The Active Eye: Perspectives on Eye Movement Research

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Many of the behaviours that humans engage in require visual information for their successful completion. In order to acquire this visual information, we point our high-resolution foveae at those locations from which information is required. The foveae are relocated to new locations around three times every second. Eye movements, therefore, offer crucial insights into understanding human behaviour for two reasons. First, the locations selected for fixation provide us with insights into the changing moment-to-moment information requirements for the behaviours we engage in. Second, despite the fact that our eyes move, on average, three or four times per second, we are unaware of this and most of the time we are not conscious of where we are pointing our eyes. Thus, eye movements provide an ideal and powerful objective measure of ongoing cognitive processes and information requirements during behaviour. The utility of eye movements for understanding aspects of human behaviour is now recognised in a wide diversity of research disciplines. Indeed, the prevalence, diversity and utility of eye movements as research tools are evident from the contributions to be found in this volume.

In this brief overview, we take a glimpse at some of the emerging areas of study in eye movement research. To do so comprehensively and in a manner that reflects the impressive breadth of work contained in this volume would be a task that is both beyond the expertise of the authors and beyond the length of the chapter that we have been asked to write. Instead, we choose to introduce some emerging areas (with a clear bias towards our own research interests) that we feel will play an increasingly important role in shaping the direction that eye movement research will take over the coming years. A number of articles have reviewed eye movement research from particular perspectives and we refer the reader to several key reviews of eye movement research. Kowler (2011) provides a review of a wide variety of findings in eye movement research over the last 25 years or so. For a review of the link between eye movements and perception, see Schutz et al. (2011). Eckstein (2011) discusses contemporary and historical views on visual search and the roles that eye movements play in this process. While slightly earlier than the other reviews,

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M. Horsley et al. (eds.), *Current Trends in Eye Tracking Research,*
DOI 10.1007/978-3-319-02868-2_1,

Rayner (1998) offers an important overview of eye movements in reading. In this chapter, we focus upon the link between eye movements, perception and action.

1 Perception in Action

When we perceive our environment, we are acting in order to gain information that will help us perform the tasks in which we engage. In this way, perception is not simply the passive reception of information from our surroundings, but is an active part of how we operate in the world. This view is increasingly prominent in cognitive psychology (e.g. Hommel et al. 2001; Bridgeman and Tseng 2011). Indeed, Hommel et al. (2001) suggested that perception and action are 'functionally equivalent', with both processes working to allow us to build representations of the world around us. Perception and action processes appear to be linked in a bidirectional manner, so that each is able to affect the other: While perception informs the performance of action, action influences perceptual processes.

With this more active role for perception proposed, the question then is how to measure it. This is perhaps more difficult; as Bridgeman and Tseng (2011) state: Most effectors, such as the hands, double as tools for both action and perception. This is where eye movements become an invaluable tool: Eyes select and sample visual information and, thus, provide an online measure of perception, yet do not act directly upon the environment. Eye movements are an important means of investigating perception and action because they are perception in action, directed by the task to examine the world and allow us to complete the tasks set for us.

The importance of eye movements for coordinating perception and action can be seen clearly in the many studies that have made use of them. The eyes have two crucial functions: first, to gather information about the world and, second, to provide feedback during tasks, for example, when we manipulate an object. Using eye movements, these processes can be measured online as tasks are performed in both laboratory and real-world environments. For example, in the laboratory, Ballard et al. (1992) used a block-copying task in which participants moved a series of coloured squares from one location to a target area and arranged them to match a model depicting an arrangement of blocks that they had to recreate. The eye movements of the participants as they did this were shown to link strongly to the actions they were carrying out. The eyes followed a clear pattern of checking the model, preceding the hands to the blocks for the pick-up, then checking the model once more before placing the block in its correct position.

Ultimately, if we wish to understand the link between perception and action, we must do so in the context of natural behaviours conducted in real world environments. Mobile eye-tracking devices permit eye movement recordings to be made in untethered, real-world activities. This technological advancement has not only allowed researchers to study eye movements in the context of natural action but has also identified key insights into the relationship between vision and action that were not previously recognised. Mobile systems were developed in the 1950s by

