Available online at www.sciencedirect.com
SCIENCE DIRECT®
Cognition 87 (2003) B69–B77
COGNITION
www.elsevier.com/locate/cognit

Brief article

Infants learn phonotactic regularities from brief auditory experience

Kyle E. Chambers*, Kristine H. Onishi, Cynthia Fisher

Department of Psychology, University of Illinois at Urbana–Champaign, 603 East Daniel Street, Champaign, IL 61820, USA

Received 9 October 2002; received in revised form 18 November 2002; accepted 18 November 2002

Abstract

Two experiments investigated whether novel phonotactic regularities, not present in English, could be acquired by 16.5-month-old infants from brief auditory experience. Subjects listened to consonant–vowel–consonant syllables in which particular consonants were artificially restricted to either initial or final position (e.g. /bæp/ not /pæb/). In a later head-turn preference test, infants listened longer to new syllables that violated the experimental phonotactic constraints than to new syllables that honored them. Thus, infants rapidly learned phonotactic regularities from brief auditory experience and extended them to unstudied syllables, documenting the sensitivity of the infant's language processing system to abstractions over linguistic experience.

Keywords: Infants; Language acquisition; Speech perception; Phonotactic learning; Statistical learning

1. Introduction

Languages have phonotactic regularities that describe what sound sequences are legal or likely. In English, for example, the /ŋ/ at the end of "sing" never occurs word-initially, while the /h/ in "hat" never occurs word-finally. Knowledge of such regularities affects language perception and production. Phonotactic knowledge biases speech sound identification (e.g. Massaro & Cohen, 1983; Pitt, 1998; Vitevitch, Luce, Charles-Luce, & Kemmerer, 1997) and word and syllable segmentation (e.g. McQueen, 1998; Pitt, 1998; Smith & Pitt, 1999), and can even cause adults to hear illusory vowels when confronted with illegal consonant sequences (e.g. Dupoux, Pallier, Kakehi, & Mehler, 2001). Speech errors are phonotactically regular, creating legal sequences virtually all of the time (e.g.

* Corresponding author. Tel.: +1-217-244-6098.
E-mail address: kechambe@uiuc.edu (K.E. Chambers).

0010-0277/02/$ - see front matter © 2002 Elsevier Science B.V. All rights reserved.
doi:10.1016/S0010-0277(02)00233-0

Dell, Reed, Adams, & Meyer, 2000). Sensitivity to native-language phonotactics begins early: 9-month-olds discriminate legal from illegal (Jusczyk, Friederici, Wessels, Svenkerud, & Jusczyk, 1993) and frequent from infrequent sequences (Jusczyk, Luce, & Charles-Luce, 1994), and use phonotactic probabilities to find word boundaries (Mattys & Jusczyk, 2001).

Cross-linguistic similarity in phonotactic regularities suggests that these regularities are influenced by inherent properties of the linguistic, cognitive, articulatory, or auditory systems (e.g. Moreton, 2002). At the same time, cross-linguistic variability in these regularities tells us that they must be learned, at least in part. How are they acquired?

The development of phonotactic knowledge requires a learning mechanism that stores phonological sequences and is sensitive to generalizations over those sequences. The malleability of adults' phonotactic knowledge following production (Dell et al., 2000) or perception training (Onishi, Chambers, & Fisher, 2002) suggests that this learning mechanism is present in adulthood. For example, adults who heard consonant–vowel–consonant (CVC) syllables in which particular consonants were restricted to either the onset or coda position were then faster to repeat new syllables that were consistent rather than inconsistent with the experimental phonotactics (Onishi et al., 2002). These findings reveal sensitivity to phonotactic regularities in ongoing linguistic experience. Adults encoded information about experimental regularities and generalized to new syllables honoring those regularities. The present research asked whether infants would display similarly rapid detection and generalization of phonotactic regularities.

Infants quickly detect sequential structure in linguistic input. Eight-month-olds used differences in transitional probability across syllables to locate word boundaries in continuous speech (Saffran, Aslin, & Newport, 1996). Seven-month-olds detected a pattern of syllable repetition (e.g. ABB or ABA) and transferred the pattern to new syllables (Marcus, Vijayan, Bandi Rao, & Vishton, 1999). Twelve-month-olds who heard syllable strings generated from a finite-state grammar later discriminated new strings consistent with the grammar from inconsistent strings, and generalized the grammar to a new vocabulary (Gomez & Gerken, 1999).

