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Oculomotor Assessment in Children,

presented in partnership with Seminars in Hearing

Steven M. Doettl, AuD, PhD and

Devin L. McCaslin, PhD

Steven M. Doettl,

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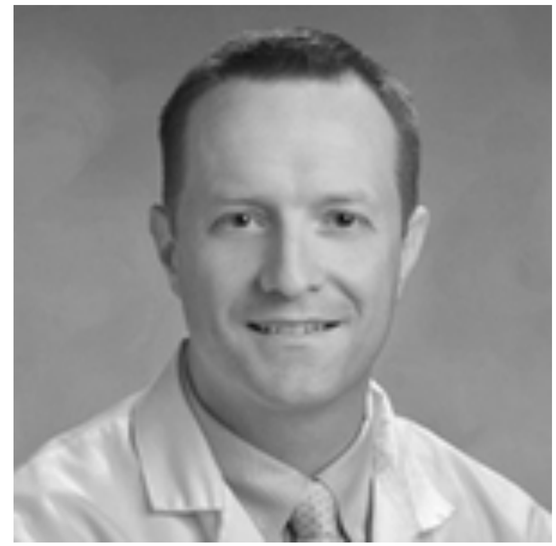

Devin L. McCaslin, PhD

Devin McCaslin is the Director of the Vestibular and Balance Program at Mayo Clinic in Rochester Minnesota. He has authored and coauthored publications that cover the areas of tinnitus, dizziness, auditory function, and outcome measures development. He is also the author of the textbook VNG/ENG (Plural). Dr. McCaslin's major academic, clinical and research interests relate to clinical electrophysiology, tinnitus, and vestibular assessment and management. He is currently a co-principal investigator on a National Institute on Deafness and Other Communication Disorders funded grant investigating the high frequency aspects of vestibular function. Dr. McCaslin has served on the American Balance Society Board of Directors, American Academy of Audiology Board of Directors, and is the past president of the American Balance Society. He currently serves as the Deputy Editor-in-Chief of the Journal of the American Academy of Audiology, sits on the American Auditory Society Board of Directors.

- Presenter Disclosure:
  - Steven Doettl: Financial: Steven Doettl received an honorarium for this presentation. Non-financial: Steven Doettl has no relevant non-financial relationships to disclose.
  - Devin McCaslin: Financial: Devin McCaslin is employed by Mayo Clinic. He received an honorarium for this presentation. Non-financial: Devin McCaslin has no relevant non-financial relationships to disclose.
- Content Disclosure: This learning event does not focus exclusively on any specific product or service.
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Learning Outcomes

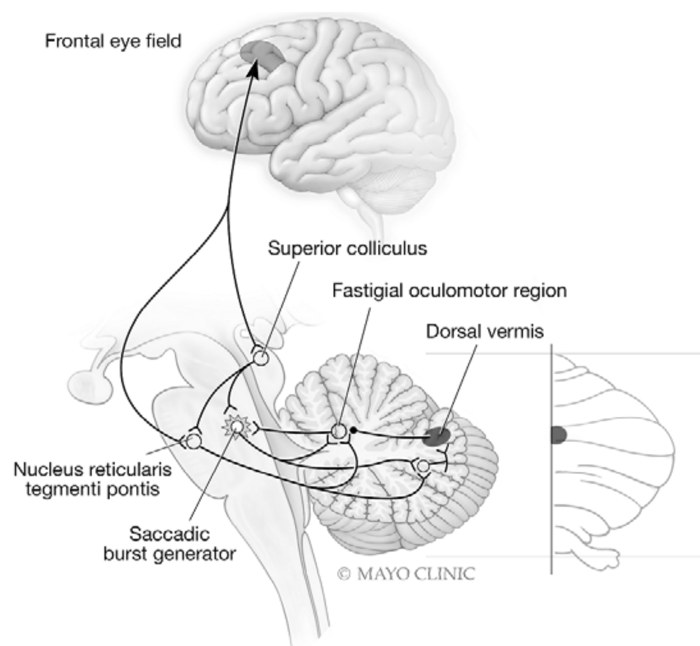
- After this course, participants will be able to
  - Describe oculomotor physiologic correlates.
  - Explain oculomotor research involving the pediatric population.
  - Explain how to use adaptation techniques in the application of oculomotor function testing in pediatrics.

Eye Movements that Move the Fovea onto a Target

- Saccades
- Smooth pursuit
- Vergence

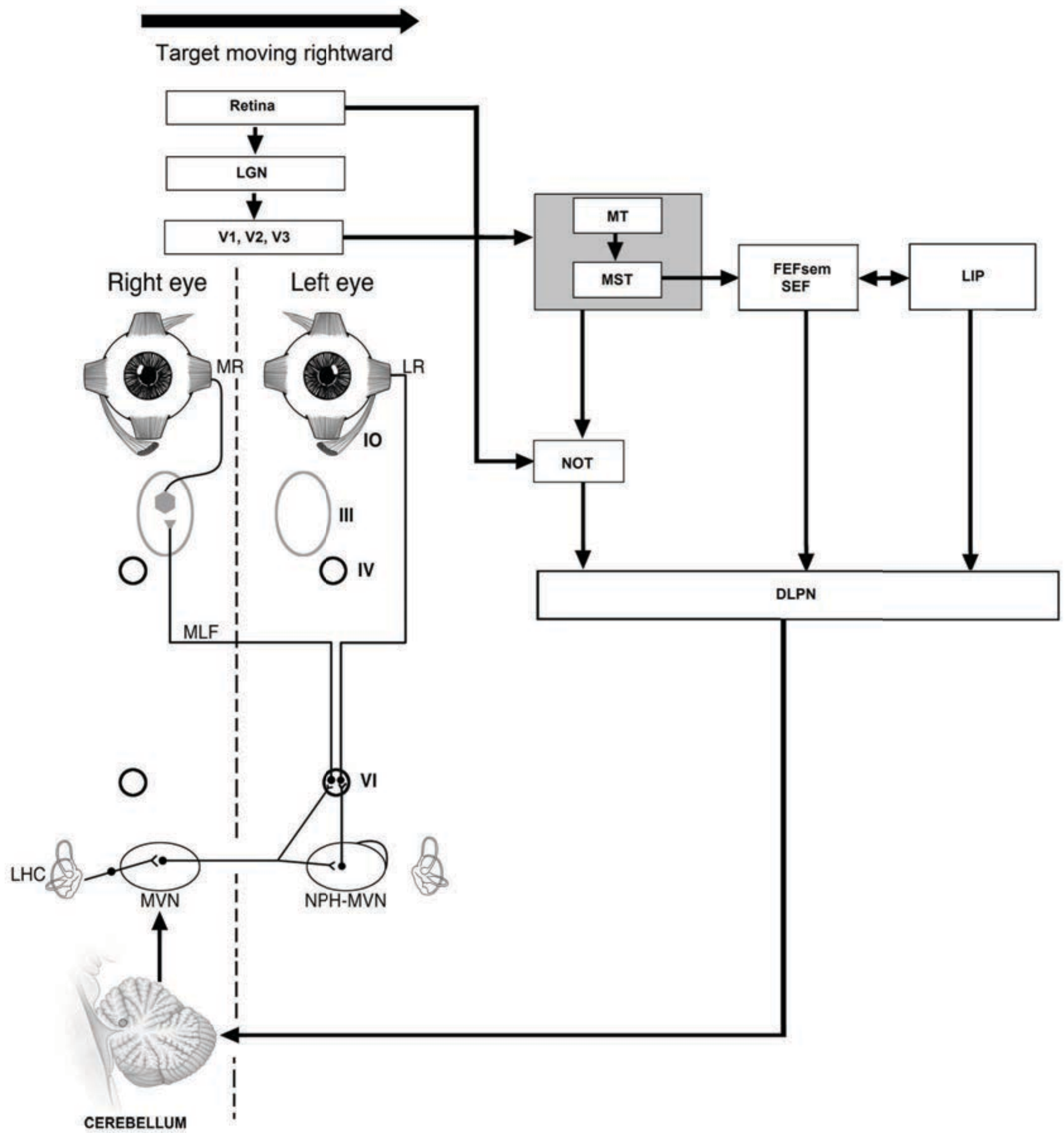
Neural Subtstrates of Oculomotor Function (Saccades)

- When a target is detected on the edge of the visual field, the OMS can quickly move the eyes in a conjugate manner and bring the image of interest onto the foveae.



