The Adaptive User: Priming to Improve Interaction

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CHI'13, April 27 – May 2, 2013, Paris, France.

Abstract
The HCI community has made incredible progress over the past few decades, but the feat of designing interfaces that are equally usable by everyone is yet to be overcome. Users' background, personality and even daily changes in mood affect their performance on visual interfaces. One proposed solution is to calibrate the interface to each user by intelligently adapting its design based on their input. However, when adapting an interface to volatile cognitive states like emotion, this method may result in constantly changing the interface and can cause a decreased sense of control for the user. In this paper, we propose the use of psychological priming techniques and show how they can be used to temporarily influence a user's cognitive state and positively affect performance.

Author Keywords
Guides, instructions, author's kit, conference publications

ACM Classification Keywords
H.5.m [Information interfaces and presentation (e.g., HCI)]: Miscellaneous.

General Terms
Documentation, Standardization

Introduction

Traditional approaches to design have focused primarily on designing the optimal interface for a typical user. Although this approach has been accepted for many years, the notion of the typical user is fast becoming obsolete. Recent research in HCI and Visualization has indicated that individual differences such as culture, personality, age, and experience all impact a user's performance on (or preferences for) a visual design. For example, extroversion correlates with a user's color preference in an interface [1] and locus of control modulates performance on complex tasks when the interface contains a nested-box metaphor [10]. Given the increasing number of known individual differences that impact interaction, it is likely that one or more cognitive factors will cause a user to perform at less than optimal levels on a visual interface. Additionally, groups of people will likely 'see' the same visualization differently, complicating collaboration on the same visual design.

One proposed solution is to calibrate the user interface to each individual by intelligently adapting its design based on passive or explicit user input. Previous work has found that adaptive systems result in performance or satisfaction gains, when it responds to motor abilities [3], vision [3], or brain sensing [9], among others. Unfortunately, adapting visual design to volatile user states such as affect (emotion) or cognitive load can, in some cases, be challenging. Indiscriminately modifying the design of an interface may prevent the user from establishing a clear mental model of the system, decreasing the user's effectiveness and increasing feelings of loss of control.

To avoid this pitfall, we suggest an alternative: rather than only adapting the interface to the user, we can also adapt the user to the interface. We propose that adaptation can be a two-way construct in which both the user and the machine adapt to each other. In this paper, we share existing research that demonstrates how priming techniques can be used to temporarily affect a user's cognitive state and positively influence performance. We discuss design implications and the potential benefits of such a construct.

Adaptive Systems: Successes and Challenges

Designing a personalized interface for every user is clearly impractical. However, recent research has demonstrated the success of adaptive systems and how these can be used to significantly influence a user's performance. For instance, previous work by Gojas and Weld [3] demonstrated how interfaces can be adapted to a user's motor and visual abilities. Solovey et al. [9] showed how brain input technologies (fNIRS) can be used to detect a user's cognitive state and automatically adapt their workload as they perform complex robot navigation tasks.

However, a critical challenge arises when adapting visual interfaces to a user's cognitive states - aspects of the user that constantly change and are dependent on task and situation [8]. The unpredictability and volatility of cognitive states makes it difficult to design visual interfaces that are predictable and controllable. Designers must take care to avoid constantly modifying the visual information in response to every change in user state. Instead of adapting the system to the user, we propose that psychological priming can be used to influence user adaptation.

Influencing Cognitive States

Psychologists have developed numerous priming techniques to temporarily manipulate cognitive states. Many interesting experiments exist (some are described

Figure 1: An example of the Navon letter task [7] used by Förster et al. [2]. This priming stimuli can be used to alter a user's processing style from global to local and vice versa. When practicing a global processing style, people attend to the whole of a visualization whereas when practicing a local processing style, they attend to details [7].
For global processing priming, individuals are shown a series of these letter and are asked to identify the global target letters. When priming for local processing, individuals are asked to identify the local target letters. After performing this task, people are more likely adapt the respective processing style for subsequent tasks.

in [6]), but we limit our discussion to describing general priming effects and their potential for adapting users to interfaces.

Priming involves three main variables. **Target states** are the intended changes in perception, cognition, or behavior in a given situation. These states are induced by **stimuli** such as images, videos, text, or simple tasks. **Tasks** follow exposure to stimuli and are intended to make use of the induced target state.

For example, in Lewis et al. [5], participants were shown an image of a laughing baby (stimuli) to induce positive affect (target state) which increased their performance on creativity tests (tasks). Förster et al. [2] discusses how participants were primed via task involving a series of large letters comprised of small letters (see Figure 1) to alter their processing style from either global to local or vice versa (target state), which influenced the processing strategy they used on subsequent tasks.

Focusing on relevant work in HCI and Visualization, Lewis et al. demonstrated how users can be affectively primed by embedding images into a sketching application [5] and, using emotionally charged stories, Harrison et al. showed how users can be primed to make fewer errors when interpreting visualizations [4].

Implications on Design

Some cognitive states or personality traits also have the potential to adversely affect on interaction with a visual interface [5, 10]. As a result, a person's performance with a visual interface may be a distortion of their full capabilities.

One potential application of priming is that we may be able to negate these inherent disadvantages. For example, subtly presenting a positive news article or picture could amplify the performance of someone who is not having a good day. Framing a question differently may avoid bias pitfalls that exist because of a user's personality traits. In the future, intelligent systems may have an understanding of the user's traits and states in order to 'nudge' them at just the right moment. Just as an athlete stretches in order to prepare their muscles for an athletic event, primes may enable us to optimally prepare the mind for interaction with a visual design.

A second potential application for user priming is to modify collaboration on a visual interface. When a group of people collaborate over the same data, they bring a mix of personality, experience, and bias to the table. While this diverse environment has its advantages, it can also be helpful for people to see the visual interface as everyone else is seeing it. Priming may be able to take two people with polar personalities and nudge them towards a common center, allowing them to interact with the data on a level playing field.

Priming may also help the exploration of data by nudging users towards new perspectives. Manipulating a person (or group's) cognitive state could allow them to see an interface with 'new eyes', potentially resulting in novel insights or interactions.

By combining both priming and adaptive systems, we believe the two techniques can build toward a symbiosis between the system and the user, where not only does the system adapt to better suit the user's needs, but systems can also encourage adaptation by the user to enhance performance.

Challenges

Clearly, there are many challenges that lie ahead. While identifying a person's stable traits and personality require a one-time investment by the user (typically a survey), counteracting cognitive states provides a more daunting challenge, as they can change from moment to moment, making them difficult to monitor. One possible solution is through the use of physiological measures such as brain input or galvanic skin response as a continuous means of assessing the user's cognitive state.

Additionally, there are lingering questions about the impact of priming. How unobtrusively can we prime a user? What are appropriate or inappropriate environments for priming users? How long do the lingering effects from a prime last? What are the ethical implications of modifying behavior without the user's awareness? Answering these questions may bring us a step closer to developing visual interfaces that are able to overcome variances of individual differences.

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