



Assessing reading literacy with the finger-voice span

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gist of the talk

- finger-pointing reading requires the fine coordination of three motor systems with different intrinsic dynamics
 - voice **articulation**
 - **eye** movements
 - **finger** movements
- multimodal tracking evidence of their relative pace is a reliable indicator of a reader's decoding efficiency and language skills



finger-pointing reading

what is it?

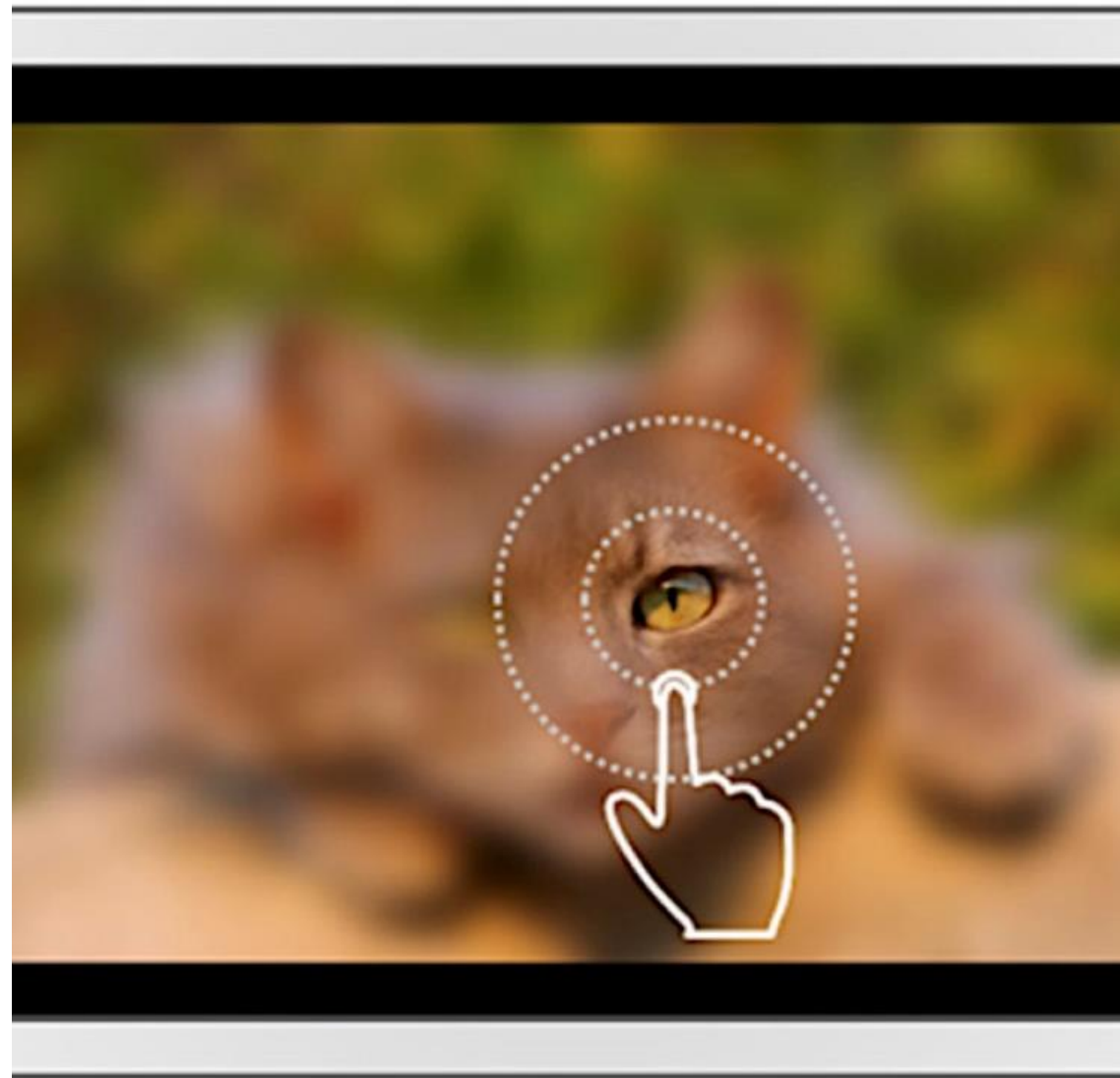


- [finger-pointing reading](#) is based on the learners' ability to accurately [pronounce](#) a printed word in a text line [while](#) the index finger is [pointing](#) to it
- it is known to support the development of word reading in context in [young readers](#), through [integration](#) of the auditory perception of syllables and the visuo-spatial orientation of printed words built upon the [visual and tactile exploration](#) of their spatial dimension (Mesmer and Lake, 2010; Mesmer and Williams, 2015)

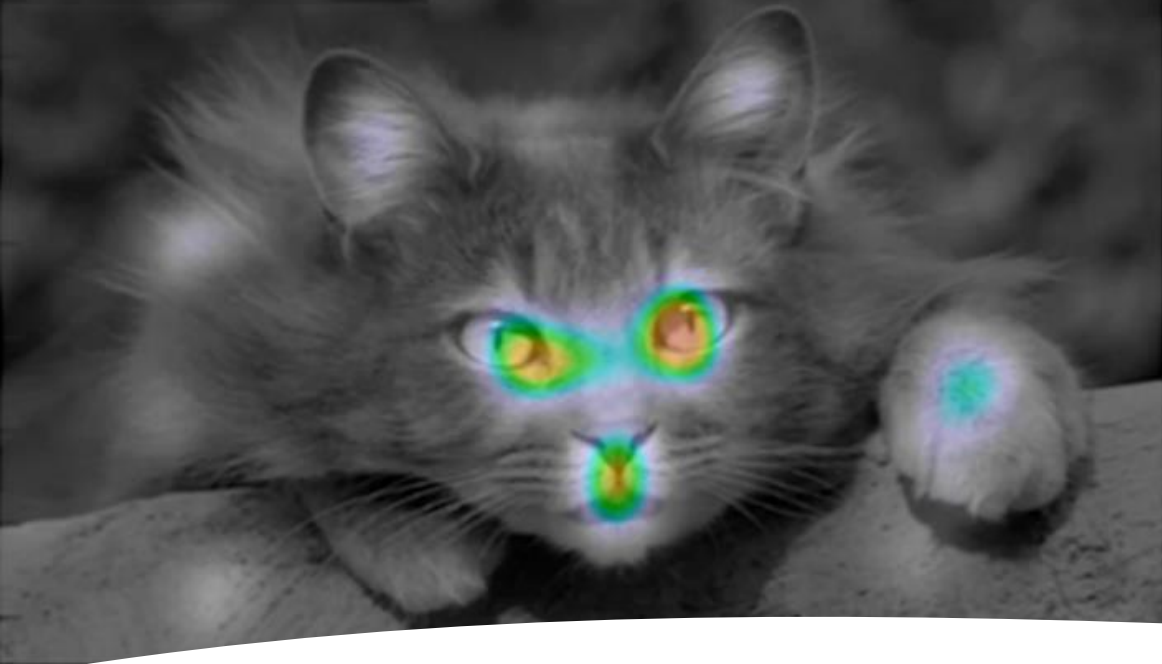


the eye-finger connection (Lio et al. 2019)

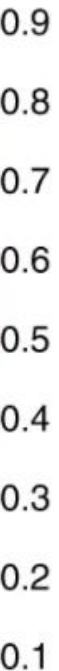
- deblurring



Eye-tracking



Digit-tracking



the eye-finger
connection (II)

- evidence for a *strong correlation* between finger & eye movements in visual image exploration

ASD



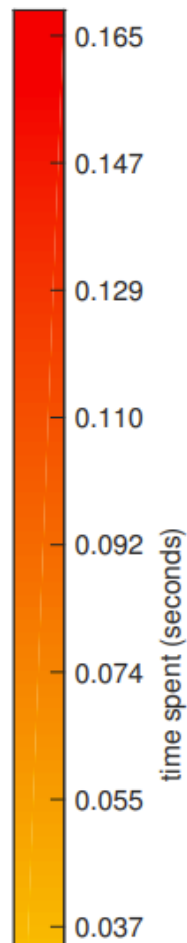
CTRL



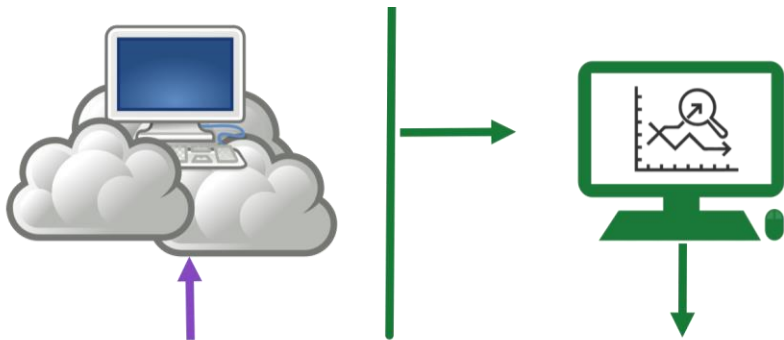
the eye-finger
connection (III)

- Autism Spectrum Disorder subjects vs controls

La prima obiezione che mi arriva è se raccontarle non possa generare emulazione . Che si tratti di resoconti giornalistici o di fiction , una parte di chi osserva finirà necessariamente per specchiarsi . E specchiarsi significa che non esiste emulazione possibile perché la strada intrapresa era già quella .



a text page as a
visual space

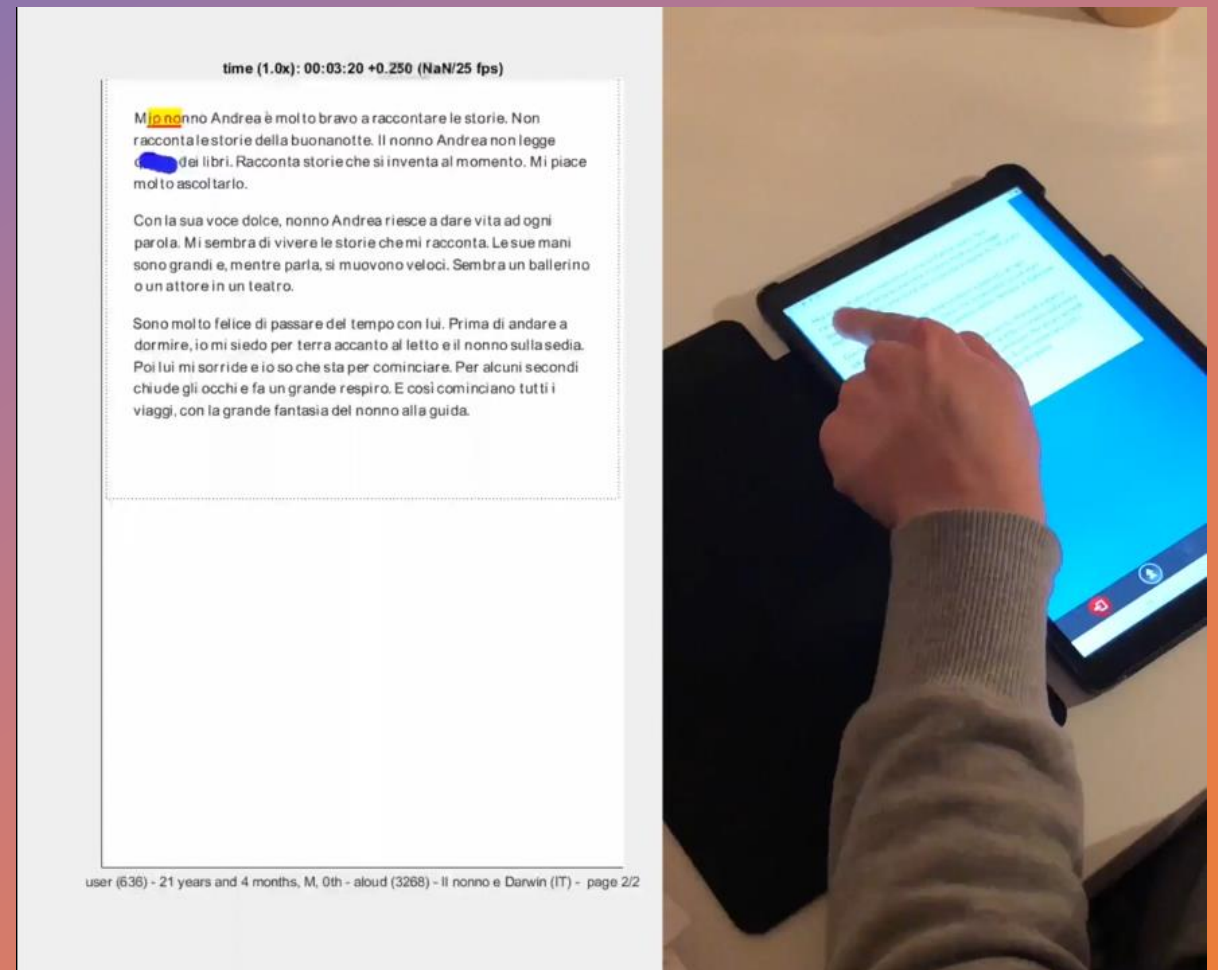


ReadLet

finger-tracking everywhere

- a reader can use a **tablet** as a *reading book*
- while reading (silently or aloud), the reader is asked to **underline the words** she's reading with the finger of her dominant hand
- **finger movements and voice** are *captured* by the tablet, encrypted and sent to a central server through an *Internet connection*
- data are post-processed, **time-aligned** with the text and the reader's voice and analyzed in terms of *direction, path, speed*

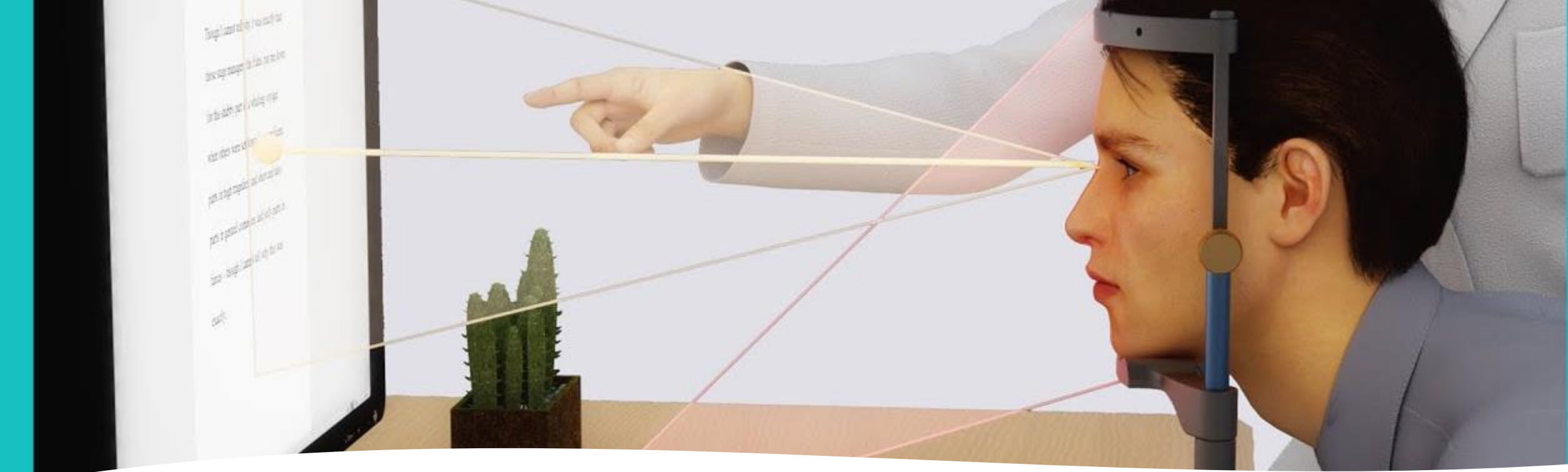
finger reading



finger-pointing reading

the finger as a
proxy of the eye?



