The surprise generating mechanisms of human attention (Abstract)

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Within the field of human-computer interaction, human attention has been often modeled as a system decomposable in independent, individually analyzable, components. This work argues that human attention should be described instead as a complex system whose behavior emerges from the interaction of several internal and external components including sensorial input and motivational drive.
We are particularly interested in the study of attentional processes because the ability of evaluating current attentional focus and of predicting how certain stimuli may switch/disturb or maintain such focus, is extremely important in the design of software systems capable of dynamically adapting to the user's environment and cognitive load [1].

In the first section, attention will be introduced as studied in cognitive psychology, that is, as the collection of reactive and deliberative processes guiding the selective handling of incoming sensory information [2, 3, 4, 5]. We will see how attention can either be controlled voluntarily by the subject or be captured by some external event [6, 7, 8] and how, in order to evaluate and / or drive someone's attentional focus, one must take into consideration the set of environmental sensory stimuli (including visual, auditory, tactile), as well as the person's current tasks, goals, and motivations or intentions. Finally we will briefly introduce some of the theories that address the problem of how all these factors interact [9, 10, 11, 12, 13, 14, 15].

The second section will briefly argue that the attentional system is, and should be modeled as, a complex system. The argument is based on the fact that the human attentional system displays many of the surprise generating mechanisms that Casti [16] attributes to complexity: paradox, instability, connectivity, and emergence (we will not discuss uncomputability). Many **paradoxes** have been highlighted in attentional processes, especially in relation to visual attention, including, for example, the change blindness phenomena, i.e. the "failure to see large changes that normally would be noticed easily" [17, p.16], and the phenomenon of *amodal percepts* [18], such as the perceptual experience by which we may focus on linear contours around the perimeter of illusory figures. An example of paradoxical attentional mechanisms, which is not related to visual attention, is discussed by Kruschke [19] as the phenomenon of "perseveration of attention through relevance shifts" (p. 812). **Instability** seems to pervade attentional processes, in fact we don't always manage to keep attention on a target stimulus nor can we consistently avoid distractors. In the cognitive psychology literature this instability is explained through the definition of *interference effects* such as *negative priming* [20] and the *Stroop effect* [21]. In relation to **connectivity and emergence**, it has been demonstrated that the many sensorial and motivational components of the attentional system are strongly connected. Chun and Wolfe, for example, state that the "the guidance of attention is determined by interactions between the bottom-up input and top-down perceptual set" [4, p.280], and Grossberg [22, p.4] sees "behavioral data […] as the emergent properties of a dynamical process which is taking place moment-by-moment in an individual mind". Furthermore, the emerging attentional behavior is obviously the result of the interaction between the system's components and the environment.

The final section of the extended abstract will first present some of the existing models offering insights on how attentional focus may emerge from the interaction of top-down and bottom-up processes as well as the role of attention within the human cognitive system. These include Grossberg's connectionist *Adaptive Resonance Theory* (ART) [22, 23, 24]; Anderson's rule based *Adaptive control of thought–rational* (ACT-R) theory [25]; and the connectionist models developed by Kruschke and his colleagues [19]. This section will then introduce the current techniques used to (1) detect current user's attentional state, (2) detect and evaluate possible alternative user's attentional states, (3) define strategies for presentation of alternative states to the user (see [1] for a review). Finally it will be argued that the use of more complete models of attentional processes (such as the ones discussed above) would allow a better support for human attention than those offered by current techniques.

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