EYE TRACKING

A. Your Address

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B. Synonyms

N/A

C. Definition

Eye tracking is a method in which movements of the eye are assessed using recording devices and programs. Eye-tracking paradigms allow for the measurement of physiological processes, such as fixations and saccades of the eye as well as dilation of the pupil, and the comparison of these physiological processes to neural processes. Eye tracking has been extensively used in research on visual attention such as during presentation of visual stimuli (e.g., images, written text, film clips).

D. Historical Background

The development of eye-tracking technology and its uses can be organized into three distinct stages (Rayner, 1998). The first era, spanning from the late 1890s to the 1920s, involved the discovery and study of basic characteristics of eye movements through the use of after-images, visual observation, mechanical methods (i.e., caps), and photography (Yarbus, 1967). Saccadic suppression (the concept that information is not processed during eye movements), saccade latency (the time required to initiate eye movements), and perceptual span (the region of effective vision) were primary topics studied during this period. Initial observations concerning eye movements in reading also occurred in that era.

The second era ranged from the 1920s-1970s and coincided with the behaviorist movement, and consequently was focused more on the applied aspects of eye tracking. That is, eye movement recordings provided supplementary information but were not the primary focus of research. Some studies concerning scene perception were carried out during this time but research involving the use of eye tracking to infer attentional and cognitive processes was limited. Methods for eye tracking in this era included those previously mentioned, with the addition of electro-oculography (EOG) and photoelectric methods. Towards the latter part of this stage, eye-tracking research slowed considerably as a result of little advancement in technological improvement.

The third era (1970s-present) marked rapid improvement in eye-tracking technology, allowing for more accurate measurements that could more easily be obtained, including stationary as well as mobile assessments. This advancement granted the ability to interface eye-tracking systems with laboratory computers, which in turn allowed for the collection and analysis of significant amounts of data with relatively fine-grained acquisition. The use of eye tracking as a tool for the examination of attentional and cognitive processes increased such as in the context of language processing and dynamic tasks (i.e., driving). Also, in this era, research began to assess the eye movements of individuals with certain mental disorders, such as autism spectrum disorders (ASD), in comparison to healthy individuals in order to gain an understanding of the differences in attentional and cognitive processing patterns in these individuals (Yarbus, 1967).

E. Current Knowledge

Multiple Types

Current research varies with the type of eye-tracking equipment and programs used. A common method of eye tracking is EOG, which utilizes electrodes placed around the targeted eye in order to record electrical potentials from the skin around the eyes. More invasive eye-tracking techniques involve the usage of contact lenses, which may contain a magnetic search coil. Because the lens is directly placed upon the eye, it allows for more sensitive recordings of eye movements with the drawback of being a time intensive procedure that may cause discomfort to patients.

Cameras are also used in eye-tracking technology to measure movements of the pupil and cornea reflections, also known as Purkinje images. Combined with video processing programs, video-based eye-tracking methods rely on infrared (IR) light or reflections to properly track eye saccades. Camera eye trackers are also able to measure pupil dilations during experimental tasks in order to understand underlying psychological concepts such as cognitive load and arousal (Piquado et al., 2010). Although inexpensive, this form of eye tracking often entails the head to be fixated in a certain angle using a chin-rest (Duchowski, 2007). Newer forms of eye tracking include mobile systems in which a head-mounted display is adhered to participants to simulate natural movements. Mobile systems are non-invasive and more comfortable than chin-rests, and can even be used with infants (Franchak et al., 2011).

Popular Research Topics

Because only recently has more advanced eye-tracking technology become more readily available, current knowledge and research regarding eye tracking is still eclectic in scope. For instance, eye-tracking paradigms have been developed in the context of neurological studies with the goal of examining how the brain processes visual cues. Neural patterns of activity predict varying levels of eye movements for the processing of the cue being attended to (Duchowski et al., 2002). Using eye tracking, research has found that prefrontal cortex activity changes depending on the visual task and is involved in guiding behavior (Asaad et al., 2000). Recent studies have also started to use brain image acquisition alongside eye tracking to further reveal associations between eye movements and brain processes.

Eye tracking is also employed to improve understanding of the attentional deficits inherent in ASD (Guillon et al., 2014). In this context, images of faces for example are presented during eye tracking with the purpose of investigating deficits in visual attention to socioemotional stimuli among patients with varying levels of ASD. However, evidence from ASD experiments with eye tracking remains mixed, with some studies suggesting attentional impairments in ASD, such as diminished eye gaze, while other studies discuss that eye movements may not be generally deficient in ASD but rather vary depending on the type of social interaction.

Other popular research topics that use eye-tracking technology explore how visual attention impacts real-life applications. Because of the increasing numbers of automobile accidents, the impact of visual attention on driving ability has become a frequently studied topic with the goal to improve road safety. Such studies have been able to distinguish how drivers attend to different aspects of the road (Dishart & Land, 1998) and the effects of cognitive load on visual processing (Palinko et al., 2010). Dyslexia and reading difficulties have also been a common topic in research with eye tracking, demonstrating that eye fixations for dyslexic children tend to be more unstable compared to control groups (Eden et al., 1994). Other real-life applications use eye tracking to explore how individuals visually attend to art, film, and advertisements, with possible effects on consumer behavior.

F. Future Directions

The future of eye tracking largely resides in the field of learning and education through the improvement of multimedia learning materials. These materials, which combine verbal and graphical material in order to improve information retention, have been widely implemented by instructors in various disciplines. Multimedia learning materials can challenge an individual’s working memory due to the associated cognitive load. However, by improving information presentation, it is possible to reduce cognitive load, thereby allowing more cognitive resources to be allocated to determination of meaning (Liu et al., 2011). Traditional self-report measures have proven ineffective in determining cognitive load and tracking cognitive processes while working with multimedia material. In contrast, eye tracking constitutes a promising method for determining cognitive load, based on patterns of fixation and saccades and changes in pupil dilation that occur while reviewing multimedia material.

Also, eye tracking has been studied as a prospective instructional tool for observational learning used to model reading an illustrated text (Mason et al., 2015). Through eye-tracking technology, it is possible to create Eye-Movement Modeling Examples (EMMEs), which are gaze replay videos of an expert, that are used to model a learner’s behavior while reading multimedia material. EMMEs have been shown to lead to improved integrative processing of multimedia material and information retention, particularly in individuals with low reading comprehension ability. Additionally, *i*Map, a program that produces statistical fixation maps of eye movement data, could potentially be useful for creating these models (Caldara & Miellet, 2011).

Eye-tracking methodology also offers promise for the categorization of mental illness (Shic, 2016). As various spectrums are constantly refined, eye tracking constitutes a valuable and inexpensive tool to compare the eye movements of individuals with neurological disorders to normal patients. One such example is the inclusion of eye tracking as a way to better understand neurological illnesses in the study of pathological aging processes. Recent studies have found disordered fixations in adults with dementia (Fernandez et al., 2016). Also, there is evidence that reaction times are generally longer for those individuals with Alzheimer’s Disease compared to healthy controls (Crawford et al., 2015). Eye tracking can also be utilized to help improve reaction times through practice over longer periods. These applications support the future potential of eye tracking in clinical use. Combined with the fact that eye-tracking technology is now readily available, great progress in the understanding and treatment of mental disease, and many other broad topics of research by use of this methodology, can be expected.

G. See also

→ Attention

→ Attentional Blink

→ Eyeblink Conditioning

→ Fixed Pupils

→ Visual Field Deficit

→ Visual Neglect

→ Visual Search

→ Visual Tracking

H. References and Readings

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