Chapter 4
Pediatric Visual Acuity Testing

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ABSTRACT

Visual acuity measurement is an essential component of any eye exam. In adults and older children, letter-based acuity (i.e., recognition acuity) is commonly used to measure vision. However, in infants and toddlers, performing traditional visual acuity testing is nearly impossible. Instead, modified optotypes such as gratings and pictures are shown to observe the young child's visual behavior. Additionally, there are objective visual acuity methods that negate the need for observing visual behavior. For the practicing clinician, the choices are many and can be confusing. With new commercial products coming into the market every day, it is nearly impossible to comprehensively cover each one of them. Instead, in this chapter, commonly used and/or studied visual acuity tests are covered. For each test, the set-up, procedure, documentation, and scientific evidence supporting or negating its use are discussed.

INTRODUCTION

Visual acuity is one of the commonly measured visual functions as part of a pediatric eye examination. It is the ability of the visual system to identify a target or resolve spatial details of a target. The threshold for identifying a target is defined as recognition acuity (i.e., recognition of letters or shapes) and the threshold for resolving spatial details within a target is defined as resolution acuity (i.e., resolving the thickness of the black bars in a black and white grating). Development of vision has been studied using behavioral observations and electrophysiological studies. Robert Fantz, a psychologist, formalized the use of pattern stimuli (black and white gratings on a gray background) to understand the looking behavior of infants called forced preferential looking (FPL) ((Fantz, 1963; Frantz et al., 1962). Data obtained from FPL experiments show that the monocular grating acuity at 1 month of age (about 1 cycle/degree (cpd), approximate Snellen equivalent 20/600) develops rapidly in the first year reaching about 6 cpd at 1 year of age (Snellen equivalent 20/100), followed by a gradual increase until reaching adult-like acuity (25 cpd, Snellen equivalent 20/25) at 5 years (Mayer et al., 1995). Similarly, the mean recognition acuity (using picture-based optotypes) reaches 20/25 by 4 years of age. Additionally, electrophysiological studies

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using visually evoked potential (VEP), using a bold pattern stimulus such as a square-wave grating, also show a rapid development of grating acuity in the first 6 months that continues during the second half, reaching adult-like levels by 1 year of age, which is earlier than FPL techniques (Norcia & Tyler, 1985).

While letter-based charts can be used to measure visual acuity in older children (6 years and above), modified charts containing shapes, or finite number of letters, are used in toddler and preschool children to improve testability. In infants and toddlers, since communication is challenging, clinicians rely on other techniques such as behavioral observations (observing the infant looking behavior towards the visual stimuli) or objective technique such as VEP to measure visual acuity. While VEPs are not frequently used in clinic, behavioral observations are and demand significant examiner experience to accurately interpret results. Since there are significant methodological differences between these methods, direct comparison of visual acuity across these methods is discouraged. Despite these challenges, visual acuity measurement is integral to a pediatric eye exam for several reasons, the most important being the detection of unilateral or bilateral amblyopia. Defined as a developmental disorder affecting spatial vision with a prevalence of 1-3% (Webber & Wood, 2005), amblyopia is characterized by reduced visual acuity in one or both eyes and is the common cause of reduced vision in children, and can impact other visual functions such as accommodation, binocular function, contrast sensitivity and reading performance (Kelly et al., 2015; McKee et al., 2003; Weakley, 2001). Without early intervention, visual acuity loss remains even if spectacle correction is provided later. Since visual acuity is the current clinical standard for diagnosing amblyopia, it is important for clinicians to be familiar with clinical visual acuity tests in children. Additionally, understanding visual acuity norms in children can help clinicians differentiate reduced vision from age-expected vision. This chapter covers the various qualitative and quantitative visual acuity tests for infants, toddlers, and preschoolers.

VISUAL ACUITY TESTING IN INFANTS AND TODDLERS

Tests that are suitable for infants and toddlers require minimal or no verbal response from the child and depend on either the clinician's observation of visual behavior to the stimulus presented, or the utilization of instrumentation to measure visual acuity (e.g., VEP). While most tests allow the clinician to make qualitative measures of visual acuity, some do not and are qualitative.

Clinical Pearl: *Several studies have shown that children have better acuities with grating than recognition acuity (Friendly et al., 1990; Kushner et al., 1995; Mayer, 1986; Mayer et al., 1984; Rydberg et al., 1999). In particular, grating acuity overestimates vision in strabismic amblyopia (Kushner et al., 1995). For this reason, Snellen equivalents (provided in the accompanying test manuals of grating acuity tests) are not used for clinical interpretation and instead the grating acuity is recorded in cycles per cm (c/cm) or cycles per degree (cpd).*

All quantitative tests discussed in this section measure grating acuity except for Cardiff test.
The quantitative and qualitative procedures discussed in this section are:

- **Qualitative vision assessment of fixation pattern**
  - Fix and Follow (monocular fixation pattern)
  - Fixation preference test (binocular fixation pattern)