



Original Articles

Does a lack of auditory experience affect sequential learning?

Janne von Koss Torkildsen^{a,*}, Joanne Arciuli^b, Christiane Lingås Haukedal^a, Ona Bø Wie^{a,c}^a University of Oslo, P.O. Box 1140 Blindern, 0318 Oslo, Norway^b University of Sydney, Lidcombe, NSW 2141, Australia^c Oslo University Hospital, Postboks 4950 Nydalen, 0424 Oslo, Norway

ARTICLE INFO

Keywords:

Sequence learning
 Statistical learning
 Audition
 Vision
 Deafness
 Auditory deprivation

ABSTRACT

To understand the interaction between sensory experiences and cognition, it is critical to investigate the possibility that deprivation in one sensory modality might affect cognition in other modalities. Here we are concerned with the hypothesis that early experience with sound is vital to the development of domain-general sequential processing skills. In line with this hypothesis, a seminal empirical study found that prelingually deaf children had impaired sequence learning in the visual modality. In order to assess the limits of this hypothesis, the current study employed a different visual sequence learning task in an investigation of prelingually deaf children with cochlear implants and normal hearing children. Results showed statistically significant learning in each of the two groups, and no significant difference in the amount of learning between groups. Moreover, there was no association between the age at which the child received their implant (and thus access to electric hearing) and their performance on the sequential learning task. We discuss key differences between our study and the previous study, and argue that the field must reconsider claims about domain-general cognitive impairment resulting from early auditory deprivation.

1. Introduction

A period of sensory deprivation during early childhood may affect broader aspects of cognition as a child develops. Especially striking is the possibility that deprivation in one sensory modality can adversely affect cognition in other modalities. The current study examined the possible link between early deafness and later visual sequence learning.

A number of studies have suggested that early deafness has an impact on an individual's cognition that extends beyond the auditory domain. For example, deaf children perform worse than children with normal hearing (NH) on visual tasks measuring design copying, visuo-motor precision, and figure-ground perception (Erden, Otman, & Tunay, 2004; Horn, Fagan, Dillon, Pisoni, & Miyamoto, 2007). On the other hand, deaf individuals display enhanced performance in some other visual tasks, such as temporal processing of visual flashes (Iversen, Patel, Nicodemus, & Emmorey, 2015). In the tactile domain, deaf children have been found to outperform children with NH on measures of shape discrimination by blind palpation (Cranney & Ashton, 1982). For fuller information regarding neurocognitive effects of early deafness, see Bavalier and Neville (2002) and Kral, Kronenberger, Pisoni and O'Donoghue (2016).

Some of the differences in nonverbal cognition between deaf and NH individuals may result from neural reorganization related to

experience with sign language (Lee et al., 2001; Weisberg, Koo, Crain, & Eden, 2012). Therefore children with cochlear implants (CI), who have experienced a period of auditory deprivation in infancy, but who have been provided with a sense of sound via CI and primarily use oral language, represent a unique source of information that may contribute to a more complete understanding of how early sensory experiences affect cognition. Some studies have found that children with CI appear to differ from their normal hearing peers in non-auditory cognition (Cleary, Pisoni, & Geers, 2001; Conway, Karpicke et al., 2011; Schlumberger, Narbona, & Manrique, 2004). Thus, empirical investigations of the impact of early deafness on children with CI compared to children with NH are a particular focus in this field of inquiry.

One influential theoretical framework regarding the effects of early auditory deprivation on cognition is the auditory scaffolding hypothesis (Conway, Pisoni, & Kronenberger, 2009). Based on the observation that sound is an inherently sequential signal, and that auditory perception relies fundamentally on serial order, it has been proposed that early sound exposure provides crucial experiences with tracking sequential patterns in the environment. Consequently, a lack of auditory input in infancy may “delay the development of general cognitive abilities related to representing temporal or sequential patterns” (Conway et al., 2009, p. 275).

Only two previous studies have directly investigated implicit

* Corresponding author at: Faculty of Educational Sciences, University of Oslo, Postboks 1140 Blindern, 0318 Oslo, Norway.
 E-mail address: janneto@isp.uio.no (J.v.K. Torkildsen).

learning of visual sequential information in individuals with hearing loss. In line with the auditory scaffolding hypothesis, Conway, Pisoni, Anaya, Karpicke, and Henning (2011) found a significant difference between the performance of prelingually deaf children with CI and children with NH on a serial recall task measuring implicit learning of visual sequential patterns. On average, the 23 children with CI (aged 5–10) showed no learning. By contrast, age-matched NH peers did show significant learning. In addition, there was a negative correlation between performance on the learning task and the age at which the child received their implant. The other study on this topic employed a serial reaction time (SRT) task to assess visual sequential learning in 18 adults with severe to profound hearing loss. That study reported impaired learning compared to adults with NH (Lévesque, Théoret, & Champoux, 2014). However, there was no relation between the degree of sequence learning and the age of hearing loss onset.

These two previous studies have been interpreted as evidence that deaf or severely hearing impaired individuals acquire a domain-general sequence learning deficit. Although this is an intriguing possibility in and of itself, one reason that such a deficit has important ramifications is because it may adversely affect a broad range of other cognitive activities that draw on implicit sequence learning. For instance, compromised sequential learning may be one of a number of contributing factors that underpin below-average language skills typically observed in children with CI (e.g. Houston et al., 2012). Indeed, studies have found associations between individual differences in visual sequence learning and language processing in infants, children and adults with NH (Conway, Karpicke, & Pisoni, 2007; Kidd & Arciuli, 2016; Shafto, Conway, Field, & Houston, 2012).

