Timecourse of concurrent learning of adjacent and nonadjacent dependencies

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Background & Aims

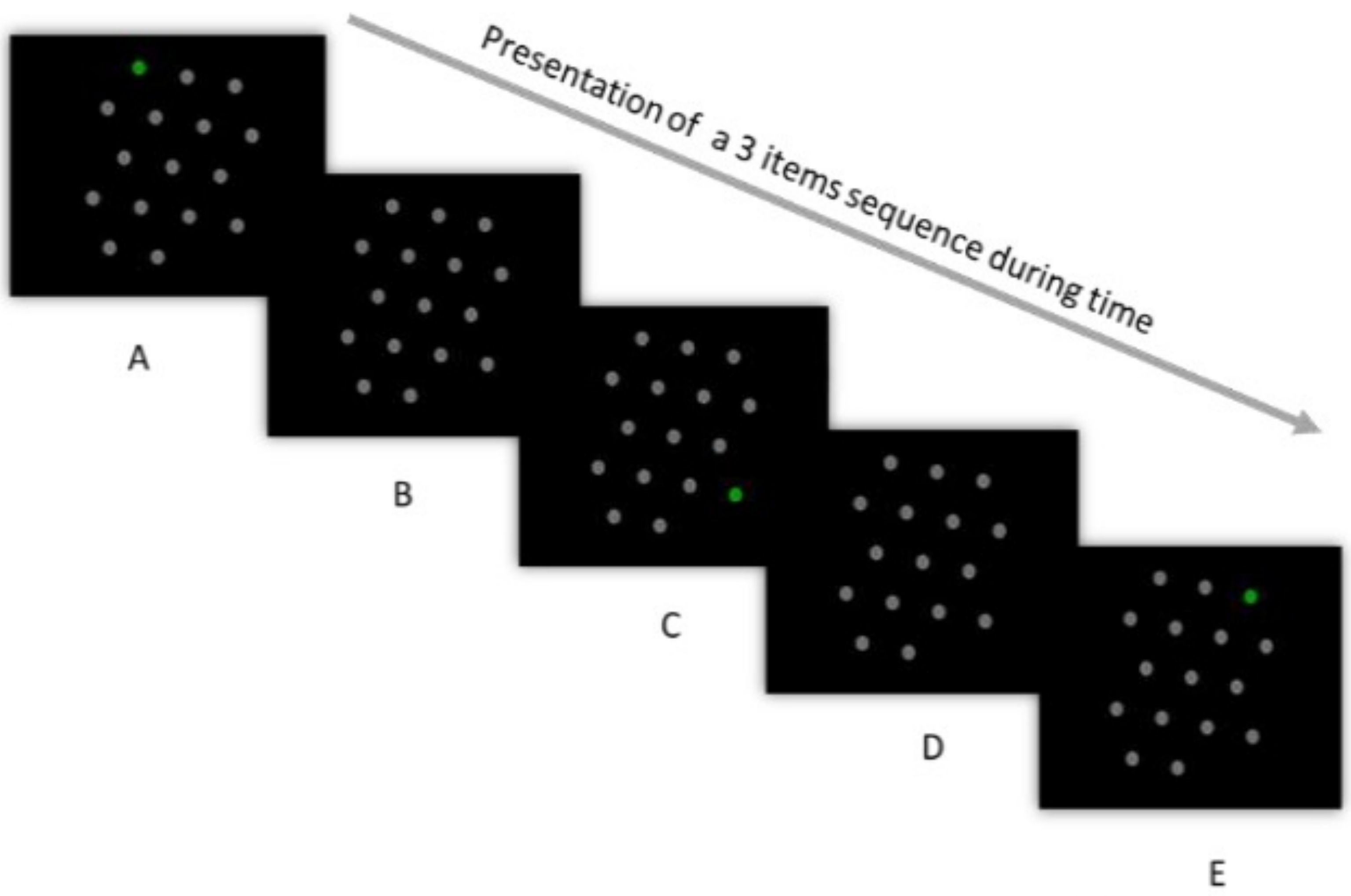
- Visual statistical learning is a form of implicit learning of the regularities among adjacent and nonadjacent elements across time and/or space.
- Adjacent dependencies
  - E.g., ‘pre’ is more likely to be followed by ‘ty’ than ‘on’
- Nonadjacent dependencies
  - E.g., rules such as *“**is** X-**ing**”* (where X is a verb)
- Both coexist in languages.
  - E.g., She ***is*** go***ing*** to a party.
- We use syntax rules to make predictions in language.
  - E.g., when we hear “she” we predict “is”, not “are”, will follow.