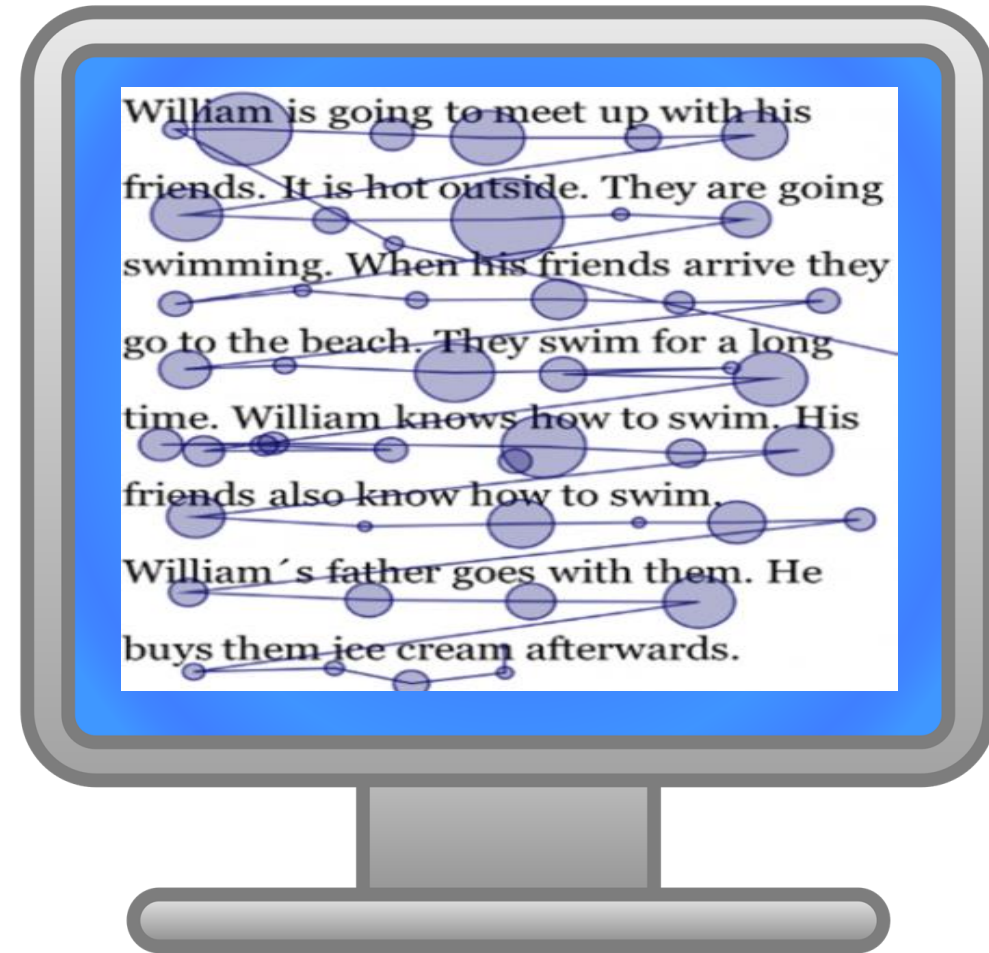


eye tracking technology

- eye position
- eye movement
- millisecond precision

eye reading

- discrete signal (saccade & fixations)
 - fixation duration
 - scanning path
 - fixation rate
 - skipping rate

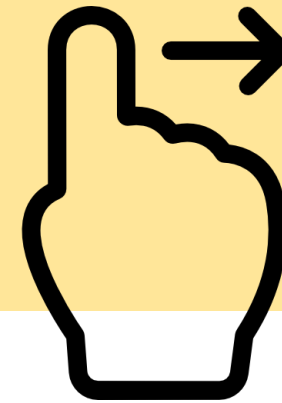


finger reading

- continuous signal (sliding movement)
 - tracking time
 - tracking path & direction
 - speed variation
 - (little skipping)



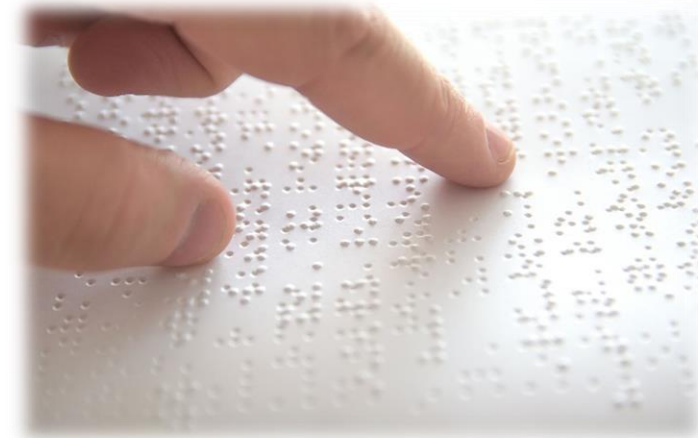
... Ziggy is an alien from a distant planet



finger movements in Braille reading

(Nonaka, Ito & Stoffregen, 2021)

- continual alternating phases of finger positive/negative acceleration punctuated by reversals of direction
- mean velocities and degree of intermittency are similar across forward and backward scanning movements
- *rate* of alternating (positive/negative) phases *increases* as the finger slows down



finger reading

time (1.0x): 00:03:20 +0.250 (NaN/25 fps)

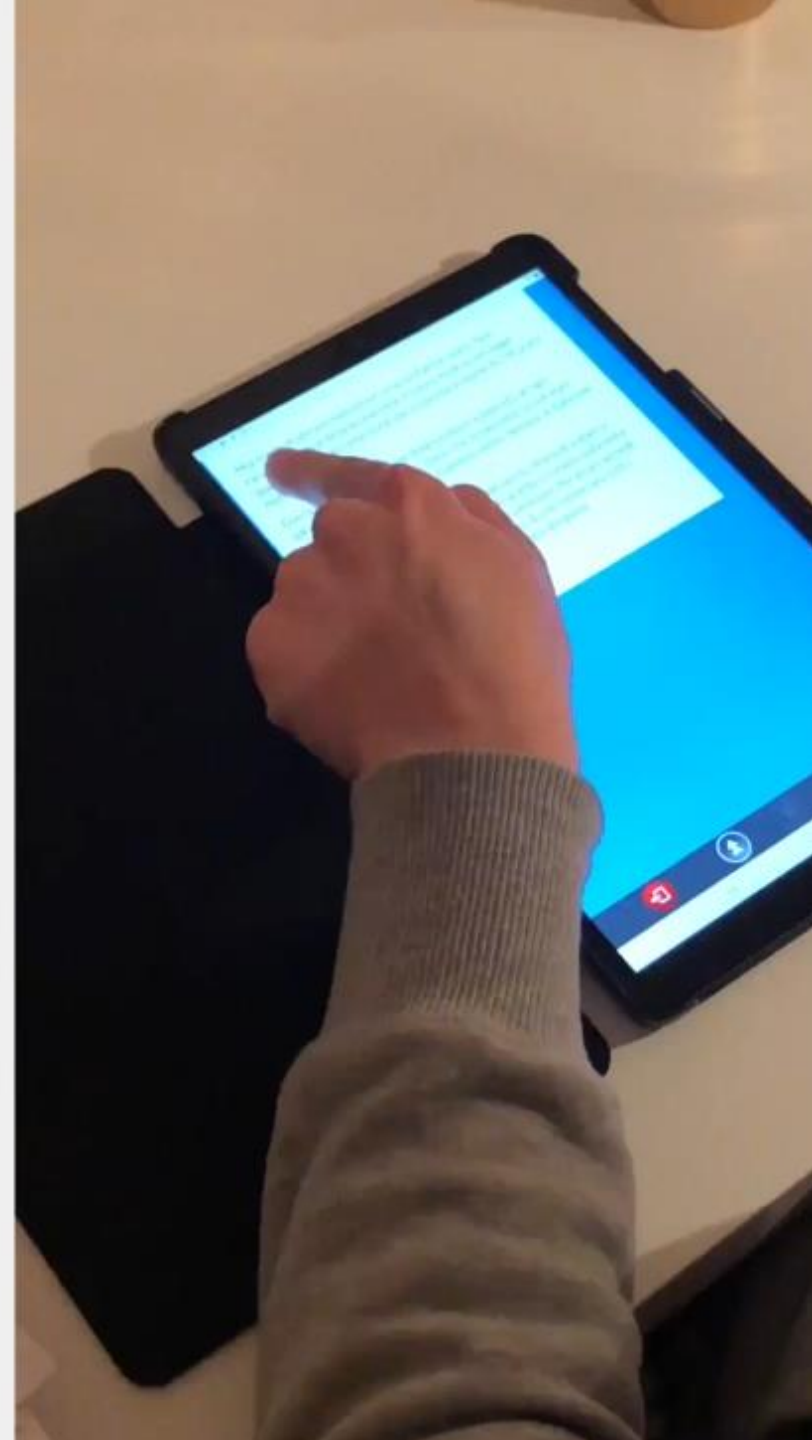
My nonno Andrea è molto bravo a raccontare le storie. Non racconta le storie della buonanotte. Il nonno Andrea non legge dei libri. Racconta storie che si inventa al momento. Mi piace molto ascoltarlo.

Con la sua voce dolce, nonno Andrea riesce a dare vita ad ogni parola. Mi sembra di vivere le storie che mi racconta. Le sue mani sono grandi e, mentre parla, si muovono veloci. Sembra un ballerino o un attore in un teatro.

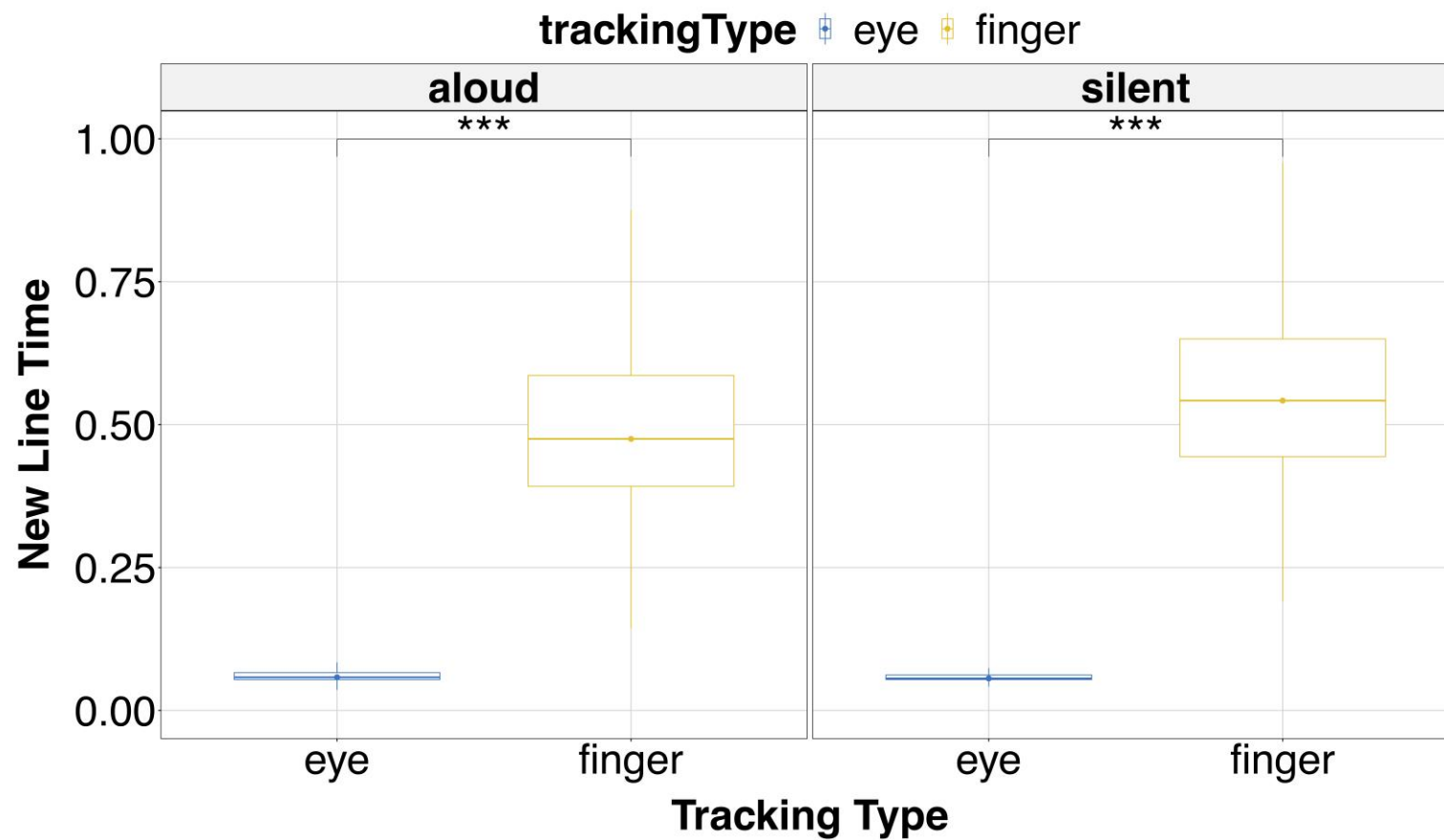
Sono molto felice di passare del tempo con lui. Prima di andare a dormire, io mi siedo per terra accanto al letto e il nonno sulla sedia. Poi lui mi sorride e io so che sta per cominciare. Per alcuni secondi chiude gli occhi e fa un grande respiro. E così cominciano tutti i viaggi, con la grande fantasia del nonno alla guida.