In the current study, we used a different measure of visual sequential learning in order to explore the limits of the auditory scaffolding hypothesis. In doing this we sought to address some questions raised by the previous two studies that have been conducted. One question relates to the nature of stimuli used to assess sequential learning. A common feature of the two previous studies of implicit visual sequence learning is that they used stimuli that were highly familiar and thus may have lent themselves to the use of learning strategies such as verbal rehearsal processes.

The visual stimuli used in the study by Conway, Pisoni, et al. (2011) were squares of four different colors appearing in one of four different locations on the screen. The task was based on the Simon memory game where children view a sequence of colors and then are asked to reproduce the sequence by pressing colored response panels in the correct order (Cleary et al., 2001; Pisoni & Cleary, 2004). In the Conway, Pisoni, et al. 2011 study this game was used to test implicit learning: First, the child was presented with color sequences adhering to an underlying grammar, and then the experiment transitioned seamlessly into a test phase where the child was presented with both novel grammatical and novel ungrammatical sequences which they had to reproduce. Implicit learning was assessed by comparing the number of grammatical and ungrammatical sequences that were reproduced correctly. While participants were not told about the underlying grammar, they were instructed at the beginning of the experiment to “remember the patterns of colors you see on the screen.” In their review paper, Pisoni, Kronenberger, Chandramouli, and Conway (2016) stated the following when describing a version of the Simon memory game:

“...many of the participants, particularly the normal-hearing children, likely recoded the serial patterns using well-learned automatized verbal labels and coding strategies in order to create stable representations of the stimulus patterns in working memory for maintenance and rehearsal prior to response organization and motor output. When compared to the group of normal-hearing controls, the deaf children with CIs may have used a different encoding strategy and less efficient verbal rehearsal processes for maintaining temporal sequences of the color name codes in working memory.”

p.4

Thus, it is reasonable to suggest that verbal rehearsal strategies may have come into play in the study by Conway, Pisoni, et al. 2011. The fact that participants were given explicit instructions to remember patterns and that presentation rates were slow, may further have encouraged the use of explicit verbal strategies. The stimuli used in the Lévesque et al. (2014) were asterisks in specific locations on the screen which were associated with digits on the keyboard. As digits have well-learned automatized labels, this task also lent itself to verbal rehearsal strategies. Consequently it may be that group differences observed in the previous two studies were related to differences in verbal rehearsal strategies rather than sequence learning per se.

In line with this possibility, a number of studies have shown that short-term verbal memory is compromised in children with CI (Harris et al., 2013; Pisoni & Cleary, 2003). In an overview of this literature, Hirshorn and colleagues have suggested that differences between deaf and NH individuals “are specific to tasks that require serial order recall of linguistic material, with little to no consequences for cognition at large” (Hirshorn, Fernandez, & Bavelier, 2012, p. 90). Accordingly, this view predicts that differences in sequential learning between children who have experienced a period of deafness and NH individuals should be restricted to tasks that involve highly familiar stimuli with automatized verbal labels and sufficient time for verbal (i.e., phonological) rehearsal. Thus, using stimuli that are unfamiliar and do not have automatized verbal labels, allows us to test the possibility that the previous findings may reflect (at least to some degree) the effect of processing highly familiar stimuli.

The paradigms employed by Conway, Pisoni, et al. (2011) and Lévesque et al. (2014) are only two of a large number of tasks which have been used to measure sequence learning skills in children and adults (for an overview, see Siegelman, Bogaerts, Christiansen, & Frost, 2017). One commonly used method is the embedded triplet paradigm (Arciuli & Simpson, 2011; Fiser & Aslin, 2002; Kidd & Arciuli, 2016; Turk-Browne, Jungé, & Scholl, 2005). In this paradigm participants view a continuous stream of individually presented stimuli during a familiarization phase with no instructions to learn or remember. Unbeknownst to participants the stream consists of stimuli that co-occur in triplets. Learning is assessed during a separate surprise test phase where participants undertake forced choice trials to identify embedded versus foil triplets. Often, responses are untimed and learning data is based on accuracy rates. In a study of adults, Siegelman and Frost (2015) found that the embedded triplet task of visual sequence learning (using complex visual shapes as stimuli) had better test–retest reliability than a number of other tasks used to measure implicit learning.

In addition to exploring these issues regarding the nature of stimuli and instructions to participants, we also wanted to assess visual sequence learning in those with CI versus normal hearing peers using a larger sample size than the previous two studies, which is especially important when examining the link between age of implantation and capacity for sequence learning. Conway, Pisoni, et al. (2011) found a significant negative correlation between sequential learning and age of implantation in a sample of 22 children. However, in the study by Lévesque et al. (2014), there was no significant difference in sequence learning performance between the 9 prelingually and the 9 postlingually deaf adults. Thus, to further our understanding of how auditory deprivation may influence sequence learning, there is a need for studies of larger samples with detailed information regarding age of hearing loss and age of implantation.

In sum, there may be a number of reasons why deaf children and adults have been found to perform poorly on visual sequential learning in the two previous studies by Conway et al. (2009) and Lévesque et al. (2014). Before we can draw firm conclusions about domain-general sequence learning impairment as a secondary cognitive consequence of early deafness, it is critical to investigate sequence learning in other tasks. In the present study we used the embedded triplet paradigm with stimuli that were unfamiliar and that did not have automatized verbal labels. Further, we used relatively fast stimulus presentation times and

Download English Version:

<https://daneshyari.com/en/article/5041405>

Download Persian Version:

<https://daneshyari.com/article/5041405>

[Daneshyari.com](https://daneshyari.com)