



Visual Sequelae of Long Haul COVID-19

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Disclosure

- None
- Please do not take photos or record the photos and videos of patients. I have permission from patients for this lecture, but not beyond that.

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- IBO study group (Washington DC/VA/MD)
- Tuesday Think Tank

Damage from COVID-19

- Cardiovascular – one year later
 - Heart failure – 39% increase non-hospitalized
 - Blood clots – 2.2 x increase pulmonary emboli
 - Cardiac arrest – 5.8 x increase if hospitalized
 - Myocarditis – 14 x increase if hospitalized
- 1 in 7 Cardiac adverse event if had COVID

Cardiac effects SARS-CoV2

	NON-HOSPITALIZED	HOSPITALIZED	NEEDED INTENSIVE CARE
Cardiac arrest	negligible	482%	2,774%
Stroke	24%	177%	310%
Heart failure	39%	270%	522%
Pulmonary embolism	119%	855%	2,426%
Myocarditis	277%	1,264%	3,940%

Indirect Effects of COVID-19

- Social isolation
- Financial distress
- Changes in dietary habits
- Changes in physical activity
- Trauma and grief
- Risks for cardiovascular disease

Delayed Virus Clearance

- Possible cause of long COVID
- Need research

RECOVER

- 30 research teams participating in the NIH-sponsored RECOVER (Researching COVID to Enhance Recovery) Initiative.
- Identify risk factors for long COVID
- Develop strategies for preventing and treating it
- Learn why some people experience faster and fuller recoveries than others

Symptoms at 3 to 6 months post COVID

- 40% of patients with long-COVID symptoms recorded between 3 and 6 months
- No symptoms/diagnosis in the first 3 months
- Delay in presentation
- Delayed onset of long-COVID features

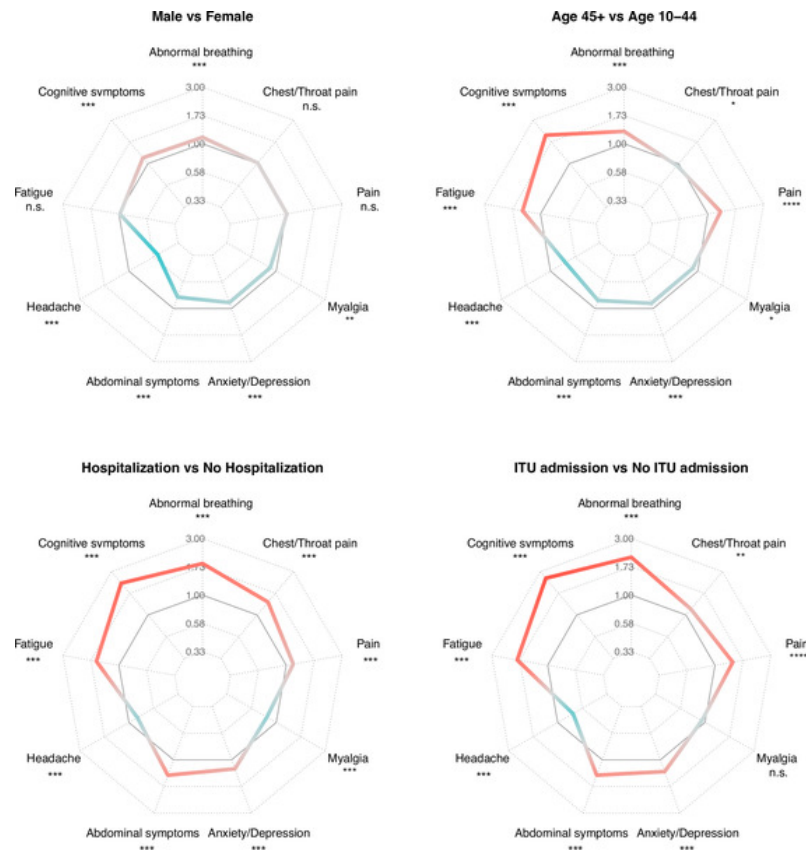
Long COVID Symptoms

- Pain (overall) – 34.2% (greater incidence at 3 to 6 months)
- Headaches – increase incidence women and younger patients, less acutely ill
- Fatigue – 39.8%
- Brain fog
- Anosmia (loss of smell) – 11% to 23.6%
- Ageusia (loss of taste) / dysegeusia (distortion of taste) – 9% to 15.6%
- Dyspnea (shortness of breath) – 36%

Additional Long COVID Symptoms

- Anxiety – 22.1%
- Depression – 14.9%
- Fever – 1%
- Chronic cough – 16.9% - 60%
- Sleep problems
- Lung problems
- Chest pain – 13.1%

Fig 5. Spider plots summarizing the HRs for each long-COVID feature in subgroups based upon sex, age, and severity of COVID-19 as proxied by requiring hospitalization or ITU admission.



