A green light to greatness.
Eye Color and Autism: A Preliminary Study and Implications for Diagnosis and Treatment

Kevin Callahan, Ph.D., BCSE
Phoenix Ma, Ed.D.
Heather O’Shea, Ph.D.; BCBA-D
Lindsey R. Eason, M.Ed., Doctoral Candidate

University of North Texas Business Leadership Building
July 27th, 2013
Presentation Objectives

1. Present previous hypotheses and research findings related to eye pigmentation and human behavior and genetic/medical conditions

2. Summarize the results of research conducted at UNT investigating eye color and autism

3. Discuss the implications of future eye color research for the diagnosis and treatment of individuals with Autism Spectrum Disorder (ASD)
Why Eye Color and Autism?

“...significant progress has been made in our clinical and neurobiologic understanding of this disorder. Despite these advances,...we still have much to learn. The etiology of autism remains largely unknown, and there are still no metabolic, genetic, or radiographic markers to aid in the diagnosis and to develop more focused and effective treatment. Investigators...[must] consider a broad range of novel research questions [to] expand and extend what is known...”

Bauman and Kemper, 2005
Eye Color and Genetic Conditions

- “Eye color is significant to the phenotype of multiple genetic disorders, including:
  - Waardenburg Syndrome,
  - Angelman Syndrome,
  - Prader-Willi Syndrome” (Ferretti et al., 2009)
  - Albinism

- The gene for eye color, Herc2, is located on Chromosome 15, an area of interest for ASD
Eye Color and Medical Conditions

• “Eye color has been proven relevant to risk of:
  – Macular degeneration;
  – Glaucoma; and
  – Melanoma” (Ferretti, Pinto-Martin, Souders, & Levy, 2009)
  – Schizophrenia (Happy & Collins, 1972)

• Melanin may play a role in the Ascending Recticular Activation System related to learning, memory, arousal, and sleep-wake transitions (Ferretti et al., 2009)
Previous Eye Color Research

Possible significant correlations between eye color and behavior

– Early studies:
  • Kastein & Trace (1966): The Birth of Language
  • Morgan Worthy (1974): Eye Color, Sex, and Race (revised in 1999)
  • Gary and Glover (1976): Eye Color, Sex, and Children’s Behavior

– Worthy’s Hypothesis: “Self-paced” versus “Reactive” Responses
  • Animal studies/Human studies
  • Eye Color Reactivity Model: “Dark-eyed people are more physiologically sensitive or reactive than are light-eyed people.”
Eye Color 101

- Eye color is a multi-gene characteristic determined by the amount of melanin produced by our cells and the scattering of light in the iris of the eye (the iris is the colored part of the eye surrounding the pupil) (see Hale et al. article...)
  - Melanin is a dark, granular substance governing pigment in the skin, choroid, pia, and brain nuclei
  - Eye melanin is qualitatively different from cutaneous, choroid, and hair melanin (Kent, 1956)
  - The more melanin one has deposited in the front of the iris, the darker one’s eyes will be:
    - Thus, eye color varies from blue to black
    - Melanin is unrelated to melatonin...
Hypothesized Differences Between Dark Eyes versus Light Eyes (Worthy, 1999)

**Dark Eyed Organisms**
(REEACT-APPROACH-FLEE):

- Specialize in behaviors that require sensitivity, speed, & reactivity
- More physically & behaviorally responsive
- Lower thresholds of excitation
- Respond more to color
- Tend to be better on cognitive tasks requiring perceptual speed & accuracy
- More predisposed to social responding
- Females tend to have slightly darker eyes than males (and are more reactive)

**Light Eyed Organisms**
(WAIT-FREEZE-STALK):

- Specialize in behaviors that require hesitation and inhibition
- Respond relatively more to “form”
- Tend to perform better on spatial tasks
The research road ahead

“In spite of its obvious importance to education and its significance in the quest to determine the influence of genetics and environment on behavior, there is a paucity of research controlled for eye color reported on the behavior of children done across the important developmental years.”