Norman Mackworth and used in real environments in the 1960s (e.g. Mackworth and Thomas 1962; Thomas 1968). These devices were cumbersome and it was not until the 1990s that less obtrusive and more versatile mobile eye trackers were developed (Ballard et al. 1995; Land 1992). Using such devices, the tight link between vision and action is strikingly clear in real-world activities. Land et al. (1999) and Hayhoe (2000) measured participants' eye movements as they went through the stages of making a cup of tea or preparing a sandwich. Again, the findings demonstrated how vision acts to inform our behaviour: Throughout the constantly changing demands of the task, the participant's eyes precede the actions, fixating the required objects for the next step in the process. Furthermore, Hayhoe (2000) showed that when making a sandwich, the action intention could influence the deployment of attention. Participants were seated in front of either a non-cluttered tabletop, containing only the items needed for the sandwich-making task, or a busier tabletop, containing irrelevant objects along with the important ones. While these irrelevant objects were fixated, the greatest percentage of fixations came in the viewing period before the task began. Once the participants had started, task-irrelevant objects were rarely fixated: Almost all fixations were made to task-relevant items.

These examples illustrate the intimate link between vision and action and the manner in which eyes are deployed on a moment-to-moment basis to gather information and provide feedback for actions. The bidirectional nature of the perception–action coupling is evident in tasks where perceptual decisions are made in the presence of action. Indeed, before an action has begun, the intention to carry out an action influences how participants view a scene, even when the intention is created by a seemingly minor manipulation such as the performance of a particular grip type. For example, Bekkering and Neggers (2002) asked participants to find targets based on colour or orientation, in order to grasp or point at them. For orientation-defined targets, when participants searched to grasp the object, they made fewer incorrect saccades to the distracter objects compared to the situation when targets were defined by colour. This difference between colour- and orientation-based search was absent when participants were searching only to point to the object rather than grasp. The preparation of the grasp led to enhanced processing of the relevant feature for the action, in this case the objects' orientation, and, thus, detection of targets defined by that feature was enhanced. Similarly, Fagioli et al. (2007) asked participants to prepare different types of gestures, such as pointing or grasping. Before they could carry out these prepared actions, participants were given a detection task, which required them to find the odd one out in a set of objects. This target was defined by either its location or its orientation. Preparing a pointing gesture resulted in participants spotting the location oddity sooner, while the orientation oddity was spotted soonest when a grasping gesture was prepared. Thus, even when the action prepared did not directly relate to the following task, the enhanced processing of relevant dimensions was continued. Symes et al. (2008) used this action–preparation paradigm in a different task setting to look at change detection. Here, power and precision grip types were formed by participants during change blindness trials, and it was demonstrated that change detection improved for objects whose size matched the grip type held by the participant.

In all three studies that have used this paradigm, the effect is clear: By forming an intention to act, sometimes not even requiring the actual action posture itself, the perception of the environment is changed. By forming an intention to grip, information that informs gripping, like the orientation of an object or its size, becomes more relevant and prioritised in the examination of the scene. Our perceptions are influenced by our intentions to act, and, thus, perception is used here to gain the information we know we may require.

Eye movements are an invaluable measure in a paradigm such as this. Not all the above studies used eye movements as a measure: They are used most in the Bekkering and Neggers (2002) study, but it is clear how eye movements can add to this kind of research. They give us the ability to see how the influence of the intention to act unfolds across the task and to see what measures are most affected—saccade time, fixation duration and scan path, amongst many others. As in the studies by Land et al. (1999) and Hayhoe (2000), eye movements give us a window onto how perception operates across the course of a task, from the first intention to act and through the process of carrying out the task itself.

The relationship between perception and action means not only that eye movements offer a crucial tool for understanding this relationship but also that we must be cautious when studying eye movements and perception in the absence of action. It is becoming increasingly clear that any exploration of visual perception and eye movements should consider the possible influence of action. For example, if we wish to understand memory representations, it is important to consider these in the context of real environments (Tatler and Land 2011; Tatler and Tatler 2013) and natural behaviours (Tatler et al., 2013). Similarly, any understanding of the factors that underlie decisions about when and where to move the eyes must consider these decisions in the context of natural behaviours (Tatler et al. 2011; Tatler this volume). Of course, this is not to say that all eye movement research should be conducted in real-world settings using mobile eye trackers. Many of the behaviours we engage in involve being seated in front of a display screen of some sort: for example, working at a computer or using a handheld computer device. However, even in these situations, an understanding of perception in the context of action is important. When using the Internet, we do not passively watch but actively interact with the viewed content—scrolling, clicking and entering text as needed. Similarly, computing devices are increasingly using touch and gesture interfaces. The bidirectional relationship between perception and action, therefore, necessitates that these interactive situations are studied in a manner that is relevant to the interactions being undertaken.