Taquet M, Dercon Q, Luciano S, Geddes JR, Husain M, et al. (2021) Incidence, co-occurrence, and evolution of long-COVID features: A 6-month retrospective cohort study of 273,618 survivors of COVID-19. PLOS Medicine 18(9): e1003773. <https://doi.org/10.1371/journal.pmed.1003773>
<https://journals.plos.org/plosmedicine/article?id=10.1371/journal.pmed.1003773>

Symptoms - Early

- Strong connection - abnormal breathing, chest/throat pain, fatigue, and anxiety/depression are particularly interconnected
- Weak connection - myalgia and cognitive symptoms
- Different origin and/or mechanism relative to the other long-COVID features.

Neural Connections

“The data are growing to suggest that there are more neural consequences of this infection than we originally thought,”
Lee Gehrke, a molecular biologist at the Massachusetts
Institute of Technology

Changes in Brain Structure MRI

- Pronounced reduction in grey matter thickness and contrast in the lateral orbitofrontal cortex and Para hippocampal gyrus
- Relative increase of diffusion indices, a marker of tissue damage, in the regions of the brain functionally-connected to the piriform cortex, anterior olfactory nucleus and olfactory tubercle
- Greater reduction in global measures of brain size and increase in cerebrospinal fluid volume - additional diffuse atrophy in the infected participants
- Cortical surface - grey matter thickness in Para hippocampal gyrus, lateral orbitofrontal cortex, anterior insula and anterior cingulate cortex, supramarginal gyrus and temporal pole

Tissue Damage

- Increase of a diffusion index (mean diffusivity) medial and lateral orbitofrontal cortex, anterior insula, anterior cingulate cortex and amygdala.
- Reduction of grey matter thickness in fronto-parietal and temporal regions
- 401 SARS-CoV-2 infected participants also showed larger cognitive decline between the two time points in the Trail Making Test compared with the controls
- Duration taken to complete the alphanumeric trail correlating *post hoc* with the cognitive and olfactory-related crus II of the cerebellum which was significantly atrophic in the SARS-CoV-2 participants
- Longitudinal abnormalities in limbic cortical areas with direct neuronal connectivity to the primary olfactory system

Brain imaging before and after COVID-19 in UK Biobank Gwenaëlle Douaud, Soojin Lee, Fidel Alfaro-Almagro, Christoph Arthofer, Chaoyue Wang, Paul McCarthy, Frederik Lange, Jesper L.R. Andersson, Ludovica Griffanti, Eugene Duff, Saad Jbabdi, Bernd Tschler, Anderson M. Winkler, Thomas E. Nichols, Rory Collins, Paul M. Matthews, Naomi Allen, Karla L. Miller, Stephen M. Smith **doi:** <https://doi.org/10.1101/2021.06.11.21258690> Preprinted article
https://www.medrxiv.org/content/10.1101/2021.06.11.21258690v3?fbclid=IwAR0vwvhudSPWAriuTm3oO0V3ZfzO61p_QFN49DK-DjBrW2MOKQRcl5vNsFs

Cognitive Functioning

- Cognitive outcomes were reported by 13 studies
- 6 studies reported cognitive deficits (median frequency, 17.6%; IQR, 15.0%-21.6%)
- 5 studies reported loss of memory (median frequency, 28.3%; IQR, 18.6%-35.8%)
- 4 studies reported difficulty concentrating (frequency, 22.0%, 25.4%, 25.6%, and 28.0%).

