Maintaining Concentration to Achieve Task Completion

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Concentration is the eternal secret of every mortal achievement
Stefan Zweig (1881-1942, Austrian philosopher)

Abstract
When faced with a challenging goal, knowledge workers need to concentrate on their tasks so that they move forward toward completion. Since frustrations, distractions, and interruptions can interfere with their smooth progress, design strategies should enable users to maintain concentration. This paper promotes awareness of this issue, reviews related work, and suggests three initial strategies: Reduce short-term and working memory load, provide information abundant interfaces, and increase automaticity.

Keywords
Maintain concentration, task completion, goal attainment, interface design, flow, calm, focus, situation awareness, avoid interruption

Project/problem statement
Information and communications technologies can amplify user capabilities in many ways, but users can also suffer from annoying frustrations, interruptions and distractions. The goal of this paper is to promote increased research and design consideration for interfaces that support sustained concentration so that users can achieve task completion. Related topics of calm computing, flow, and situation awareness propel our work, which emphasizes designs that promote user control to attain goals.

Background

- Ben Shneiderman and Ben Bederson are in a continuing dialog about design philosophies.
- They are inspired by interface design projects for hierarchical and network data discovery, high-dimensional data exploration, voting machines, photo management, digital libraries, etc.

Challenge

Enabling users to maintain concentration is the next challenge for interface designers.

Frustration and anxiety is high in computer usage.

Distractions and interruptions interfere with task completion

Our goals:
- raise awareness
- promote research
- encourage developers to think about enabling users to maintain concentration

The varying rhythms of life include times of solitary reflection in natural settings, relaxation while listening to music with friends, and casual conversation with family. Sometimes the rhythms shift to purposeful action to achieve meaningful personal or professional goals within strict time limits. In these times, modern information and communication technologies can be remarkable amplifiers of human capabilities. Users who maintain their concentration can move smoothly along the path to goal attainment. When they do so, they can feel mastery of the interface, satisfaction in completion of their tasks, and responsibility for the outcomes.

Unfortunately some interface experiences produce annoying frustrations that distract users' attention. These frustrations can lead to poorer workplace performance, lower self-esteem, and stressful relationships with colleagues [2, 10].

When users are working towards a meaningful goal within fixed time limits, distractions and interruptions can severely undermine progress, increase frustration, and raise error rates. Perceived anxiety and physiological measures of blood pressure, heart rate, masseter muscle tension, and psychogalvanic skin response have all been used to demonstrate that computer use can be debilitating. Moreover, frustrated and fatigued users may make poor decisions that could result in loss of data, damage to equipment, or loss of life in systems such as air-traffic control, military, and medical care.

While there is a large literature on maintaining situation awareness in life-critical systems designed for professionals, little work has been done on maintaining concentration in business-oriented tasks such as writing documents, preparing spreadsheets, and managing databases. There is also little guidance available for designers of Internet and World Wide Web applications as they enable users to manage email, find information, and make shopping decisions.

A clearer understanding of how interface designs enable users to maintain concentration and complete tasks, while avoiding frustration would be helpful. We hope to raise awareness, promote research, and encourage designers to place greater emphasis on enabling users to concentrate on their tasks in the face of tempting distractions and unwanted interruptions.

Process: Study related work

The need to maintain concentration has been raised and studied as a human factors problem in diverse professional domains such as air traffic control, military systems, and process control rooms. These domains are characterized by long training periods for operators carrying out complex life-critical tasks in which low error rates are necessary, even under stress. This research often deals with the extremes such as the need to keep vigilant for long periods of time and the struggle to cope with information overload when crisis conditions produce high demands. In this paper we are more concerned with middle to high levels of demand on diverse users who are seeking to accomplish meaningful tasks within a time limit.

In life-critical and process control applications, related work on maintaining concentration is usually

Designers can reduce distractions and interruptions.

Lessons can be learned from design of:
- air-traffic control
- military
- medical care
- automobile
- sports

Flow is a closely related theme

discussed in the broader topic of situation awareness [6]. This rich topic deals with enabling operators in high demand situations to perceive necessary cues, to comprehend information by combining, interpreting and retaining, and to project forward in time so as to anticipate future events and make appropriate plans.