2 Social Interaction

As we increasingly move towards the study of eye movements and perception in ecologically valid situations, it becomes clearer that not only might it be inappropriate to study vision in isolation from action in many circumstances but it might also be inappropriate to study individuals behaving in isolation from other individuals. Humans are highly social beings and many of the behaviours we engage in are carried out in the presence of, in collaboration with or in competition with others.

We have a strong tendency from an early age to attend to the same locations that others are attending to. The intimate link between eye direction and our behavioural goals and intentions means that eyes provide a strong cue to understand where another individual is attending. Human eyes appear uniquely well equipped for signalling eye direction to others: We have whiter and more exposed scleras than other great apes (Kobayashi and Kohshima 1997), and the high contrast between the sclera and iris in human eyes provides easily detectable directional signals. Indeed, we are extremely good at detecting the direction of another person's gaze (Symons et al. 2004). Not only are we able to detect where someone else is looking but we are also able to use this information to orient our own eyes to the same locations in space. This tendency to follow the gaze direction of another individual can be seen from as early as infancy (e.g. Senju and Csibra 2008), and it has been suggested that it leads to a shared mental state that is central to the development of 'Theory of Mind' (Baron-Cohen 1995).

How an individual's gaze direction cues the gaze direction of an observer has been the subject of much of the eye movement research on social attention. Laboratory-based experiments using Posner (1980)-type paradigms to investigate the attentional effects of gaze cues have mostly found that participants' eyes reflexively orient to gazed locations (Ricciardelli et al. 2002; Tipples 2002; Galfano et al. 2012). Studies using more complex scenes appear to support these findings; when viewing images containing people, observers have a strong tendency to fixate on the eyes of individuals (Birmingham et al. 2009) or the objects that they are looking at (Castelhano et al. 2007). However, recent studies using real-world settings suggest that this tendency might be critically modulated by the social factors during natural interactions.

Laidlaw et al. (2011) recorded participants sitting in a waiting room and found that they were more likely to look at a confederate displayed on a video monitor than the same confederate present in the waiting room. Similar results for gaze following rather than seeking were found by Gallup et al. (2012). They observed people walking past an attractive item in a hallway and found that people were more likely to look in the same direction as somebody walking in front of them than somebody walking towards them. The results of these studies were explained by their respective authors as being due to participants trying to avoid potential interactions with strangers. It seems that the mere potential for a social interaction changes the way in which we seek and follow gaze cues. These findings highlight the limitations of using laboratory-based paradigms to investigate natural gaze-cueing behaviour.

Freeth et al. (2013) investigated the effect of the presence of a speaker on a listener's gaze behaviour when a social interaction was actually taking place. Participants answered questions from an experimenter who was either physically present or on a video monitor. There was no significant difference found across conditions in terms of the amount of time participants spent looking at the face of the speaker. However, the presence of eye contact caused participants to look at the speaker's face for longer in the real-world condition only. This shows that the effect of a speaker's gaze behaviour on the eye movements of a listener is dependent on the speaker being present.

If we are to understand the use of gaze cues in social interactions, then, it is important to remember that in most natural situations, gaze cues are not employed in isolation: Typically, these occur as part of an interaction and are accompanied by other communicative signals like gestures and spoken language. In recent years, research carried out in more ecologically valid environments (including real-world paradigms) has not only challenged the idea of reflexive gaze following but has also been able to consider important aspects of natural gaze cue utilisation not considered in Posner-type tasks. In particular, there has been emerging interest in studying the role of gaze cues in natural communication and the effects of social factors on gaze seeking and following.

In natural communication, gaze cues are usually used alongside spoken language. Therefore, understanding the interaction between these cues and spoken language is vital for understanding how gaze cues are naturally utilised. Hanna and Brennan (2007) used a real-world communicative paradigm to investigate natural dialogue and gaze cues. They found that listeners in a block-identification task would use the gaze cues of a speaker to find a target block before the point of verbal disambiguation, showing that gaze cues are used to aid and speed up communication during a collaborative task. In an experiment with more controlled language stimuli (Nappa et al. 2009), young children were found to use the object-directed gaze cues of an adult (presented on a screen) to interpret the meaning of made-up verbs used in spoken sentences. A similar study by Stuadte and Crocker (2011) used an adult population and showed participants videos of a robot describing the spatial and featural relations between a series of visible items, whilst providing gaze cues. The robot made incorrect statements about the relations between the items that had the potential to be corrected in two different ways. The experimenters found that participants would correct in the way that used the gazed item as the object of the sentence, suggesting that they were inferring meaning from the robot's gaze. These results collectively show that, when used alongside language, gaze cues are used to solve ambiguities in spoken language and aid in the understanding of another's intentions.