user (636) - 21 years and 4 months, M, 0th - aloud (3268) - Il nonno e Darwin (IT) - page 2/2

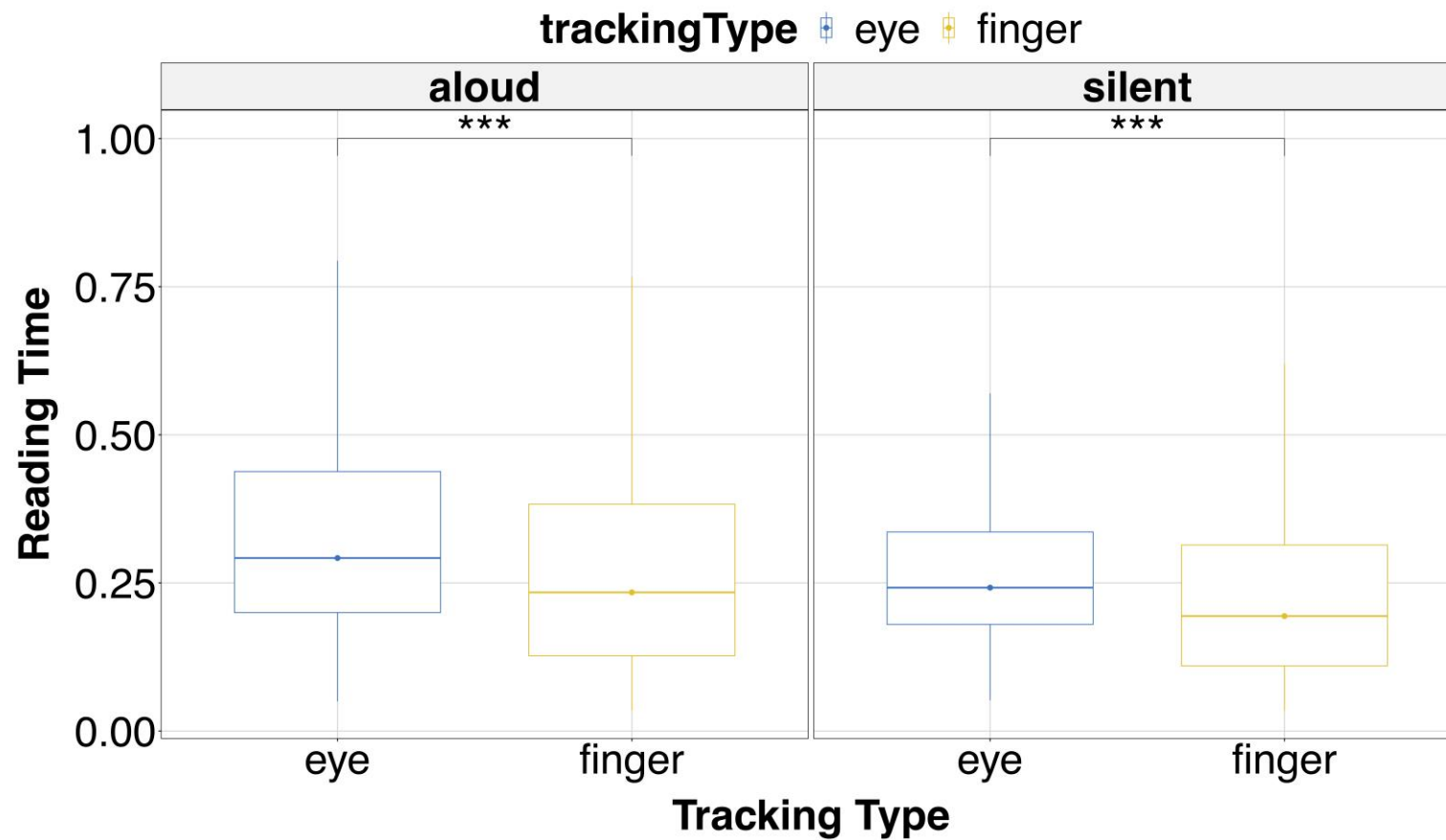
December 6 2023, Bulgarian Academy of Sciences, Sofia



skipping
to newline



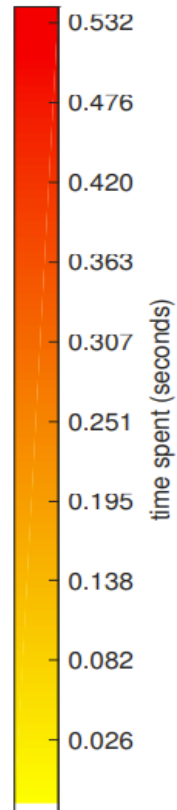
eye fixation >
finger tracking



The first objection that gets to me ...

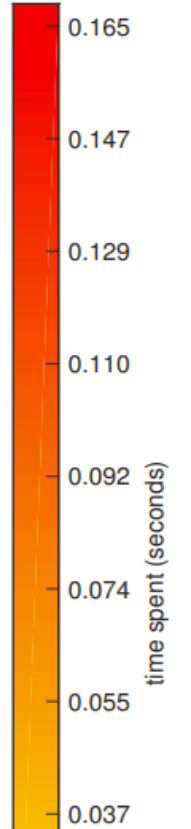
eye tracking

La prima obiezione che mi arriva è se raccontarle non possa generare emulazione. Che si tratti di resoconti giornalistici o di fiction, una parte di chi osserva finirà necessariamente per specchiarsi. E specchiarsi significa che non esiste emulazione possibile perché la strada intrapresa era già quella.



finger tracking

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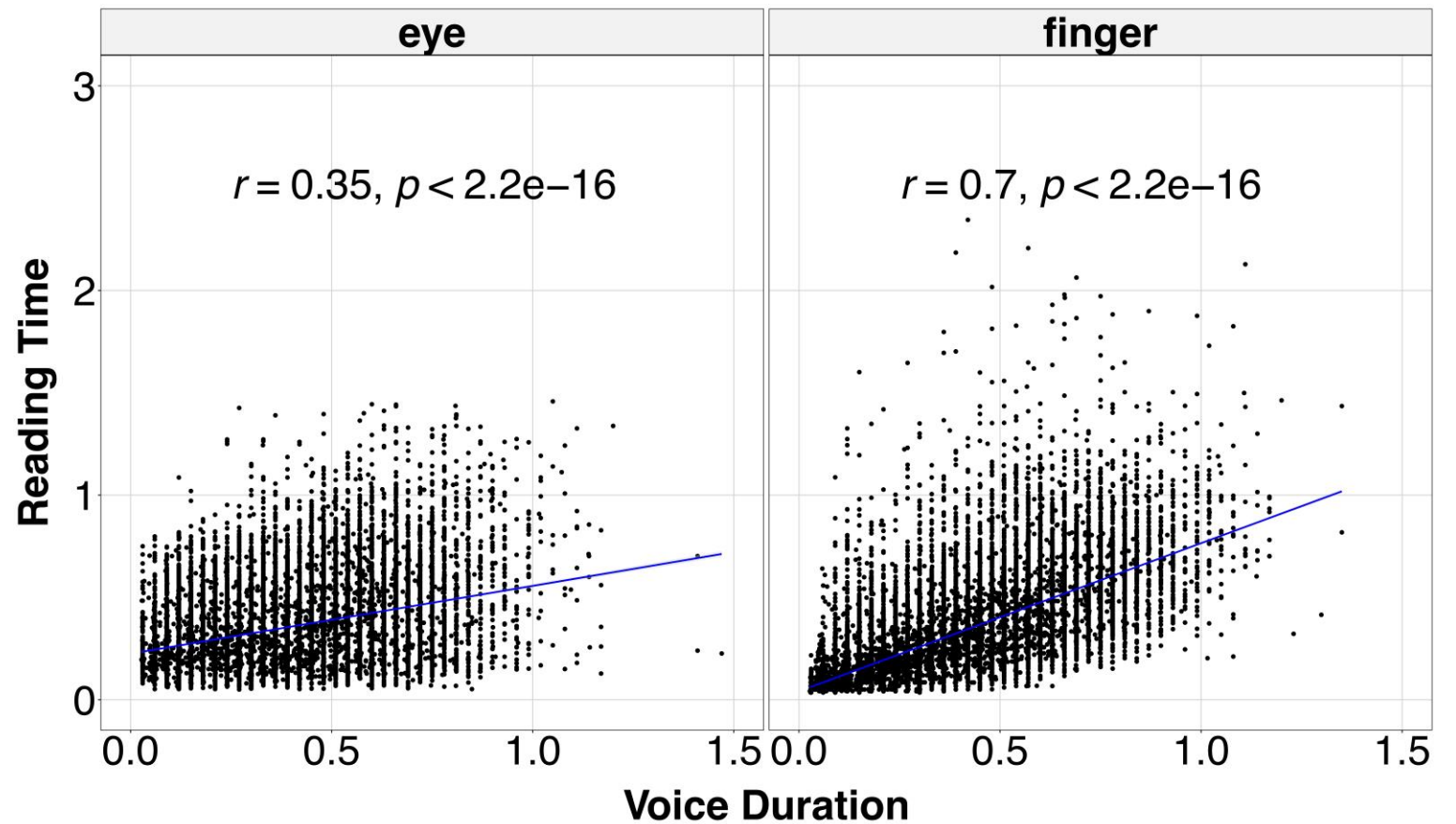
discrete vs. continuous

finger-pointing reading

the finger as a proxy
of the voice ...



correlation
with voice
rate



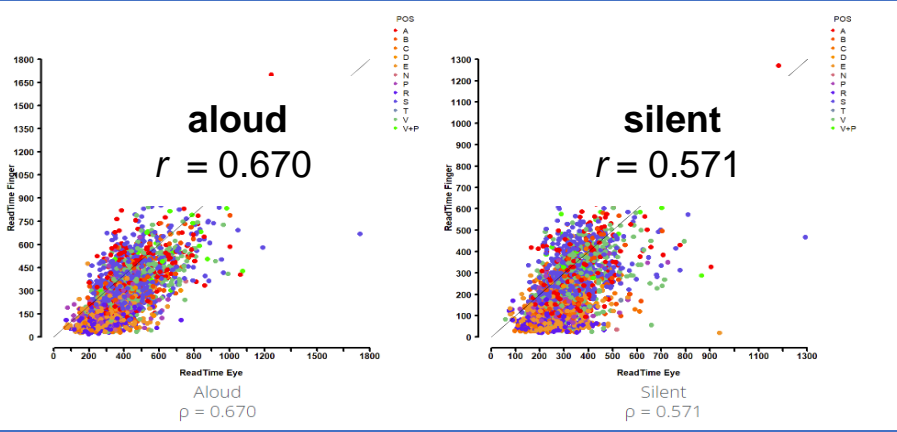
finger-pointing reading

... and the eye

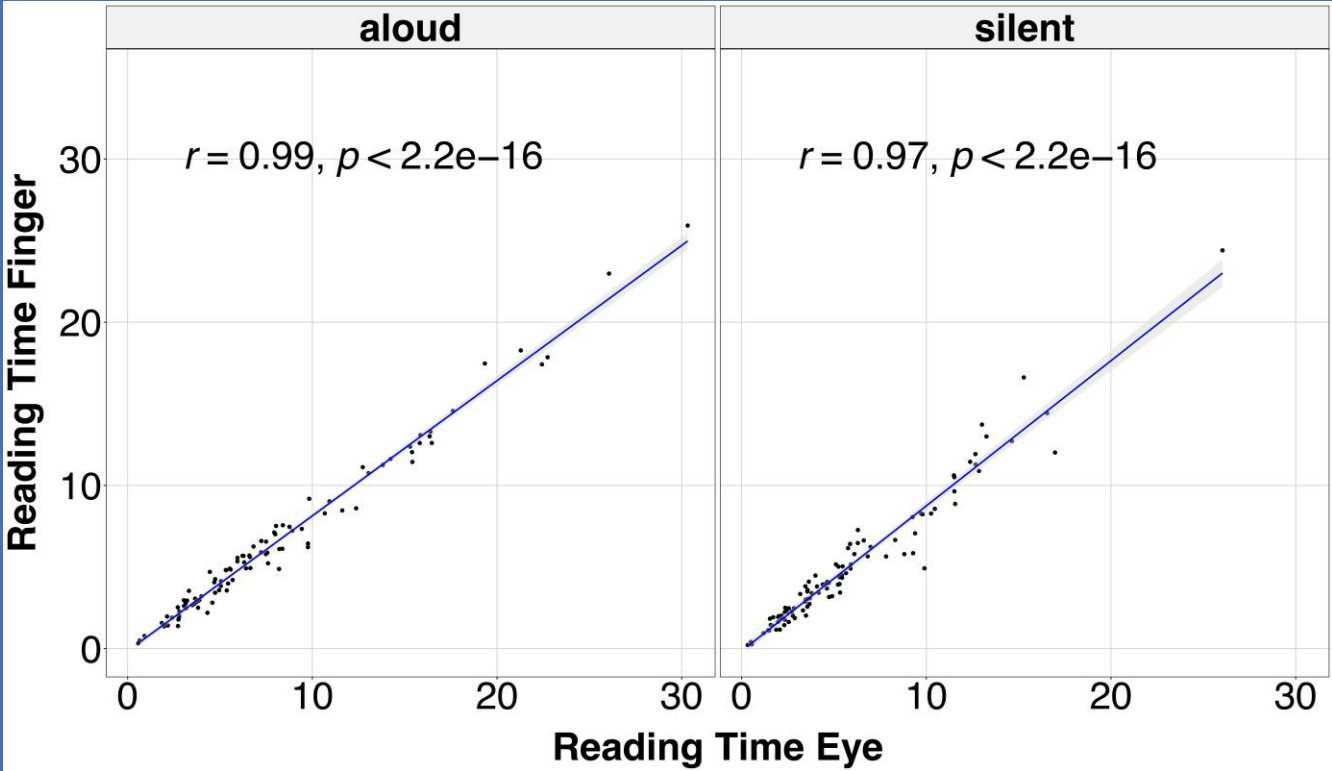


eye-finger correlation

words



sentences



finger-pointing reading

eye-voice span
finger-voice span



time (1.0x): 00:00:05 +0.079 / 00:04:22 (NaN/25 fps)

"Dance On A Volcano" dei Genesis è un brano potentissimo che predispone l'animo a cose straordinarie. È la colonna sonora «del capolavoro del genio Makko», come dice Diego Bianchi, andato in onda a Propaganda Live il 5 aprile scorso.

