How Children Inspect Visual Information During Language Comprehension

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Statistics & Data Science

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100 1915-2015 PSYCHOLOGY

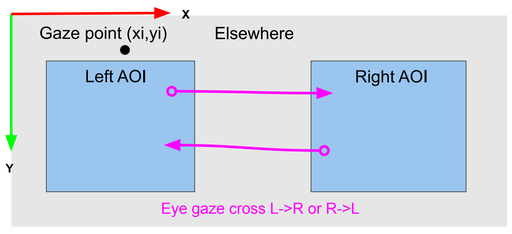
Background and Introduction

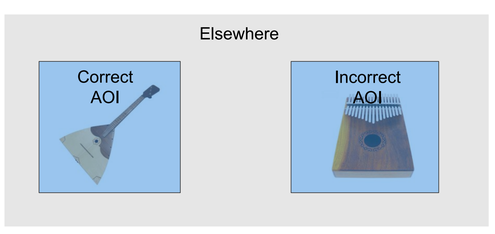
- Does how children process visual information in images depend on image content and external stimuli? To determine this, one of our project advisors (Dr. Vales) carried out a study in which 60 children ages 4-7 watched videos showing two novel objects while pre-recorded messages were played; each message corresponded to one of the objects. The children ultimately were asked to select one object that corresponds to the referent object in the message.
- In this poster, we use eye-tracking data from the study to explore relationships between the novel object type and children's' reactions before and after an external stimuli, as well as how various factors contribute to children's final decisions.

Data Preprocessing and Feature Engineering

- The initial data frame has 1.5 million rows and 155 columns.
- There are 60 participants, each watched about 18 videos.
- Eye-gaze data is summarized by defining areas of interest (AOI), at any given time the children are looking at correct object, incorrect object, neither, or no data.
- AOI were also separated into correct/incorrect AOI defined according to the active AOI and correct response for trial.
- We further subdivide the data into two phases based on when particular information regarding language comprehension is read to the children.

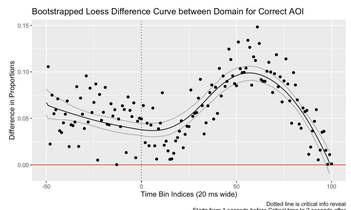
Category	Variable	Description
Passages	Length	Length of the passage (s)
	Critical information period	When the critical information of the passage starts & ends (s)
	Domain	Domain of the two objects in the passage (animal/instrument)
Eye Movement	Correct AOI, Incorrect AOI, elsewhere	Gaze point falls inside the AOI for the correct/incorrect object, or elsewhere on the screen
	Recording Timestamp	Internal clock from eye tracker (ms), t=0 is start of first trial
	Time spent on Correct/Incorrect AOI	Number of hits on correct/incorrect AOI over a time window
	Prop Correct/Incorrect AOI	Proportion of hits on correct /incorrect AOI over a time window
	Number of crosses	Number of time two consecutive gazes cross between two AOIs
Behavioral Response	Correctness of Response	Whether the child chooses the correct referent object
Demographics	Age	Age of the participant
	Gender	Female or male

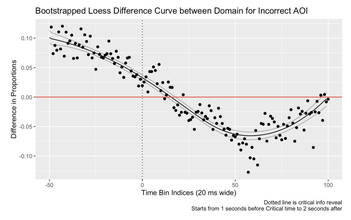




Analysis and Results

Differences between Fixation Time
For each domain, the proportion of children looking at the correct/incorrect AOI was calculated for every time bin, 20 ms, starting 1s before critical phase to 2s after. Then the difference between the domains were calculated. These difference points were then subject to nonparametric bootstrapping via resampling cases. The bootstrapping estimates the difference of fixation averages between the domains in the population along with its variation. The result was that the difference curve for the correct AOI, was significantly different between the domains. For the incorrect AOI, the differences were significantly nonzero at all points except 0.5 seconds past the critical start, when the two curves overlap.



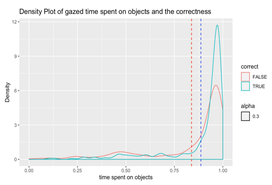


Correctness of response ~ hits on correct object
How does the *number* or *proportion* of hits on correct AOI in a trial influence the response? We look at *critical info period only* and *the entire span* of the trial.

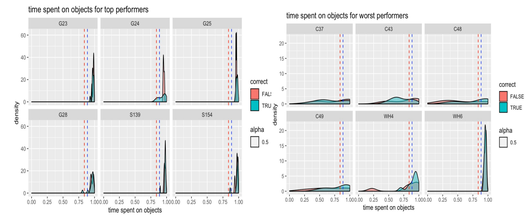
Welch Two Sample t-test

H0	Ha	P	95%CI	Result
Mean porp correct AOI during critical info for correct trials is <= that for incorrect trials.	Mean proportion of correct AOI during critical info for correct trials is higher than incorrect trials	1.76E-09	[0.08, Inf]	Sufficient evidence to reject H0
In all time span, average time spent on both AOIs for correct choice is the same as incorrect choice	In all time span, average time spent on both AOIs for correct choice is more than incorrect choice	0.0083	[0.0125, 0.0843]	Sufficient evidence to reject H0
During critical phase, average time spent on both AOIs for correct choice is the same as incorrect choice	During critical phase, average time spent on both AOIs for correct choice is more than incorrect choice	0.0857	[-0.0029, 0.0446]	No sufficient evidence to reject H0

Correlation between the percentage of time spent gazing at AOIs and participants' correctness of response - On average, there is more gazing time spent on objects for correct responses. Worst performers tend to spend fewer time gazing at AOIs, since their density plots are more flat, which means their gazing time spent at AOIs are more spread out, while the top performers' gazing time is more concentrated at the right.



	Correct Response	Incorrect Response
Average Percentage of Time Spent on two AOIs	88.68%	83.85%



Average eye fixation crosses between the left and right media - During the critical information interval, the four highest scoring participants had a higher average than the total 60 children who averaged 1.725 fixation crosses. Two sample t test performed to determine if there is a significant difference between the average number of left and right fixation crosses during the critical information time vs time interval following it. Resulting p value of 0.4423

Highest Scoring Participants	G25	G28	S139	S154
Average number of times, in all trials, that two consecutive eye fixations cross the middle boundary during critical information time	3.11	2.33	3.13	2.45
Average number of times, in all trials, that two consecutive eye fixations cross the middle boundary after critical information time	3.65	3.94	3.75	1.65

Conclusion

- There is a significant difference between the animal and instrument average fixation curves for both the correct AOI and incorrect AOI.
- The amount of gazing time spent at AOI (AOI for both correct and incorrect objects) has a positive correlation with correctness. In other words, if a participant spends more time gazing at AOIs for one slide, he or she has a higher chance to give a correct response.
- There is a significant difference between the percentage of gaze time spent on AOI (for both correct and incorrect objects) VS elsewhere on the slides for top performers and worst performers. Top performers tend to spend more time gazing at AOI. (Top performers refer to the participants with high accuracy in terms of their responses)
- There is no significant difference between the average number of consecutive left and right fixation crosses during the time the critical information is being read compared with the time interval immediately following the critical information.
- For participants who choose the correct object, their average proportion of fixations on the correct AOI is higher than that those who choose the incorrect object.

References: Pomper, R., & Saffran, J. R. (2018). Familiar Object Salience Affects Novel Word Learning. Child Development, 90(2). doi: 10.1111/cdev.13053