Concentration while driving is a growing concern, especially as electronic devices such as navigation systems and cell phones are increasingly used [12]. Navigation systems are especially demanding during destination entry, and can result in 'capture' of user attention so that drivers no longer perceive traffic conditions, road signs, and other vehicles. Similar problems have been documented for cell phone use, even with hands-free installations.

In less demanding situations, such as sports, maintaining concentration is still an issue since competitive pressures and external distractions from spectators require clear focus of attention to achieve high performance. Coaches actively train athletes in concentration techniques to ensure high physical performance and close coordination with teammates.

Psychologist Mihaly Csikszentmihalyi suggests that people perform at their peak when they are in the 'flow' state [3, 4]. Being 'in the flow' is marked by a high degree of concentration in achieving a clear goal while working at the optimal point of challenge between boredom and being overwhelmed by anxiety. People who are in a flow state are focused on their tasks, applying their skills, engaged in the challenge, and less aware of external activity. They are in control of their environment and eager for rapid feedback to assess their progress [1]. They often lose track of time and may perceive the elapsed time as much shorter than the actual time. Elation at completion is often part of the flow state.

Many activities can result in a flow state. In addition to athletics and music, even computer programmers have reported intense experiences in code-writing sessions in which they produced intricate programs that ran correctly the first time. They may have worked several hours, but they perceive the elapsed time as less than an hour. Recent studies of software suggest that users of well-designed software perceive the elapsed time of use as less than users of poorly-designed software [5].

Some computer visionaries, such as Marc Weiser and John Seeley Brown, described the goal of calm computing [14] as a companion for ubiquitous computing. They recognize that "information technology is more often the enemy of calm" but they suggest that when computing devices are embedded and become invisible, then users can "remain serene and in control." Their design suggestions for calm technology include enabling users to shift attention easily from the periphery to the center and back. This enables users to concentrate on items at the center while keeping aware of the items at the periphery, thereby increasing user control. Weiser and Brown generated much discussion of calm technology, but research interest has not matured.

Another source of research on concentration in use of information and communications technologies has come from those interested in attentive user interfaces and notification systems [8, 11]. Ironically, this body of work focuses on "predicting the interruptability of users" so as to deliver information when it will cause the least harm [9]. An Interruption Workbench with a Bayesian network models user behavior so as to infer when the system should interrupt users. While the goal of lowering the cost of interruptions seems admirable, the emphasis on mixed initiative systems undermines

Calm computing is an inspiration

Our solutions:

1) Reduce short-term and working memory load

2) Provide information abundant interfaces

3) Increase automaticity

More solutions are possible, e.g.:

Role managers to shift focus among sets of topics, people, documents, web pages

Feedback tools to inform users how well they are maintaining concentration and making progress towards their goal

Concentration managers to control and limit distractions and interruptions

Increased error prevention strategies the reduce wasted time and ensure correct complete solutions

the desire of many users to remain in control. There are undoubtedly situations where this approach is valuable, but we question the merit of placing such an emphasis on computer-inferred interruptability, rather than providing users with tools to manage the interruptions or, as we say, maintain concentration. We can separate these two streams of work by clarifying that computer-controlled notification systems may be useful in some business practices such as customer-support call centers, where maximization of throughput and standard operating practices are vital. By contrast, our emphasis is on less predictable knowledge worker situations in which users want to and are permitted to take control over their use of technology.

Solutions: Three strategies

Building on previous work leads to strategies that help users maintain concentration. We offer three in this short paper, but more are possible.

1) Reduce short-term and working memory load: The large volume of domain-related content needed for work places high demands on short-term and working memory, especially if complex problem solving is required. Reducing the burden on memory can be accomplished by effective display design that provides ready access to information needed for a decision. Compact layouts that reduce scrolling are highly beneficial, even if the density of information is greater. For example, choosing among 100 airline destinations in a 2-D grid is much easier than scrolling through 10 displays of ten items each. Similarly, broader shallower menu trees are almost always advantageous.

Disruptions can erase short-term memory, forcing users to spend time and effort to recover their status before continuing. Minimizing disruptions such as notices of software updates or email arrivals allows users to continue making progress towards task completion. Since anxiety, frustration, and fear also undermine short term memory capacity by consuming attentional resources, designers need to reduce occurrences of confusing dialog boxes and obscure error messages. After a disruption, apprehension about what else might go wrong will reduce user performance for cognitively demanding tasks.