Piccoli filamenti neri, potrebbero essere peli di ratto o anche fuliggine, convergono verso un punto a formare uno strano animale nero. Sono milioni di filamenti e presto l'animale diventa enorme. Davanti a lui un ragazzino, Simone, più piccolo della bocca rossa e spaventosa della bestia, sta lì, fermo. Saldo. Attorno a lui gli anziani si accalcano e gli dicono: «Vieni via ragazzo, quella bestia nera, quando si forma, è invincibile. L'unica è far finta di non vederla, è aspettare che passi. Fidati, noi la conosciamo bene».

DECODING (CONV_v03)



time (1.0x): 00:00:00 +0.000 / 00:04:37 (NaN/25 fps)

DECODING (WARPai_v01)

Per conoscere la storia di un paese non basta studiare quella delle sue istituzioni, ma è necessario anche sondare la parte sommersa, scavare tra gli atti giudiziari e cercare di venirne a capo. Le organizzazioni criminali sono consorzi criminal-imprenditoriali che non hanno sofferto la crisi economica, basando il loro core business sul monopolio del traffico di stupefacenti. Con i proventi di quello invadono ogni altro settore. Non raccontare questo meccanismo e non raccontare i protagonisti significa conoscere la storia a metà. Ecco perché ho deciso di portare in televisione le biografie dei boss.

La prima obiezione che mi arriva è se raccontarle non possa generare emulazione. Che si tratti di resoconti giornalistici o di fiction, una parte di chi osserva finirà necessariamente per specchiarsi. E specchiarsi significa che non esiste emulazione possibile perché la strada intrapresa era già quella.

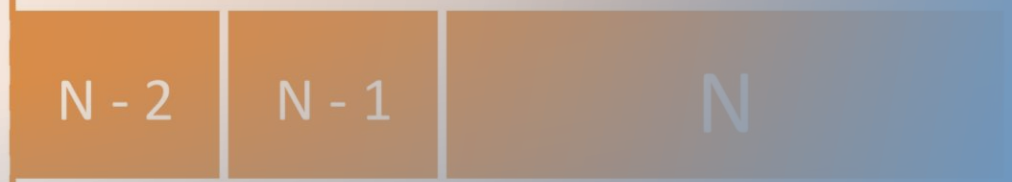
user (659) - 28 years and 2 months, F, 21st - aloud (2010, EYETRACKER) - Perché e come intervistare i boss - Elogio della parola (IT)
ep. #1/2 (eid = 0), page #2/6 (gid = 1)



saccade



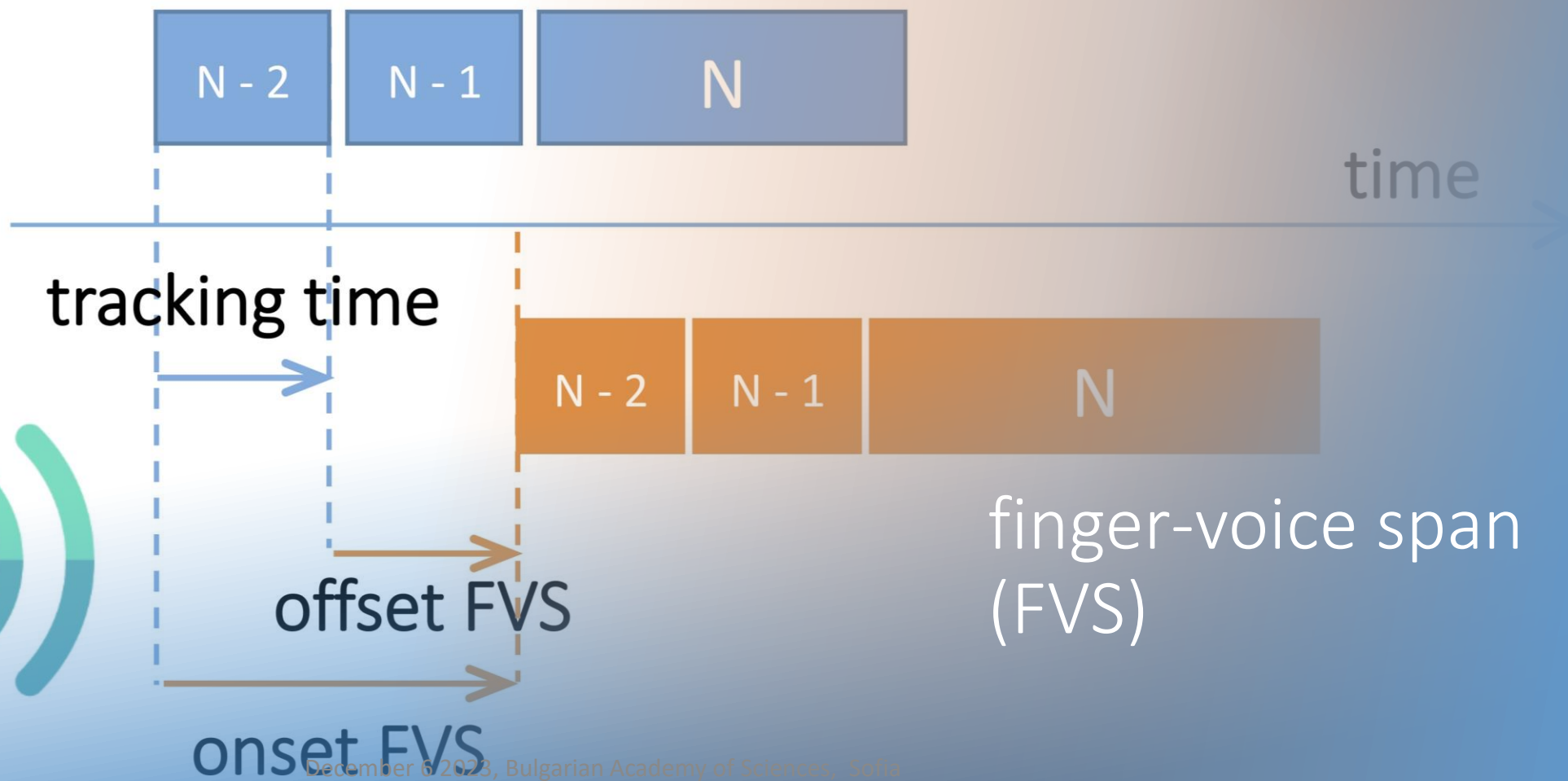
gaze time

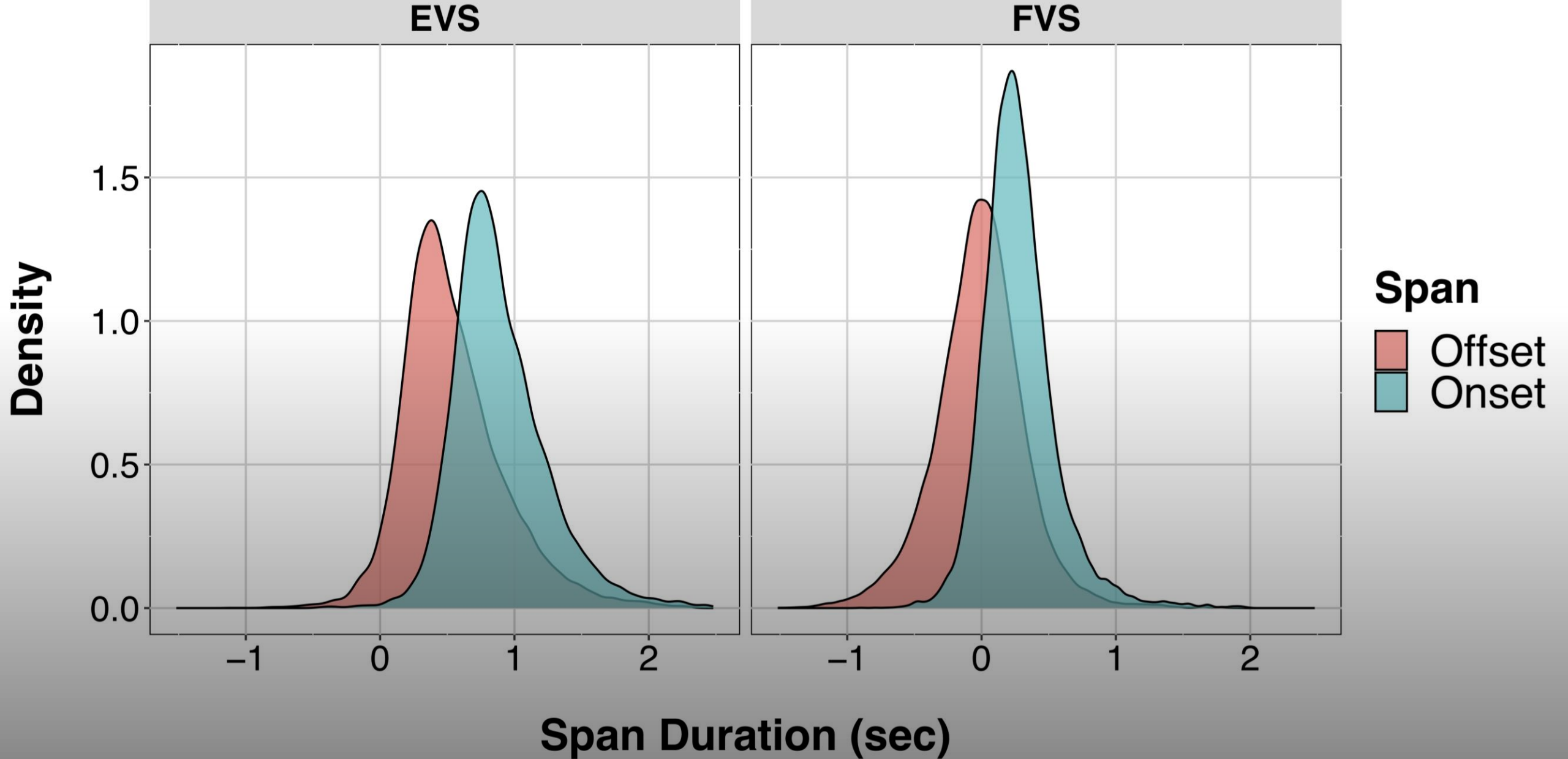


eye-voice span (EVS)

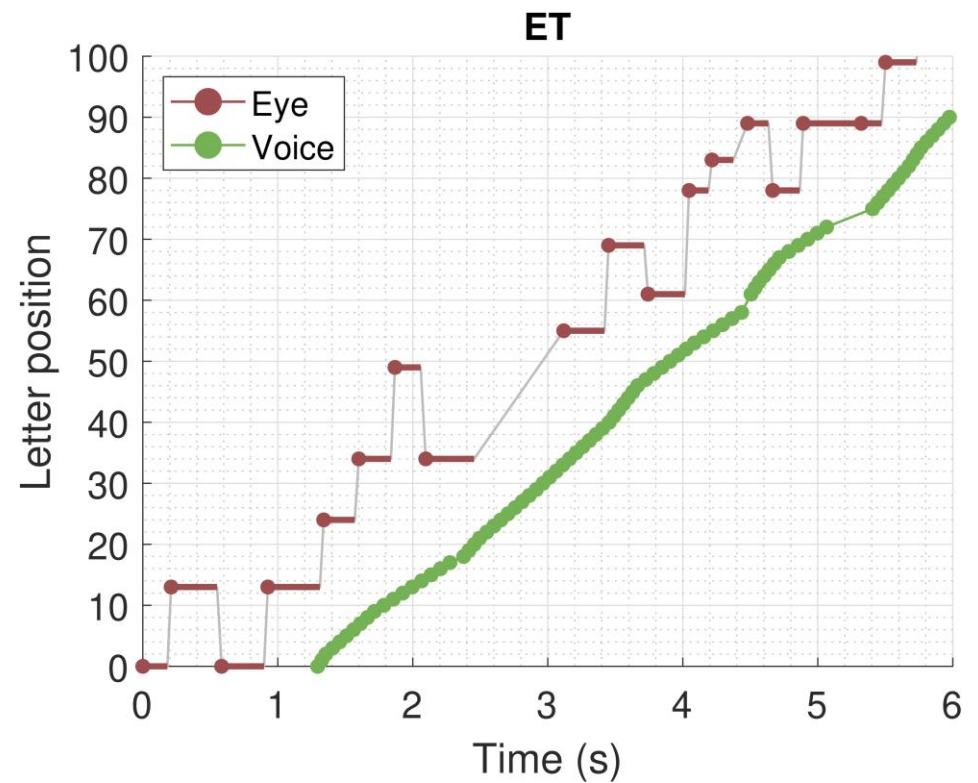
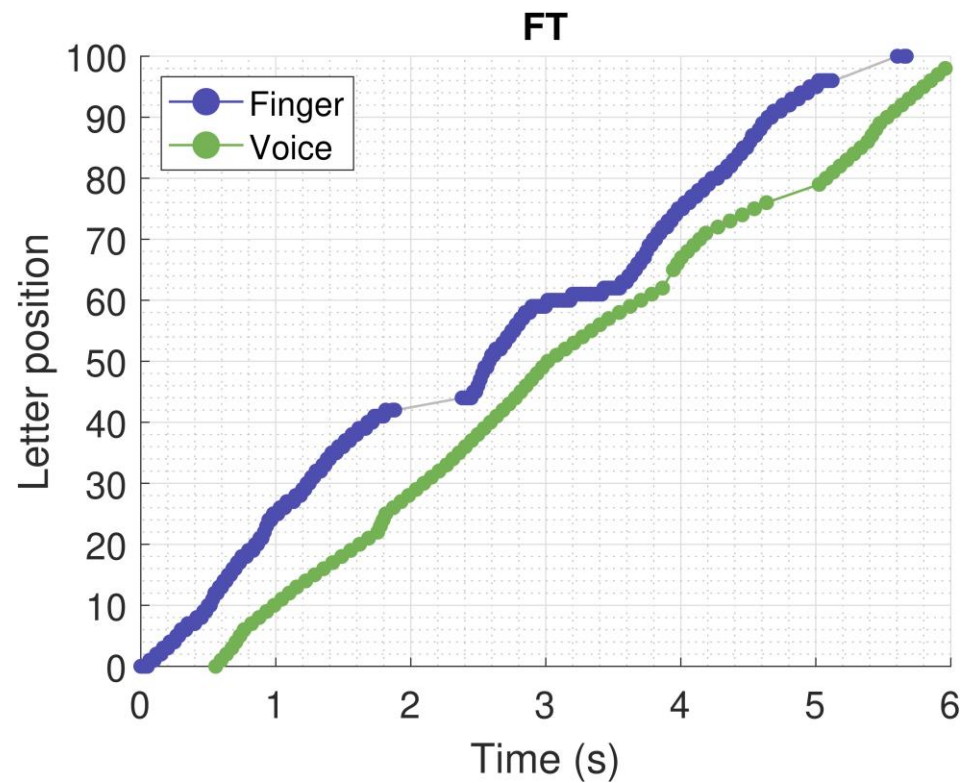
offset EVS

