Chapter 16
Eye-Tracking in the Real World: Insights About the Urban Environment

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ABSTRACT
Visual behaviour provides an objective and measurable indication of cognitive processes and perceptions that may otherwise be difficult to assess. The development of eye-tracking technology has allowed the accurate and relatively convenient measurement of visual behaviour. Most research using this technology has been based in a laboratory setting. This is not without good reason, as eye-tracking ‘in the wild’—in real, naturalistic, and outdoor settings—poses logistical and methodological difficulties. One particular limitation that afflicts eye-tracking research, including real-world eye-tracking, is the difficulty in directly attributing attention to what is being looked at. This chapter presents three case studies that illustrate the use of eye-tracking in real-world settings with attempts to overcome this limitation. The chapter concludes by discussing the future direction of eye-tracking research, including how to integrate it with multisensory experiences, its use in conjunction with virtual reality technology, and its implications for urban planning and environmental design.

INTRODUCTION
The goal of this chapter is to highlight the use of mobile eye-tracking as a behavioural research method for studying human interactions with and responses to outdoor urban environments. In particular, we aim to promote the use of eye-tracking in real-world, stimuli-rich, dynamic settings in order to improve the ecological validity and realism of gaze tracking. We begin by outlining why it is useful to study eye movements, and then highlight the need to do this in real-world settings due to limitations with studying...
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eye movements in laboratory settings. After detailing potential pitfalls with the mobile application of the method we then present three case studies in which eye-tracking has been used in real-world, outdoor, urban environments. These case studies highlight attempts to address a key limitation of eye-tracking research – the potential disconnect between where we look and where our attention is focused. The chapter concludes with a discussion of the future direction of eye-tracking research, in the context of working to improve the realism of the research settings and make them more applicable to behaviour in dynamic urban environments. This includes a reflection upon the potential of the data collected through this method to inform urban planning and design decision-making. Ultimately, during this chapter we hope to persuade the reader of the merits of eye-tracking research and the need to increase its use in real-world outdoor situations whilst assessing people’s visual engagement with everyday urban settings.

STUDYING EYE MOVEMENTS

The eyes are often quoted as being ‘windows to our soul’. This sentiment reveals the deep connection between the eyes and being human. They provide us with vision, the most dominant of our five senses that uses over a third of our brain (Findlay and Gilchrist, 2003), and they are also an essential part of social interaction (Emery, 2000). The eyes also provide a link to the cognitive and perceptual processes that are taking place ‘under the bonnet’, within our brains. What we look at, when we look, how we look and how long we look all have implications for how we process, interpret and interact with the environment around us. For example, from earliest infancy we look at things that grab our attention and interest us, and this can result in ‘sticky fixations’ where an infant under the age of 3 months finds it difficult to look away from a central stimulus. It is only from 3 months onwards that we find it easier to disengage from something that initially holds our attention (Johnson et al, 1991). This very early developmental behaviour highlights the ingrained connection between our eyes and the outside world. There is also a strong connection between where we look, the outside world and our actions in that world. When performing a routine task, such as making a cup of tea or preparing a sandwich, we tend to look at objects involved in that task just before they are needed (Hayhoe, Shrivastava, Mruczek & Pelz, 2003). These ‘just in time’ fixations mean we might only look at the knife we will use to butter our bread half-a-second before actually picking it up. The link between attention and where we look is highlighted by how difficult it is to pay attention to one location whilst moving our eyes to a different location (Hoffman and Subramaniam, 1995). Try it yourself.

One of the main reasons we move our eyes is because of the two different types of photoreceptors. Rod and cone photoreceptors have different functions and are distributed differently within the retina (see Figure 1). Cones are almost entirely found at the centre of the retina, within an area of 2° visual angle called the fovea. The density of cones within this small area means the fovea provides a high degree of spatial resolution, allowing us to see detailed visual information. The rest of the visual field outside the fovea, which is dominated by rod photoreceptors, has relatively low spatial resolution and provides limited visual detail about our environment. The fovea therefore acts as a ‘spotlight’ allowing us to perceive great detail, but the extent of this detail is limited due to the fovea’s small size. Most animals with eyes, including humans, have therefore developed the ability to move the eyes so that the foveal spotlight can be directed at what may be important within the environment. These eye movements are called saccades. Visual input is suppressed during a saccade however (Matin, 1974), and it is only when the eyes come...