Chapter 53
Eye Movements and Attention

Fiona Mulvey
IT University of Copenhagen, Denmark

Michael Heubner
Technische Universität Dresden, Germany

ABSTRACT

When it comes to measuring attention, or quantifying it in any way, it is not easy to pin down what exactly we measure. Advances in technology have enabled the construction of complex models of certain aspects of attention and identified many of the structures and factors involved in the changing nature of attention. In this chapter, we will go with a working definition of attention as the concentration or focusing of mental effort on sensory or internal mental events. In terms of eye movements, we are mainly concerned with visual attention, pertaining to events and external stimuli in the environment, but not exclusively so. Eye movements may also offer an opportunity to measure internal or subjective events and states. This chapter will look at what might be possible beyond direct, point and click gaze control, in inferring subjective states. The aim is to identify and explain those measures from cognitive psychology which are most promising in terms of future technologies for gaze based human computer interaction.

INTRODUCTION

In 1890, William James defined attention as:

The taking possession of the mind, in clear and vivid form, of one out of what seem several simultaneously possible objects or trains of thought. Focalization, concentration of consciousness are of its essence. It implies withdrawal from some things in order to deal effectively with others. (1890)

Despite great advances in the methods of cognitive psychology and neuroscience since this definition was formulated, our definition of what attention is has not greatly changed in the interim. When it comes to measuring attention, or quantifying it in any way, it is not easy to pin down what exactly we measure. Advances in technology have enabled the construction of complex models of certain aspects of attention and identified many of the structures and factors involved in the changing nature of attention. However, dependant concepts

DOI: 10.4018/978-1-4666-4422-9.ch053

such as consciousness, attentional control and processing capacity (as implied in James' definition above) are still debated. In this chapter, we will go with a working definition of attention as the concentration or focusing of mental effort on sensory or internal mental events. In terms of eye movements, we are mainly concerned with visual attention, pertaining to events and external stimuli in the environment, but not exclusively so. Eye movements may also offer an opportunity to measure internal or subjective events and states, and it is this aspect of eye movements as a major output of the seeing brain with a potential trace of internal cognitive states which we will now address. The purpose of including this in a book on gaze control is that these measures point towards a future use of eye movements in human computer interaction as a means of characterising the individual user, on a moment-to-moment basis. Eye movements, therefore, potentially offer a rich stream of information from the individual to the computer. Currently, human computer interaction is dominated by information flowing in the opposite direction.

Eye movements are a relatively direct and unobtrusively observable output of the active brain, with the added possibility of a direct measure of the visual stimulus registered and sent on to the perceiving brain on a moment-to-moment basis. The sensory registration of light by the eye is the basis of, but is vastly different to, the world perceived; perception is much more than simply vision. It is the ongoing selection and processing of samples of information in order to build and maintain a detailed and effective representation of reality, using limited sense organs. The way in which we achieve this is by a process of active vision. As we have seen in the introduction to this book, the image registered by the eye is severely limited. Therefore, when we perceive reality, we are actively processing rudimentary samples of the visual world in order to maintain an internal, rich and stable world which we can move around in and manipulate according to our current goals.

Having confronted the limitations of the image registered by the retina, we know that extensive elaboration takes place between registration and perception. However, it is often the case that information is ignored, rather than elaborated, in order to maintain a stable reality. For example, during saccadic suppression the light registered on the retina is not processed further. Because the eye is limited in terms of having only a small central area of high acuity vision, and because research methods (including direct measurement of receptor response) have resulted in quite a detailed model of the retina's structure and sensitivity to light, we can estimate the registered image during the stable periods of fixation with relatively high spatial accuracy. Of course, the validity of these measures varies depending on the limitations of the particular eye tracker used. Alongside this, we must take into consideration the limited angle of high acuity vision. These two factors mean that the eye needs to move to see the entirety of even relatively small objects or areas of interest in maximum detail. If we measure, therefore, the movements of the eye on a given stimulus during a given task, we have an information-rich trace of the active vision process, as the eye is directed to what is relevant to the purposes of the viewer, as higher processes direct it, or as the stimulus itself takes control and attracts the eye to changes in the environment by reflex. Within the eye movement trace, we have behavioural information directly related to the changing attentional states of the viewer. So far, in interactive settings, eye movements have been used largely as a means of controlling an interface. This chapter will look at what might be possible beyond direct, point and click gaze control, in inferring subjective states. The aim is to identify and explain those measures from cognitive psychology which are most promising in terms of future technologies for gaze based human computer interaction. We will explain attention using a levels of processing approach. The approach is not undisputed, although it is now widely accepted in cognitive