onset EVS

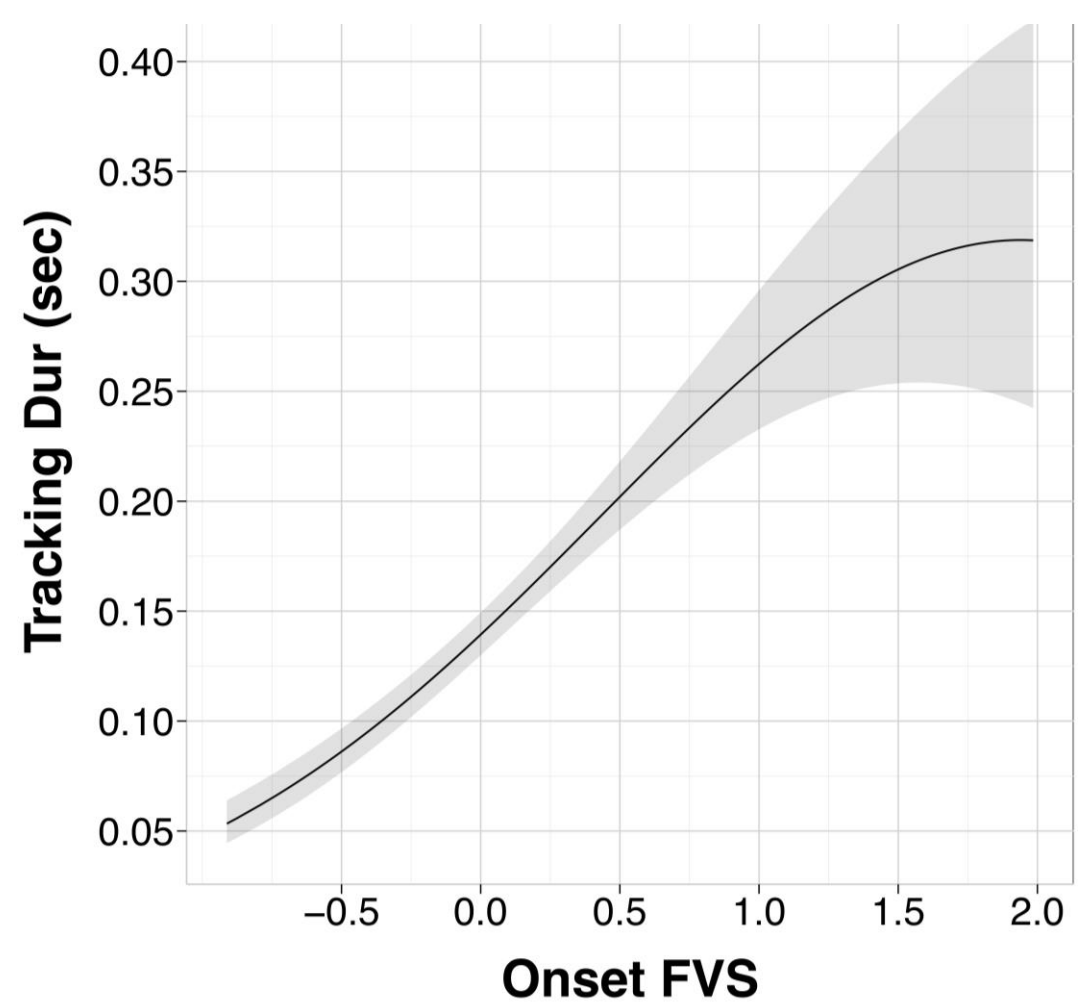
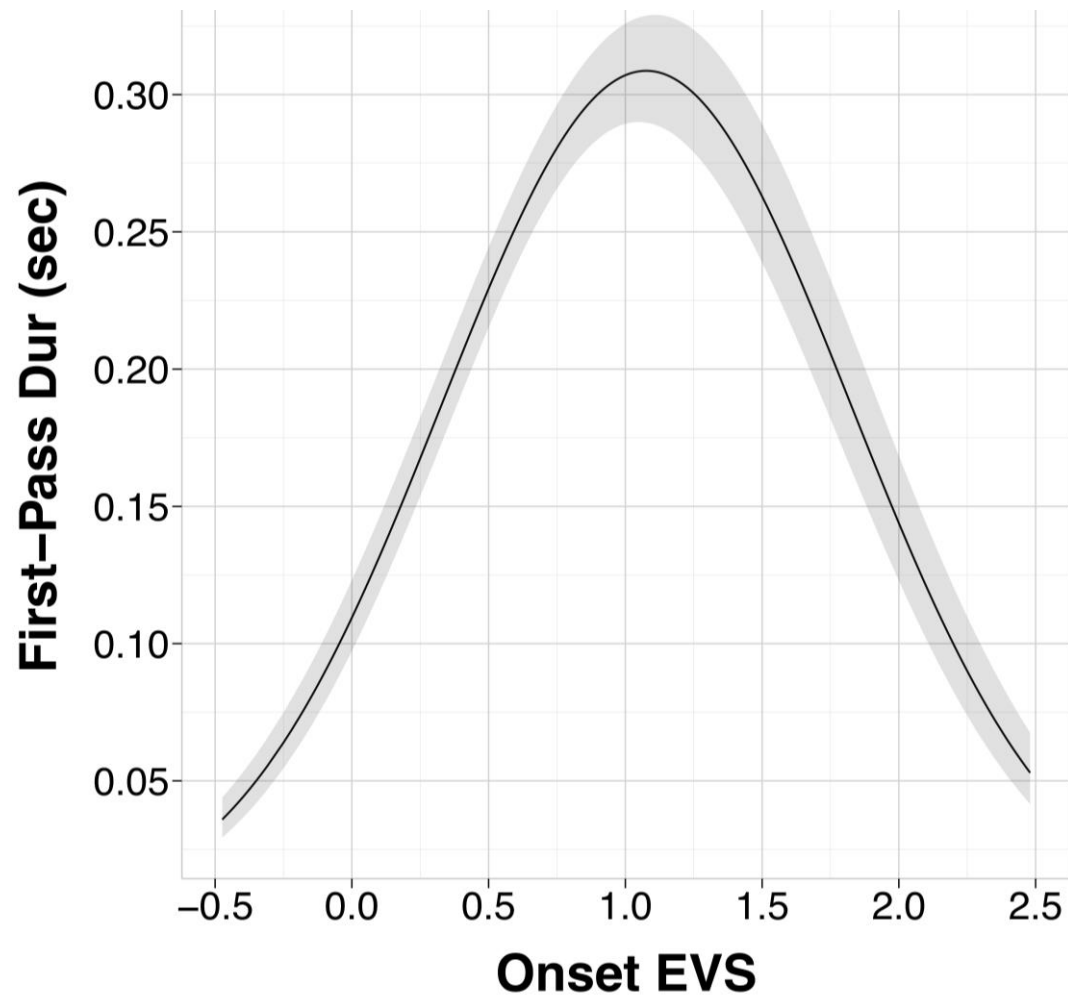




