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Understanding Phonological Acquisition through Phonetic Perception: The Influence of Exposure and Acoustic Salience*

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ABSTRACT. The change from universal to language-specific speech perception occurs in the second half of the first year. Through head turn preference procedures, we examined changes in Dutch infants' perception of two consonant, one vowel, and two tonal contrasts at three time windows in the first year of life. Sensitivity to some, but not all, native and non-native contrasts followed the traditional perceptual tuning trajectory. We suggest that initial biases, linguistic exposure and acoustic salience are influential factors in the perceptual tuning process.

Keywords: infant, phonological development, initial sensitivity, perceptual tuning, exposure, acoustic salience

1. Introduction

Infants have an astounding initial sensitivity to the subtleties of speech, which comes into being even before birth. Newborns show initial biases to native and non-native contrasts of consonants, vowels and prosody (Nazzi, Bertoncini and Mehler 1998; Aldridge, Stillman and Bower 2001; Hoonhorst, Colin, Markessis, Radeau, Deltenre and Serniclaes 2009). During the first year after birth, they shift to contrasts within their native language. This process of tuning in to the native language inventories manifests itself in several ways (Aslin and Pisoni 1980): maintenance and/or realignment of the initial sensitivity to native contrasts (Burns, Yoshida, Hill and Werker 2007), decreased sensitivity to non-native contrasts (Anderson, Morgan and White 2003), and increased ability to discriminate the more subtle native contrasts (Kuhl, Stevens, Hayashi, Deguchi, Kiritani and Iverson 2006). The language-specific perceptual tuning for consonants, vowels and tones occurs around 8-12 months, 6-8 months and 6-9 months, respectively, after which infants' discrimination of non-native contrasts greatly deteriorates (Werker and Tees 1984; Kuhl, Williams, Lacerda, Stevens and Lindblom 1992; Liu and Kager 2014).

In the consonant domain, voice onset time (VOT) refers to the length of time between the release of a stop consonant and the onset of vocal-fold vibration. In one study, infants show initial sensitivity to VOT contrasts crossing the −30 and +30ms boundaries (Hoonhorst et al. 2009), and quickly tune in to the contrast(s) in their native language. A meta-analysis of VOT contrasts across 17 studies show that infants tend to be highly sensitive to VOT contrasts that cross the category boundary of their native language. In addition, discrimination of contrasts within the category boundary is generally poorer than crossing the category boundary (Galle and McMurray 2014).

In the vowel domain, 0- to 1-day-old English or Spanish newborns display initial sensitivity in the vowel space closely matching native vowel targets, and adult-like perception of /i/, /u/, /y/ and /ɯ/ (Aldridge, Stillman and Bower 2001). 1- to 6-month-old English infants distinguish both native (e.g., /a/-/i/, /a/-/u/) and non-native (e.g., /za/-/řa/, /a/-/ɔ/) contrasts (Trehub 1973, 1976; Kuhl 1979, 1983). English infants at 2 months discriminate the native /i/-/ɪ/ contrast (Swoboda, Morse and Leavitt 1976). During language-specific perceptual tuning, 6-month-old American and Swedish infants' perception of English /i/ or Swedish /y/ is influenced by the prototypes of their native phonetic categories (Kuhl et al. 1992). Similarly, 4-6-month-old English infants show language-specific perceptual patterns when discriminating the German /ʊ/-/ʏ/ and /u/-/y/ contrasts (Polka and Werker 1994). At 8 months, Catalan but not Spanish infants are sensitive to the Catalan /e/-/ɛ/ contrast (Bosch and Sebastián-Gallés 2003). The mismatch negativity amplitude in 12-month-old infants is higher for native vowel phonemes and lower for non-native ones than in 6-month-olds (Cheour, Ceponiene, Lehtokoski, Luuk, Allik, Alho and Näätänen 1998).

In tone languages, lexical tones are pitch variations distinguishing meaning at the word level, a linguistic function lacking in non-tone languages. For tone-learning infants, Mandarin and Cantonese infants show language-specific preferences as early as 4 months in Cantonese tone discrimination (Yeung, Chen and Werker 2013). Mandarin infants at 6 and 9 months retain their sensitivity to Thai tonal contrasts (Mattock and Burnham 2006). At 6 months, Yorùbá infants are more attentive to Yorùbá tones than English infants (Harrison 2000). Meanwhile, non-tone-learning infants display perceptual deterioration in the second half of the first year of life. Reduced sensitivity to Thai tones is found in 9- but not 4- and 6-month-old English infants (Mattock, Molnar, Polka and Burnham 2008). Yeung et al. (2013) also report sensitivity decline in Cantonese tone with English infants from 4 to 9 months.