Other research on gaze cues and spoken language has focused on how changing language can affect the utilisation of gaze cues. In a task in which gaze cues were inessential for its successful completion (Knoeferle and Kreysa 2012), participants followed gaze cues more often when hearing a German sentence in the common subject–verb–object (SVO) structure than the less common (but still grammatically legal) object–verb–subject (OVS) structure. The authors suggested this finding was due to the extra difficulty in processing the OVS sentences leaving fewer processing resources for gaze cue utilisation. Macdonald and Tatler (2013) investigated the effect of changing language specificity on the use of gaze cues using a real-world communicative task, involving a one-to-one interaction between an instructor (experimenter) and participant. The instructor manipulated his use of gaze as well as the specificity of his instructions in a simple block-building task. Participants were found to only seek and follow gaze cues when the language was ambiguous, suggesting that gaze cues are used flexibly, depending on other information that is available. It, therefore, appears that the difficulty and specificity of language affects the utilisation of gaze cues during communication.

The above results show the value of using real-world paradigms when investigating gaze utilisation, as the effects of language and social context on gaze behaviour can be taken into account. Gaze cues have been shown to support and disambiguate spoken language as well as provide insight into a speaker's intentions. Our gaze-seeking and -following behaviour has been shown to be sensitive to potential social interactions and our social perceptions of those with whom we interact. The benefits of using more ecologically valid paradigms across different areas of social cognition and social neuroscience are the subject of a number of recent review articles (Risko et al. 2012; Skarratt et al. 2012; Przyrembel et al. 2012), and with technological advances providing more opportunities (see Clark and Gergle 2011 for discussion), the trend for investigating social interactions in the real world is likely to continue.

3 Magic and Misdirection

While we are still very much discovering the role of the eyes in natural social interaction, magicians (and other experts in misdirection) seem to have possessed mastery of this situation for centuries (e.g. see Kuhn and Martinez 2011; Lamont and Wiseman 1999). Misdirection, in the broadest sense, is the means by which a magician diverts the audience's attention from the mechanics of a trick, for example, the palming of a coin or pocketing of a card (Kuhn and Tatler 2011). More specifically, misdirection is an umbrella term for a number of different behaviours, including gesture, speech, posture and gaze cues. A magician must include some or all of these aspects at once for misdirection to be successful. As yet, our understanding of the cumulative effect that these behaviours have on an audience's attention is incomplete, and Kuhn et al. (2008), amongst others, have argued for more research in this area because of the rich insights it can potentially offer about psychological processes. Much can be learnt about visual perception and cognition from studying the conditions in which we fail to perceive or understand events, or in which we can be made to believe that we have seen something that did not occur (Kuhn and Martinez 2011). Magic, therefore, offers a medium in which we can study psychological processes in an ecologically valid, real-world situation, but still manipulate the nature of cues used by the magician in order to misdirect the observer.

Kuhn and Tatler (2005) were the first researchers to examine an observer's eye movements as they watched a magic trick. They developed a trick in which a magician (Gustav Kuhn) made a cigarette and lighter disappear using a combination of two methods of misdirection—gaze cues and gesture—to conceal a simple drop of each object onto the magician's lap. The trick was unusual in that the drop of the cigarette was performed in full view of the participant: The magician dropped the cigarette from a height at which it would be visible for about 120 ms as it dropped. This trick was performed live in front of participants, in a one-to-one interaction with the magician; half of the participants expected a magic trick, half did not. Surprisingly, only two out of the 20 participants noticed the drop on the first performance of the trick; however, when the performance was repeated, all noticed the drop. At the time that the magician dropped the cigarette from one hand, participants tended to be looking either at the magician's other hand or at his face. This was the case irrespective of whether the participant was expecting to see a magic trick or not and persisted even on the second trial when all participants perceived the drop. This led Kuhn and Tatler (2005) to conclude that prior information seemed to have no effect on strategic eye movements in this situation as they were similar across both groups and that a magician manipulates an observer's attention rather than their gaze because the eye movement behaviour was the same.