Slower Response Time

- 81,337 individuals
- Complex tasks requiring reasoning, planning and problem solving
- Verbal analogies, Blocks and Tower of London
- Working memory functions such as Digit Span and Spatial Span or Emotional Discriminations. Analysis of individual task median response times also indicated significant slower median response time especially ventilated group
- 0.47 SD global composite score reduction for the hospitalized with ventilator sub-group was greater than the average 10-year decline in global performance between the ages of 20 to 70

Brain Fog

- Trouble concentrating and difficulty finding the correct words
- Not explained by differences Spatial Span and Digit Span scores show robust age-related differences.
- Recovery from COVID-19 infection may be associated problems in higher cognitive or 'executive' function
- Preliminary reports of executive dysfunction in some patients at hospital discharge and ventilated patients with acute respiratory distress syndrome pre-pandemic
- [https://www.thelancet.com/journals/eclinm/article/PIIS2589-5370\(21\)00324-2/fulltext](https://www.thelancet.com/journals/eclinm/article/PIIS2589-5370(21)00324-2/fulltext)

Long COVID in Children

- Fatigue (64, 71.1%), dyspnea (45, 50.0%) and myalgia (41, 45.6%) were the most frequently reported symptoms, and were significantly associated with older age >11 years
- Sleep disturbances (30, 33.3%), chest pain (28, 31.1%), paresthesia (26, 28.9%), headache (26, 28.9%), hair loss (24, 26.7%), anosmia-ageusia or parosmia/euosmia (23, 25.6%), gastrointestinal symptoms (18, 20.0%)
- Dizziness (17, 18.9%), weight loss of >5% of body weight (17, 18.9%), memory impairment (16, 17.8%), vasomotor complaints (13, 14.4%), arthralgia (13, 14.4%), tremor (12, 13.3%), cough (9, 10.0%), palpitations (8, 8.9%), difficulty in concentration (8, 8.9%), tic exacerbation (2, 2.2%) and tinnitus (1, 1.1%)
- Recurrent febrile episodes (2, 2.2%), developmental regression (2, 2.2%) and obstructive sleep apnea (2, 2.2%)

Effect of Symptoms on Children

- 58.9% of Children reported impairment in daily activities
- Research on visual function??

Patient: AS 12-22-20

- 26 year old audio engineer
- Last exam 10 years earlier after completed VT for CI, AI, OMD
- Feels dizzy. Vision worse since Thanksgiving
- COVID Oct. 2020 was Ok after
- Now feels pressure around eyes, head
- Sees clearly, but when looking at laptop feels very tired
- When looks up from device takes a long time to get clear

Symptoms - AS

- Increase brain fog when visual symptoms are worse
- Loses place when reading, no diplopia
- Works in restaurant, bothered by noise of TVs
- Lights flickering gets headaches
- “Feels bad”
- BIVSS: 51
- Medical history: Levothyroxine

Patient: AS – 12/22/20

- VA (unaided) Far OD 20/20+3 (feels blurry) OS 20/15-1
OU 20/15
- Near: OD 20/20-3 OS 20/20 OU 20/20-1
- Retinoscopy OD +0.50sph OS +0.75
- Subjective: Plano OU

Exam Findings - AS

Stereo	RDS 250 sec Randot Circles 20 sec of arc
Cover Test	Distance 2 XP Near 12 XP' OS lower lid began twitching during test
NPC	3.5"/5"/OS out/+ diplopia recedes to 4"/5.5"/OS out/+ diplopia NPC with +0.50 3"/4.5"/OS out/+ diplopia
MEM	OD +1 to +1.25 OS +1.00
Worth 4 dot	Fused with luster 16", 3 feet, 6 feet, 13 feet
EOM	Full range, comitant, jerky, discomfort Saccades 20% undershoot

Exam - AS

Phoria	Distance Horizontal: ortho Vertical: iso Near Horizontal: 4 exo W/+1.00 10 exo Vertical: iso MThorington Horizontal: 15 exo Vertical: iso
Vergence	Distance BO 12/16/12 BI x/8/5 Near BO 16/28/10 BI x/12/10 Step near BO x/10/8 BI x/10/6
FCC / NRA / PRA	+0.50 / +1.50 / -1.25D
Amp Accommodation	8D OD, OS
MAF/BAF	OD 3cpm Plus 15 sec, 20 sec, 7 sec Minus 4 sec, 10 sec OS 3.5cpm Plus 5 sec, 10 Minus 4 sec to 7 sec clear/blur OU 4cpm Plus 18 sec Minus 7 sec then 5 sec no suppression
Ocular health	+ Alpha Omega OD, OS 1 to 2 sec