Apart from initial biases and linguistic experience, it has been suggested that the acoustic salience of a contrast plays a role in phonological development in infancy (Yeung et al., 2013). However, few previous studies have investigated the relationship between acoustic salience and the perceptual tuning process. To understand this potential factor along with the other factors, we conducted several studies across the consonant, vowel and tonal domains.

2. Experiment 1: Consonants

2.1 Participants

106 Dutch infants aged 5-6, 8-9, and 11-12 months participated in the study. Data from 90 participants were used for analysis, with 30 infants per age group. Data from 16 participants were excluded from analysis for various reasons: age too young or old for the group (3); fussiness (1), crying (2), sleeping (1) or inattentiveness (2) during the experiment; inability to habituate after 12 trials (2); and individual average looking time (LT) for each sound category in the test phase more than 2 standard deviations (SD) from the mean LT of that category (5). All parents reported normal hearing and no language impairments for the infants included in the analysis below.

2.2 Materials

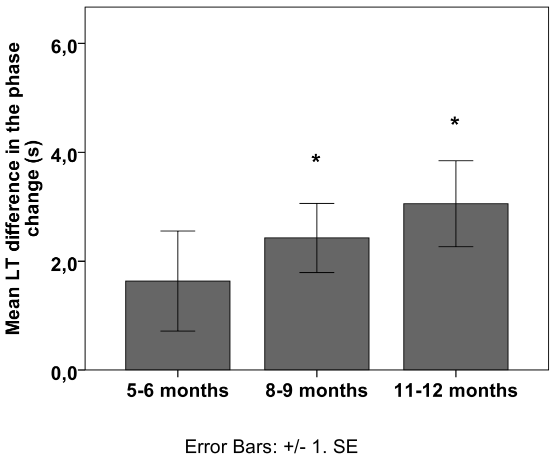
A 2-way contrast in voicing (/b/-/p/), but not aspiration (/p/-/p^h/), occurs in Dutch. The mean prevoicing duration for /b/ is –83ms (SD = 54ms), and for /p/ is 19ms (SD = 12ms) (Van Alphen and Smits 2004). Infants were tested on their discrimination of a 3-way stop contrast along the VOT continuum: prevoiced /ba/, voiceless /pa/, and aspirated /p^{h}a/. The syllables /ba/, /pa/, and /p^{h}a/ spoken by a female Dutch-English bilingual speaker were recorded in a sound-proof phonetics lab at [name suppressed] University with a DAT Tascam DA-40 recorder and a Sennheiser ME-64 microphone. The prevoiced and aspirated consonants of /ba/ and /p^{h}a/ were extracted by PRAAT (Boersma and Weenink 2012), and concatenated with the syllable /pa/ without its original onset, ensuring that the only cross-stimuli differences were the VOT. The VOT values were –130, +10 and +40ms.

2.3 Procedure

A double-oddball visual habituation paradigm designed via the ZEP program (Veenker 2007) was adopted in this study. The paradigm was based on the oddity visual habituation paradigm and is close to that being used in visual habituation and event-related potential studies (Houston, Horn, Qi, Ting and Gao 2007; Garcia-Sierra et al. 2011). Infants went through four phases: pre-test, habituation, test, and post-test. In the pre-test and post-test phases, infants saw randomly appearing figures on a 3×3 grid on the screen, to allow for a comparison of general attention at the beginning and end of the test. A trial ended if an infant looked away for more than 2 seconds or reached a maximum of 45 seconds. During the habituation phase, infants heard repeated tokens of /pa/. The habituation criterion was reached when infants' average LT across three trials was less than 65% of the average LT in the first three trials. A total of 12 trials were presented in the test phase, in which infants heard 8 habituation trials of /pa/ and 2 novel trials each of /ba/ and /pʰa/. Novel trials were presented at the 1st or 2nd, 5th, 8th and 12th position with counterbalanced presentation order. The visual stimuli were pictures of a static female face in the habituation and test phases. The inter-stimulus interval was set as 1 second in all phases. Experimenters and parents were blind to the stimuli.