Neural Subtstrates of Oculomotor Function (Pursuit)

- The pursuit system is a voluntary oculomotor control system that enables an observer to hold the foveae on a target that is moving slowly (<70° per second).
- The primary purpose of this system is to keep slow moving images stabilized on the foveae when the target is moving and the head is stable.

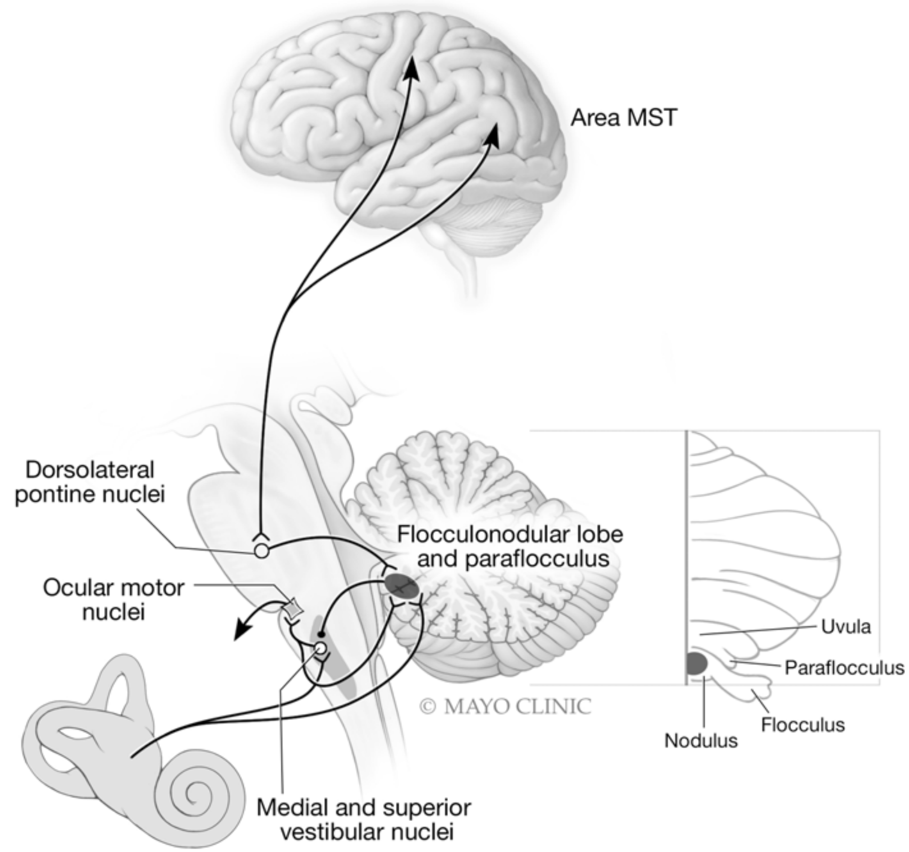

Target moving rightward
Retina
LGN
V1, V2, V3
MT
MST
FEFsem
SEF
LIP
Right eye
Left eye
MR
LR
IO
III
IV
MLF
NOT
DLPN
VI
LHC
MVN
NPH-MVN
CEREBELLUM

Eye Movements that Keep the Fovea Fixed on a Target

- Gaze
- Optokinetic
- Vestibulo-ocular reflex

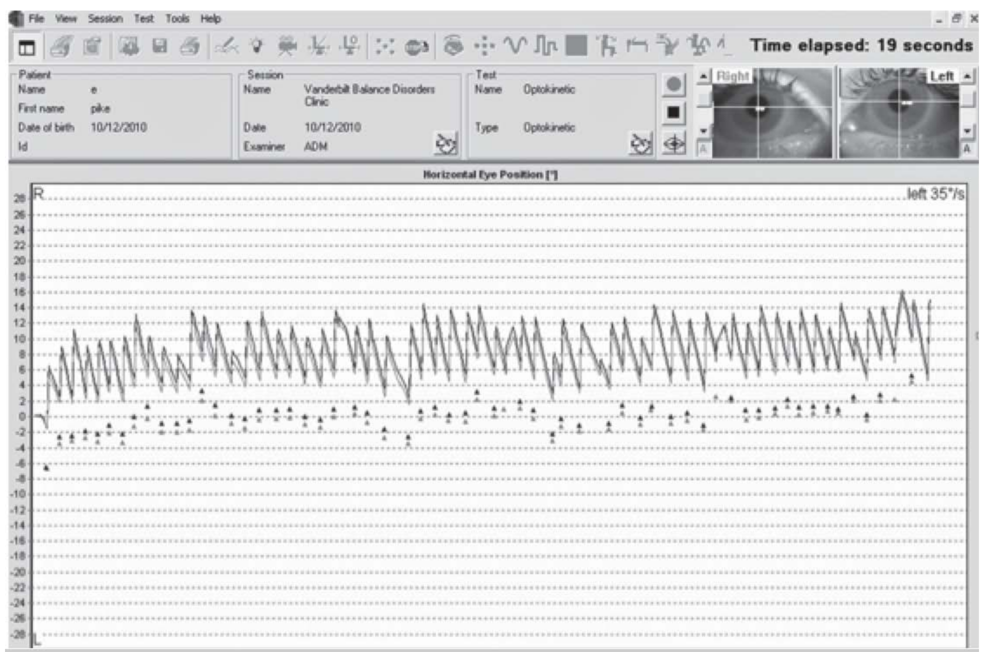
Neural Subtstrates of Oculomotor Function (Gaze)

- Gaze-holding describes the function of holding the foveae motionless on a target in the primary position or eccentric (deviated) position



Neural Subtstrates of Oculomotor Function (OPK)

- The optokinetic (OKN) system is a reflexive functional class of eye movement that works in concert with the vestibular system to stabilize a moving visual environment on the retina when the head is stationary.



Oculomotor Testing In Children

- Oculomotor function as described previously demonstrates significant age effects associated with noted development of specific neural substrates including:
- Superior Colliculus
- Frontal lobes
- Parietal lobes
- Thalamus
- Basal ganglia
- Cerebellum

Oculomotor Testing In Children

- Well-established that oculomotor (smooth pursuit, saccade, optokinetic, gaze and spontaneous) development occurs throughout childhood and even into adulthood.
  - Kowler & Martins, 1982; Salman, Sharpe, Lillikas, Dennis, & Steinbach, 2006; Rutsche, Baumann, Jing, & Mojon 2005; Klein & Foerster, 2001; Fukushima, Hatta, & Fukushima, 2000; Yang, Bucci, Kapoula, 2002; D'Agostino, Melagrana, Pasquale, & Taborelli, 1997; Lewis & Maurer, 2005; Kenyon, 1988; Levens, 1988; Aring, Gronlund, Hellstrom, & Ygge, 2007; Paus, Babenko, & Radil, 1990

Oculomotor Testing In Children

- However, current data is research oriented
  - Research protocols vs standard clinical protocols
    - Different measurement protocols
      - Head fixation and eye position (relative to the target)
    - Target Characteristics
      - Size, shape, color, and meaning
    - Analysis techniques
      - Extraction and interpolation

VNG-Based Research

- Doettl, S. M., Plyler, P. N., McCaslin, D. L., & Schay, N. L. (2015).
  - 63 Subjects
  - Group 1 = 30 4-6 year olds (youngest testable population)
    - 13 – 4 year olds
    - 7 – 5 year olds
    - 9 – 6 year olds
      - Average age of 4.86 years
  - Group 2 = 33 21-60 year olds
    - Average age of 25.2 years