These findings involve the sequencing of whole syllables, widely regarded as salient perceptual units even for young infants (e.g. Eimas, 1999; Jusczyk, Jusczyk, Kennedy, Schomberg, & Koenig, 1995). Infants can also respond to within-syllable similarity: Jusczyk, Goodman, and Baumann (1999) found that 9-month-olds preferred to listen to lists of CVC syllables that all shared a single onset consonant (e.g. /mod, mɪb, mʌn, mɪʃ,.../), or whose onset consonants shared the same manner of articulation (e.g. liquid onsets: /l, r/). Attention to sound similarities within syllables is a prerequisite for learning phonotactic regularities. To learn phonotactics, however, infants must go beyond the detection of within-syllable similarity in a highly uniform set of syllables. Infants must track the distribution of multiple speech segments across varying syllables, retain in memory information about the positions of each of those segments, and generalize this knowledge to new syllables. Moreover, they must track the positions of individual segments rather than featurally-defined classes of segments: in English, for example, /ŋ/ never begins English words, but other nasal consonants do (/m, n/). Jusczyk et al. expressed doubt that infants in their tasks would prefer lists in which multiple, phonetically unrelated consonants appeared in the onset position; but this is precisely the kind of

pattern that infants must detect to acquire the native-language phonotactics, and which adults detected in earlier studies of phonotactic learning.

Hollich, Jusczyk, and Luce (2001) reported initial evidence for one of these additional requirements for phonotactic learning, finding that infants could generalize from experience with a set of highly similar syllables. Fifteen-month-olds were familiarized with syllables constituting a dense neighborhood surrounding a single target syllable. Neighbors were syllables differing from the target by one phoneme (e.g. /lɜ˞b/ and /tɪb/ were neighbors of /tɜ˞b/). After familiarization, the infants discriminated the target from a non-target syllable even if the target syllable had been held out of the familiarization list. This result suggests that 15-month-olds have some ability to detect similarity across syllables and to generalize to new syllables, treating as familiar a novel syllable that is highly similar to those they have recently heard.

The present experiments go beyond these findings by asking whether infants can acquire and generalize new phonotactic regularities from listening practice. These experiments parallel the adult phonotactic learning experiments reported by Onishi et al. (2002). Infants first listened to syllables in which two sets of five unrelated consonants were artificially restricted to the onset or coda position, with assignment of consonants to positions counterbalanced across infants. The infants later heard test trials composed of syllables not presented during familiarization; legal items honored the experimental constraints, whereas illegal items violated them. If infants detected the phonotactic patterns in the familiarization phase, they should discriminate legal from illegal syllables in the listening preference test.

2. Experiment 1

2.1. Method

2.1.1. Participants

Eight 16.5-month-olds (range: 15.8–16.9; four male, four female) from monolingual American-English-speaking homes participated in the experiment. Two infants were randomly assigned to each of four sublists (see below). Ten additional infants were tested but not included because they were overly fussy (nine) or active (one).

2.1.2. Materials

The key manipulation involved restricting consonants to particular syllable positions in familiarization lists, counterbalanced across subjects. Two groups of five consonants that could not be differentiated by a single phonetic feature or set of features were selected (group 1: /b, k, m, t, f/; group 2: /p, g, n, tʃ, s/). These were combined to create two sets of 25 syllable frames, one with group 1 consonants as onsets and group 2 consonants as codas (e.g. /b_p/), and one with group 2 consonants as onsets and group 1 consonants as codas (e.g. /p_b/). Each frame set was combined with the vowels /æ/ and /ɪ/, creating two master lists of 50 syllables. Each master list was divided into two 25-syllable sublists (with vowel quality divided as evenly as possible between sublists), such that if one sublist were studied, the other would be unstudied and legal at test. Sublists created from the master

list exhibiting the opposite constraint would be unstudied and illegal at test. Vulgar words were replaced by syllables with the same consonants but the other vowel (e.g. /bætʃ/).[1] Syllables were recorded by a female native English speaker in a sound-attenuated booth with items from both master lists intermixed.