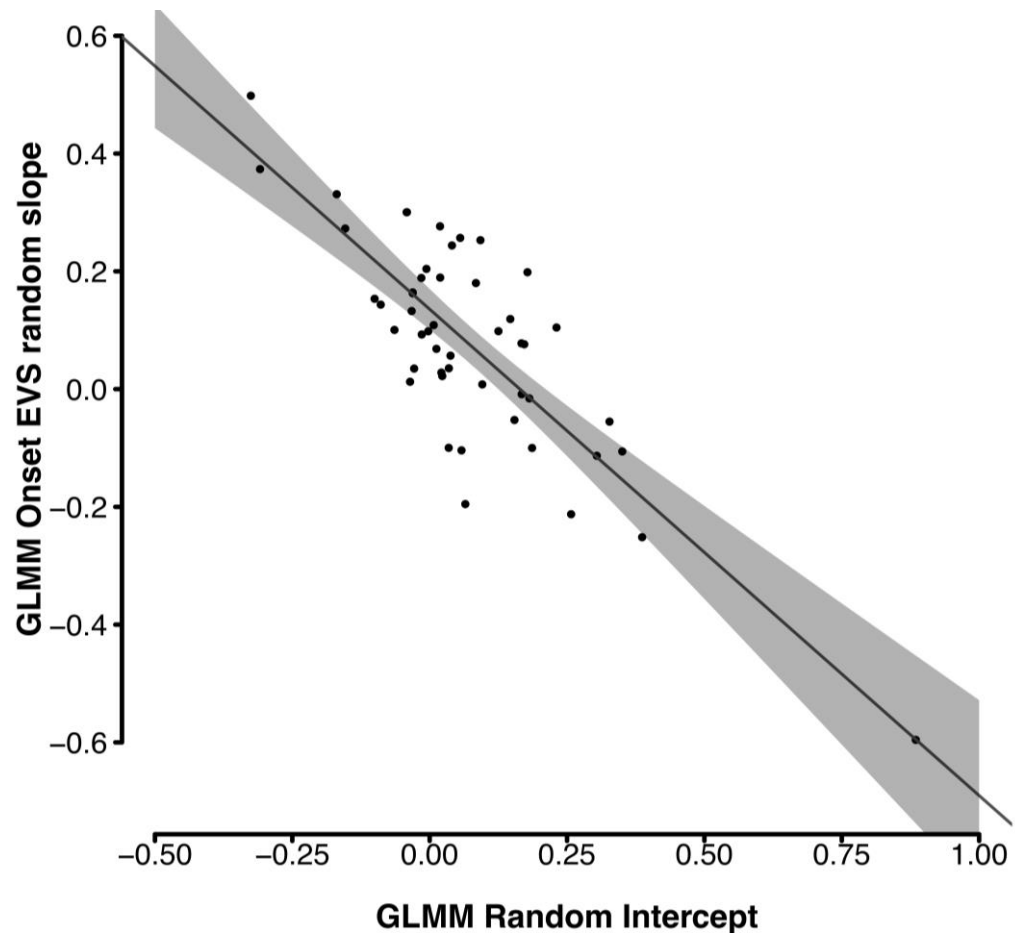
density distribution for EVS and FVS



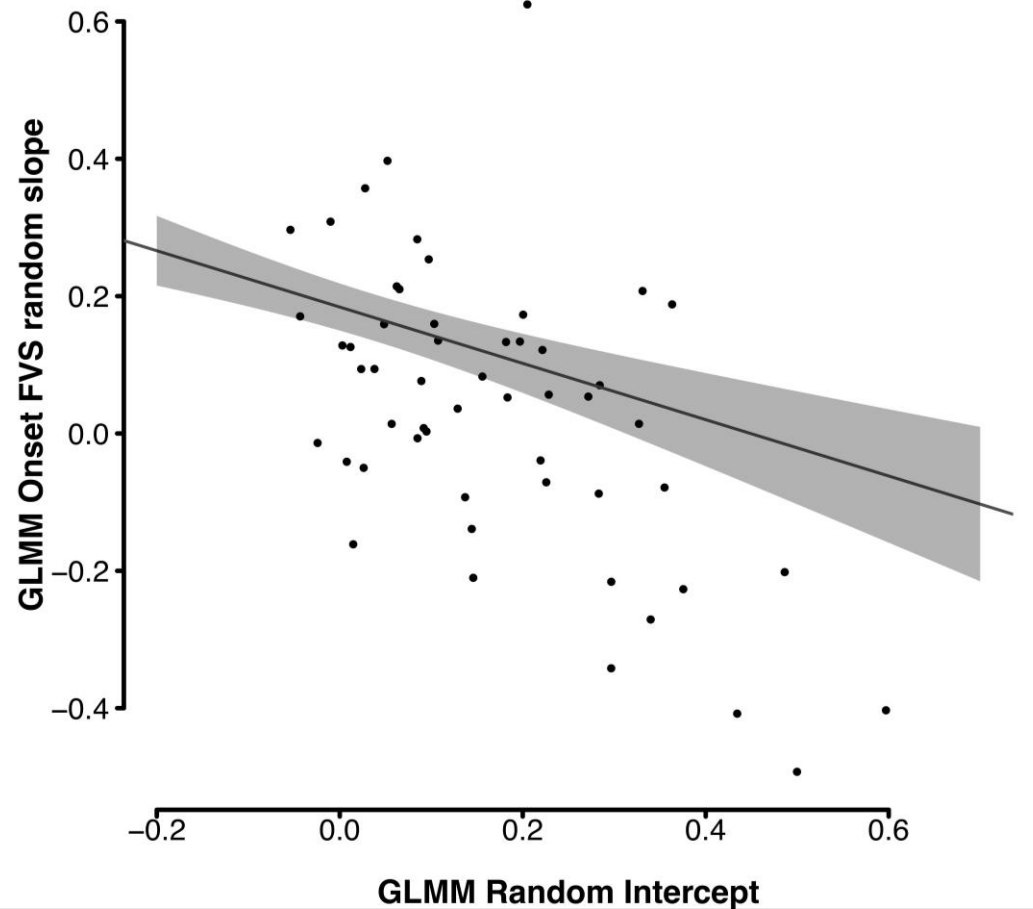
voice, finger and eye movements



the voice span affects tracking duration



eye



finger

fixation and tracking times as a function of articulation rate

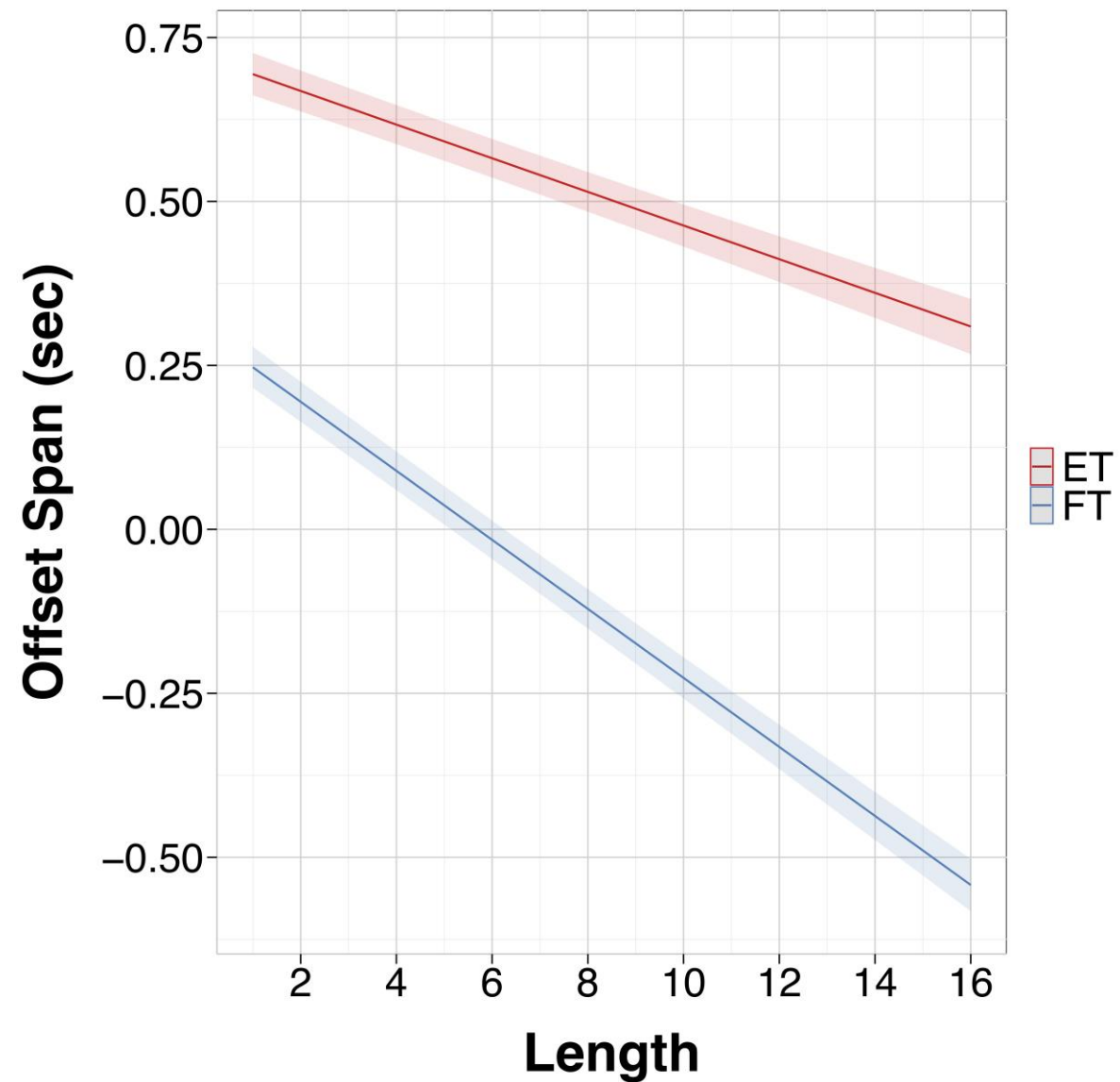
finger-pointing reading

what modulates
the voice span?

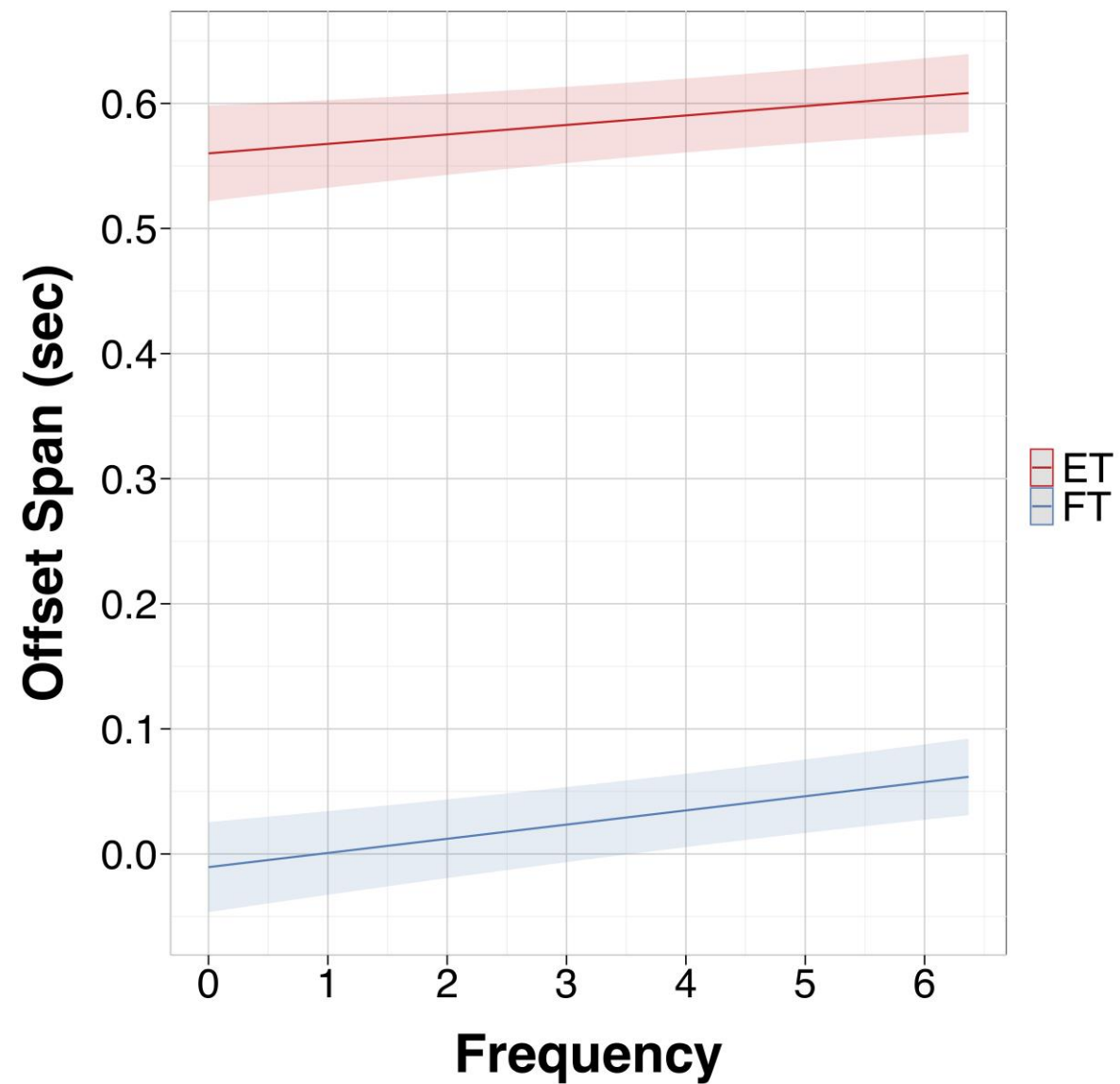


buffer capacity

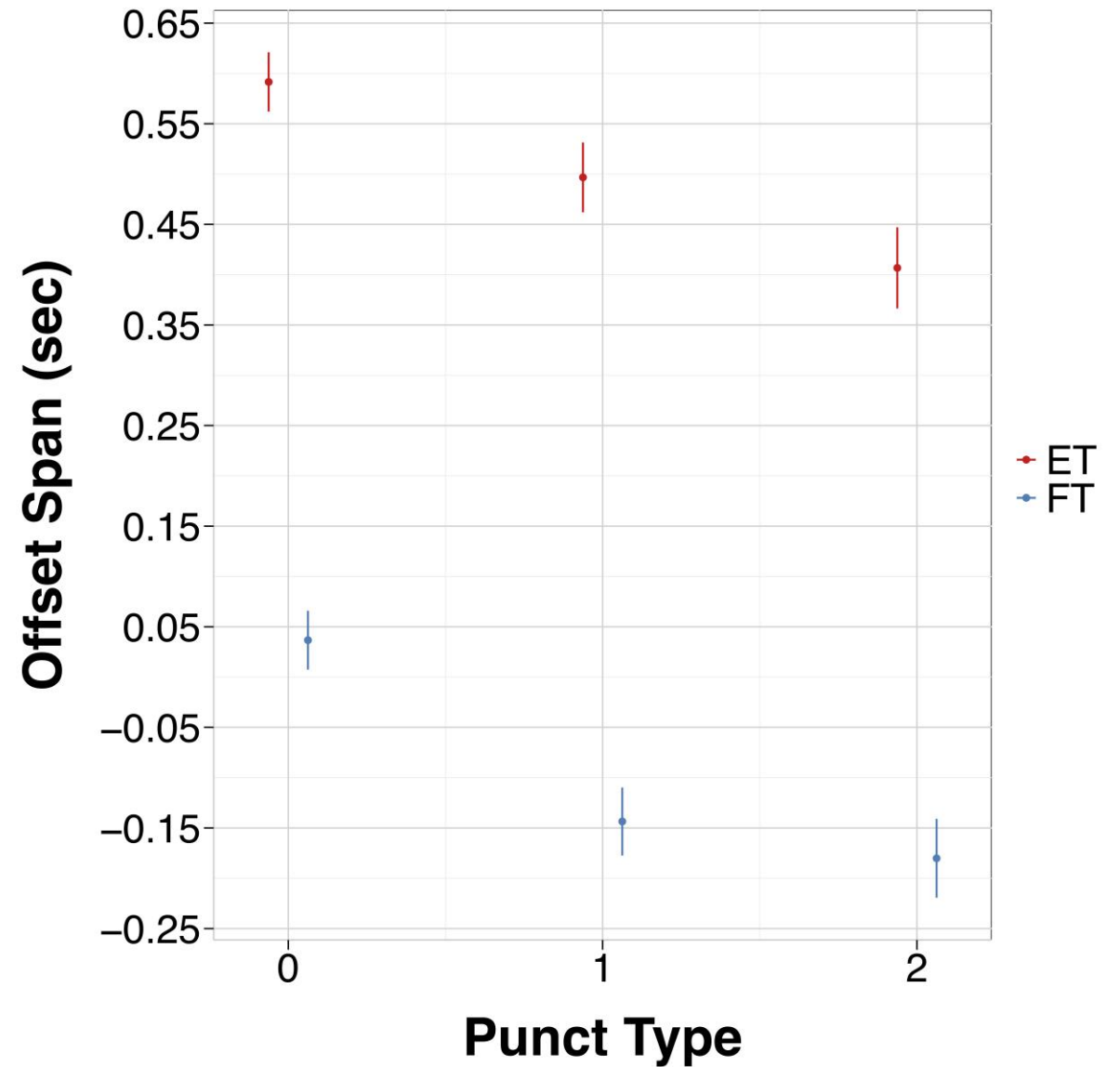
offset span ~
(length + frequency + punctType) * trackMode + (1| token) + (1| subject)



automaticity



implicit prosody



finger-pointing reading

what about
multi-word chunks?



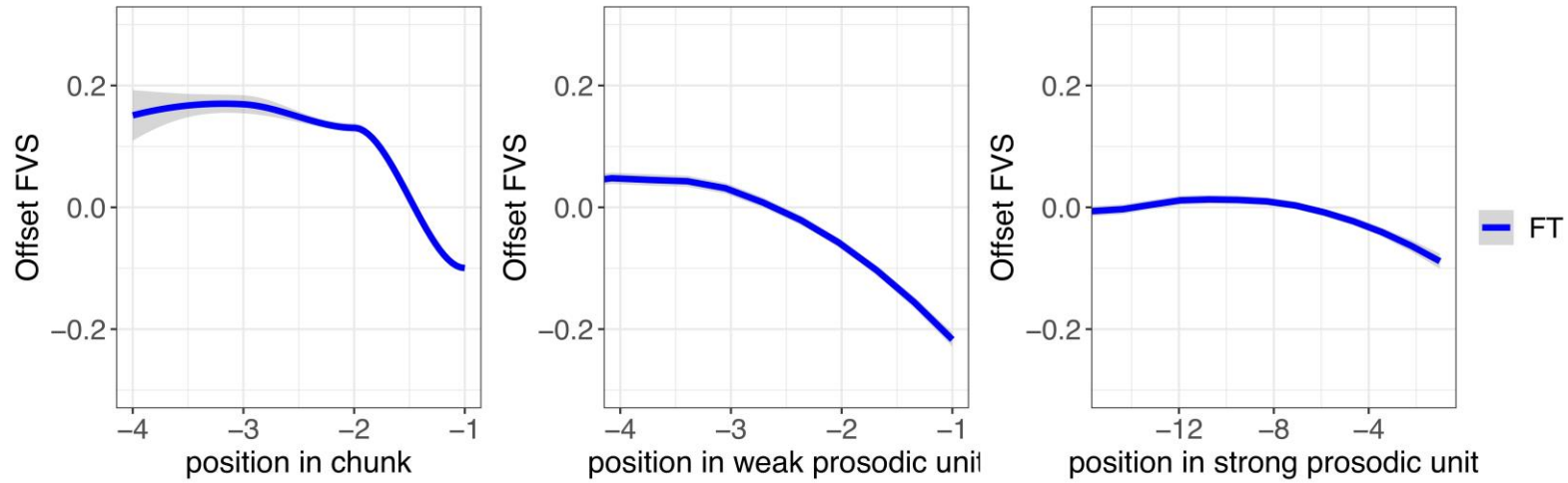
chunking: a
non-recursive
level of phrasal
constituency