VNG-Based Research

- Visual screening prior to evaluation using the 10ft. Snellen Letter or Picture Chart
- All subjects with no history of significant visual, vestibular, or neurologic pathology
- Standard (default clinical protocols) oculomotor assessment using Synapsis VNG2 Ulmer system

Saccades

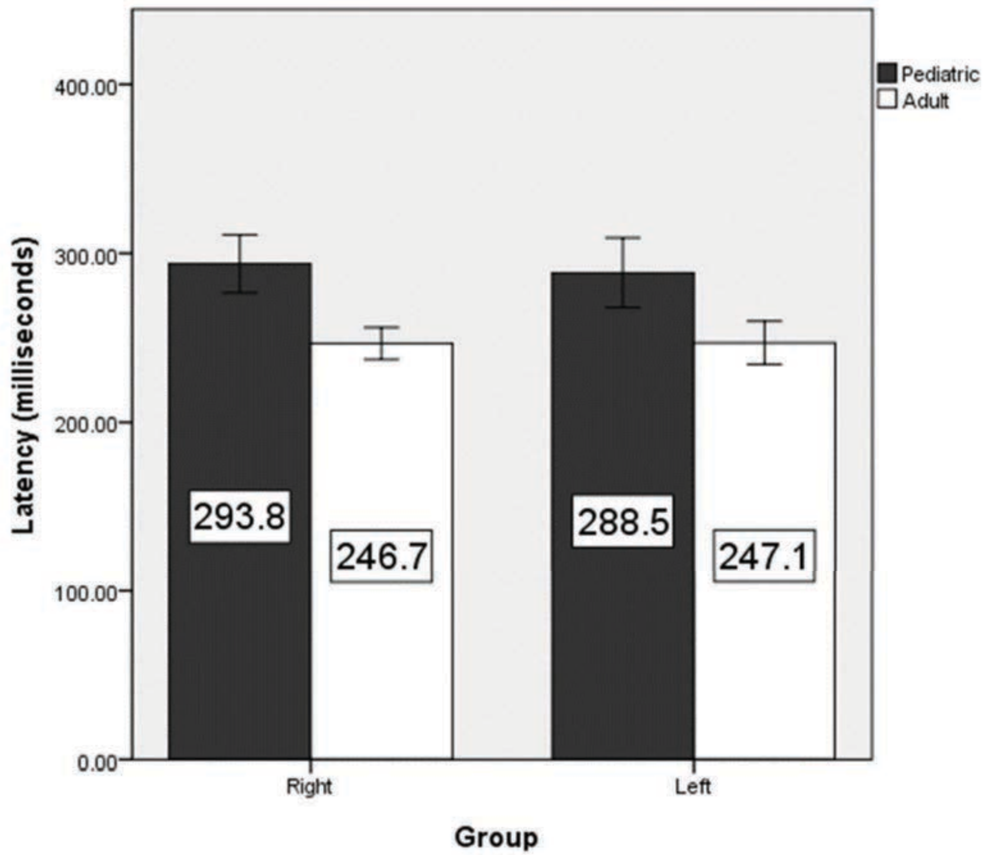


Figure 1. Mean saccade latency values for the right and left directons for the pediatric and adult groups. Standard error bars are noted.

Smooth Pursuit

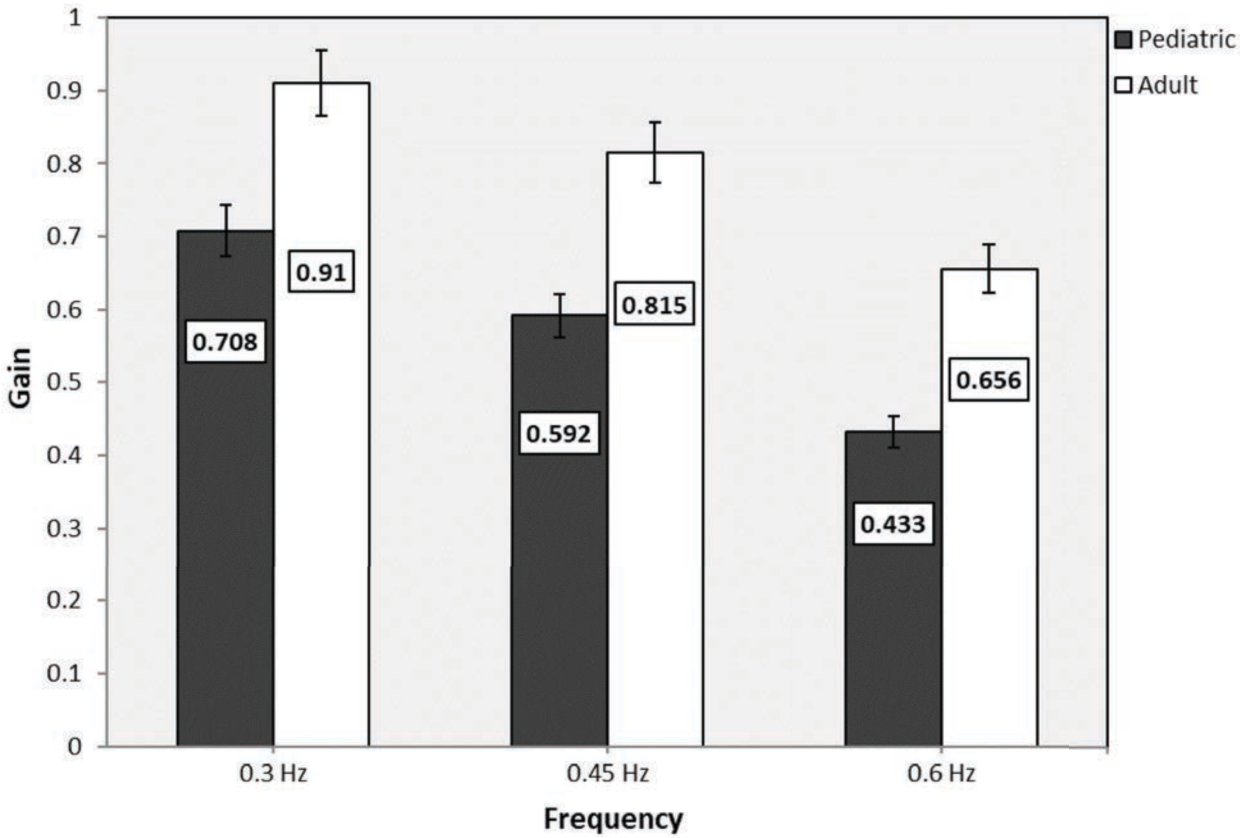


Figure 2 Mean gain values for the pediatric and adult groups at the three frequencies evaluated. Standard error bars are noted.[17]

