Journal of Experimental Child Psychology 132 (2015) 51–64

Contents lists available at ScienceDirect

Journal of Experimental Child Psychology

journal homepage: www.elsevier.com/locate/jecp

Infant auditory short-term memory for non-linguistic sounds

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ARTICLE INFO

Article history:
Received 20 December 2013
Revised 6 December 2014
Available online 12 January 2015

Keywords:
Infant
Auditory working memory
Auditory short-term memory
Auditory perception
Short-term memory
Working memory

ABSTRACT

This research explores auditory short-term memory (STM) capacity for non-linguistic sounds in 10-month-old infants. Infants were presented with auditory streams composed of repeating sequences of either 2 or 4 unique instruments (e.g., flute, piano, cello; 350 or 700 ms in duration) followed by a 500-ms retention interval. These instrument sequences either stayed the same for every repetition (Constant) or changed by 1 instrument per sequence (Varying). Using the head-turn preference procedure, infant listening durations were recorded for each stream type (2- or 4-instrument sequences composed of 350- or 700-ms notes). Preference for the Varying stream was taken as evidence of auditory STM because detection of the novel instrument required memory for all of the instruments in a given sequence. Results demonstrate that infants listened longer to Varying streams for 2-instrument sequences, but not 4-instrument sequences, composed of 350-ms notes (Experiment 1), although this effect did not hold when note durations were increased to 700 ms (Experiment 2). Experiment 3 replicates and extends results from Experiments 1 and 2 and provides support for a duration account of capacity limits in infant auditory STM.

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http://dx.doi.org/10.1016/j.jecp.2014.12.001
0022-0965/

Introduction

Short-term memory (STM), or working memory, allows information to be stored temporarily and used quickly for tasks requiring some amount of online processing (Baddeley & Hitch, 1974). One distinct feature of STM is that it is highly capacity limited; thus, the amount of information an individual is able to hold or manage is highly constrained. Although these limits have been well-studied in adults, far less research has examined such limits in young children, particularly infants.

Deficits in working memory have been tied to several important cognitive deficits, including inattention, distractibility, and attention deficit hyperactivity disorder (ADHD) (Martinussen & Tannock, 2006; Rapport, Orban, Kofler, & Friedman, 2013), reading (Gathercole, Tiffant, Briscoe, Thorn, & ALSPAC team, 2005; Siegel & Ryan, 1989), language (Archibald & Gathercole, 2006; Weismer et al., 2000), and math (Alloway & Passolunghi, 2011; Zheng, Swanson, & Marcoulides, 2011), and working memory has been linked with the ability to acquire new knowledge and skills, particularly in the development of reading and language (Alloway, Gathercole, Kirkwood, & Elliott, 2009; Atkins & Baddeley, 1998; Service, 1992). This profusion of working memory-related findings has schools scrambling to include working memory assessments in an attempt to identify children at risk for deficit (e.g., Normand & Tannock, 2014). Clearly, intervention attempts would be facilitated by earlier detection of deficits marked by low working memory capacity.

Auditory working memory capacity is typically assessed through verbal tasks, with most studies focused on memory for digits or pronounceable nonwords and aimed at the process of language acquisition (e.g., Baddeley, Gathercole, & Papagno, 1998; Gathercole & Baddeley, 1989; Gathercole, Hitch, Service, & Martin, 1997; Hoff, Core, & Bridges, 2008). These studies have revealed impressive development during an important period of language acquisition and have also revealed correlations between later vocabulary development and early auditory/phonological working memory capacity (Gathercole & Baddeley, 1989), although the direction of the relationship is debated (Gupta & Tisdale, 2009; Snowling, Chiat, & Hulme, 1991). These studies have critically informed research aimed at understanding the development of language and the interactive influence of lower cognitive functions on subsequent development.

A few studies have addressed the specific question of capacity (e.g., Gathercole & Pickering, 1999) but typically have used language-based memory items to assess limits in verbal working memory. In addition to requiring participants old enough to talk and follow instructions, tasks that rely on verbal responses reflect performance across a number of domains beyond memory, including temperament, attention, and speech. For example, phonological working memory tasks often require that children repeat nonwords after the experimenter (Hoff et al., 2008), which likely places additional cognitive and motor demands on children. These tasks also rely heavily on children's existing knowledge of the phonological rules of the language (Gathercole, 2006). The vast majority of work on working memory has examined either visuospatial objects or auditory–verbal objects (words and nonwords). Very little work has examined auditory information that cannot be verbally encoded, essentially confounding estimates of auditory STM capacity with issues pertaining to language fluency and expertise—a particularly thorny issue for developmental researchers. Much of this work reveals important links between early STM development and later language proficiency. However, it is unclear whether the relation is being driven by limits in phonological STM or more domain-general STM resources. For example, in their longitudinal research, Gathercole and colleagues (2005) found evidence for separate effects of phonological and general STM systems. In particular, children who were rated as having poor phonological STM at 5 years but not at 8 years of age showed more impairment on measures of language proficiency than children with persistent phonological impairment (Gathercole et al., 2005). The authors reasoned that early measures of phonological STM are disproportionately influenced by tertiary STM systems due to the relative underdevelopment of lexical support systems. Clearly, auditory STM is linked to vocabulary development, language acquisition, and language proficiency, although it is currently unclear exactly how.

In addition to concerns of language and memory confounds, there is reason to believe that estimates of STM capacity differ across verbal and non-verbal tasks. For example, in work with adults, Li, Cowan, and Saults (2013) found significantly reduced STM capacity for tones relative to visual