Is S3D Viewing Safe for Children?

Maureen Powers PhD FCOVD-A FAAO FARVO
Director of Research
Gemstone Foundation
Rodeo, California

www.gemstonefoundation.org
www.eyesinconflict.org
(510) 254-0500 office
Three factors are especially relevant for S3D viewing

**Acuity**: the ability to resolve a given image, or to see relatively small images.

**Accommodation**: the ability to focus the eyes on the (moving in 3D space) image.

**Binocular control**: the ability to point the two eyes at the same place at the same time; this is necessary to attain stereopsis.
Development of the Fovea

5 days after birth

Candy, Crowell & Banks 1998; Yuodelis & Hendrickson 1986

Slide courtesy Dr. Rowan Candy
Development of Behavioral Acuity


Slide courtesy Dr. Rowan Candy
Acuity: Bottom Line

- Development is incomplete in most children until age 5 or older.
- In studies of school-age children, 15-25% are found to have acuity lower than 20/30.
- Good news: Most problems with acuity can be corrected with glasses.
Development of Accommodation

Two kinds of focus are important:

– Static accommodation (the ability to focus at any given plane relative to the face)
– Dynamic accommodation (called “facility”- the ability to re-focus rapidly from far to near and back again, like looking from the TV to a book)
Development of Accommodation

Raw Data - Individual subjects

Tondel & Candy, IOVS 2007 & Vis Res 2008; Candy & Bharadwaj, JVis 2007

Slide courtesy Dr. Rowan Candy
Accommodation: Bottom Line

• The ability to focus using the lens is well developed by school age.

• **Good news**: Problems with static accommodation can be addressed with glasses.

• **Bad news**: Problems with dynamic accommodation cannot, and can cause eyestrain.
Development of Stereopsis

Photo courtesy Dr. Eileen Birch
Random dot stereo test stimuli show that infants perceive 3D by about 5 months of age, on average. (Fox et al, 1980; Birch & Petrig, 1996)

Images courtesy Dr. Eileen Birch
Stereopsis: Bottom Line

- **Good news**: Ability to recognize and respond to stereo occurs in infancy, by 4-5 months of age.
- **Bad news**: Does not mean all children (a) have and (b) use the ability.
So, by the time they enter school…

- Acuity should be at or near 20/20 (so they should pass school screening)
- Accommodation should be functioning well (so they should be able to focus, and to re-focus rapidly)
- Binocular control should be good (because they can see stereo – and you can’t do that without binocular control)
Stereopsis in Grade School

N=42, grades 3-6

11/42 (26%) were > 60
Stereopsis in Adolescents

RDS Stereo

N=96

31/96 (32%) >50

Knueppel & Powers, COVD 2010
To the extent that binocular control and stereopsis are related…

• Children with binocular complaints while reading may also experience discomfort with S3D.
• Problems viewing stereo may indicate underlying problems with binocular control.
  However...
• The number of children affected is unknown.
Binocular vision impacts reading
Henry looked to the right. He looked to the left. He looked up, and he looked down. Where had Frog gone? Henry did not like being alone in the forest. “Frog, where are you?” Henry called. “Please come back!”

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Binocular control during reading – Example from a good reader

Right & Left Eye Saccade Record

Famed American architect Frank Lloyd Wright was one of the earliest architects to break away from the cluttered Victorian style, and now many regard him as the father of contemporary architecture. He was noted for both his original designs and his unusual use of building materials. In 1900, he developed his “prairie house,” a new style of residence with long low lines. This home was a forerunner of today’s “ranch house.” Typical of his unique building methods was the Imperial Hotel in Tokyo, Japan. It was built on hundreds of concrete columns and has withstood the shock of earthquakes that leveled all other large buildings. Wright’s influence has been felt throughout the world.
Binocular control during reading – Example from a poor reader

Right & Left Eye Saccade Record

Bliss How, desiring his workman's wages for his children, started thinking. By 1845, he had designed a machine for sewing and he succeeded in patenting it. The idea that made Howe's sewing machine practical was carrying the thread in the point of the needle instead of the head. Americans showed no interest in Howe's machine, so he departed for England. There it proved its value in a corset factory. When he came home, he discovered copies of his machine being manufactured and sold. Since Howe had the patents, he sued the manufacturers and was able to win every case. As a result he became a millionaire.
And they read slower when binocular control is poor.