- Most research has focused on adjacent dependency learning. This study aims to test learning of adjacent and nonadjacent dependencies individually and simultaneously (Iao et al., 2021)
  - Also focuses on timecourse of learning either dependency.

Participants

	Experiment 1	Experiment 2	Experiment 3
Total	32	32	32
Female	24	24	25
Male	7	8	7
Age – Mean (SD)	24 (2.51)	23 (14.43)	27 (11.82)
Age range	18 – 29 years	18 – 62 years	19 – 57 years

Methods



Phase A	**Beginning of 3 items sequence. 1st item of sequence is presented. Gaze contingent eye-tracking until gaze hits target. Time displayed for 275 ms after gaze hits target.**
Phase B, D	Time displayed for 750 ms of the blank period that guessing occurs.
Phase C	2nd item of sequence is presented. Gaze contingent eye-tracking until gaze hits target. Time displayed for 275 ms after gaze hits target.
Phase E	3rd item of sequence is presented. Gaze contingent eye-tracking until gaze hits target. Time displayed for 275 ms after gaze hits target.

Learning is quantified as the number of raw eye-samples on the target location during the 750ms guessing period.

Credit: Sofia Tsitsopoulou

- All participants were exposed to adjacent and nonadjacent dependencies
  - Adjacent dependencies A-B-C
  - Nonadjacent dependencies A-B-C.

Dependee
Target
Random

- Two blocks with four sequences of three elements, repeated 40 times per block (all experiments)
- Participants were either encouraged to predict the next target (experiments 2 & 3) or not (experiment 1).
- Adjacent and nonadjacent dependencies presented in separate blocks (experiments 1 & 2) or concurrent blocks (experiment 3).

