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Research Report

Exploring the neurodevelopment of visual statistical learning using event-related brain potentials

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ABSTRACT

Implicit statistical learning (ISL) allows for the learning of environmental patterns and is thought to be important for many aspects of perception, cognition, and language development. However, very little is known about the development of the underlying neural mechanisms that support ISL. To explore the neurodevelopment of ISL, we investigated the event-related potential (ERP) correlates of learning in adults, older children (aged 9–12), and younger children (aged 6–9) using a novel predictor-target paradigm. In this task, which was a modification of the standard oddball paradigm, participants were instructed to view a serial input stream of visual stimuli and to respond with a button press when a particular target appeared. Unbeknownst to the participants, covert statistical probabilities were embedded in the task such that the target was predicted to varying degrees by different predictor stimuli. The results were similar across all three age groups: a P300 component that was elicited by the high predictor stimulus after sufficient exposure to the statistical probabilities. These neurophysiological findings provide evidence for developmental invariance in ISL, with adult-like competence reached by at least age 6.

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1. Introduction

Implicit statistical learning (ISL) refers to the automatic, incidental, and effortless acquisition of statistical patterns in the environment (Cleeremans et al., 1998; Conway and Christiansen, 2006; Eimer, Goschke, Schlaghecken, & Sturmer, 1996; Fiser and Aslin, 2002; Perruchet and Pacton, 2006). The use of ISL processes are believed to play an important role in language learning (Conway et al., 2010; Misyak et al., 2010; Saffran, 2003; Saffran et al., 1996) in addition to other aspects

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of cognitive development such as visual perception (Fiser and Aslin, 2002; Turk-Browne et al., 2010), motor skill learning (Robertson, 2007), and social intuition (Lieberman, 2000). These abilities are domain-general in the sense that the same general mechanisms appear to be used across multiple domains in parallel (Saffran and Thiessen, 2007). However, few studies have probed the neural mechanisms mediating ISL in adults, let alone in children, making it difficult to specify the neurocognitive development of these processes.

Reber (1993) suggested that implicit learning is developmentally invariant, a claim which has been supported by recent work examining saccadic eye movements in a behavioral learning paradigm (Amso and Davidow, 2012). However, other research has provided evidence of developmental differences (Barry, 2007; McNealy et al., 2010; Mecklenbräuker et al., 2003; Thomas et al., 2004). Perhaps not surprisingly, in most cases where developmental differences in implicit learning are found, adults out-perform children. However, the evidence is not straightforward. Some proposals take the somewhat paradoxical stance that cognitive limitations may confer a computational advantage for learning (Conway et al., 2003; Elman, 1993; Newport, 1990), which would indicate that ISL might be more efficient in childhood. Overall, relatively little is known about the

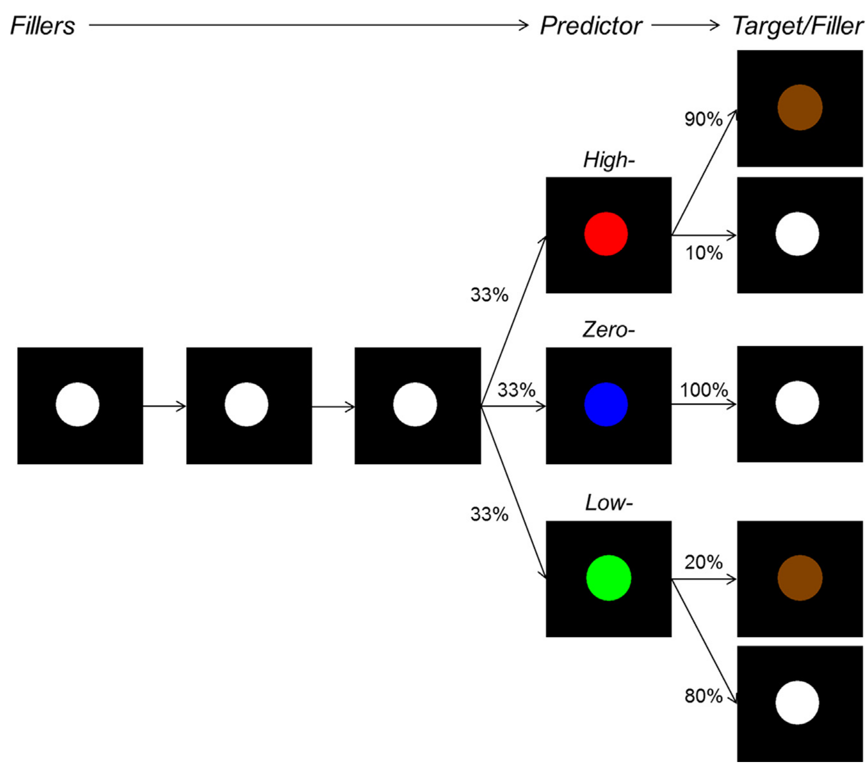

Fig. 1 – An example sequence of colored circles for each of the three stimulus types (high-, low-, and zero-probability predictor conditions). In the example three filler circles are used prior to the appearance of a predictor, but this number could vary from one to five. After the appearance of either the target or filler following a predictor, the process would repeat. In this example the target is brown, but circle color was randomly distributed across conditions for each participant.

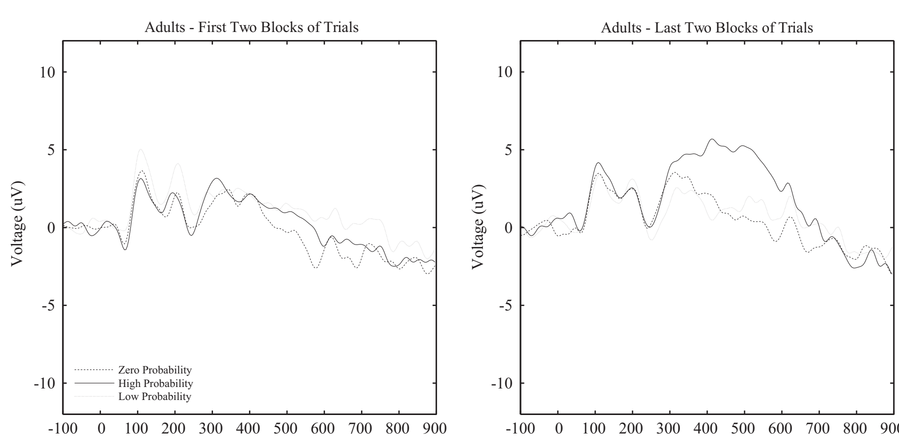

Fig. 2 – Averaged ERP waveforms in the centro-parietal region (POz) for the adult group, for first two blocks (left) and last two blocks (right).

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