the black cat

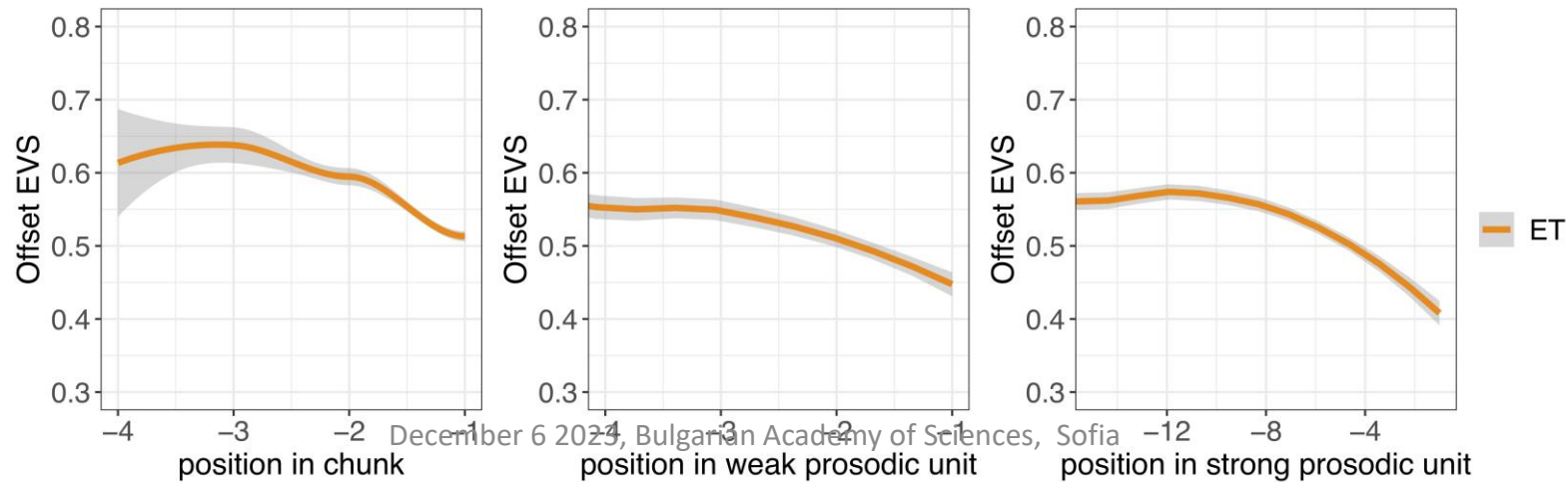
of my eldest daughter

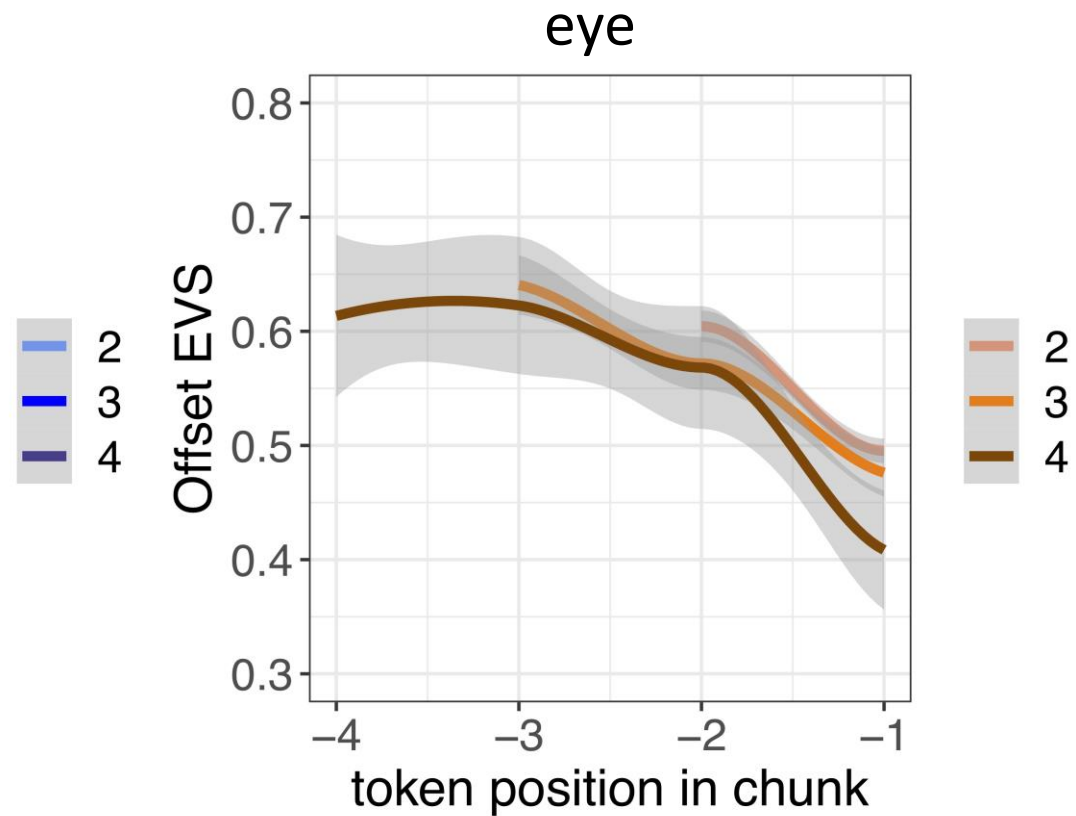
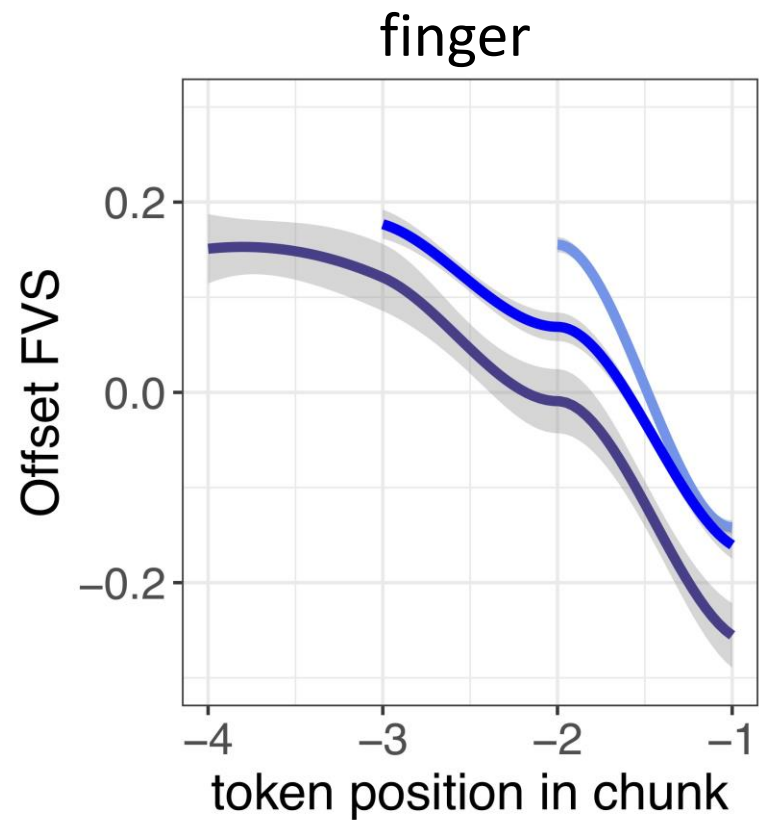
offset span at token position within chunk

