX* for the first time.

### 1.3 Assessing Emotional Responses via Analyzing Users' Skin Conductance Parameters

Changes in the electrical activity of the skin (the so-called Electrodermal Activity – EDA) can be produced by various physical and emotional stimuli. We use the parameters derived from Skin Conductance (SC) responses, especially the Alternating Current (AC) component of the SC.

In contrast with our earlier experiments applying Heart Rate Variability (HPV), measuring Skin Conductance (SC) in our INTERFACE methodology is relatively new to us[1]. We are working on it to complement the INTERFACE system with a component focusing mainly on the *emotional* aspects of the HCI, in addition to our well-tried approach of *mental effort*.

## 2 Applying INTERFACE to Study Interactions of Editing E-Learning Material

We have used INTERFACE in various areas (e.g. mailing systems, CAD, WAP-based software, flight control system, etc.) [4, 5, 6]. We published details from a multimedia development project led by us [3], where we focused on the software usage of the students. Now, we focus on the other side of e-learning: we aim to study *how the teachers use the development tools*.

[1] An interesting series of experiments using the new version of the ISAX to analyze SC responses is finished by one of our colleagues [8, 9, 10]. It is a good example of the promising way to use data mining techniques in empirical usability studies, as it is mentioned in the followings. However, in that case, the tool was not yet integrated into the complex INTERFACE system.

Among evaluating the user interface, as in the previous applications of the INTERFACE system, a specific aim of this series of experiments was to compare the holistic and analytic *cognitive style* of users' mental activity and emotional responses during designing e-learning material.

The series of experiments started in December 2007 with pilot experiments. The main part of the series started on 14th December and finished in March.

32 participants were involved.

During the two-hour-long sessions, the task was to design and edit e-learning material with the *Moodle* Learning Management System (LMS). Participants, with basic knowledge about Moodle, executed this task with the help of prepared materials: "raw" texts and illustrations (pictures, video files).

Analysis of the data, especially the statistical analysis of the hundreds of variables is in progress. To execute the statistical calculations and explore the deeper mechanisms, we use the SPSS 17.0 for Windows statistical and the SPSS Clementine 12.0 data mining software package.

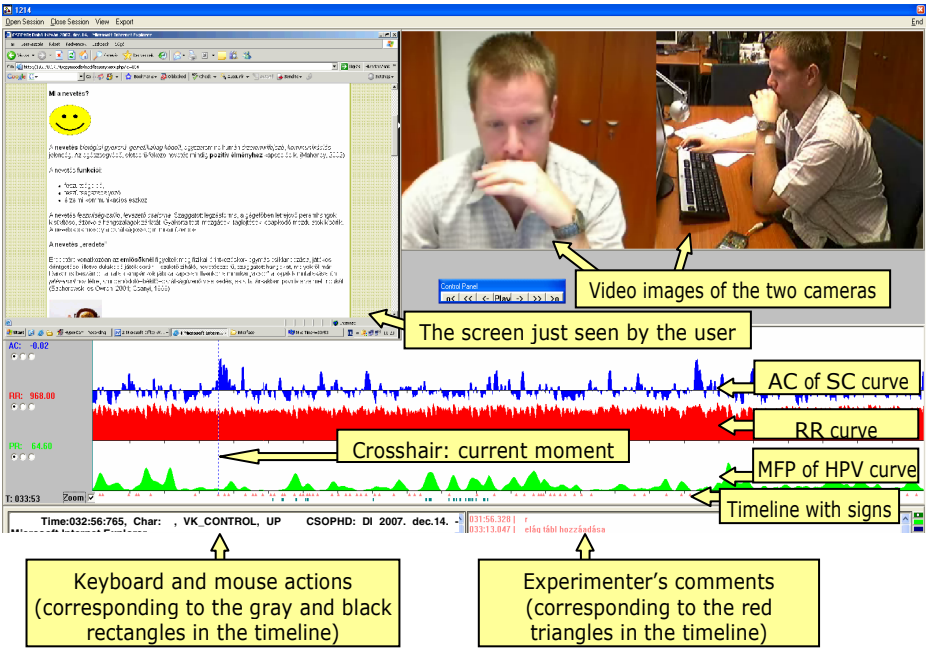


**Fig. 2.** The INTERFACE Viewer software. In the moment of this screenshot, the user is thinking, so the 3rd (green) curve is low.

## 2.1 Instruments to Determine Cognitive Styles

In our examination, four questionnaires are used to identify holistic and analytic cognitive style users:

- *Cognitive Style Index (CSI)* [1] to measure the whole/part-processing dimension of cognitive style, identifying an individual's cognitive style as being either analyst or intuitive.
- *Personal Style Inventory (PSI)* measures dimensions of the Myers-Briggs Type Inventory (MBTI). It is based on Carl Jung's theory of personality types. These four dimensions are: extroversion-introversion, sensing-intuition, thinking-feeling, and judging-perceiving.
- *Kirton's Adaptor–Innovator Inventory (KAI)* assesses a person's position on the adaption-innovation continuum. When confronted with a problem, the adaptor turns on to conventional procedures in order to find solutions. In contrast, innovators will typically redefine the problem by approaching it from a novel perspective.
- *Digital Natives – Digital Immigrants* [14]: the term digital native is coined as it pertains to a new breed of student entering educational establishments. Today's learners represent the first generations to grow up with this new technology. However, digital immigrants apply printing documents rather than commenting on screen or printing out emails.