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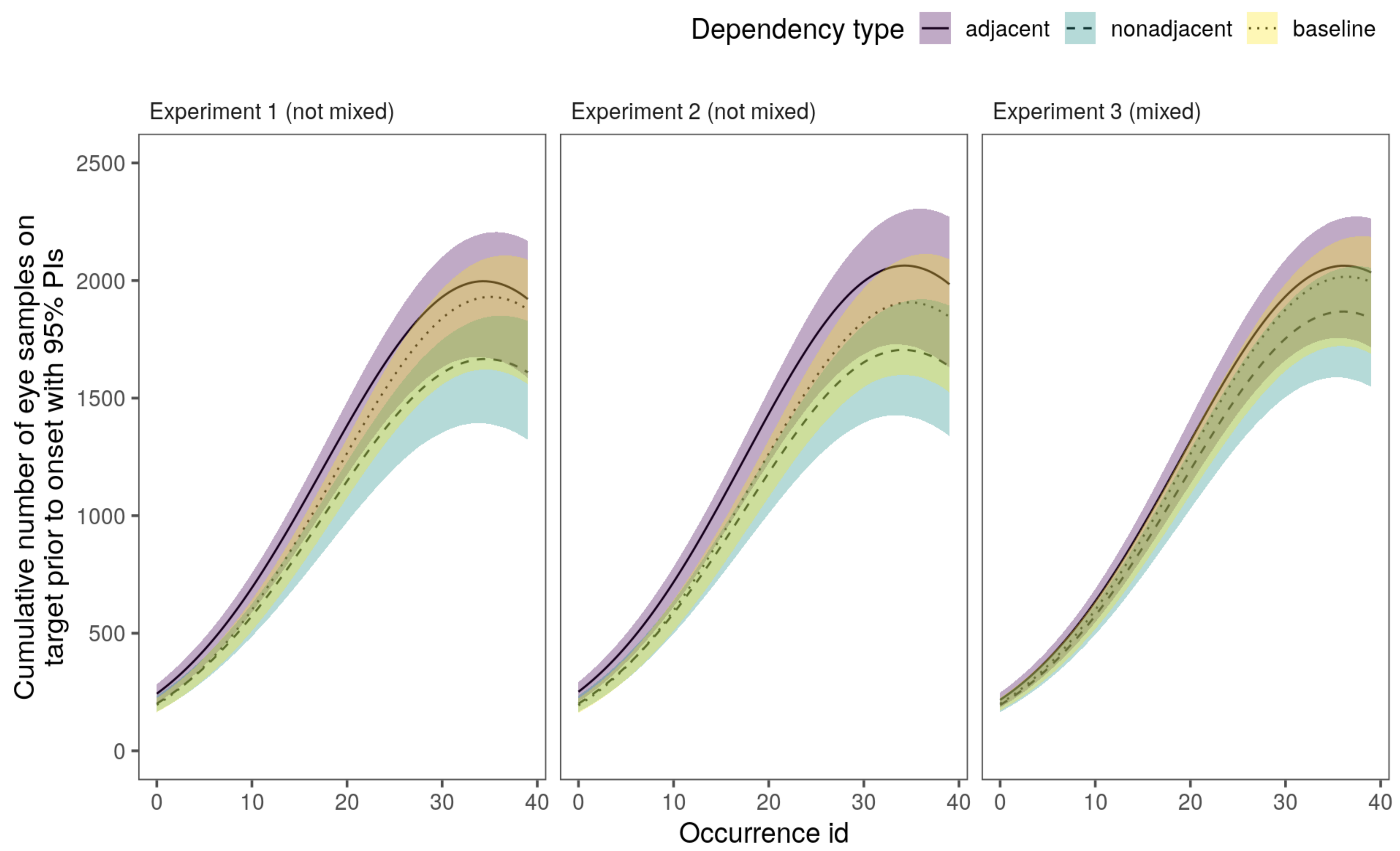
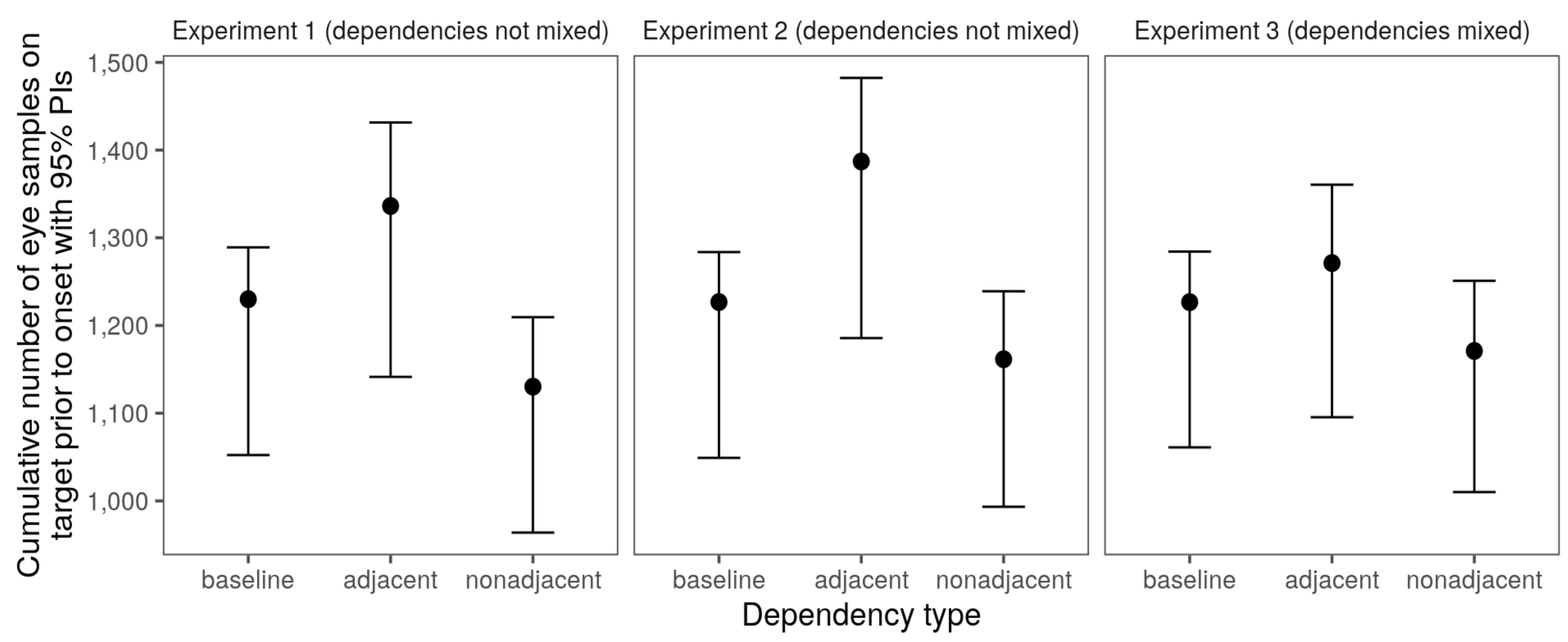
Results

