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Eye tracking studies of normative and atypical development ☆

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Abstract

This paper reviews the use of eye tracking measures (saccades, smooth-pursuit eye movements, fixations during scene and face perception, and pupillary dilation) to study typical and clinical populations of children and adolescents and evaluates the use of these measures. The studies are evaluated with a focus on points that may be of general interest to developmentalists (the contribution of contextual and temporal factors in performance, methods of analyzing age-related differences, and the role of the psychometric properties of the tests in interpretation of differences across age and clinical groups). Some limitations of eye tracking are pointed out (e.g., the nature of the relation between oculomotor and other motor systems, constraints in making inferences about the brain from psychophysiological data). Finally, the potential of eye tracking measures for probing normative and abnormal development is explored.

Keywords: Development; Eye movements; Saccades; Antisaccades; Smooth pursuit; Pupillary dilation; ADHD; Schizophrenia; Autism; Pervasive Developmental Disorders

The eyes have been a window to the mind in typical and clinical populations for more than a century. We take in the world through our eyes, and almost everything we do during the time we are awake involves eye movements. Furthermore, although

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we are not aware of it, our pupils dilate rapidly all the time in response to a large array of cognitive and emotional stimuli, whether internally or externally generated. Thus, our eyes reveal a great deal about what we are thinking and feeling, and eye tracking measures can harness this potential to improve our understanding of the mind and its development.

Eye tracking provides a non-invasive method for elucidating a wide variety of cognitive processes, from visual–spatial attention to object perception, memory, and language. Eye tracking measures can also be helpful in examining socio-emotional processes, such as motivation, response to different types of rewards, and aspects of social information processing. The basic characteristics of eye tracking measures are well delineated, which allows researchers to make stronger inferences about specific cognitive and emotional processes from eye tracking tasks. Eye tracking also enables measurement of variables that are difficult to obtain through other methods, such as direct assessment of where individuals are looking at in static or dynamic visual stimuli and momentary recruitment of cognitive resources in accordance with task demands. Because the neural substrates of eye movements are fairly well established, eye tracking has also been used to make inferences about how the brain processes information. Although there is a very large and sound body of research on eye tracking in adults and non-human primates, this research has so far been vastly underutilized in research with children and adolescents. This article will provide an overview of eye tracking studies in healthy and clinical populations of children and adolescents, with the hope that these measures can be added to the toolkit of developmentalists as they seek to understand cognitive and social processes and their neural substrates in typical and atypical development.

In the first section, I will briefly review key eye tracking measures (saccades, smooth-pursuit eye movements, eye movements during face and scene perception, and task-specific pupillary dilations) to provide some basic background information for the rest of the paper. The next two sections will summarize studies in which these measures have been used in typical and several atypical populations of children and adolescents. In the final section, I will evaluate studies that have used eye tracking as a research tool, emphasizing points that may be of general interest to developmentalists, list limitations of eye tracking as a tool, and end with its potentials for addressing developmental questions.

The goal of the paper is not to review how eye tracking measures have contributed to understanding of specific developmental or clinical phenomena or models and theories of normative and atypical development (which would require placing these studies in the context of a broader body of research that does not involve eye tracking or children), but to provide a sense of why and how these measures have been used in typical and atypical populations of children and adolescents and to appraise these measures as tools for probing development.

Eye movements in children have been reviewed by Hainline (1988), so this paper will focus on research conducted since 1988. I will also limit the review to studies of participants from 4 to 5 years of age through adolescence. For reviews of eye tracking in infancy, the reader is referred to Haith (2004), Simion and Butterworth (1998), and Von Hofsten (2004). To limit the scope of the manuscript, I will not cover research on eye movements that have been recorded during reading (for reviews, see Liversedge & Findlay, 2000; Rayner, 1998; Starr & Rayner, 2001) or in learning disabilities.