2.4 Results

The $\log_{10}$ transformed mean LTs (to ensure the normal distribution of the dataset to fit the analysis below) of the habituation trials in the test phase were compared to those of each of the two types of novel trials using a repeated measures ANOVA with age as the between-subjects factor. For the /b/-/p/ contrast, the main effect was significant ($F(1, 87) = 27.515$, $p < .001$), but the interaction of age and contrast was not ($F(2, 87) = 1.344$, $p = .266$). Looking at the individual age groups, infants in the 5-6 month group show a weaker discrimination pattern ($p = .104$), and the other age groups discriminated the contrast ($p = .001$) (Fig. 1). For the /p/-/pʰ/ contrast, both main effect ($F(1, 87) = 16.845$, $p < .001$) and the interaction of age and contrast were significant ($F(2, 81) = 7.137$, $p = .001$) (Fig. 2). Pairwise comparisons showed that the LT difference during the phase change was significantly different between 5-6 and 11-12-month-olds ($p = .007$), whereas 8-9-month-olds sat in between the two ages and did not differ significantly from either of them. Looking into the individual age groups, only infants of 5-6 months ($p < .001$) but not the other age groups ($p = .257$) discriminated the contrast.



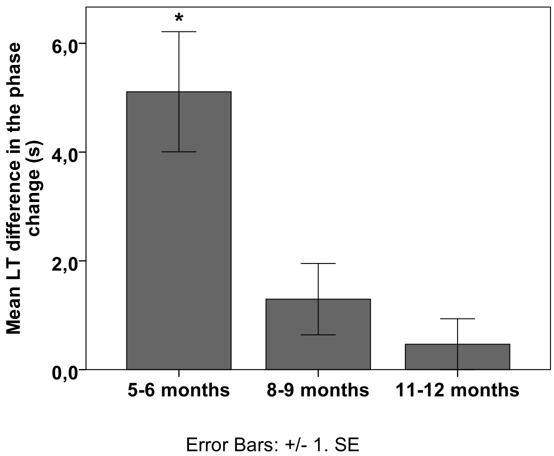


Fig. 1 (left) Mean LT differences of the native /b/-/p/ contrast during the phase change
Fig. 2 (right) Mean LT differences of the non-native /p/-/pʰ/ contrast during the phase change

2.5 Discussion

The current study tracked the developmental trajectory of Dutch infants' VOT perception in relation to initial sensitivity and native language experience in the first year of life. Dutch infants showed initial sensitivity to both contrasts, followed by sensitivity progression for the native long-lead contrast, and regression for the non-native long-lag contrast. In addition, Figures 1 and 2 suggest that 5-6-month-old infants might perceive the aspiration contrast more easily than the prevoicing contrast, reflecting the factor of contrast salience. In brief, Dutch infants' perception of VOT contrasts was compatible with the time window of language-specific perceptual tuning for consonants.

3. Experiment 2: Vowels

3.1 Participants

168 Dutch infants aged 5-6, 8-9, and 11-12 months participated in this study. Data from 150 participants were included for analysis, with 50 infants per age group. Data from 18 participants were excluded from the analysis for various reasons: inability to habituate after 25 trials (2); inattentiveness during the experiment (3); LT less than 2 seconds for both trials in the test phase (4), and individual average LT for each sound category in the test phase more than 2 SD from the mean of the age group (9).

3.2 Materials

An /i/-/ɪ/ contrast occurs in Dutch (e.g., *riet* 'reed' versus *rit* 'ride'), differing in spectrum (F1 and F2) but not duration (Curtin, Fennell and Escudero 2009). The syllables /bip/ and /bɪp/ spoken by a female Dutch speaker were recorded under the same settings as in Experiment 1. The duration and intensity of the stimuli were kept constant via PRAAT. The other natural properties of the contrast were kept intact.

3.3 Procedure

The infants' discrimination performance was assessed via a visual habituation paradigm (Mattock et al. 2008; Liu and Kager 2014). The auditory stimuli were presented along with a visual pattern (a static bull's eye). The infants' LT at the screen was measured for each trial, and the auditory presentation was contingent on the infants' looking. The paradigm consisted of three phases: habituation, test, and post-test. In the habituation phase, infants heard repeated tokens of one sound category. When the habituation criterion was reached, the infants received two trials in the test phase in which tokens different from the habituation category were presented. Discrimination was indicated by a significant LT recovery upon hearing the new stimuli. The other settings were identical to those in Experiment 1.

3.4 Results

The $\log_{10}$ transformed mean LTs during the phase change (the last two habituation trials versus the two test trials) were compared using a repeated measures ANOVA with age as the between-subjects factor.[1] Both the main effect of phase change ($F(1, 147) = 7.434$, $p = .007$) and the interaction of age and phase change ($F(2, 147) = 7.893$, $p = .001$) were significant (Fig. 3). Looking at the individual age groups, only infants in the 11-12 month group ($p < .001$) but not the other age groups ($p = .461$) discriminated the contrast during the phase change.