Gary and Glover (1976)
UNT Research Questions

• What is the distribution of eye color among individuals with ASD?
  – What is the relationship between the distribution of eye color in ASD versus the U.S. population?
  – Is any specific category of eye color over-represented among individuals with ASD?

• What is the relationship between eye color category and symptom severity levels in the core deficit areas of autism?

• Do parents report any unusual or interesting observations about the eye color or eye functions of their children with ASD
UNT Eye Color Studies

• Mail Survey of Parents of Children with ASD
  – Xxx respondents
  – Problems encountered
  – Findings

• National Follow-up Study (currently underway)
  – Direct observations of eye color
  – ACES centers in xx western states
  – New York Center
Eye Color Distribution in the U.S.*

• Blue: 35.4%
• Grey: 5.2%
• Bluish-Grey: 1.6%
• Bluish-Green: 1.7%
• Green: 10.7%
• Brownish-Green: 0.4%
• Hazel: 5.3%
• Brown: 39.7%
• Black: n/a

* Soni & Neuhoff (1985)
### Comparison of National/Texas Eye Color Distribution with ASD Sample

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Soni &amp; Neuhoff (1985)</td>
<td>35.4</td>
<td>5.2</td>
<td>1.6</td>
<td>1.7</td>
<td>10.7</td>
<td>0.4</td>
<td>5.3</td>
<td>39.7</td>
<td>--</td>
</tr>
<tr>
<td>Contact Lens Forum* (1987)</td>
<td>35</td>
<td>7</td>
<td>--</td>
<td>--</td>
<td>12</td>
<td>--</td>
<td>6</td>
<td>40</td>
<td>--</td>
</tr>
<tr>
<td>Callahan et al. (2005)</td>
<td>34.9</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>4.8</td>
<td>--</td>
<td>18.3</td>
<td>38.1</td>
<td>4.0</td>
</tr>
<tr>
<td>Texas DMV (2005)</td>
<td>24.8</td>
<td>2.9</td>
<td>--</td>
<td>--</td>
<td>10.6</td>
<td>--</td>
<td>9.0</td>
<td>51.4</td>
<td>1.3</td>
</tr>
<tr>
<td>Ferretti et al. (2009)</td>
<td>50.0</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>12.5</td>
<td>--</td>
<td>--</td>
<td>37.5</td>
<td>--</td>
</tr>
</tbody>
</table>

* Based on Soni & Neuhoff (1985)
Parent Anecdotal Responses

• 40% of parents responded yes to the question, “Have you ever noticed any unusual or interesting observations regarding the eyes or eye color of your child with autism?”

• Responses were grouped within thematic areas:
  – Unusual pupil dilation:
    • Unusually large (many cases)
    • Unusually small (one case)
  – Eyes change colors during episodes of severe behaviors or moods
  – Unusual shape or appearance of eyes
  – Unusual eye functions
UNT Follow-up Research

• On-site observations of eye color
• National survey of eye color
• Mastery Training of Data Collectors
• Reliability Checks
• Fidelity Checks
• Results TBD
Implications for Future Research

• Happy and Collins (1972) report that biophysical evidence may implicate neuromelanin in a protective capacity in nerve cells, and that melanin may have a function other than mere pigmentation
  – There may be a link between melanin pigmentation and a postulated defect in the noradreneric pathways in the ascending reticular activating system (ARAS) among children with ASD.

• Hale et al. (1978) findings (see article summary sheet)

• Markle (1975) “recent evidence indicates that melanin speed neural transmission...”
Implications for Future Research, continued

• “There is still a tremendous amount of research that must be done before we embark with full confidence” on a course of developing individual teaching materials or strategies based on eye color.”
  Gary & Glover (1976)
NAC, NPDC, & UNT web sites

• National Autism Center:
  – http://www.nationalautismcenter.org/

• National Professional Development Center for ASD:
  – http://autismpdca.fpg.unc.edu/

• UNT Kristin Farmer Autism Center
  – www.autism.unt.edu
Questions?

Enjoy the rest of the conference; Stay cool, and safe travels home!