Exam Findings - AS

- DEM: V: 63 per H: 40 per Ratio: 14 percentile
- Accuracy: 60 to 99 percentile
- Standing Angels: Difficulty with contralateral movement, lag, segmented
- Chalkboard Circles: Difficulty with contralateral

Diagnosis - AS

- Convergence Insufficiency
- Accommodative Insufficiency
- Oculomotor Dysfunction
- Post Concussion Syndrome / Long Haul COVID

Treatment Plan - AS

- Rx +0.50sph OU FL-41 tint (preferred w/o prism)
- Blue light blocker
- Nutrition: D3, B complex, DHA, Omega 3
- Neuro-Optometric Visual Rehabilitation
- Referral to doctor in TN

Vision Therapy - AS

- Chalkboard circles – wall, in air, window
- Pointer in straw
 - Shake arms then repeat at a different angle
- Closed eye finger touches
 - Shake arms then repeat with different finger
- Hart chart – Level 1, 2, 3 (80 bpm – 84 bpm)
- Walk - building to 20 minutes 3x per day

Movement

- Specific procedures
- Breaks between procedures
- Enhance awareness
- Breaks during daily living activities



AS - 2nd session

- Increase in symptoms 5/10
- Watched TV for 2.5 hours!
- Increase in floaters
- Vestibular stimulation
- Wach's Salute – check status

AS – session 3 & 4

- Home reinforcement 5 x, walked, watched TV 2.5 hrs w/ breaks
- Improved comprehension
- Symptoms 2 or 3/10, feels worse in small room
- EOM – arms length 16 to 20” horizontal and vertical
- Head movement 45 degrees, but 20 comfortable with cognitive
- Malhotra eye movements Level 3 – level 4 difficult cognitive load
- Wach’s Salute
- Belgau ball toss – unable to do eyes only

AS – Report from OD

- Additional comprehensive program of OVRT can help . . .
- Visual skills are functional
- Need supportive vertical prism
- Head tilt to straight with Brock string
- Stress peripheral field awareness
- Adapt to glasses and return for evaluation

AS – Continue Therapy

- Wach's Salute
- Belgau ball toss
- Near Far Hart chart to 4" taking $\frac{1}{2}$ second to clear
- Ghost thumb
- Chiastopic thumbs
- Prism saccades

Vestibular Ocular

- Ambient Focal Reintegration (Dr. Marsha Benshir)
- Long Swings
 - Yoga
 - Gradually increase to 20 repetition
- Visual Motion Sensitivity (VOMS test modified)
 - Seated
 - Standing
 - Walking
 - Gradually increase to 10 repetition

Home Reinforcement

- Angels – laying on back . . .
- Chalkboard circles – emphasis on awareness
- Walking with peripheral awareness, breathing
- Belgau ball toss



Peripheral Awareness - Fusion

- Aware of volume of space
- Standing in doorway
- Be aware of both sides of door frame
- Add fusion targets
- Volume of space in front and behind
- Vestibular
- Movement
- Cognitive load



AS – Improved Symptoms

- Walk and watch movie without symptoms with breaks after 1 hr
- Dizzy occasionally when neck and back tight
- Improved comprehension, read longer periods
- Symptoms 2/10
- EOM –horizontal and vertical increase cognitive load
- Head movement 45 degrees
- Malhotra eye movements Level 4 – with cognitive load

Neuro-Optometric Visual Rehabilitation

- Increase function with awareness
- Cognitive load
- Movement – supine, seated, standing, walking
- Modify for virtual sessions

History - CK

- 25 yo female referred by VT/Neuro Rehab OD
- April 26, 2020 COVID Day 5 test negative
- Sx shortness of breath, COVID toes, diarrhea, blood clots in lungs
- Day 20 loss of smell, appetite, poor circulation in feet, fatigue
- Day 68 positive antibody test Dx COVID-19
- Aug to Oct 2020 (month 4) – Slow onset of fatigue, shortness of breath returned
- Nov to Dec 2020 – Fatigue, joint pain, difficulty walking, wheeled walker in Dec, Neuro PT
- Slow movements painful

History – CK cont.

