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Brief article

From domain-generality to domain-sensitivity: 4-Month-olds learn an abstract repetition rule in music that 7-month-olds do not

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A R T I C L E I N F O

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A B S T R A C T

Learning must be constrained for it to lead to productive generalizations. Although biology is undoubtedly an important source of constraints, prior experience may be another, leading learners to represent input in ways that are more conducive to some generalizations than others, and/or to up- and down-weight features when entertaining generalizations. In two experiments, 4-month-old and 7-month-old infants were familiarized with sequences of musical chords or tones adhering either to an AAB pattern or an ABA pattern. In both cases, the 4-month-olds learned the generalization, but the 7-month-olds did not. The success of the 4-month-olds appears to contradict an account that this type of pattern learning is the provenance of a language-specific rule-learning module. It is not yet clear what drives the age-related change, but plausible candidates include differential experience with language and music, as well as interactions between general cognitive development and stimulus complexity.

1. Introduction

Much of adult cognition has been characterized as a set of special-purpose processing routines or modules (Fodor, 1983; Marr, 1982; Pinker, 1997), with functions such as face-recognition (Kanwisher, McDermott, & Chun, 2002), speech-perception (Liberman & Mattingly, 1985), syntax (Chomsky, 1995), and theory of mind (Scholl & Leslie, 1999). Do these domain-specific capacities characterize the initial state of humans? Are the constraints required for learning specific to particular domains, or is the initial state better characterized by at least some domain-general learning mechanisms that may come to 'fit' themselves differently to different input (Jacobs, 1997, 1999; Karmiloff-Smith, 1992)?

One way in which learning may change during development is by tuning to the properties of the environment. Several examples of such input-based tuning exist in music and language. While younger infants discriminate a broad range of speech contrasts, older infants distinguish mainly those found in their input (e.g., Bosch & Sebastián-Gallés, 2003; Werker & Tees, 1984). The change appears to be driven by the phonetic distributions in the input (Maye, Werker, & Gerken, 2002). Similarly, Gerken and Bollt (2008) showed that, while 7.5-month-olds learn both a "natural" stress rule (one found in human languages) and an "unnatural" rule (one not typical of human language) equally well, 9-month-olds learn only the natural rule.

In music, learners' perception seems to tune to general properties such as the importance of relative pitch over absolute pitch (Saffran, 2003; Saffran & Griepentrog, 2001), and the importance of tonality and key (Trainor & Trehub, 1992). Learners also become sensitive to the characteristics of music in their own culture, assimilating rhythmic alterations differently depending on the meters of their native music (Hannon & Trehub, 2005), and becoming sensitive to particular scale structures used in their culture by a year of age (Lynch & Eilers, 1992). There is even evidence of infants tuning to species-relevant stimuli in the domain of face recognition (Pascalis, de Haan, & Nelson, 2002). Thus, the infant may start as something of

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a generalist, becoming a specialist through exposure to her environment.

What about specialization across domains? Marcus, Fernandes, and Johnson (2007) found that 7-month-old infants fail to learn an abstract generalization (sequences must follow an AAB or ABB repetition pattern) over sequences of tones, though they learn the analogous generalization over syllable sequences (Marcus, Vijayan, Rao, & Vishton, 1999). This finding could be taken to reflect a "rule-learning" module that is innately predisposed to process speech sounds. However, a number of recent studies have cast doubt on this claim. Seven-month-olds have been shown to learn AAB/ABB generalizations with pictures of dogs (Saffran, Pollack, Seibel, & Shkolnik, 2007), and 11-month-olds with simple shapes (Johnson et al., 2009). Furthermore, Murphy, Mondragon, and Murphy (2008) found that rats can learn the generalization in both speech and tones. Why, then, do infants fail with tone stimuli?