Smooth Pursuit

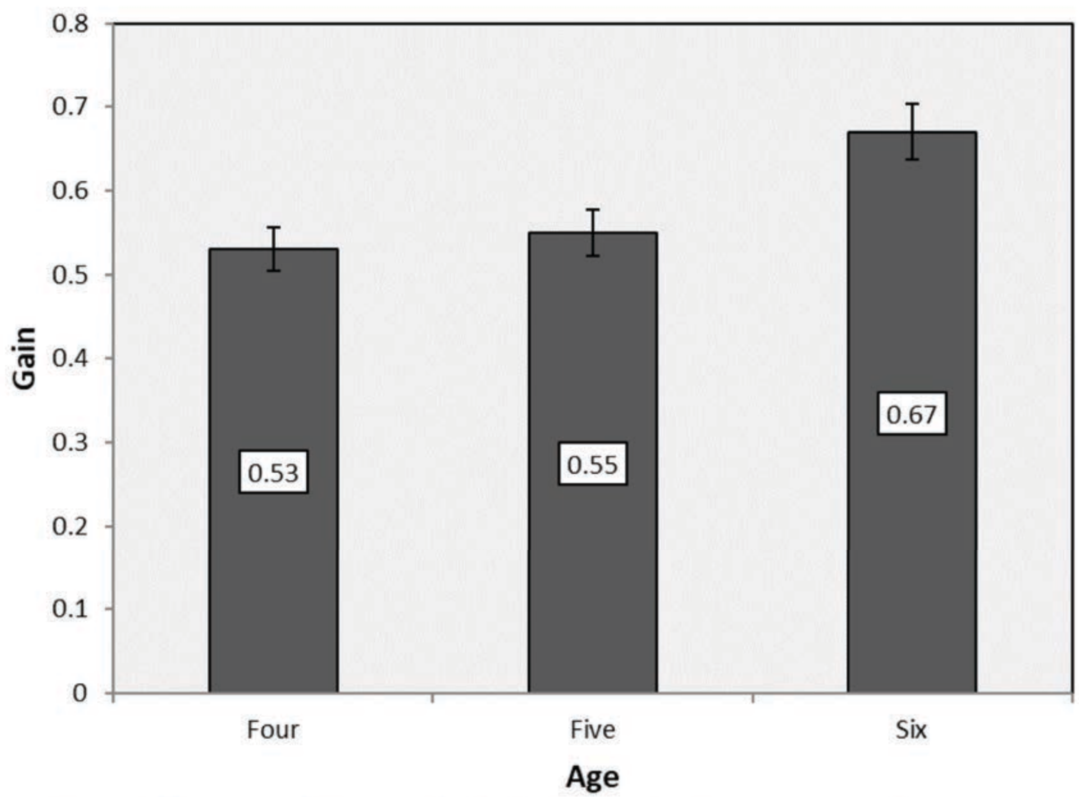
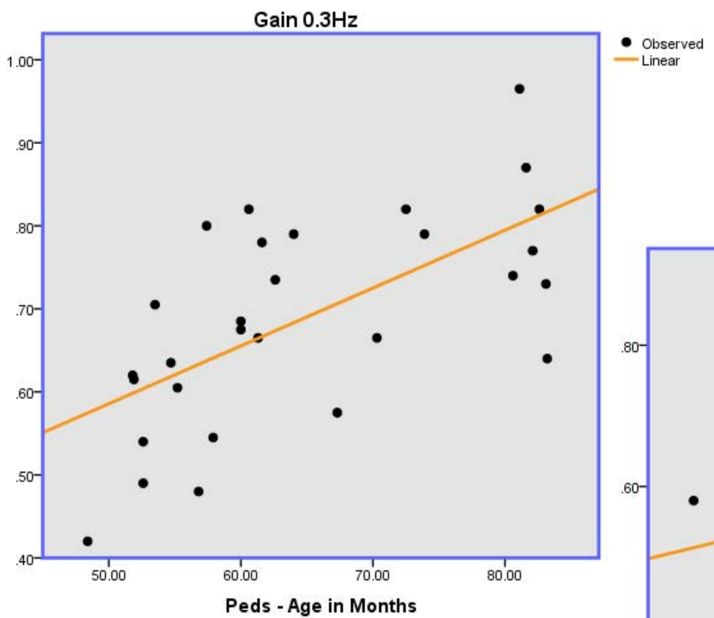
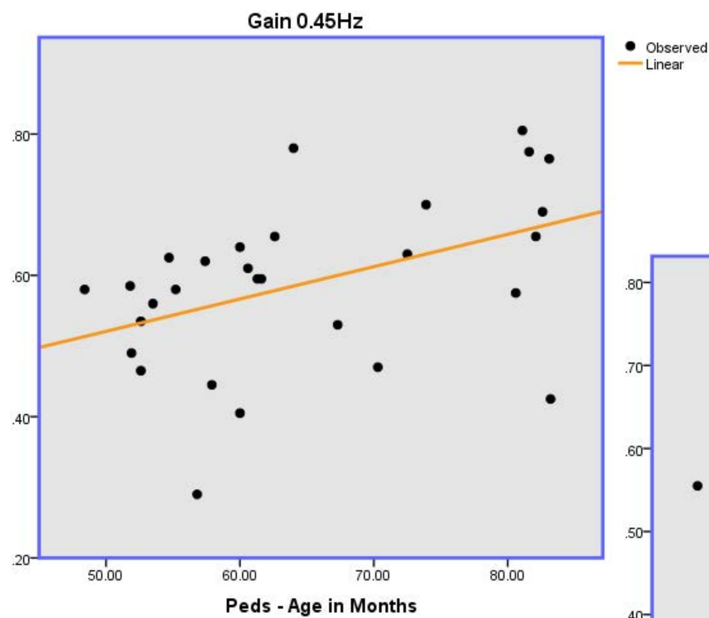
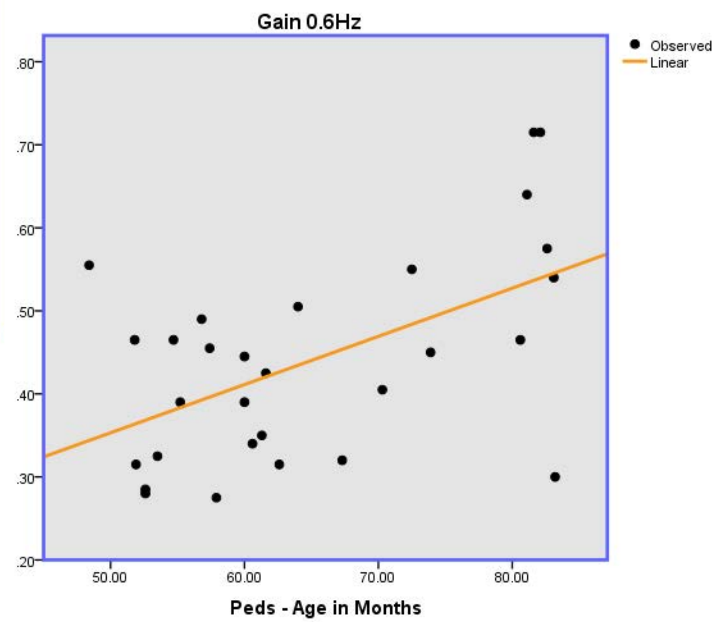


Figure 3 Mean smooth pursuit gain for the pediatric group in age in years averaged for frequency. Standard error bars are noted.[17]

