

# Timecourse of concurrent learning of adjacent and nonadjacent dependencies

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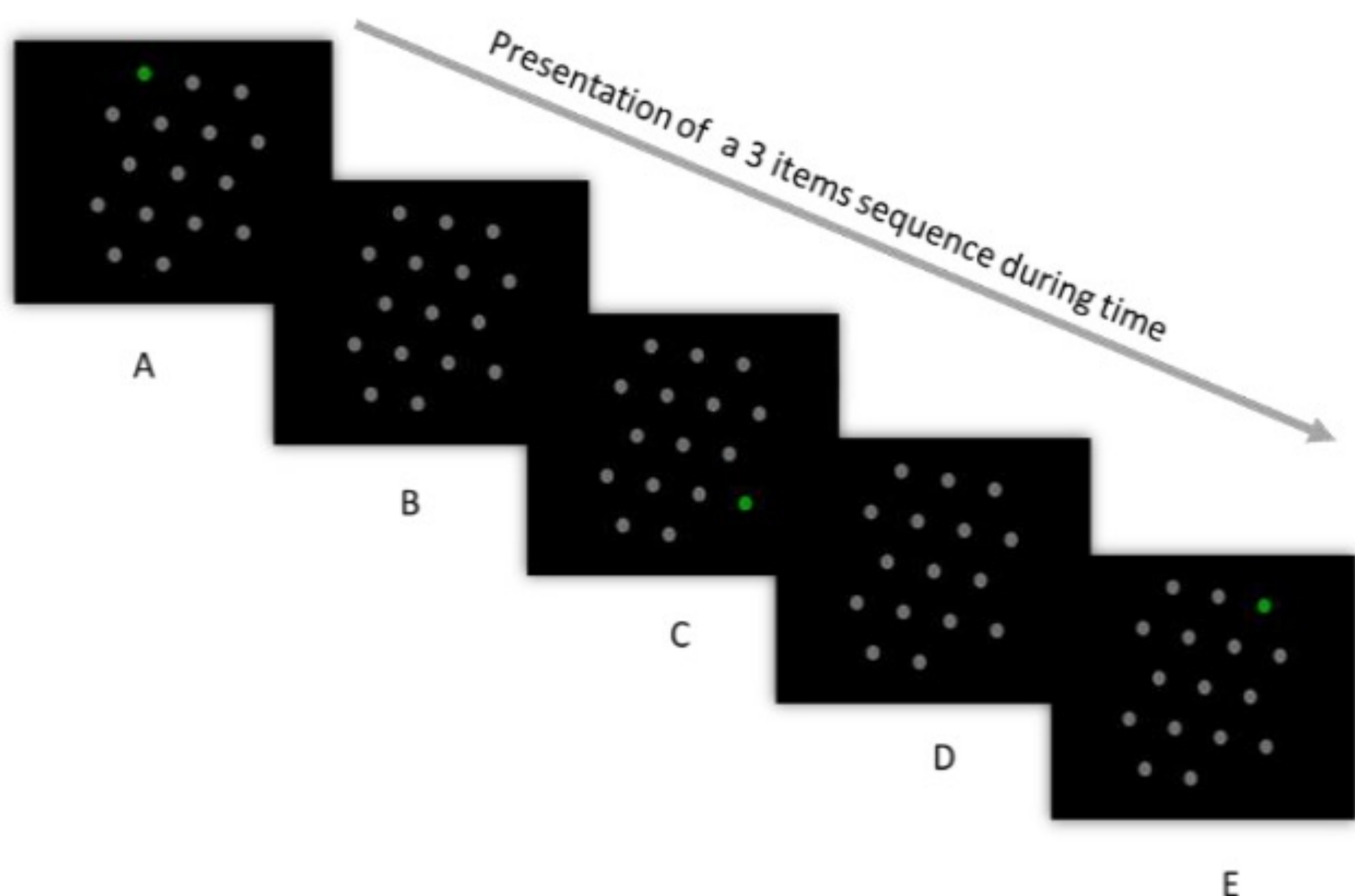
## Background & Aims

- Visual statistical learning is a form of implicit learning of the statistical regularities among adjacent and nonadjacent elements across time and/or space.
- Adjacent dependencies
  - E.g., syllable '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 visual scenery, music, and natural languages
  - E.g., She is going 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 looks at prediction based on nonadjacent dependency learning.
  - Also looks at prediction of both dependencies at the same time.

## 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. 1<sup>st</sup> 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** 2<sup>nd</sup> item of sequence is presented. Gaze contingent eye-tracking until gaze hits target. Time displayed for 275 ms after gaze hits target.