Subjects were familiarized with one of the four sublists and tested on two others, one unstudied legal and one unstudied illegal. The illegal test syllables were the reverse of the familiarization syllables; thus an infant who heard /pɪb/ in familiarization would hear the illegal item /bɪp/ at test. Each sublist, and hence each syllable, appeared in every part of the design (studied, unstudied legal, unstudied illegal) across subjects.

Familiarization lists consisted of one sublist of 25 syllables repeated six times in different random orders with 1 s pauses between syllables (approximate duration: 3 min 48 s). The ten test trials consisted of five legal and five illegal trials, each containing a randomly ordered sequence of five syllables, none of which were presented in the familiarization list. Across these five syllables in each test trial, all ten consonants and both vowels were presented, thereby eliminating segment differences between the legal and illegal test trials. Within a trial, syllables were separated by 1 s pauses. Syllable order within test trials was fixed, and the first syllable of each test trial began with a different consonant. Test trial order was randomized separately for each infant, with the constraints that the first two trials included a legal and an illegal trial, and no more than two trials of the same type occurred in a row. Approximately the same number of legal and illegal trials were presented from the left and right loudspeakers.

2.1.3. Apparatus

The experiment was conducted in a three-sided booth of white curtains, dimly lit from above. A green light protruded from the center curtain and red lights from the side curtains, at infant eye level. A loudspeaker was concealed behind the curtains beneath each side light. A centrally-located video camera was hidden behind white mesh. A coder in another room watched the infant on silent video and indicated to a computer the timing and direction of infant head turns. An experimenter accompanied the parent and infant into the testing room, and remained concealed behind the apparatus during the experiment.

2.1.4. Procedure

The infants were tested using the head-turn preference procedure (Kemler-Nelson et al., 1995). Each infant sat on a parent's lap in the center of the testing booth. The parent and concealed experimenter wore earplugs and aviation-style headphones presenting masking music. The experiment began with a *familiarization phase* in which one familiarization list played continuously from both speakers, not contingent on the infant's behavior. The apparatus lights were used to teach the infant the head-turn contingencies. A training "trial" began with the center light flashing. When the infant looked toward the light, it was extinguished and a side light started flashing. After the infant made a criterion head turn of at least 30° toward the light, it continued flashing until the infant looked away for

[1] In this and the following experiment, four subjects each had one legal test trial excluded from the analyses because substitutions for vulgar words resulted in this trial including familiarization syllables. All results reported remained the same when these trials were included.

Table 1
Mean (SE) listening time in seconds by trial type for Experiments 1 and 2

Experiment	Legal	Illegal
1	5.49 (0.92)	7.95 (0.86)
2	5.10 (0.97)	6.24 (0.93)

two consecutive seconds, ending the trial. The next trial began with the flashing of the center light.

Following familiarization, the experimenter entered the testing booth and entertained the infant with a puppet for 1 min. In the *test phase*, trials proceeded as in familiarization except that the stimuli played from only one speaker at a time, and stimulus presentation was contingent on the infant's head turns. When the infant turned toward the flashing side light, syllables began to play from the speaker on that side. The syllables continued to play, and the light to flash, until the infant turned away for two consecutive seconds or until the five-syllable test list played three times (approximately 22.5 s). The ten test trials were presented in this fashion, and mean listening times were calculated for legal and illegal trials.

To assess reliability, a coder measured all of the infants' listening times offline from silent videotape. Primary and reliability coders' times were within 0.5 s of each other on 81% of trials. Individual trials were excluded from the analyses if the ratio of the two coders' measured listening times was less than 0.6; one trial was excluded for this reason. Analyses based on the reliability coder's times displayed the same pattern as those based on the primary coder's times. One additional trial from one infant was dropped because the infant failed to make a criterion head turn. Each infant contributed at least four legal and four illegal trials to the analyses.

2.2. Results and discussion

The infants discriminated between the legal and illegal syllables, listening longer to illegal than to legal items (see Table 1; $t(7) = 2.65$, $P < 0.05$; Wilcoxon $Z = 2.10$, $P < 0.05$). Seven of the eight infants listened longer to illegal trials. The results suggest that the infants learned the phonotactic regularities established during familiarization, and generalized them to new syllables during test. The direction of the effect, a preference for the illegal items that least resembled the training set, is consistent with prior experiments with novel materials and familiarization phases of similar duration and complexity (e.g. Hollich et al., 2001; Saffran et al., 1996). A few minutes of listening allowed the infants to detect the novel phonotactic regularities in the familiarization syllables.