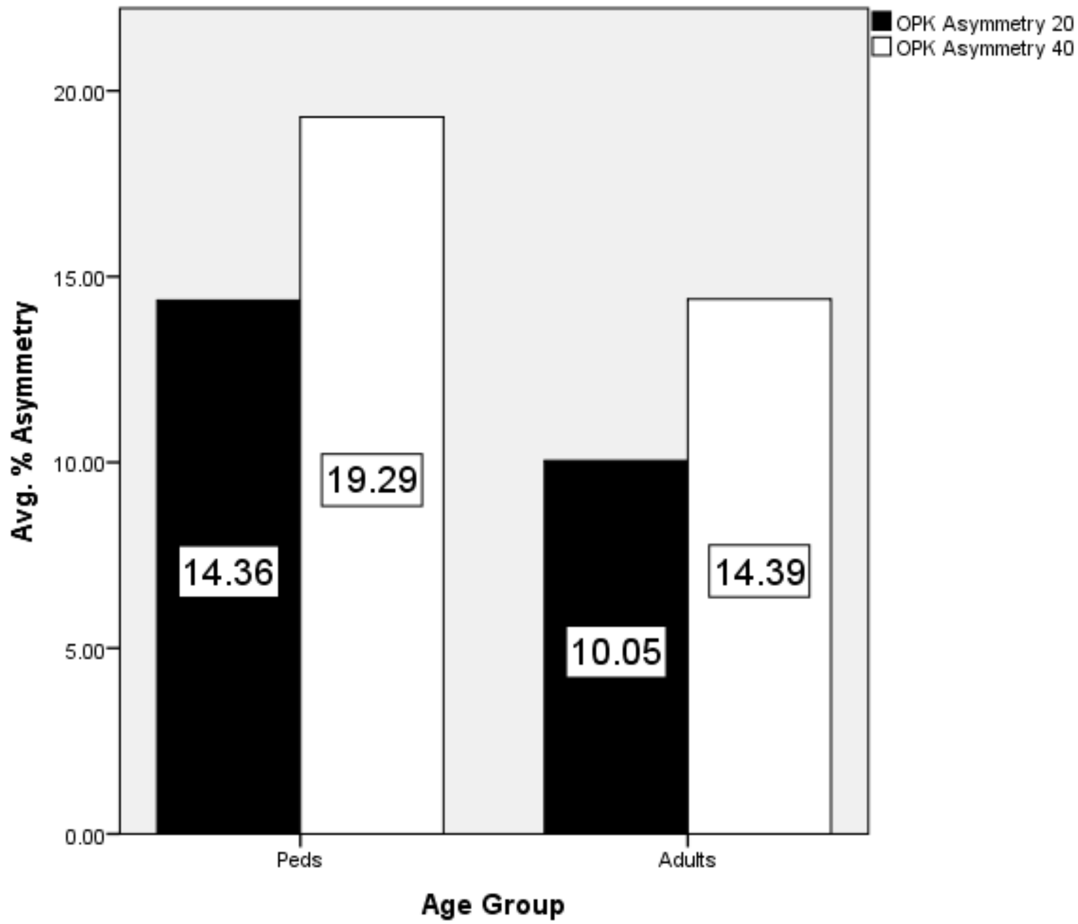
Smooth Pursuit







OPK



OPK Asymmetry 20
OPK Asymmetry 40
Avg. % Asymmetry
20.00
15.00
10.00
5.00
0.00
14.36
19.29
10.05
14.39
Peds
Adults
Age Group

Additional Data

Doettl et al (data in preparation for submission)

- Older Adults – Ages 61-90 years
- Adults – Ages 21-60 years
- Pediatrics – Ages 4-6 years
  - Latency
    - Adults and pediatrics were significantly different
    - Adults and older adults were significantly different
    - ***Pediatrics and older adults were NOT statistically different

Figure 1. Mean Saccade Latency Values for Group.

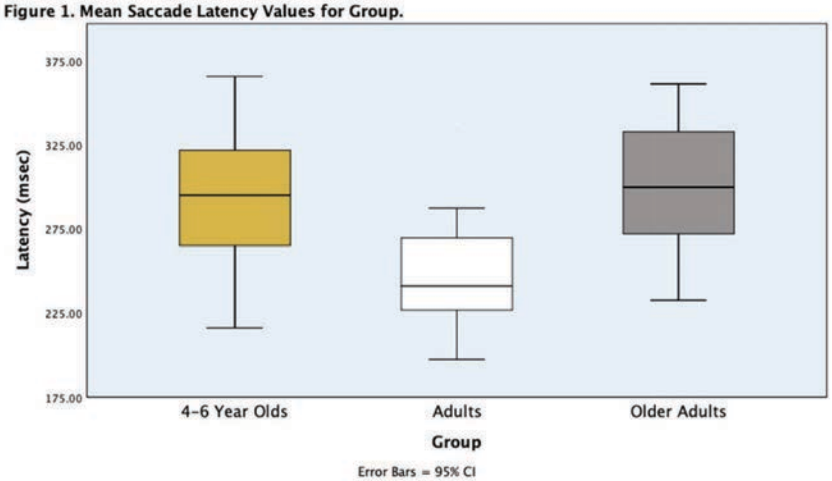
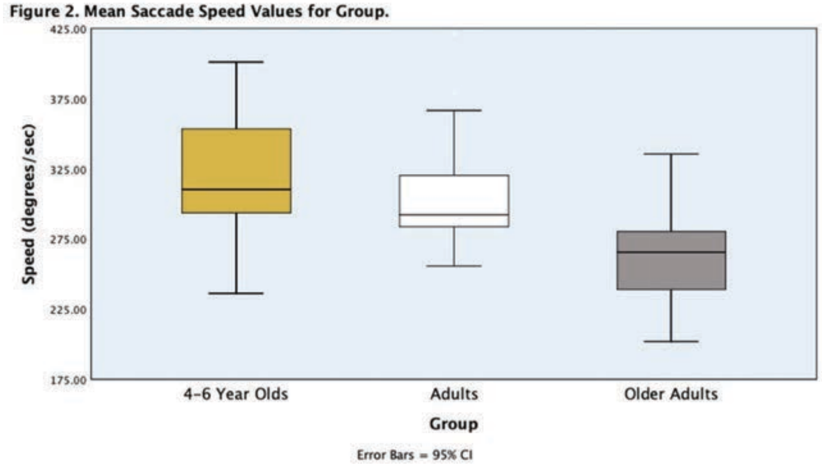


Figure 2. Mean Saccade Speed Values for Group.



Additional Data

- Doettl et al (data in preparation for submission)
  - Smooth Pursuit
  - 0.3
    - Pediatric, adult, and older adult groups are all statistically significant
  - 0.45
    - Pediatric, adult, and older adult groups are all statistically significant
  - 0.6
    - Pediatric group is statistically significant compared to adults and older adults

Table 5. One-way Multiple Analysis of Variance Results for Smooth Pursuit Gain for Age Group

Group	0.3 Hz (sd)	Gain Values 0.45 Hz (sd)	0.6 Hz (sd)
Pediatric	0.71(0.12)	0.59(0.11)	0.43(0.11)
Adult	0.91(0.05)	0.82(0.07)	0.66(0.10)
Older Adult	0.82(0.13)	0.72(0.15)	0.61(0.19)

	F	df	p	partial η^2	Ω
Group (Pillai's Trace)	10.137	6,158	<0.001*	0.278	1.000

*p < .05

Other Findings

- No significant differences were noted for:
- Saccade
  - Velocity
  - Accuracy/Precision
- OPK
  - SPV
  - Gain

However, some other interesting differences were noted……

Artifact

- Potential Errors (Stockwell, 1983)
  - inattention
  - movement of the eye away from the visual target
  - eye blinks
  - calibration errors
  - head movement during
  - testing
  - ENG electrical
  - interference
  - VNG tracking problems

Artifact

- Fukushima, Hatta, and Fukushima, 2000
  - Significantly increased errors in saccade testing in children under 7 years of age (antisaccade task)
- Klein and Foerster, 2001
  - 6-26 years - increased saccade errors in younger age range
- Rutsche, Baumann, Jing, and Mojon (2006)
  - Pursuit & Saccade function in the first 6 years of life.
  - Increased attention time to the task with increasing age.

Artifact

- Doettl, S. M., Plyler, P. N., & McCaslin, D. L. (2017).
  - Retrospective analysis of the oculomotor data with regard to artifact.
    - Are instances of artifact greater in children than adults during VNG oculomotor testing?
    - If there is greater artifact in children does it affect the oculomotor results?