We imposed vergence stress, and found that reading rate decreased significantly with increasing stress.

Powers, Morita, Miner & Tyler ARVO 2010
How can we identify kids at risk?

• **Screen** for farsighted tendency (hyperopia): children who see better at far don’t read well.

• **Use a symptom survey** (CISS; QOL): scores correlate with severity of signs, and people are generally honest when reporting how they feel.

• **Incorporate a web re-direct** in your S3D films and TV for people who are experiencing viewing difficulties.
Binocular/Accommodative Complaints: Grades 3-12

Symptom Score (CISS)

Percent of Students

average % N=1038

Morita, Hoffman & Powers, ARVO 2010
Symptoms of Discomfort

Morita et al., ARVO 2010
Discomfort: Adolescents
Binocular Control in High School

Outside "Adequate" Ranges

Percent of Students

Base In Break
Base In Recovery
Base Out Break
Accommodative Facility
Accommodative Amplitude
Base Out Recovery
Snellen Acuity
Near Point of Convergence

Grisham, Powers & Riles, Optom 2007; Powers, Grisham & Riles Optom 2008
Nature and Nurture

• The developing visual system is highly plastic.
• The extent of plasticity is determined by genetics. However:
• Environmental stimuli are essential.
  – Without appropriate stimulation, development can be abnormal.
  – Even with them, the results are unpredictable.
  – Plasticity (AKA Learning) remains into adulthood
When eyes work better together, reading improves

The Eyes Have It!

Ann Street Open Court Fluency

Percent Change

Before After

3rd
5th
6th
4th
How does this relate to S3D?
• Most children will be fine – no complaints.
• Some children will not be comfortable, but will not complain
• Some children will be uncomfortable and will complain.
  – Proportion of those experiencing discomfort could be 25% or more.
• Some children will be so uncomfortable that they refuse to watch or play games.
  – Best guess is that this proportion will be 5-10% of school age children. But this is a guess.
Concerns for the Industry

1. Need to determine what proportion express symptoms of discomfort while watching S3D TV.
2. Expect that children will be different from adults.
3. How likely are people (adults included) to act on their discomfort?
4. How does “near” vs “far” pertain?
Near vs Far

• The data I talked about are all within 40 cm of the face. Relevant for gaming, but perhaps not for TV viewing.
• There are no data at intermediate distances, such as might occur for airport screening, cooking, or desktop implementations.
Opportunities for the Industry

1. Increase awareness of a public health issue that impacts quality of life, especially with regard to education.

   The public health issue is binocular vision. People need to optimize their visual systems for driving, for diving, or for being able to read comfortably. Society as a whole will benefit.
Two eyes are better than one.

I did not believe this myself (as a stabismic)

But it is true: Testimonials, children who read better in school (my research and others), plus books like Fixing My Gaze (by Sue Barry) and many clinical experiences provide compelling evidence that having stereo vision improves quality of life.

That is the real bottom line, for all of us.
Opportunities for the Industry

2. Provide a practice site (in consultation with developmental optometrists) where children can try to improve their binocular comfort by playing a game in 3D—one that requires coordinated movement of the 2 eyes.

- Such games have been shown to improve eye coordination and reduce symptoms.
- Could be a simple animation that requires use of the glasses (or autostereo function) that comes with the S3D TV product.
Opportunities for the Industry

3. Use S3D TV in educational contexts, to improve motivation for children to learn.

- Sesame Street legitimized TV as an educational medium by showing that entertaining and engaging characters can enhance student attention and facilitate learning.
- S3D TV could do the same – Who knows where applying this exciting technology to educational products and goals could lead?
Summary

• Acuity, accommodation, and the ability to appreciate stereo are all well developed by school age in normal children.
• However, relatively large numbers of school-age children demonstrate binocular vision problems and poor stereoacuity, and a relatively large proportion also have symptoms of binocular dysfunction.
• Public awareness of the impact of S3D and binocular control on education is lacking.
www.eyesinconflict.com
Visagraph of a 14-year-old reading at a 3rd grade level

Visagraph of a 14-year-old reading at a 12th grade level
This study, based on children with anomalous stereo vision, shows that susceptibility to stereo disruption remains until at least 4.6 years of age.

N=152

Fawcett, Wang & Birch, IOVS 2005
Stereopsis in Grade School

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Knueppel & Powers, COVD 2010
Children complain of symptoms

Morita, Hoffman & Powers, COVD 2010