### 2.2 Hypotheses from the Point of View of Cognitive Styles

**I. Analytical type**
The analytical type of tutors/e-curriculum designers is active and experience-oriented in e-learning. The analytic type prefers:

- curriculum rich in visual and verbal units
- possibilities and exercises that require analyses
- simulations, models, videos
- to annotate and rearrange the curriculum by their own principle.

**II. Holistic type**
The "holistic type" of tutors/e-curriculum designers is more active. They build up their curriculums and personal learning environments from these units. The holistic type prefers:

- curriculum linking up memorized units and parts of curriculum
- to connect parts together
- experience, particular cases and exercises (compilation, thesaurus, collection of curiosity, suggested reading)
- to comprehend the curriculum as a whole.

### 2.3 Procedure

**1st phase (10 minutes)**
In this phase participants were asked to execute 3 tasks to detect their mental activity under different circumstances. Detection of different patterns of HPV and SC gives bases for comparison with responses during task period patterns: without any activity, after 1 minute alertness period participants count down for 1.5 minute, 2 minutes relaxation period.

**2nd phase (45 minutes)**
The task is to design and edit e-learning material with the help of *Moodle* system. Participants, with basic knowledge about Moodle Learning Management System (LMS), execute this task with the help of prepared materials: 2 pages "raw" text about the learning material, and illustrations (pictures, video files).

**3rd phase (10 minutes)**
Interview section about participants' experiences during task execution. The structured interview has 3 main topics: prepared learning material (e.g. satisfaction, difficulties), circumstances of work, experiences with Moodle.

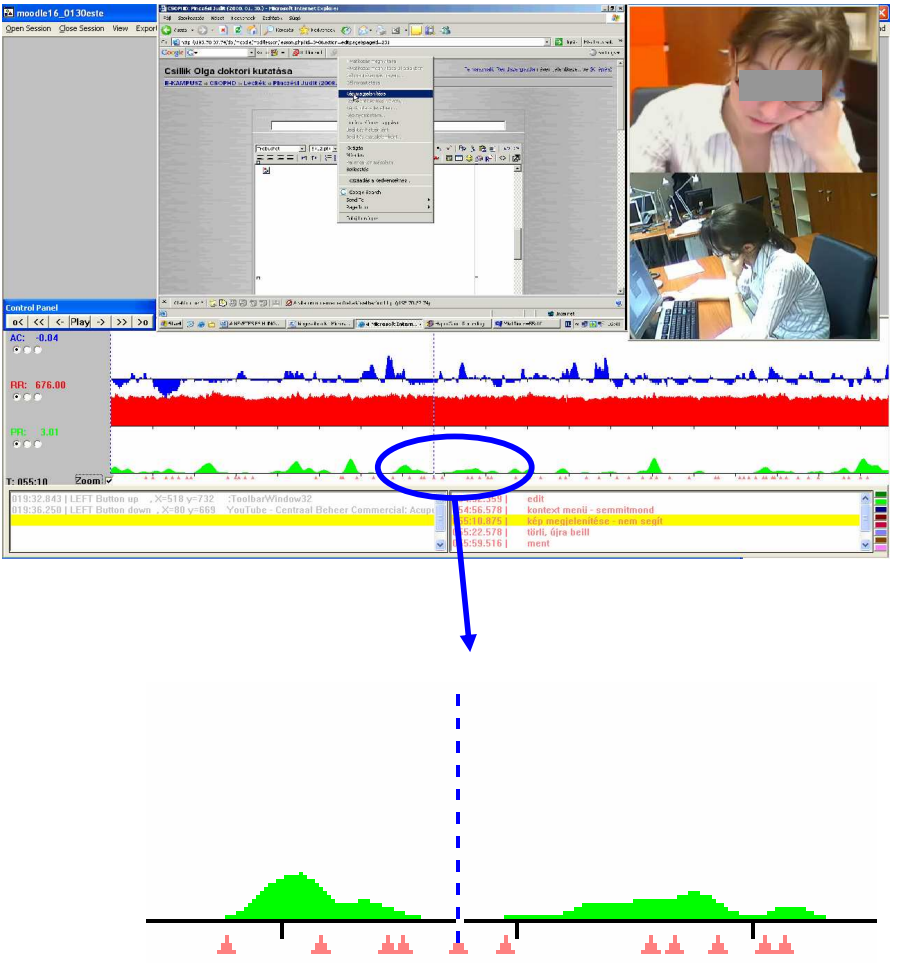


**Fig. 3.** In the moment of this screenshot, the HPV profile curve is low. This is caused by a typical software problem: the currently selected image doesn't appear; the user try to solve this problem by the help of the context menu; but this is not a desktop application, it is a simple web-based software – the context menu contains only the standard commands of the web browser. The seriousness of this problem depends on the user's cognitive style: the analytical-type users cope with this easier.

## 3 Conclusion

Based on the results presented here as well as in related papers, it can be stated that the INTERFACE methodology can help us to understand the mechanisms underlying the HCI in depth.

Studying the individual differences, such as differences in cognitive styles is a really important opportunity to understand HCI, in spite of choosing the easier way to design for "average" users.

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