Artifact

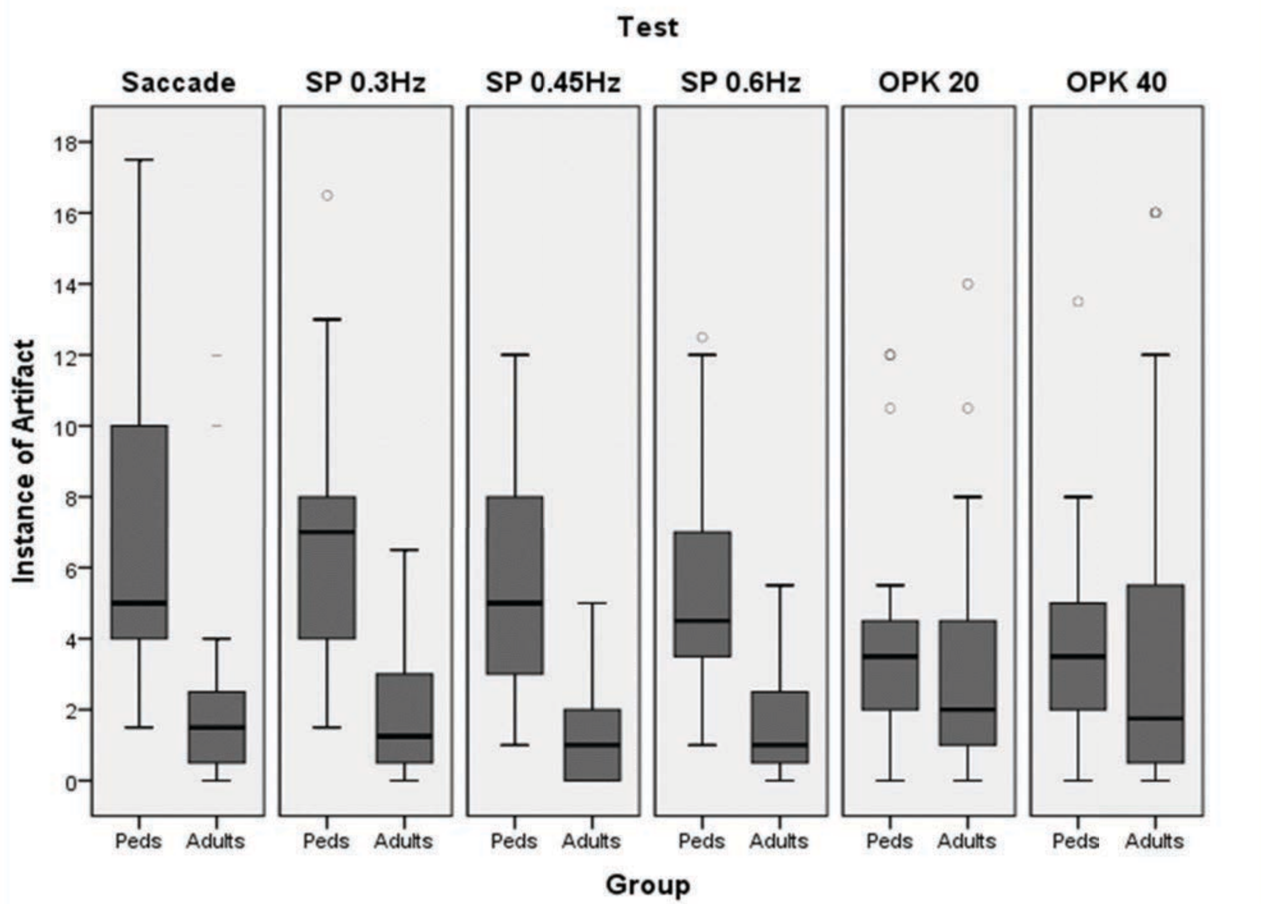


Figure 1: Mean instances of artifact for the pediatric and adult groups for each oculomotor test studied. Standard deviations and outliers are noted.

Artifact

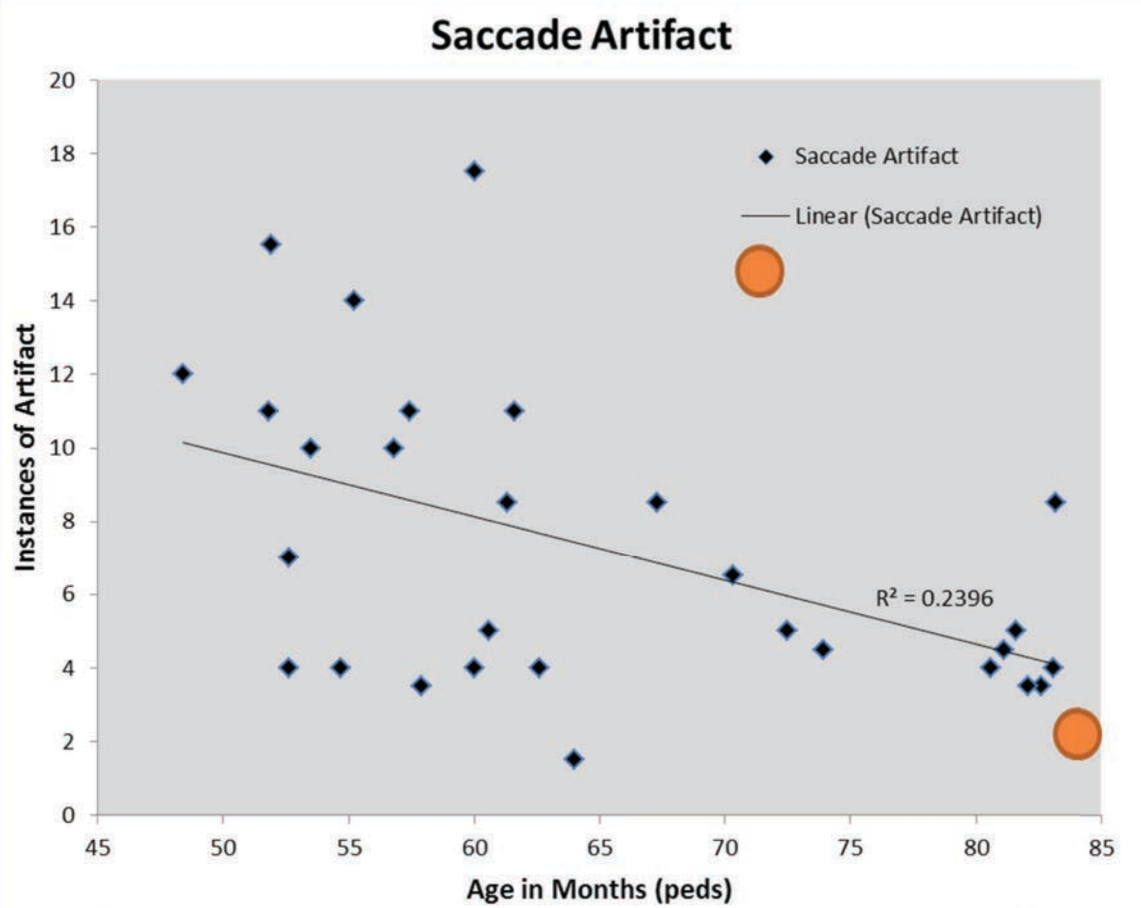


Figure 3: Linear regression analysis for instances of artifact during saccade testing for the pediatric group to evaluate the prediction of artifact by age in months. R-squared value is noted.