3. Experiment 2

In Experiment 1, infants learned new consonant-position regularities. Experiment 2 replicated this finding with two procedural changes: We reduced the amount of familiarization from six to five repetitions of each syllable, and increased the delay between study and test from 1 to 2 min. These changes made the infant's experience more similar to that

of adults in a previous study of phonotactic learning (Onishi et al., 2002) by providing infants with the same number of syllable repetitions and the same delay length that the adults received.

3.1. Method

3.1.1. Participants

Eight 16.5-month-old infants (range: 16.3–16.9; four male, four female) from the same population as Experiment 1 participated. Nine additional infants were tested but not included because they were overly fussy (eight) or drowsy (one).

3.1.2. Materials

The materials were identical to those of Experiment 1. Test order was randomized for each infant with the constraints that the first trial was legal for half of the infants and illegal for the other half and that legal and illegal trials were distributed approximately evenly across the two halves of the test session. Approximately the same number of legal and illegal trials were presented from the left and right loudspeakers.

3.1.3. Procedure

The procedure was identical to Experiment 1 except that the 25 study syllables were presented five times each (approximate duration: 3 min 10 s) and the delay between familiarization and test was increased to 2 min.

Reliability was assessed as in Experiment 1; the two coders' times were within 0.5 s of each other on 83% of trials. Three subjects each had one trial excluded because of disagreements between the two coders' times. Analyses based on the reliability coder's times displayed the same pattern as those based on the primary coder's times. Each infant contributed at least four legal and four illegal trials to the analyses.

3.2. Results and discussion

Infants again listened reliably longer to illegal than to legal syllables (see Table 1; $t(7) = 2.37$, $P < 0.05$; Wilcoxon $Z = 2.10$, $P < 0.05$). Seven of the eight infants listened longer to illegal trials. These findings closely replicate those of Experiment 1, and provide strong evidence that infants quickly learned new phonotactic restrictions and extended them to unstudied syllables. In Experiment 2, the infants did so with the same amount of training, and with the same length of delay between familiarization and test as did adults (Onishi et al., 2002).

4. General discussion

In two experiments, infants listened longer to unstudied illegal than legal test items, suggesting that they learned the phonotactic regularities implicit in the familiarization syllables and quickly generalized these regularities to syllables not presented during familiarization. Furthermore, infants were able to learn these regularities with the same amount of training given to adults (Onishi et al., 2002). In both experiments, the novel

phonotactic regularities could not be described in terms of a smaller set of phonetic features; thus infants had to learn the distribution of each consonant as a unique item. The fact that they did so, as did the adults in our prior experiments, suggests that language users readily learn phonotactic regularities at the level of the individual segment.

These findings add to the growing literature on sequential learning about speech. Just as infants can learn probable sequences of whole syllables (e.g. Saffran et al., 1996) or patterns of syllable repetition (e.g. Gomez & Gerken, 1999; Marcus et al., 1999), our findings suggest that infants quickly learn likely sequences or syllable positions of phonemes. Such information confers a processing advantage on new syllables that are phonotactically similar to previously experienced syllables. The infant's language processor, like that of adults, adapts quickly to language experience, becoming sensitive not only to particular words or syllables, but also to generalizations over those syllables.

We do not yet know how the phonotactic generalizations were represented. Phonotactic regularities can be seen as abstractions represented separately from the lexicon (e.g. Dupoux et al., 2001; Pitt, 1998), or as the joint effects of lexical or instance representations (e.g. Goldinger, 1998; McClelland & Elman, 1986). Either account could explain our results: infants could have formed rule-like generalizations of the form "/b/ is an onset". Alternatively, unstudied legal syllables could have been treated as relatively familiar due to their similarity to familiarization syllables.

Prior studies with adults have begun to explore the nature of phonotactic learning, with the aim of constraining theories of the relevant learning mechanisms and representations. Adult speakers and listeners acquire regularities more complex than first-order restrictions on consonant position. After production (Dell et al., 2000) or perception training (Onishi et al., 2002), adults quickly learned second-order regularities in which consonant position depended on the adjacent vowel. In addition, recent findings demonstrate that adults can also generalize newly-learned consonant-position constraints to vowels not present in familiarization syllables (Chambers, Onishi, & Fisher, 2002). Taken together, these data suggest that adult listeners encode sequential information and use it at multiple levels of abstraction to learn second-order constraints, which require information about the co-occurrence of particular consonants and vowels, and to generalize first-order constraints to new vowels. Ongoing studies are exploring infants' ability to detect and generalize phonotactic regularities at different levels of complexity.