What aspects of the magician's performance resulted in the successful misdirection as the cigarette was dropped? Kuhn and Tatler (2005) ruled out the occurrence of blinks or eye movements, or the distance into peripheral vision of the dropping cigarette as possible reasons for the success of the magician's misdirection and speculated that it was the gaze direction of the magician that was crucial for the misdirection in this trick. Consistent with this possibility, the correlation between the gaze direction of the magician and the observer was highest at the misdirection events (the two object drops) during this performance (Tatler and Kuhn 2007) and, at these times, most participants were fixating the gaze target of the magician. However, these correspondences alone are not sufficient to claim that it was the magician's gaze that was central to this misdirection because the misdirecting gaze was accompanied by movement and sound cues at the magician's gaze target: The magician not only looked at the other hand when dropping an object but also waved it and clicked his fingers. In order to tease apart gaze cues from these other potential cues for misdirection, Kuhn et al. (2009) used a modified version of the trick using only a single drop (of a cigarette lighter). Crucially, two versions of the performance were filmed: In each case, the misdirection cues from the non-dropping hand (movement, etc.) were the same at the time of the drop, but in one video the normal misdirecting gaze was given by the magician, whereas in the other the magician maintained fixation on the hand from which the lighter was being dropped. The results showed that observers were significantly less likely to detect the drop when the gesture was supported by gaze cues away from the concealed event. Furthermore, it was shown that when observers watched the non-misdirected trick (where the gesture was not supported by gaze cues), they fixated significantly closer to the dropping lighter (Kuhn et al. 2009). These results demonstrate that the magician's gaze is a crucial cue for both where the observer looks during the performance and whether or not the magic is successful.

As a means of understanding the importance and use of gaze cues in interaction, misdirection is a powerful tool. First, we can manipulate the manner in which gaze cues are provided or supported by other cues and study the effects of these manipulations on observers' gaze behaviour and perception of the events. Second, we can use magic performances and an ecologically valid setting to understand more about the use and understanding of gaze cues in special populations (Kuhn et al. 2010). When watching an illusion, individuals with autistic spectrum disorders (ASDs) showed the same gaze behaviour as typically developing individuals but were slower to launch saccades to magician's face. These results challenge common notions that people on the autistic spectrum have general problems with social attention: Here, general behaviour was very much like that found in individuals without ASD, and the difference was rather subtle. While little has been done with special populations to date, magic offers a potentially valuable research tool for exploring aspects of social attention and wider visual cognition in these populations.

There is growing interest in the psychology of magic to explore a range of issues in cognitive psychology (Kuhn et al. 2008; Martinez-Conde and Macknik 2008; Macknik et al. 2010). Given the inherently visual nature of many of the striking magical performances and their reliance on illusion, misdirection and other magical acts that at least partly involve our visual sense, it seems likely that eye movement recordings will play a central role in this emerging field of research.

4 Distraction

In magical performances, we often fail to notice what should be an easily detectable visual event because we have been misdirected by a magician with mastery in controlling our attention. However, failing to detect what should be an obvious event is not restricted to situations in which we have been actively misdirected: All too commonly, we may miss external events and this can occur for a number of reasons and with a number of consequences. Failures to detect external visual events can be particularly problematic in some situations: For example, failing to detect a hazard when driving can have critical safety implications. In driving situations, a key factor that can result in failures to detect hazards is being distracted from the driving task in some way.

Researchers have quantified the variety of different causes for driver distraction into three major categories: visual, cognitive and physical. Although the ultimate outcome of these distractions is the same—an increase in crash risk—the underlying cognitive mechanisms are different (Regan et al. 2008; Anstey et al. 2004). Research has also shown that visual and cognitive task demands affect eye movements within driving situations in qualitatively different ways.

Visual distraction can be caused by a variety of different factors. The primary commonality, however, is the increase in the visual load, which is typically achieved by including an additional secondary visual task such as planning a route in a navigation system or by manipulating the visual information within the driving scene itself (Konstantopoulos et al. 2010). Interestingly, visual distraction appears to influence eye movement behaviour in a number of ways. Di Stasi et al. (2010) manipulated visual task demand by increasing traffic density. Results indicated that this increase in the visual content of the driving scene results in slower saccade peak velocities. Another measure found to have been effected by visual load is blink durations (Recarte et al. 2008; Veltman and Gaillard 1996). Research by Ahlstrom and Friedman-Berg (2006) has indicated a linear decrease in blink durations as a function of visual task demand. Benedetto et al. (2011) examined the effects of interacting with an in-vehicle information system (IVIS) on drivers' blink rates and blink durations during a simulated lane-changing task. Analyses indicated that as visual task demand was increased, blink durations significantly decreased. Results also indicated that blink rates were not significantly affected by visual task demand. It was argued that changes in eye movement metrics such as fixation number, fixation duration, saccade amplitude and gaze position were the result of gaze switching between primary and secondary visual tasks. However, as the observed pattern of gaze switching cannot account for the decrease in blink durations, this measure has been considered a reliable indicator of driver visual task demand (Benedetto et al. 2011).