finger



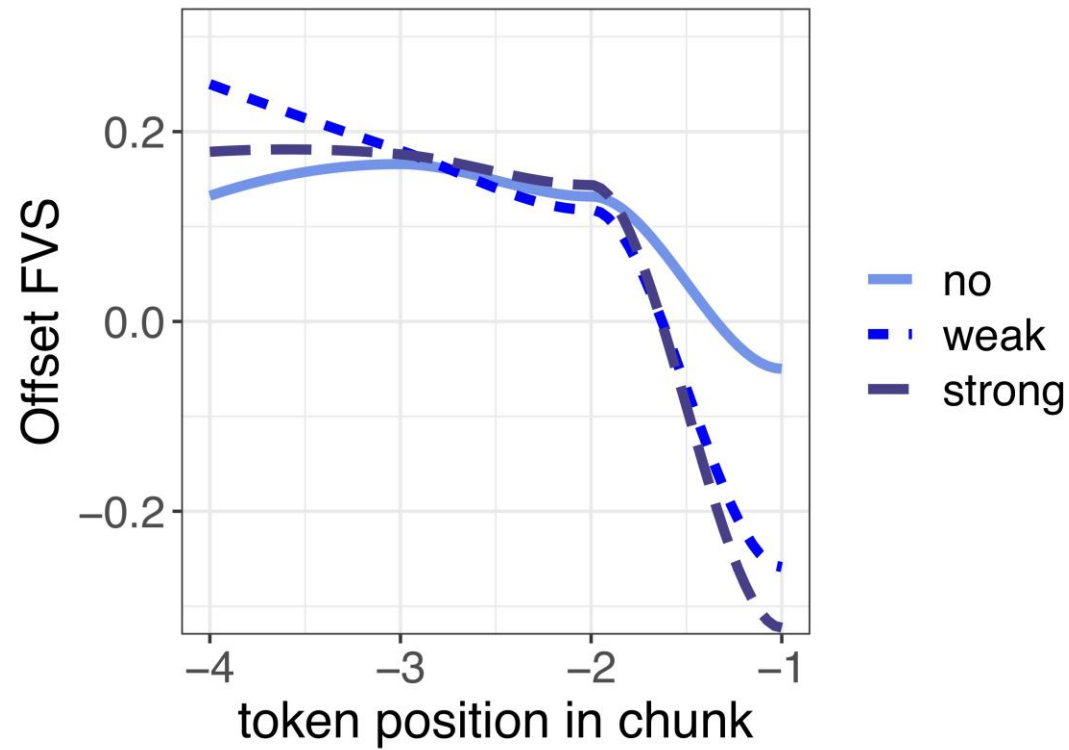
eye



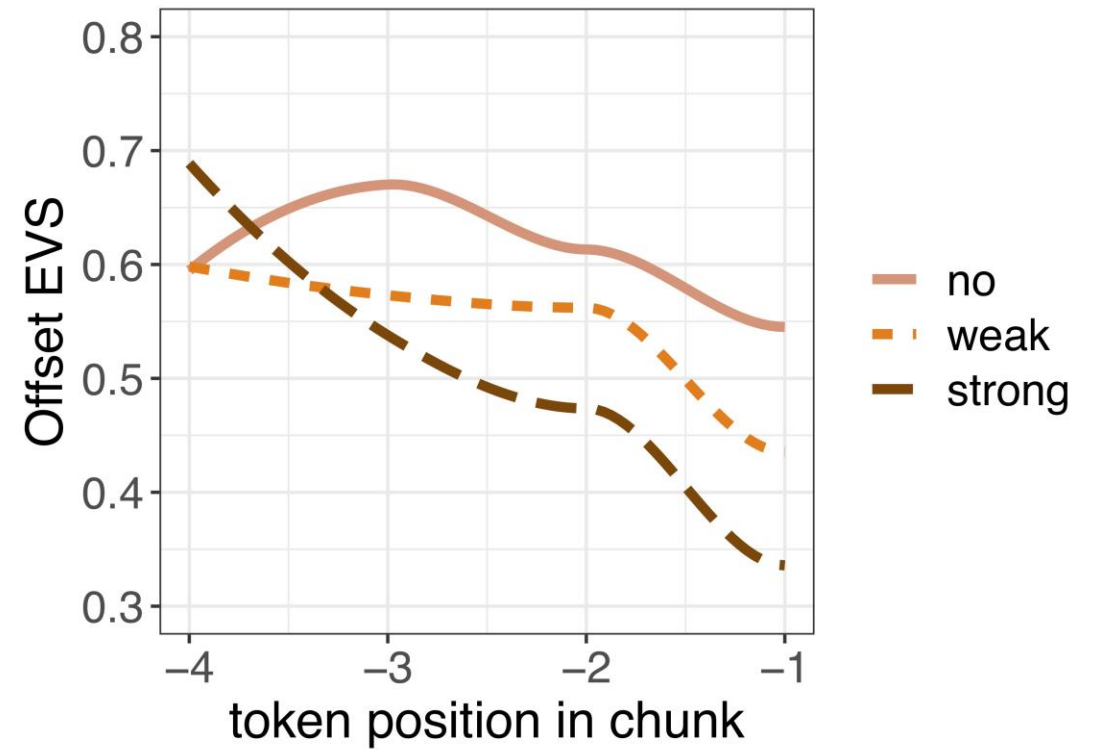


offset span for chunks of different length

finger

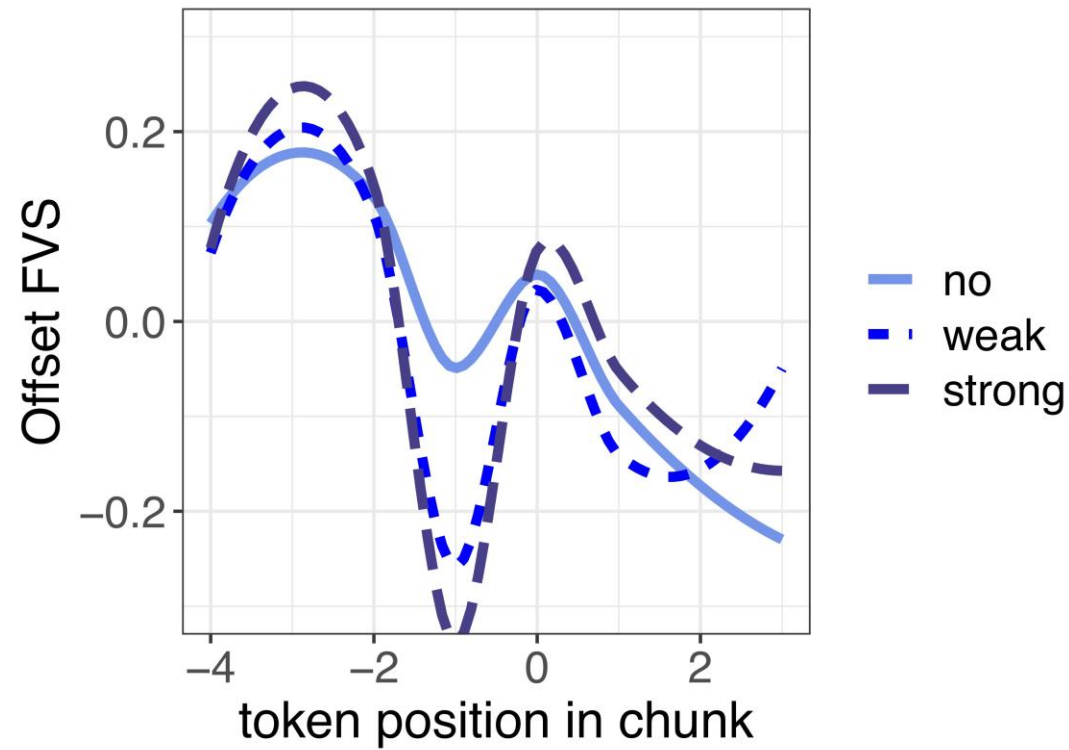


eye

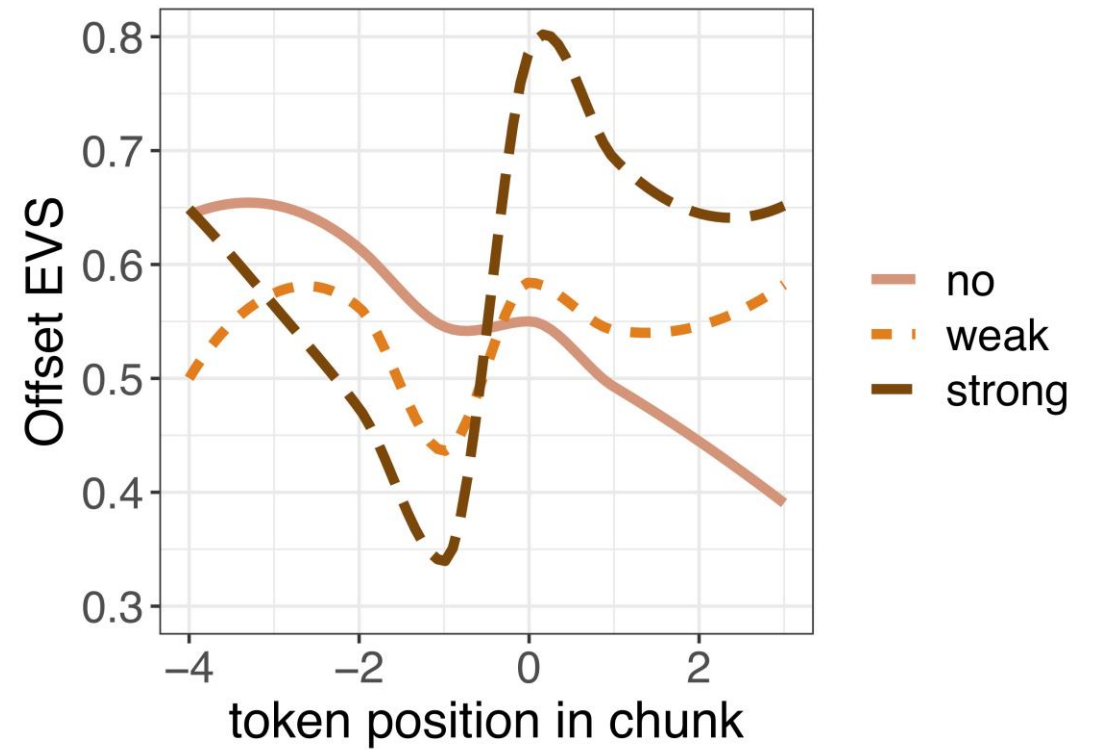


prosodic effects

finger

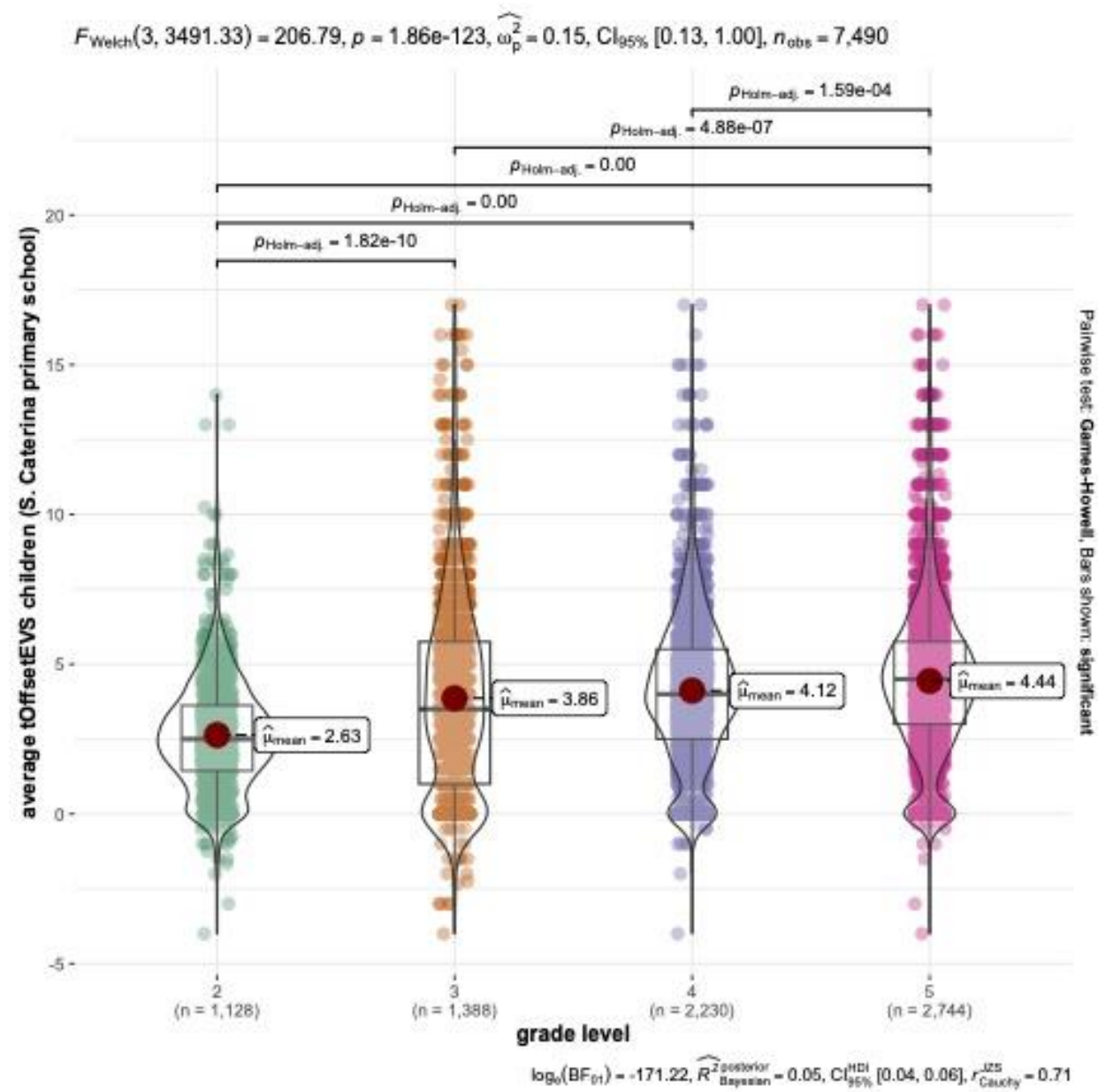


eye



across boundary effects

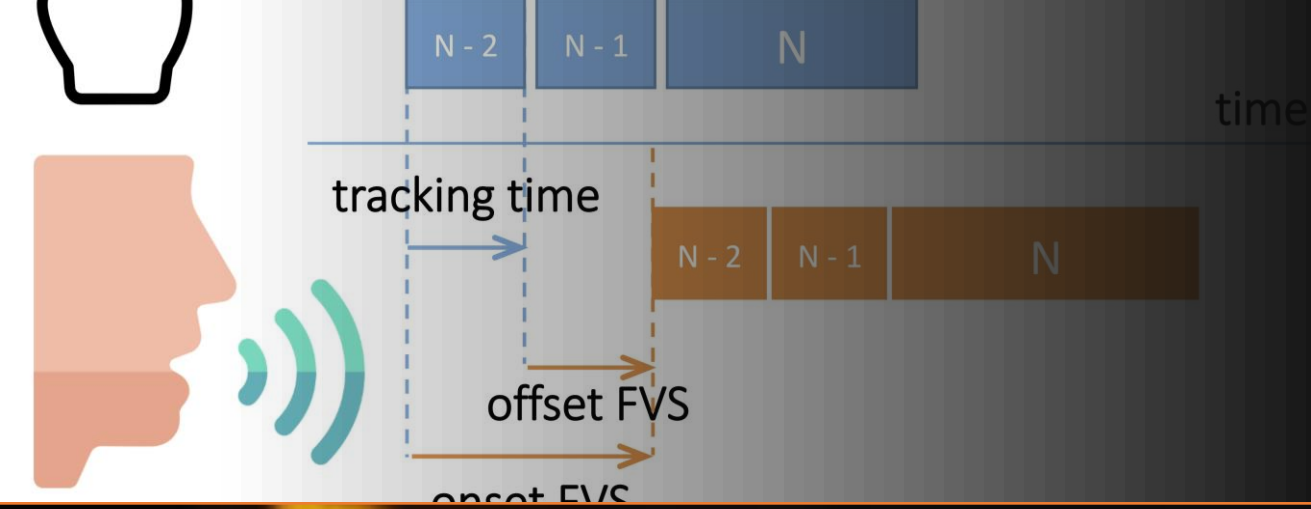
... and children?





concluding remarks

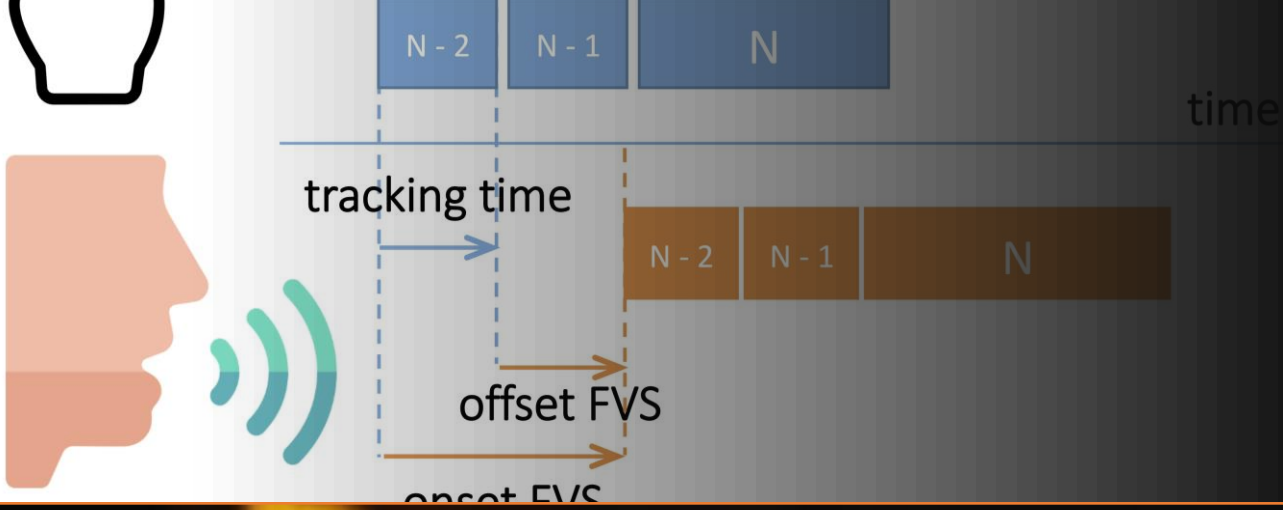




voice spans & reading proficiency

- the voice span varies across subjects depending on their **articulation rate** and **memory buffer**
- it also varies within the same reader, as it tends to **get larger** when the text contains **larger intonational** and **structural units**
- it is modulated differently depending on tracking mode: **the eye** is sensitive to **larger text units**, **the finger** to **smaller ones**





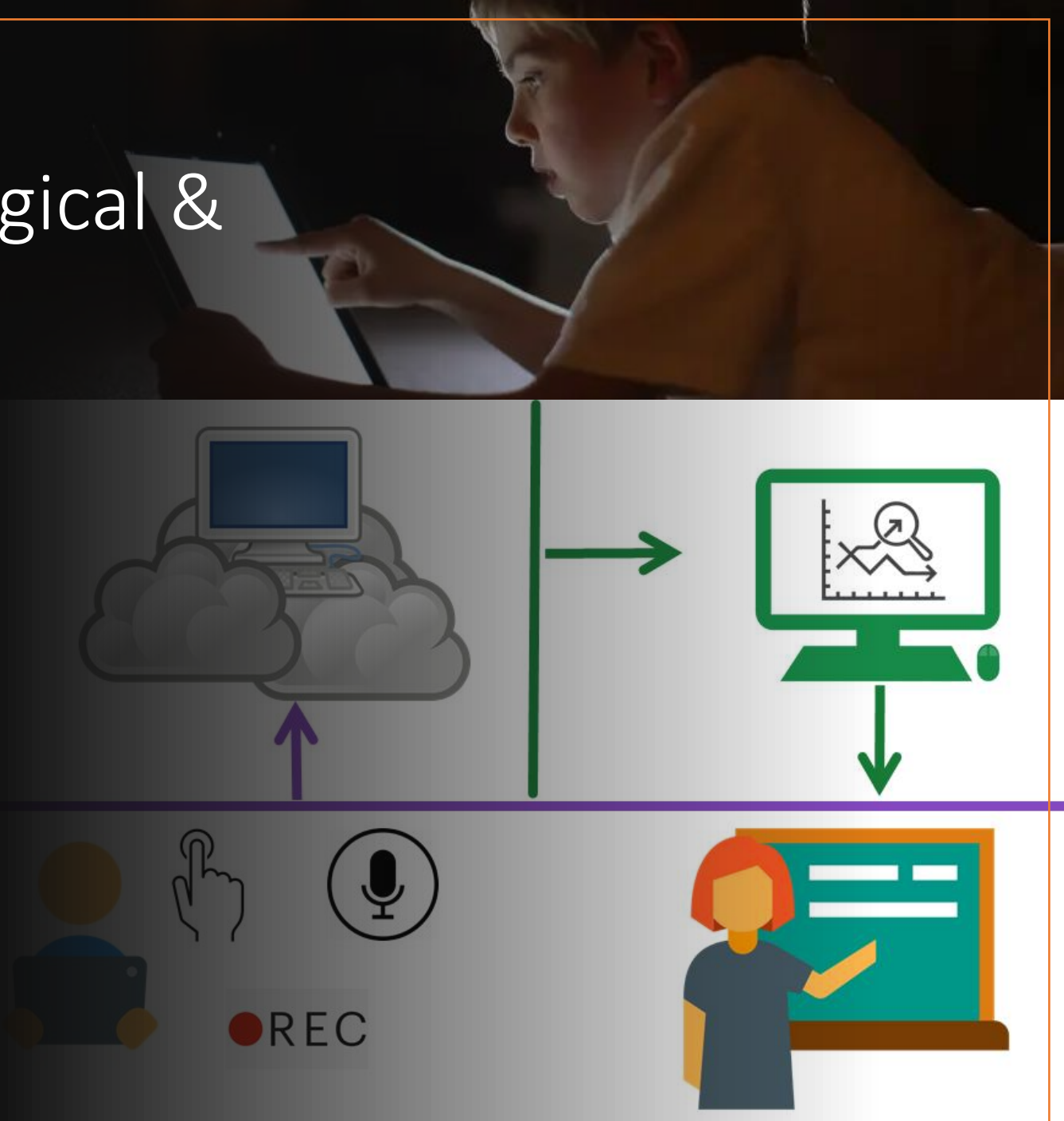
voice spans & reading proficiency

- proficient readers appear to adopt an **optimally adaptive reading strategy**, whereby they can adjust their **reading rate** and **memory buffer** to the **complexity** of a text



ReadLet: simple, ecological & powerful!

- simple, noiseless and cheap, finger tracking offers ways of monitoring **reading at scale**, using a **simple tablet** for ecological reading tasks
- its fine-grained, time-bound information can profile reading skills at both the **population and individual level**, shedding light on both **on-line and off-line** processing issues
- it can offer unprecedented opportunities for reliable, efficient and noninvasive **screening** of reading skills in **developing readers**





thanks!

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