Investigations of phonotactic learning in infancy may ultimately shed light on the acquisition of native-language phoneme categories. By about 10 months, infants become less able to discriminate phonetic distinctions not contrastive in their native language (e.g. Pegg & Werker, 1997; Werker & Lalonde, 1988). This change may arise in part from mere listening experience: infants exposed to different languages will hear different distributions of phonetic values, depending on how many and what phonemic distinctions their language makes along each phonetic dimension (e.g. Lisker & Abramson, 1964). Recent evidence suggests that phonetic discrimination by 6- and 8-month-olds is altered by exposure to unimodal versus bimodal distributions of values along a synthesized phonetic continuum (Maye, Werker, & Gerken, 2002). However, the distribution of phonetic values for each phoneme category also depends on phonotactic context (e.g. Pierrehumbert, 2000). This suggests that distributional learning, both about how phonetic values cluster in one's native language and where these values occur in syllables, is implicated in the

categorization of speech sounds (e.g. Fisher & Gleitman, 2002; Guenther & Gjaja, 1996; Jusczyk, 1997; Kuhl & Meltzoff, 1996; Werker & Tees, 1999).

The phonotactic learning investigations presented here and in previous experiments with adults (Chambers et al., 2002; Dell et al., 2000; Onishi et al., 2002) provide a new technique for exploring the nature of phonological learning and generalization across wide differences in development and linguistic knowledge. The current findings demonstrate that each listening experience adds information to infant's phonological processing system. This information accumulates to rapidly form phonotactic regularities that influence language processing, including the perception of new syllables. Ultimately, infants' sensitivity to generalizations across previously-experienced phonological sequences may produce the language-specific components of native-language phonology.

Acknowledgements

This work was supported by grants from NIH (1 R55 HD/OD34715-01), NSF (SBR 98-73450), and the UIUC Research Board to Cynthia Fisher, NIMH (MH41704) to Gregory L. Murphy, and an NIMH training grant (1 T32MH19990-01). We thank the undergraduate assistants in the Language Acquisition Lab for help in testing infants. We also thank Renée Baillargeon, Aaron Benjamin, Gary Dell, Lisa Octigan, Hyun-joo Song, and three anonymous reviewers for helpful comments.

References

Chambers, K. E., Onishi, K. H., & Fisher, C. (2002, June). *Generalizing phonotactic regularities from brief auditory experience*. Paper presented at the Eighth Conference on Laboratory Phonology, New Haven, CT.

Dell, G. S., Reed, K. D., Adams, D. R., & Meyer, A. S. (2000). Speech errors, phonotactic constraints, and implicit learning: a study of the role of experience in language production. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *26*, 1355–1367.

Dupoux, E., Pallier, C., Kakehi, K., & Mehler, J. (2001). New evidence for prelexical phonological processing in word recognition. *Language and Cognitive Processes*, *16*, 491–505.

Eimas, P. D. (1999). Segmental and syllabic representations in the perception of speech by young infants. *Journal of the Acoustical Society of America*, *105*, 1901–1911.

Fisher, C., & Gleitman, L. R. (2002). Language acquisition. In H. F. Pashler (Series Ed.) & C. R. Gallistel (Vol. Ed.), *Stevens' handbook of experimental psychology: Vol. 1. Learning and motivation* (pp. 445–496). New York: Wiley.

Goldinger, S. D. (1998). Echoes of echoes? An episodic theory of lexical access. *Psychological Review*, *105*, 251–279.

Gomez, R. L., & Gerken, L. (1999). Artificial grammar learning by 1-year-olds leads to specific and abstract knowledge. *Cognition*, *70*, 109–135.

Guenther, F. H., & Gjaja, M. N. (1996). The perceptual magnet effect as an emergent property of neural map formation. *Journal of the Acoustical Society of America*, *100*, 1111–1121.

Hollich, G., Jusczyk, P. W., & Luce, P. A. (2001, April). *Infants' memory for similar sounding words: phonetic false memories*. Paper presented to the Society for Research on Child Development, Minneapolis, MN.

