Chapter 2
Computational Approaches to Measurement of Visual Attention: Modeling Overselectivity in Intellectual and Developmental Disabilities

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ABSTRACT

Alterations in gazing patterns and visual attention have often been noted among patients with intellectual and developmental disabilities (IDD) relative to neurotypical individuals. Here, the authors discuss visual attention with a particular focus on attention overselectivity. Overselectivity is observed when a subject focuses on a limited subset of available stimuli, or attends to a limited spatial field of vision. It is a widely-observed problem among individuals with IDD, notably, children with autism spectrum disorders (ASD). In this chapter, the authors survey computational and experimental approaches to analyze selective visual attention patterns, including overselectivity. These may provide useful computational frameworks for modeling visual attention in ASD patients and quantifying how it differs from neurotypical patterns. Computer-automated routines would be a boon for the field, distilling key dependent measures for aberrant attentional processes (a) for group studies of pathological processes and (b) on a single-subject basis for clinical description and possible remediation of attentional deficits.

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INTRODUCTION

There are limits to the ability to process information, and what is commonly referred to as “attention” provides one means of winnowing down available data for more efficient management. Perhaps no one has captured the essence of selective attention as succinctly as William James, over 120 years ago:

Everyone knows what attention is. It is the taking possession by the mind, in clear and vivid form, of one out of what seem several simultaneously possible objects or trains of thought.

W James (1890). The Principles of Psychology

Over recent decades, psychologists have subdivided attention itself into a variety of forms. One category, that of visual selective attention, can be parsed into several sub-categories, including attention to regions of space, stimulus features, and whole objects (Freiwald & Kanwisher, 2004).

Computational and experimental approaches have been widely used to investigate patterns of human visual attention. In this chapter we review computational approaches designed to characterize selective attention, with a worked example on attention to facial patterns. We also discuss the potential application of computational methods to quantitatively analyze the gazing patterns of patients with IDD.

Selective attention has been classified in psychology using different organizational principles. In this discussion, we will refer to visual selective attention to specific stimuli and areas of a visual array. Posner (1987) also discusses selective attention, focusing on the process of attentional engagement and subsequent disengagement from visual stimuli. Specifically, the inability to disengage from a stimulus, which could be seen as overselectivity, has been observed in some IDD including ADHD and Schizophrenia (see for example (Butler and Javitt, 2005, Elahipanath et al., 2007, Laprevote et al., 2010, Le et al., 2003, Nestor et al., 2009, Tseng et al., 2010)).

Attentional Overselectivity in IDD Patients

In this chapter we discuss one aspect of visual selective attention and its variant, stimulus overselectivity. In overselectivity (restricted stimulus control), a subject focuses on only limited elements of a complex configuration (for example, in scanning an image of a face, attention to only a narrow array of features) or a limited spatial area in a visual display (Lovaas et al., 1979, Dube, 2009, Jemel et al., 2006). Further, we discuss visual data processing methodologies developed in other areas of computer science that may be applied to the phenomenon of attentional overselectivity; conceivably, these may contribute to understanding and quantifying abnormalities of visual attention among diagnostic subgroups of IDD patients.

Dube and McIlvane (1997) have shown that specific stimuli attended to overselectively could be systematically influenced by adjusting the schedules of reinforcement for attending. They have developed methodologies for more informative assessments and effective remediation of overselective attending (e.g., (Dube and McIlvane, 1999); (Dube et al, 1999); (Dickson et al., 2006a,b); (Dube et al., 2010)).

The phenomenology of overselectivity has also been observed in attention to facial patterns among subjects with autism. Recent studies have pointed to selective attending in autism to facial pattern arrays, notably, to the mouth and relatively less so to the eyes (the converse of typically-developing
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