- Jan 15, 2021 tremors of right arm/hand. Worse with movement
- Feb. 26, 2021 Dx Functional Neurological Disorder post COVID (University MD)April 26, 2020 COVID
- March 26, 2021 Pfizer vaccine symptoms increase, ringing ears
- April 8, 2021 Functional vision evaluation
- April 16, 2021 Pfizer second dose increase symptoms, foggy brain, nausea
- May 2021 Syntonics blue/green, prism glasses

Exam Findings – CK on 6-3-21

Acuity Acuvue Oasys -5.50 OU	Far OD 20/20-3 OS 20/20 Near OD 20/25 OS 20/20
Cover Test	Distance 5 XP Near 15 XP'
NPC	8"/12"/+ diplopia After 5 x 8"/ 10"/+ diplopia Red lens 6"/7"
Vergence	F BI x/14/6 BO 6/10/0 N BI 8/26/20 BO 23/32/20
Accommodation	Amps OD 7.5D OS 8.25D
EOM	Pass 5 on pursuits and saccades. Swaying left to right DEM: V 46 H 11 Ratio 2 Accuracy 35 to 55 percentile

NEUBIE

- Neuro-bio-electrical simulator July 2021
- Tremors, gait, fatigue worse than baseline
- Cannot write cursive or move arms and legs as before



CK on 7-13-2021

BIVSS	44
Cover Test	Near 6 XP'
NPC	5"/7"/OS out/+ diplopia 5.5"/7.5"/OS out/+ diplopia +0.50 6"/7"/OS out/+ diplopia headache worse
MEM	OD +0.50 OS +0.50
Step	BI 8/16/10 BO x/8/6
EOM	Pursuits comfort Horizontal 6" Vertical 4"

Diagnosis – CK

- Convergence Insufficiency
- Accommodative Insufficiency/Infacility
- Oculomotor Dysfunction
- Long Haul COVID

Treatment Plan - CK

- Optometric Visual Rehabilitation/Therapy
- Continue with current Rx over contacts
 - +0.50 with 0.50 BI OU
- Monitor symptoms
- Incorporate in therapy

Neuro-Optometric Visual Rehabilitation CK

- Binasals
- Pencil in tube – shake arms in between
- Thumb pursuits
- Malhotra eye movements
- Look, ready, touch, back
- Scan objects – look, reach, say & touch
- Hart Chart
- Walk forward, backwards – peripheral awareness



Therapy/Rehabilitation - CK

- Malhotra eye movements – with cognitive load
 - Petteruto Memory Box
- Hart Chart – decreasing metronome speed
- Accommodation – plus to plano rock
- Vectograms
- Slap tap
- Spot It
- Closed eye finger touches

Marsden Ball

- Hitting
- Bunting
- Catch – arms stretched out then catch
- Move feet

Symptom Checklist Key

- 0 (blank) - no symptom
- 1 - mild
- 2 - moderate
- 3 - severe
- F - fleeting (symptom is brief, appears once)
- R - remitting (symptom comes and goes)
- S - steady (symptom persists)