One possibility is that repetition patterns are available to a domain-general learning mechanism (see Gervain, Macagno, Cogoi, Peña and Mehler (2008), for evidence that some repetition patterns are learnable by newborns), but that 7-month-olds attend to and/or represent music in a way that prevents them from encoding the abstract generalizations in this case. Whatever the specific encoding factors might be, if the failure is due to attentional/representational changes rather than to an innate domain-specificity of rule-learning, then younger infants might be expected to succeed. We explore this general hypothesis in two experiments. Exp. 1 employed a design similar to that used by Marcus et al. (2007), but with the addition of a group of younger infants who might have fewer attentional/representational biases. Exp. 2 replicated the results from Exp. 1 using slightly different materials.

2. Experiment 1

2.1. Methods

2.1.1. Participants

Eighteen infants (seven females) between 3.5 and 4.5 months (mean 17 weeks) and eighteen infants (seven females) between 7 and 8 months (mean 32 weeks) were recruited from the Tucson area. Data from five additional 4-month-olds and three additional 7.5-month-olds was collected, but was excluded due to these infants' failure to complete six test trials (3 per grammar) with looking times of at least 2 s (the time required to hear one complete phrase). All infants were at least 37 weeks to term and 5 lbs 8 oz at birth, and had no history of speech or language problems in biological parents or full siblings.

2.1.2. Materials

Three-note triads were built on each of the 12 pitches between middle C and the B above. Eight (four major and four minor) were assigned to the familiarization phase, the rest to the test phase. The chord sets for each phase were further divided in half, into an A group and a B group.

Three-chord phrases were created for both AAB and ABA grammars. In both, the two "A" chords were identical. Every combination of A and B elements was represented, for a total of 16 unique familiarization phrases and four unique test phrases. The B element was higher-pitched half the time in both phases. Each phrase was 2500 ms−625 ms for each of the three chord and 625 ms of silence at the end.

A two-minute familiarization sequence for each grammar was constructed. Each sequence contained each of the 16 unique phrase three times, randomized within blocks. The three blocks had different random orders, but the same orders were used for the AAB trial and the ABA trial – i.e., if $A_1A_1B_3$ occurred first in the AAB trial, then $A_1B_3A_1$ began the ABA trial, and so on. There were no breaks beyond the phrase-final silences between phrases in a block or between blocks.

Two 30-s test trials for each grammar were constructed using the same randomized blocking procedure, again with three blocks of the four test phrases per trial. Each test trial shared a randomization sequence with a trial from the opposite grammar.

2.1.3. Procedure

The headturn preference procedure (Kemler Nelson et al., 1995) was used. Infants sat on a caregiver's lap in a small room. Caregivers listened to pop music through headphones and were instructed not to speak or direct the infant's attention. During familiarization, a light in front of the infant flashed until the observer, blind to the experimental condition and deaf to the stimuli, judged the infant to be looking at it, triggering a blinking light on the left or right. When the infant looked at the side light and then away for 2 s, the center light would resume blinking, and the cycle would repeat. This continued for the duration of the familiarization music. In this stage there was no correspondence between infants' looking behavior and the sound.

The test phase began immediately after familiarization. The lights behaved the same way, but now the sound was contingent on the infant orienting to a side light. Each time a side light began flashing and the infant oriented toward it, one of the four test trials would play, continuing until either the infant looked away for 2 s or the test trial reached its conclusion.

2.2. Results

Looking times were entered into an ANOVA with between-subjects factors age and familiarization grammar (AAB vs. ABA), and within-subjects factor test grammar (AAB vs. ABA). There was a significant effect of age ($F(1,32) = 5.94$, $p < 0.03$), with 4-month-olds looking longer, and of test grammar ($F(1,32) = 10.62$, $p < 0.005$), revealing an overall preference for AAB items. This preference did not differ between the age groups, as revealed by a nonsignificant interaction of test grammar and age ($F(1,32) = 0.74$, $p = 0.40$). The three-way interaction was significant ($F(1,32) = 5.54$, $p < 0.03$), indicating that discrimination of consistent and inconsistent test items differed by age. No other effects were significant. The 4-month-olds showed a preference for the test items that were inconsistent with familiarization ($t(17) = 2.61$, $p < 0.02$), but the 7.5-month-olds showed no preference ($t(17) = 0.33$, $p = 0.74$).