**Phase E** 3<sup>rd</sup> 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 ■ Dependee
  - Non-adjacent dependencies A-B-C. ■ Target
  - Control A-B-C. ■ 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).



## Results

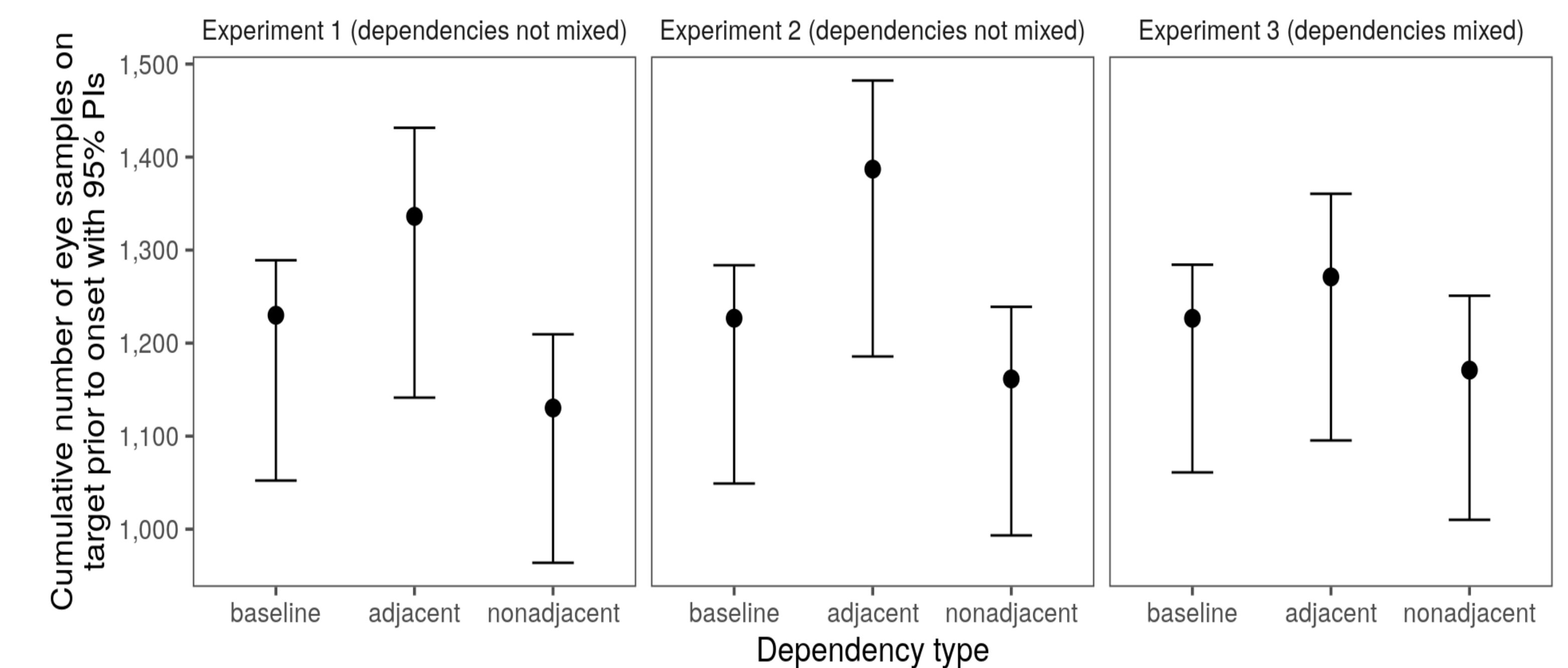
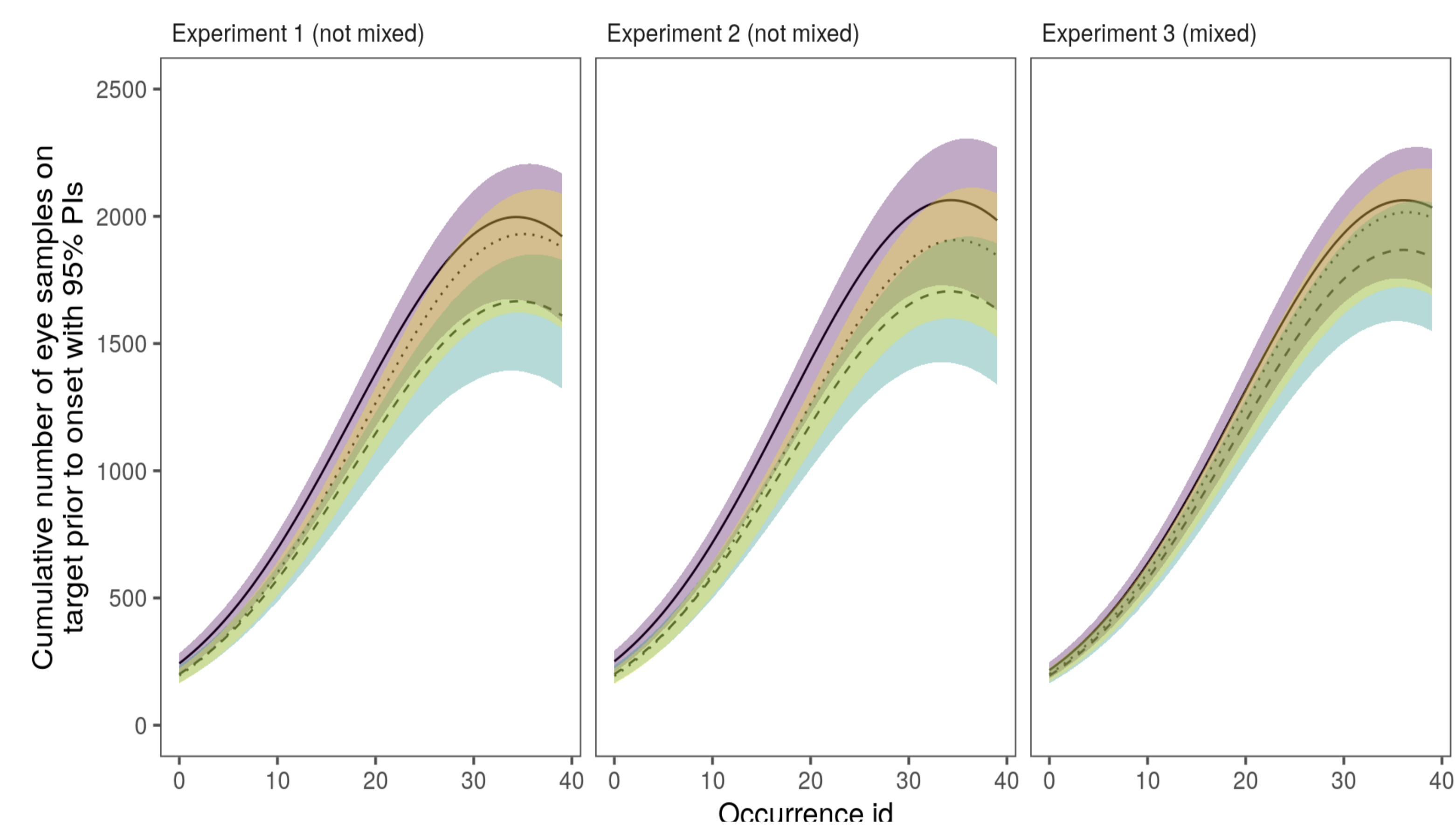
Table 2.2: Fixed effects summaries for main effects and interactions of adjacent and nonadjacent dependency (compared to baseline) and occurrence id with linear and quadratic term.