Symptoms

	Date	Headache	Vision issues	Ringin gears	Throat ulcer	Reduce d smell, appetit e	Short of breath	Nause a	Fatigu e	PEM crash	Joint pain	Multiple Knee/Hi p clicks	Hand arm Tremo r	Abnormal gait	Diarrh e	Rear hearing duller or more sensitiv e	Sleep issues	Chilblain s	Lower mood	Run cold	Event
Week 1	10/20	2, S	2, S	2, S	1, S	1, S	1, R	1, R	2, S	2, S	2,R	1, R	2, S	2, S			1, F				PEM from 2 appts the prior day, vision therapy (VT) appt
	10/21	2, S	2, S	2, S		1, S			2, S	1, S	2,R	1, R	2, S	2, S	1, R		1, F				
	10/22	2, S	2, S	2, S		1, S			2, S		2,R	1, R	2, S	2, S	1, R		1, F				Dentist appt
	10/23	2, S	2, S	2, S		1, S		1, R	2, S		2,R	1, R	2, S	2, S			1, F				Started SSDI paperwork
	10/24	2, S	2, S	2, S		1, S			2, S	1, F	2,R	1, R	2, S	2, S							Did social security disability (SSDI) paperwork yesterday
	10/25	2, S	2, S	2, S		1, S			2, S	2, R	2,R	1, R	2, S	2, S	1, F		2, F				More SSDI paperwork, rainy day
	10/26	2, S	2, S	2, S		1, S	1, R	1, R	2, S	2, S	2,R	1, R	2, S	2, S	1, F						More SSDI paperwork, windy day
Week 2	10/27	2, S	2, S	2, S		1, S		1, R	2, S	2, S	2, R	1, R	2, S	2, S		1, R					Vision therapy (VT) appt
	10/28	2, S	2, S	2, S		1, S			2, S	2, R	2, R	1, R	2, S	2, S		1, R	2, F				
	10/29	2, S	2, S	2, S		1, S	1, R		2, S		2, R	1, R	2, S	2, S		1, R	1, F				Rear hearing has been duller/more sensitive for a few days
	10/30	2, S	2, S	2, S		1, S			2, S		2, R	1, R	2, S	2, S		1, R	1, F				
	10/31	2, S	2, S	2, S		1, S			2, S		2, R	1, R	2, S	2, S	1, F	1, R	1, F				Lunch and coffee date, gave out Halloween candy
	11/1	2, S	2, S	2, S		1, S	1, R	1, F	2, S	2, R	2, R	1, R	2, S	2, S	1, R	1, R	1, F				Used computer for a while
	11/2	2, S	2, S	2, S		1, S	1, R		2, S		2, R	1, R	2, S	2, S	1, R	2, R	1, F				Used computer for a while

HC - Control



Visualization



Visualizing



CK – Current Therapy

- Building awareness of where in space
- Binocular procedures
- Fusion
- Emphasis on peripheral awareness
- Incorporate vestibular
- Cognitive load
- Movement breaks during the day



Malhotra (Kraskin) Eye Movements

- Using a detailed target or thumb
- Moving target in lazy 8 / infinity sign
- 8 seconds for one cycle, 5 cycles in each direction
- Controlling head movement
- Laying on floor supine, seated, standing
- Balance board, walking
- Maintain fixation in different gazes
- Appreciate space (between patient and target and beyond target)



Malhotra (Kraskin) Eye Movements

- Level 1: Breathe, relax try to follow target
- Level 2: Questions about the target
- Level 3: Questions about the room
- Level 4: Cognitive load
- Level 5: Eyes closed, open randomly
- Level 6: Combine with Julie Petteruto's Memory Box
- Add metronome, movement

Slap Tap

- **b b d d p p q q b d**
- Initiating movement and speech
- Controlling other movements
- Integration

Ambient Focal Reintegration (Benshir)

Horizontal

Hold thumb up at arms length at midline in front of your body

Move right thumb/arm to right follow with eyes and head (body twisting)

Be aware of other thumb, rest of your body, movement in periphery

Bring right thumb back to midline. Be aware of when you first see the left thumb

Repeat with left thumb and arm moving to left. Keep right thumb and arm upright.
Goal 10 x

Ambient Focal Reintegration (Benshir) Vertical

Hold thumb up at arms length at
midline in front of your body.
Thumbs pointing at each other

Move right thumb & arm up
follow with eyes and head as far
as neck & back allows

Be aware of other thumb, rest of
your body, movement in
periphery

Bring right thumb back to
midline. Be aware of when you
first see the left thumb

Repeat with left thumb and arm
moving to down. Keep right
thumb and arm upright. Reverse
for next with left thumb going up
and right going down

Goal 10 x

Awareness

- How far can you move your head before it gets uncomfortable?
- Can you go further on one side than the other?
- Does this get more uncomfortable as you work?
- Does this get easier or harder as your work?
- Can you keep your arms level?
- Can you keep one arm still while moving other arm?
- Combine with stepping forward and back

Breaks

- Transition between therapy procedures
- Keep it fun!



Vision

Deriving of meaning and the directing of action as a product of the processing of information triggered by radiant energy

- Dr. Robert Kraskin

Take Home

- Where is the patient?
- What are the goals?
- Modify and create environment to achieve goal
- Make it easy for the patient to reinforce at home
- Be open to expanding your horizons



References

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Resources

- College of Optometrist in Vision Development www.covd.org
- Neuro-Optometric Rehabilitation Assoc. www.noravisionrehab.org
- Optometric Extension Program - OEPP www.oepf.org
- Tuesday Think Tank (Zoom meeting every Tuesday at 11:30am ET)

Thank You

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