Chapter 2
Eye Anatomy, Eye Movements and Vision

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ABSTRACT
This chapter introduces the basics of eye anatomy, eye movements and vision. It will explain the concepts behind human vision sufficiently for the reader to understand later chapters in the book on human perception and attention, and their relationship to (and potential measurement with) eye movements. We will first describe the path of light from the environment through the structures of the eye and on to the brain, as an introduction to the physiology of vision. We will then describe the image registered by the eye, and the types of movements the eye makes in order to perceive the environment as a cogent whole. This chapter explains how eye movements can be thought of as the interface between the visual world and the brain, and why eye movement data can be analysed not only in terms of the environment, or what is looked at, but also in terms of the brain, or subjective cognitive and emotional states. These two aspects broadly define the scope and applicability of eye movements technology in research and in human computer interaction in later sections of the book.

INTRODUCTION
In order to understand why and how the eye moves, we first need to characterise the image or signal registered by the eye, and how it is processed and organised in the brain. We will see that what is registered is not the same as what is perceived, and how eye movements relate to both these aspects. This chapter intends to give the reader a good general understanding of vision and the eye. It is not intended to give an exhaustive account of the highly complex structures and functions of the visual system; there are many excellent publications already available for that purpose. Rather, the intention is to outline the basics for a
multidisciplinary audience who are interested and want to work with eye tracking and gaze-based communication.

As with any area of human anatomy, there is a regrettable amount of specialist terminology which can be daunting to the uninitiated. The reader is advised to bear in mind that long, complicated terminology does not necessarily translate to long, complicated concepts. This chapter will explain the concepts behind human vision sufficiently for the reader to understand later sections in the book on human perception and attention, and their relationship to (and potential measurement with) eye movements. We begin with a description of the path of light energy from the environment through the structures of the eye and on to the brain, as an introduction to the physiology of vision. We will then describe the image registered by the eye, and the types of movements the eye makes in order to perceive the environment as a cogent whole.

PHYLOGENY OF VISION

We begin with the major structures light passes through from the environment through the visual system, and trace its path on to the photoreceptive layer of the retina at the back of the eye ball. Figure 1 shows the gross anatomy of the human eye. The first layer which light passes through is the cornea. The cornea is a protective layer around the eyeball which serves to keep the shape of the eye, keep dust and other irritants out, protect the eye from damage, and it also contributes toward the focussing of light towards the retina. It is of fixed shape, translucent, and is responsible for 2/3 of the refracting (or focusing) power of the human eye. The innermost layer of the cornea is the corneal endothelium, a layer responsible for keeping the cornea at the perfect state of hydration for it to remain transparent. It achieves this by regulating flow to and from the ‘aqueous humour’; the liquid between the cornea and the iris. Aqueous humour is the next medium light passes through. Its purpose is to keep the cornea under the correct amount of pressure to maintain its shape and it

Figure 1. The gross anatomy of the eye (Adapted from “Schematic diagram of the human eye”, 2008. Used under the terms of the GNU Free Documentation License)