Predictor	Experiment 1		Experiment 2		Experiment 3	
	Est. with 95% PI	H <sub>1</sub>	Est. with 95% PI	H <sub>1</sub>	Est. with 95% PI	H <sub>1</sub>
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
<b>Adjacent</b>	<b>0.17 [0.09 - 0.26]</b>	<b>&gt;100</b>	<b>0.21 [0.13 - 0.29]</b>	<b>&gt;100</b>	<b>0.08 [0 - 0.17]</b>	<b>2.36</b>
<b>Nonadjacent</b>	<b>-0.16 [-0.24 - -0.08]</b>	<b>&gt;100</b>	<b>-0.15 [-0.23 - -0.07]</b>	<b>&gt;100</b>	<b>-0.08 [-0.17 - 0]</b>	<b>2.68</b>
<b>Occurrence id (linear) : Adjacent</b>	<b>-8.59 [-15.23 - -0.26]</b>	<b>15.1</b>	<b>-9.77 [-15.41 - -2.49]</b>	<b>72.31</b>	<b>-1.38 [-5.77 - 1.1]</b>	<b>1.37</b>
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<sub>1</sub> = evidence in favour of the alternative hypothesis over the null hypothesis (Bayes Factor); PI = probability interval; ':' = interaction

Dependency type ■ adjacent ■ nonadjacent ■ baseline



## 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