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Tracking Attention through Browser Mouse Tracking

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INTRODUCTION

There are different ways in which we have used the concept of attention with regard to human information processing and behavior (cf Kahneman, 1973). Attention could be taken to mean whatever one is thinking about, as when a student is lost in the thoughts of daydreaming rather than paying attention to the teacher's lesson. Attention can also be associated with where we are looking or that for which we are looking (cf Moray, 1969), as when a flashing Web advertisement takes your attention or when one is mentally focused on searching through a Web page to find information.

This attention switching or attention movement perspective on attention (cf Broadbent, 1957) is of most interest in this article. A flashing Web banner advertisement could, by design, take our attention from where we had intended to focus, or a Web page could be designed such that it draws our interest and leads us to seek further information. If a person is looking in the wrong place to find what he or she wants, then it would be good for us to know about this. This article will review some theories of attention that are relevant to understanding how human attention processing mechanisms work with regard to these issues, and will review the basics of a method that can be used to track attention movement by tracking mouse movements in a browser. This method has grounding in well-established theory, and it can be used in a laboratory or can be used remotely with data saved to a server for replay.

BACKGROUND

Serial, Parallel, and Hardwired Systems of Attention

A little over a century ago, interest in the idea of attention emerged as researchers began studying various mechanisms that might affect human mental processing limitations (e.g., Bryan & Harter, 1899; Jastrow, 1892; Solomons & Stein, 1896; Welch, 1898). Psychologists lost interest in this line of research to the study of behaviorism for several decades, but renewed interest emerged again in the 1950s (e.g., Adiseshiah, 1957; Bahrick, Noble, & Fitts, 1954; Broadbent, 1957; Garvey & Knowles, 1954). Throughout the period of the 1950s through the 1970s, researchers were in part attempting to understand why and how processing limitations occur.

Single-Channel Hypothesis

One early view in this rebirth was the *single-channel hypothesis*, which viewed the processing system as something like a single-channel, serial transmission line (Welford, 1967). In an attempt to locate the bottleneck in this communication channel, Broadbent (e.g., 1957) proposed that there is a many-to-one selection switch in the channel. It is difficult, for example, to comprehend multiple conversations at a time even though we can understand one conversation out of many and can switch our attention to another. The single-channel hypothesis, however, was not able to explain the observation that people can in other kinds of situations apparently process multiple tasks concurrently. We can, for example, comprehend only one conversation out of many, yet can concurrently drive an automobile while listening.

Undifferentiated-Capacity Hypothesis

Moray (1967) proposed that some of the problems with the single-channel hypothesis could be explained by a flexible central processor of limited capacity. Popularized by Kahneman (1973) and labeled the *undifferentiated-capacity hypothesis* by Kerr (1973), this model viewed the processing system as possessing a very general pool of resources that can be allocated to the performance of various concurrent tasks. This model attempts to explain how limitations to process a particular task will change depending on what other processing tasks might also compete for resources from the central processor. For example, some of us can talk while typing, but our typing speed and accuracy often suffers when doing so. Neither of these two models was viewed by Kahneman as adequate alone; Kahneman viewed the single-channel idea as associated with processes that have structural limitations. Our visual system, for example, can only point at and process one single view at a time.

Multiple-Resource Theory

The undifferentiated-capacity hypothesis is also not completely adequate. Researchers found, for example, that it is easier to attend to auditory and visual messages concurrently than to two concurrent audio messages (Rollins & Hendricks, 1980; Triesman & Davies, 1973). This could be due in part to the existence of more than one flexible processor operating in parallel, for example, one limited-capacity processor for visual messages and one limited-capacity processor for auditory ones, both operating in parallel and feeding into a flexible limited-capacity central processor. Friedman, Polson, and Dafoe (1988) found that there are differences in processing degradation between tasks processed in each cerebral hemisphere and a common second (concurrently performed) task, further suggesting evidence of multiple capacity- or resource-limited processors.

Automatism and Skilled Processing

A problem with the capacity explanations is that processing can sometimes appear to be resource free, or to consume from a processor that has no apparent bottlenecks or resource limitations. Early researchers such as Bryan and Harter (1899) were finding that practice could lead to the automatization of task performance, or skill acquisition. The early dual-task studies were finding that when two tasks are performed concurrently, they tend to interfere with each other less and less with continued practice. It appears that with practice, some processes become hardwired outside of the control of the flexible processing systems, and so the person can effortlessly do these automatic processes in parallel with the controlled or effortful processes that require the use of the flexible general-purpose processor (cf Shiffrin & Schneider, 1977).

The discussion above suggests that there are at least three general mechanisms involved in how people process information.

1. System components composed of a flexible, general-purpose central processor and other more specialized, but flexible, processors. These resources can process different tasks concurrently or in parallel.
2. Serial system components and structurally limited components that must be switched from one task to another. Eyes can only be pointed in one direction at a time and must be physically moved if we want to pay attention to something else. Ears can receive many conversations at once, but the preprocessor associated with them can only process a single conversation at a time.
3. Hardwired system components that do not consume the resources of these flexible parallel and serial processing components. Processes become hardwired through practice. Learning to ride a bicycle, for example, requires all of a child's attention at first, and the slightest distraction can cause the child to fall. With practice, however, the child will be able to ride effortlessly, concurrently carrying on a conversation or thinking about something else.

Voluntary Attention

The notion that we have a flexible central processor or a set of processors and can choose where to focus our thinking is associated with what is called *voluntary attention* (e.g., Hunt & Kingstone, 2003; James, 1899). A student may choose to daydream rather than listen to the teacher: Both tasks can be performed concurrently, but the student consciously and deliberately allocates most attentional resources toward thinking about something while allocating some resources to listen just enough to pick out anything important that should be written in the notebook. An online shopper consciously and deliberately chooses to use attentional resources toward