2) Provide information abundant interfaces: Human visual capacity is remarkable, with the ability to spot patterns in complex visual fields, identify exceptions in color, shape or size, and recognize movement at the periphery. Human auditory capacity has other remarkable capabilities such as the ability to recognize patterns and hear anomalies. Since human recognition of visual content on displays remains the dominant strategy for feedback from computer operations, effective information abundant designs that are in harmony with user tasks are helpful. User-controlled compact displays enable users to make rapid decisions with minimal distraction. Consistent terminology, layout, color, and sequences of actions improve performance. Also helpful are meaningful groupings and neat alignment of fields to promote scanning. By displaying more information on each screen, users require less short-term memory and have fewer cognitive distractions by reducing the need to navigate among multiple screens.

In modern computer displays, multiple windows can enable rapid access to diverse information resources that contribute to task completion. However, good design requires effective coordination among multiple windows so that selections in one window produce appropriate results in other windows. Multiple open/close and synchronized scrolling enable users to manipulate several windows at once. Smooth scrolling,

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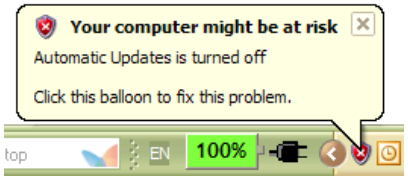

panning, and zooming with animated transitions helps preserve location awareness in a document.

3) Increase automaticity: Experienced users of interfaces are highly skilled and can perform complex sequences of actions with only a light cognitive load [6]. This high degree of automaticity, such as the driver who follows a familiar route to work with little apparent effort, is also the hallmark of users of well designed interfaces. Expert users of Emacs or Photoshop impress observers by the complex sequences they carry out rapidly and their capacity to create macros. Bederson, who designed the NoteLens note management tool with these principles in mind [1], makes heavy use of command key shortcuts so that users can keep hands on keyboards and make rapid transitions from text entry to command invocation. With experience, users can keep their concentration on tasks, gain feedback about progress, and carry out ambitious plans.

Example

One common problem is the notification balloon in Microsoft Windows XP. It is visually soft, and is no doubt designed to be less interruptive than earlier modal dialog boxes (see sidebar for example). However, we argue that it still gets in the way of users concentrating on their tasks because: 1) it sometimes disappears on its own, but users don't know when it will stick around and when it will go away – so they must attend to it immediately or risk never seeing it; 2) there is no way to see previous notifications, so users must remember important messages – further reducing their ability to concentrate; 3) there is no way to disable, delay, or prioritize notifications at times when users truly want to focus on their primary task; 4) the button to close the balloon is very small and is not accessible via the keyboard; and 5) applications use different notification styles.

We propose a modest modification which addresses these problems. A new version would have the following features: 1) a configuration button that would allow users to specify whether balloons would disappear automatically and after how long. All notifications would follow the same rule. Users should also be able to temporarily turn off notifications, or to request just notifications of a certain priority. The operating system would have to define a standard set of priorities so applications could define their notifications appropriately; 2) Next/prev buttons in the notification so users could see historical notifications. When no balloon was visible, there would have to be another mechanism for users to see notifications, such as a button in the tool tray, and a program available through the Start menu; 3) Users must be able to access the balloon via standard keyboard controls – perhaps by letting users press "alt-tab" to access it like any other application; and 4) an operating system standard API for creating and accessing notifications.

These changes, while minor, would go a long way to turning this small but important operating system feature from a frustrating and interrupting experience to one that was satisfying and informative that enabled users to maintain their concentration and feel control over their attention.

Result: New research direction

The goal for this short paper is to raise awareness of the opportunities for improved interface design by focusing on strategies for users to maintain concentration. We hope researchers might expand our list of proposed strategies with novel implementations and appropriate evaluations. Empirical studies on how

Flow is the strongest influence on our work

Situation awareness has rich resources

Work on interruptability might be productively shifted to work on maintaining concentration

well users maintain concentration are difficult to conduct since metrics of concentration or situation awareness are still emerging. We also hope that designers will consider how to reduce user frustrations, minimize interruptions, and lessen distractions. Concentration, as described in the situation awareness literature, is known to be important in life-critical applications. Concentration is helpful for normal knowledge workers to carry out their work rapidly while preserving quality. Concentration becomes even more important for creative activities, in which users are developing novel and valuable products and ideas.

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