Artifact

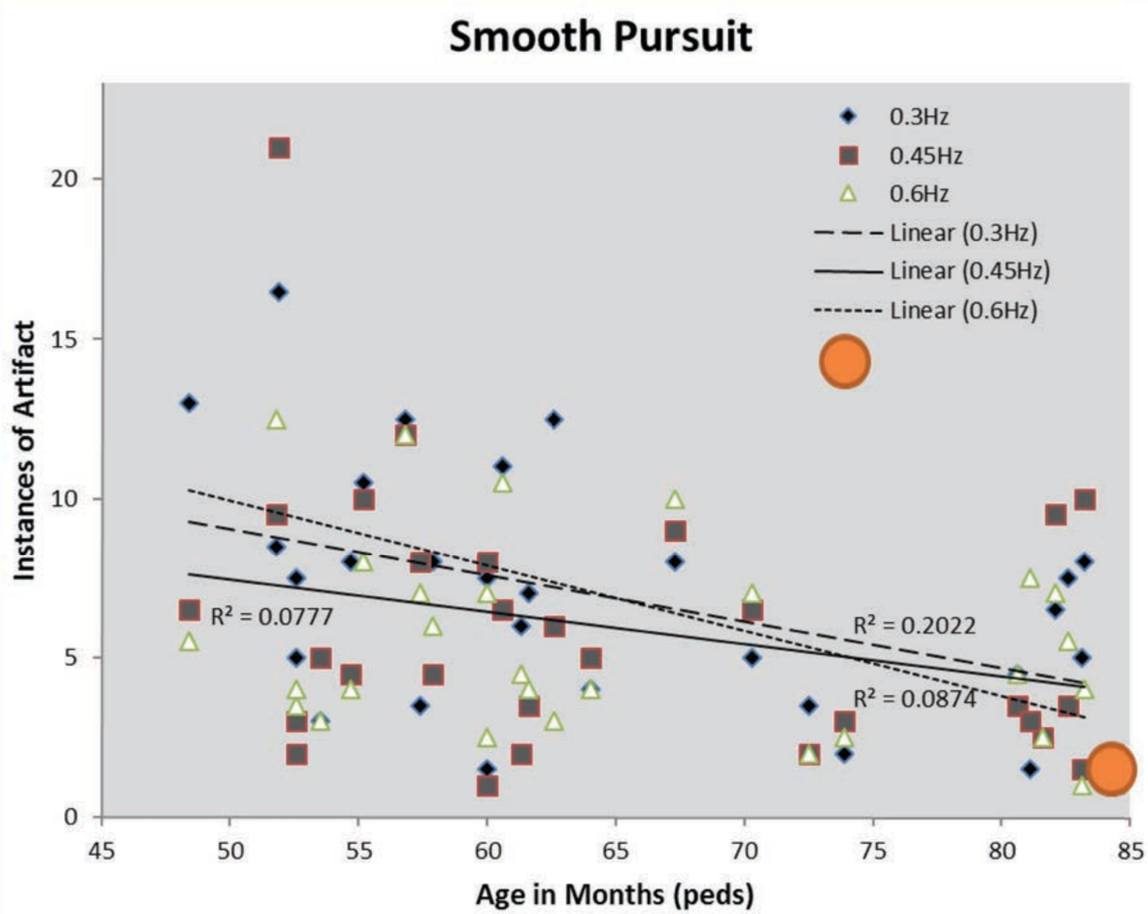


Figure 4: Linear regression analysis for instances of artifact during smooth pursuit testing for the pediatric group to evaluate the prediction of artifact by age in months. R-squared value is noted.

Artifact

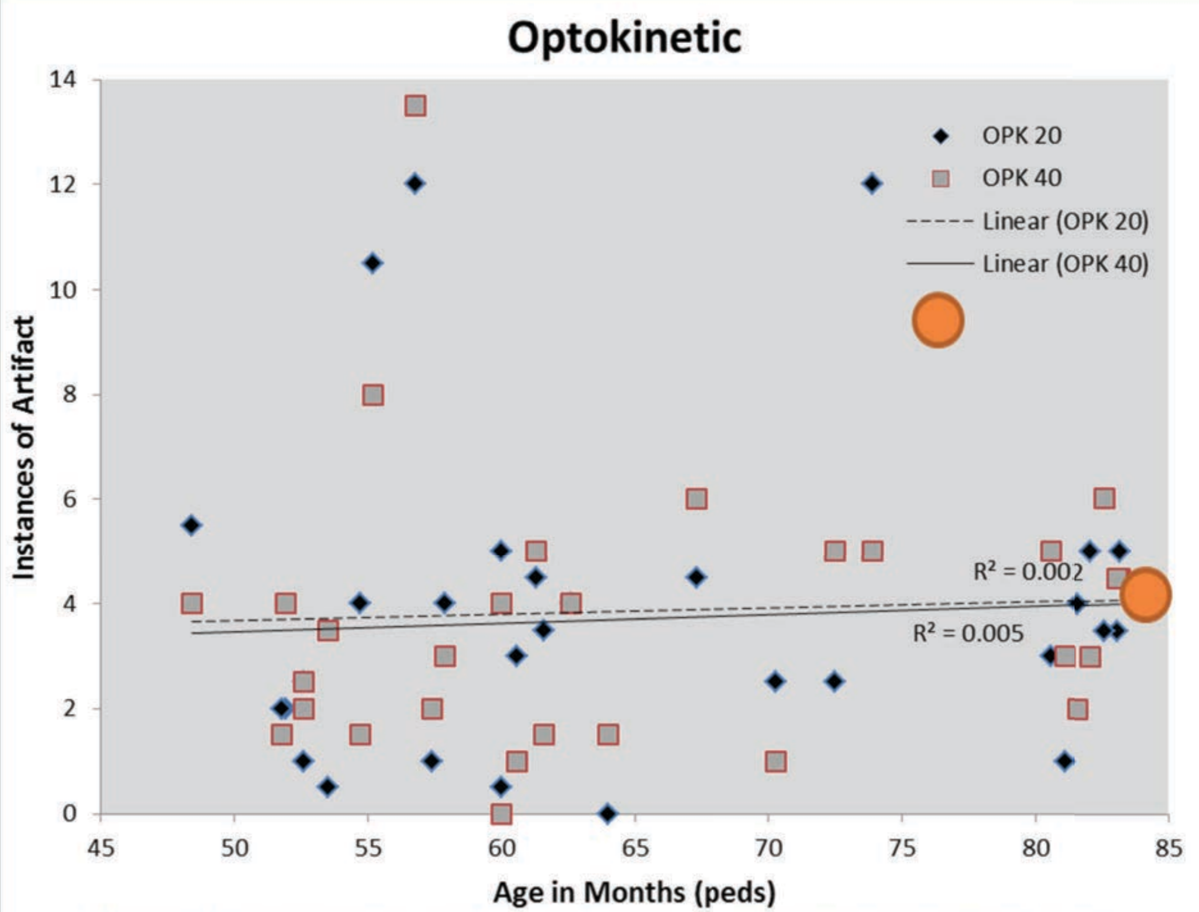


Figure 5: Linear regression analysis for instances of artifact during optokinetic testing for the pediatric group to evaluate the prediction of artifact by age in months. R-squared value is noted.