Jusczyk, P. W. (1997). *The discovery of spoken language*, Cambridge, MA: MIT Press.

Jusczyk, P. W., Friederici, A. D., Wessels, J. M., Svenkerud, V. Y., & Jusczyk, A. M. (1993). Infants' sensitivity to the sound patterns of native language words. *Journal of Memory and Language*, *32*, 402–420.

Jusczyk, P. W., Goodman, M. B., & Baumann, A. (1999). Nine-month-olds' attention to sound similarities in syllables. *Journal of Memory and Language*, *40*, 62–82.

Jusczyk, P. W., Jusczyk, A. M., Kennedy, L. J., Schomberg, T., & Koenig, N. (1995). Young infants' retention of information about bisyllabic utterances. *Journal of Experimental Psychology: Human Perception and Performance*, *21*, 822–836.

Jusczyk, P. W., Luce, P. A., & Charles-Luce, J. (1994). Infants' sensitivity to phonotactic patterns in the native language. *Journal of Memory and Language*, *33*, 630–645.

Kemler-Nelson, D. G., Jusczyk, P. W., Mandel, D. R., Myers, J., Turk, A., & Gerken, L. (1995). The Head-Turn Preference Procedure for testing auditory perception. *Infant Behavior and Development*, *18*, 111–116.

Kuhl, P. K., & Meltzoff, A. N. (1996). Infant vocalizations in response to speech: vocal imitation and developmental change. *Journal of the Acoustical Society of America*, *100*, 2425–2438.

Lisker, L., & Abramson, A. S. (1964). A cross-language study of voicing in initial stops: acoustical measurements. *Word*, *20*, 384–422.

Marcus, G. F., Vijayan, S., Bandi Rao, S., & Vishton, P. M. (1999). Rule learning by seven-month-old infants. *Science*, *283*, 77–80.

Massaro, D. W., & Cohen, M. M. (1983). Phonological context in speech perception. *Perception & Psychophysics*, *34*, 338–348.

Mattys, S. L., & Jusczyk, P. W. (2001). Phonotactic cues for segmentation of fluent speech by infants. *Cognition*, *78*, 91–121.

Maye, J., Werker, J. F., & Gerken, L. (2002). Infant sensitivity to distributional information can affect phonetic discrimination. *Cognition*, *82*, B101–B111.

McClelland, J. L., & Elman, J. L. (1986). The TRACE model of speech perception. *Cognitive Psychology*, *18*, 1–86.

McQueen, J. M. (1998). Segmentation of continuous speech using phonotactics. *Journal of Memory and Language*, *39*, 21–46.

Moreton, E. (2002). Structural constraints in the perception of English stop-sonorant clusters. *Cognition*, *84*, 55–71.

Onishi, K. H., Chambers, K. E., & Fisher, C. (2002). Learning phonotactic constraints from brief auditory experience. *Cognition*, *83*, B13–B23.

Pegg, J. E., & Werker, J. F. (1997). Adult and infant perception of two English phones. *Journal of the Acoustical Society of America*, *102*, 3742–3753.

Pierrehumbert, J. (2000). What people know about sounds of language. *Studies in the Linguistic Sciences*, *29*, 111–120.

Pitt, M. A. (1998). Phonological processes and the perception of phonotactically illegal consonant clusters. *Perception & Psychophysics*, *60*, 941–951.

Saffran, J. R., Aslin, R. N., & Newport, E. L. (1996). Statistical learning by 8-month-old infants. *Science*, *274*, 1926–1928.

Smith, K. L., & Pitt, M. A. (1999). Phonological and morphological influences in the syllabification of spoken words. *Journal of Memory and Language*, *41*, 199–222.

Vitevitch, M. S., Luce, P. A., Charles-Luce, J., & Kemmerer, D. (1997). Phonotactics and syllable stress: implications for the processing of spoken nonsense words. *Language and Speech*, *40*, 47–62.

Werker, J. F., & Lalonde, C. E. (1988). Cross-language speech perception: initial capabilities and developmental change. *Developmental Psychology*, *24*, 672–683.

Werker, J. F., & Tees, R. C. (1999). Influences on infant speech processing: toward a new synthesis. *Annual Review of Psychology*, *50*, 509–535.