Fixed effects summaries for main effects and interactions of adjacent and nonadjacent dependency (compared to baseline) and occurrence id with linear and quadratic term

	Experiment 1		Experiment 2		Experiment 3	
Predictor	**Est. with 95% PI**	**H_1**	**Est. with 95% PI**	**H_1**	**Est. with 95% PI**	**H_1**
Occurrence id (linear)	91.93 [82.42 – 98.71]	>100	91.81 [81.83 – 100.3]	>100	95.75 [88.14 – 101.06]	>100
Occurrence id (quadratic)	-30.68 [-33.48 – -27.23]	>100	-31.1 [-33.63 – -27.99]	>100	-29.41 [-32.12 – -26.36]	>100
Adjacent	**0.17 [0.09 – 0.26]**	**>100**	**0.21 [0.13 – 0.29]**	**>100**	**0.08 [0 – 0.17]**	**2.36**
Nonadjacent	**-0.16 [-0.24 – -0.08]**	**>100**	**-0.15 [-0.23 – -0.07]**	**>100**	**-0.08 [-0.17 – 0]**	**2.68**
Occurrence id (linear) : Adjacent	**-8.59 [-15.23 – -0.26]**	**15.1**	**-9.77 [-15.41 – -2.49]**	**72.31**	**-1.38 [-5.77 – 1.1]**	**1.37**
Occurrence id (quadratic) : Adjacent	0.59 [-1.53 – 3.4]	0.98	1.16 [-1.08 – 4.6]	1.3	0.1 [-2.15 – 2.46]	0.88
Occurrence id (linear) : Nonadjacent	-1.47 [-9.6 – 1.79]	1.26	-0.37 [-4.73 – 2.48]	1.04	-0.98 [-4.79 – 1.37]	1.2
Occurrence id (quadratic) : Nonadjacent	0.74 [-1.36 – 3.68]	1.03	0.24 [-1.85 – 2.56]	0.84	-0.1 [-2.45 – 2.14]	0.89

Note:
H_1 = evidence in favour of the alternative hypothesis over the null hypothesis (Bayes Factor); PI = probability interval; ‘:’ = interaction





Findings

- Adjacent dependencies showed learning relatively early in the timecourse (experiments 1 & 2)
- No learning for nonadjacent dependencies (experiments 1 & 2)
- When presented concurrently, nonadjacent dependencies inhibited learning for adjacent dependencies (experiment 3)
- Explicitness of instructions did not seem to impact on learning