Artifact

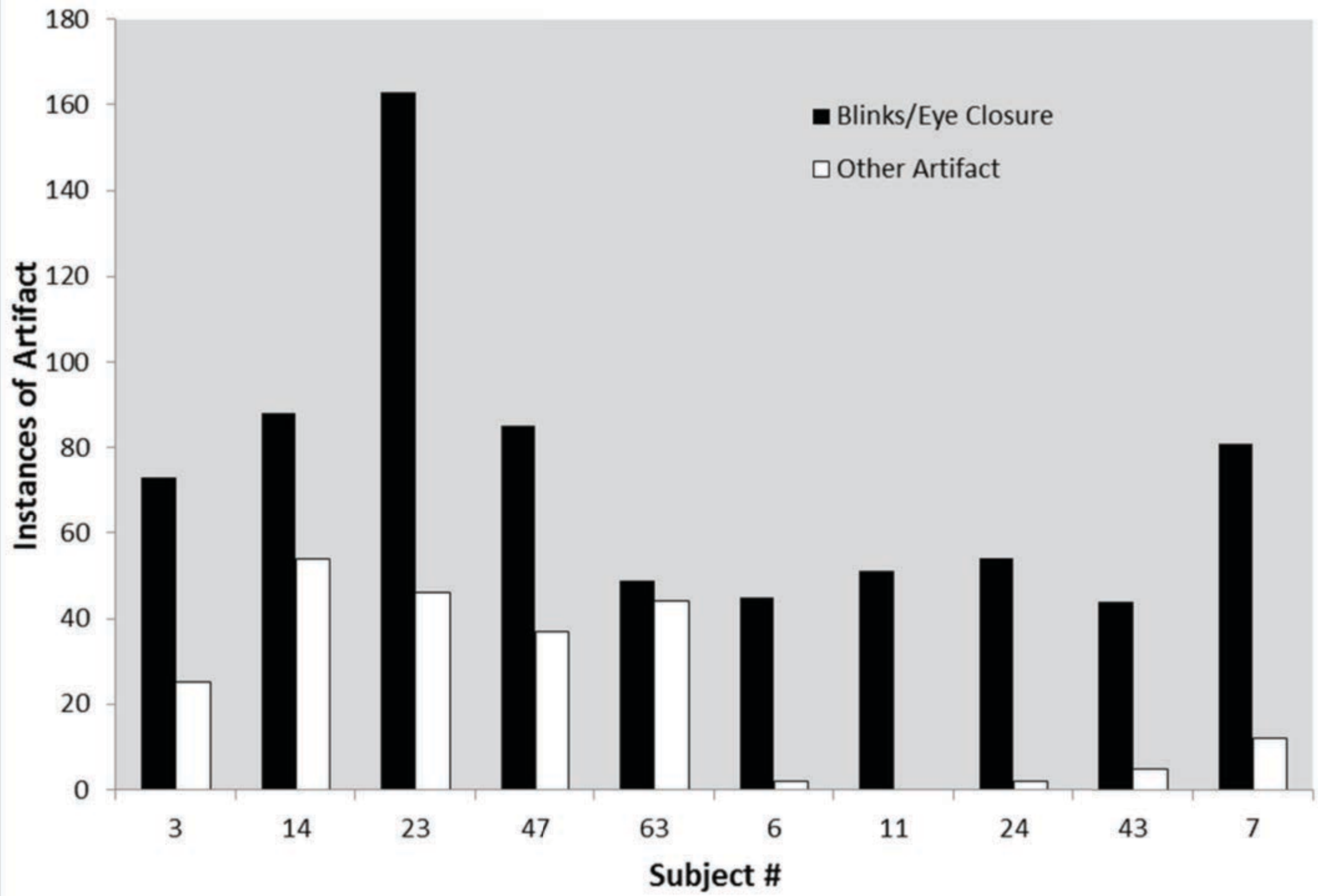


Figure 10: Instances of artifact categorized by type for the five subjects from each group with the most artifact noted across tests and trials. Subjects 3, 14, 23, 47, and 63 were from the pediatric group. Subjects 6, 11, 25, 43, and 7 were from the adult group.

Artifact Rejection Techniques

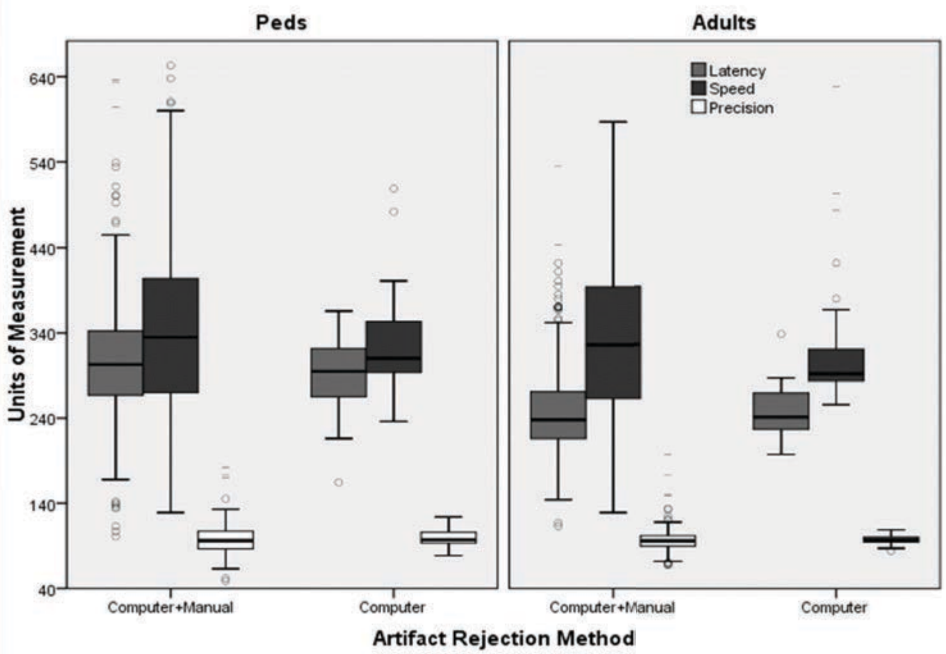


Figure 5: Mean values of saccade latency, speed, and accuracy using computer + manual versus only computer artifact rejection methods. Standard deviations and outliers are noted.

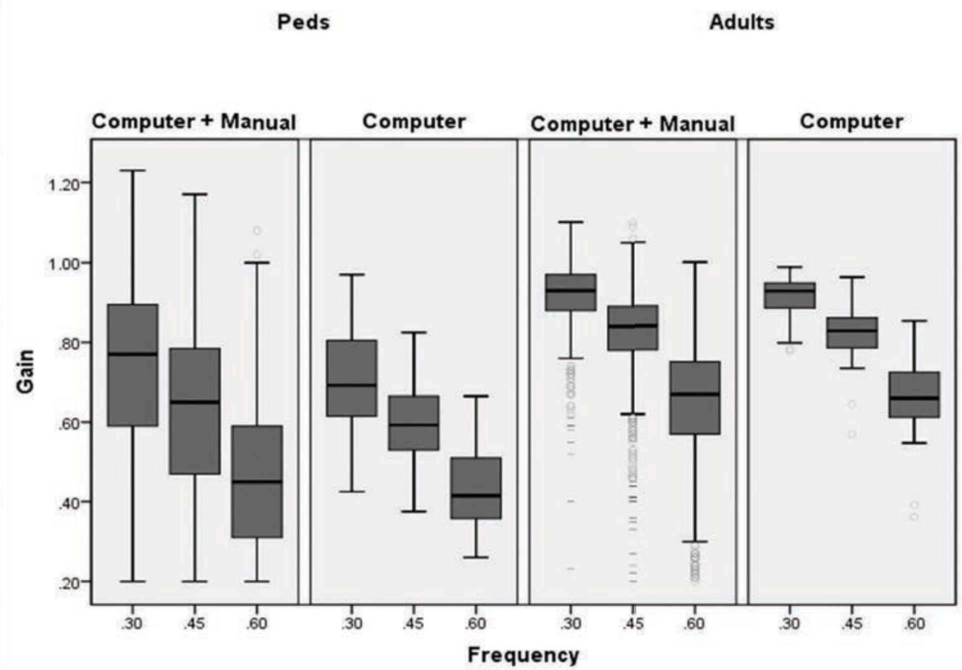


Figure 6: Mean values of smooth pursuit gain for 0.3, 0.45, and 0.6Hz using computer + manual versus only computer artifact rejection methods. Standard deviations and outliers are noted.

Additional Source

- Sinno et al (2020)
- Ages 5 to 17 years
  - Saccades
    - Saccadic latency was longer in the youngest group aged 5-8 years old (305±48msec)
      - 9-11 years old (276±22msec) (P=0.017)
      - 12-14 years old (252±34msec) (P=0.001)
      - 15-17 years (256±33msec) (P=0.001).
    - Age did not affect the results of saccadic velocity and accuracy/precision.
  - Smooth Pursuit
    - Gain increased from 0.63 in children aged 5-8 years old to 0.85 in children aged 15-17 years (P=0.0001).

Summary

- ✓ Children display longer saccade latencies
  - ✓ Approaches adult values by 15-17 years
- ✓ Children display lower pursuit gain
  - ✓ Significant correlation for gain with age in months for 4-6 years
  - ✓ Significant increase in gain up to 15-17 years
- ✓ Children display larger OPK asymmetry
  - ✓ Significant difference between 4/5 years and 6 years
  - ✓ However, this is likely not clinically relevant
- ✓ Children display increased artifact
  - ✓ Saccades and Pursuit
  - ✓ Decreased artifact with increasing age
  - ✓ Standard artifact rejections methods are sufficient

Summary

- Suggestions for Clinical Practice
  - Be cautious
    - Especially in the youngest patients
  - Use age-specific pediatric norms where available
    - Clinic/equipment norms
    - Doettl et al, (2015) – Ages 4-6
    - Sinno et al (2020) – Ages 5-17
  - Consider pediatric specific visual targets
    - Pursuit especially
  - OPK is the most robust if all else fails

Questions?

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