Research has shown that cognitive task demand affects eye movement measures in a qualitatively different manner than visual task demand manipulations. Recently, results from a hazard perception study have indicated that saccade peak velocity was significantly increased as a result of increased cognitive task demand (Savage et al. 2013). Cognitive task demand influences the spread of fixations in driving situations: When cognitive load is high, there is an increased concentration of gaze towards the centre of the road (Recarte and Nunes 2003; Savage et al. 2013). Cognitive load also influences blinking behaviour in drivers: When cognitive load is high, people blink more often (Recarte et al. 2008) and for a longer duration (Savage et al. 2013).

The fact that increasing either visual or cognitive load results in changes in eye movement behaviour means that we might be able to exploit these characteristic eye movement changes to identify periods of distraction during driving (Groeger 2000; Velichkovsky et al. 2002). The safety implications of this are self-evident: If eye movements can be used as a diagnostic marker of distraction, then we can use these to detect periods of distraction and intervene, alerting the driver to the danger of their current state. Importantly, there is clear utility in being able to differentiate visual and cognitive distraction: Any intervention may need to be tailored to whether the current situation involves an unusually high visual load—which may be due to external events in the environment—or an unusually high cognitive load—which may be more likely due to distractions by conversation and contemplation of language. Intervening appropriately may be safety critical in some situations.

Importantly, not only do we find that visual and cognitive load appear to influence eye movement behaviour in driving situations but the above findings also suggest that the manner in which these two types of load impact eye movement behaviour may be rather different. In particular, saccade peak velocity was significantly reduced as a result of increased visual load (Di Stasi et al. 2010) but significantly increased as a result of increased cognitive load (Savage et al. 2013). Similarly, increases in visual task demand have been shown to result in significantly shorter blinks (Ahlstrom and Friedman-Berg 2006), whereas blink durations increase in situations of high cognitive load (Savage et al. 2013).

As eye movement metrics are affected in qualitatively and quantitatively different ways by both cognitive and visual demand manipulations, eye movements offer a potentially powerful diagnostic tool with which to examine the interaction of the different attention networks as well as assess the driver's current mental state. The use of eye movement measures as diagnostic markers for mental state in driving is an emerging area with important practical implications. At present, there is a need to continue to identify those aspects of eye movement characteristics that will provide robust and specific markers of particular mental states before these can be applied directly to in-vehicle interventions. This research effort somewhat mirrors research effort in the potential use of eye movements as diagnostic markers of disease in clinical settings: Many neurological and psychiatric conditions are associated with atypical eye movement behaviours (Diefendorf and Dodge 1908; Lipton et al. 1983; Trillenberg et al. 2004). While, for some conditions, it is now possible to distinguish affected individuals from healthy controls with an impressive degree of accuracy (Benson et al. 2012), a remaining challenge in this field is to identify oculomotor markers that are specifically diagnostic of particular disorders.

5 Conclusion

Eye movements provide powerful research tools for those interested in a wide variety of aspects of human cognition and behaviour. The selective nature of viewing—high acuity sampling is restricted in both space and time—means that the locations selected for scrutiny by high acuity vision reveal much about the moment-to-moment demands of ongoing cognition and action. It is, therefore, unsurprising that the use of eye tracking as a behavioural measure is now very widespread and encompasses a diversity of research disciplines. Indeed, the diversity of applications of eye tracking is reflected in the contributions to this volume. Two key aspects of eye movement behaviour are becoming increasingly clear that straddle the different research interests for which eye tracking is employed. First, the intimate link between vision and action means that visual perception and cognition should be studied in the presence of the actions that we are interested in characterising. Second, the intimate link between eye movements and ongoing cognition means that eye movements offer important potential diagnostic markers of mental state. In our continuing efforts to produce ecologically valid accounts of human behaviour in a variety of situations, eye movements are likely to assume an increasingly pivotal role in shaping our understanding of perception, cognition and action.

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