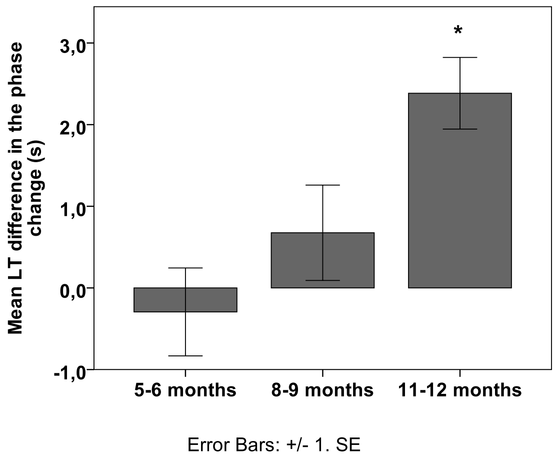


Fig. 3 Mean LT differences of the native /i/-/ɪ/ contrast during the phase change

3.5 Discussion

The data from this discrimination experiment demonstrated Dutch infants' progressive improvement in their perception of the native /i/-/ɪ/ contrast during the first year of life. Two main stages could be observed: the initial failure to discriminate at 5-6 months, and the later success in the second half of the first year. The lack of initial sensitivity was unlikely to be caused by a task effect, since infants' attention persisted in the test phase. It could be that the contrast tested (Dutch /i/-/ɪ/) is relatively difficult to distinguish acoustically at the initial stage, similar to what has been reported in previous literature on vowel duration discrimination (Sato, Sogabe and Mazuka 2010). A previous study showed that English infants discriminated a similar native contrast (Swoboda et al. 1976). Contrast salience (stimuli naturalness, formant values) and task differences may account for the difference between the two studies. Dutch infants did not discriminate the contrast until 11-12 months, later than the usual hallmark (8 months) of language-specific tuning for vowel contrasts (Kuhl et al. 1992). The perceptual tuning process is likely to be contrast-dependent, influenced by acoustic salience, input frequency, and other factors.

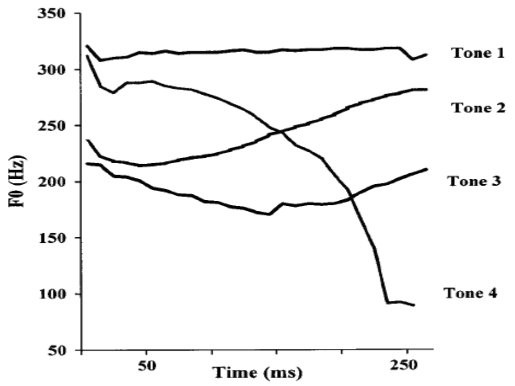
4. Experiment 3: Tones

4.1 Participants

196 Dutch infants aged 5-6, 8-9, and 11-12 months participated in this study. Data from 168 infants were incorporated into the analysis, with 28 infants per age group per contrast. Data from 28 infants were excluded from analysis for various reasons: fussing (7); inability to habituate after 25 trials (5); too short LT (< 2s) in both trials in the change phase (7); and LT difference exceeding 2 SD from the mean (9).

4.2 Materials

Four lexical tones exist in Mandarin Chinese (Fig. 4). The Mandarin high-level (T1) vs. high-falling (T4) tonal contrast was selected. The tone-bearing syllable was /ta/. Both /taT1/ ‘build’ and /taT4/ ‘big’ are words in Mandarin. The productions of a Mandarin female speaker were recorded under the same settings as in the previous experiments. To create a second contrast, the first contrast was further manipulated via PRAAT: the pitch distance between T1 and T4 was contracted to two F0 values occurring at 3/8 and 3/4 of the pitch distance of the original contrast, respectively, by introducing four interpolation points along the pitch contours (at 0%, 33%, 67% and 100%, Fig. 5). The contracted contrast shared the same acoustic properties as the T1-T4 contrast except for a narrower distance between the pitch contours, shrinking the perceptual distance between the two tones. In other words, the salience of the contracted contrast was weakened by a simple manipulation of F0.



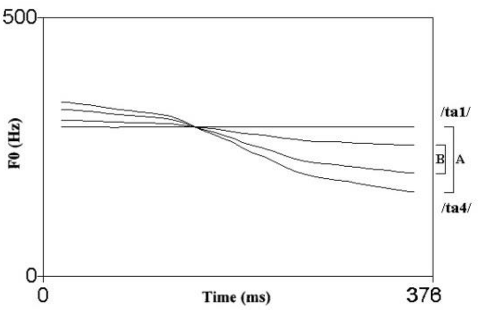


Fig. 4 (left) Tones in Mandarin Chinese (Wang, Jongman and Sereno 2001)

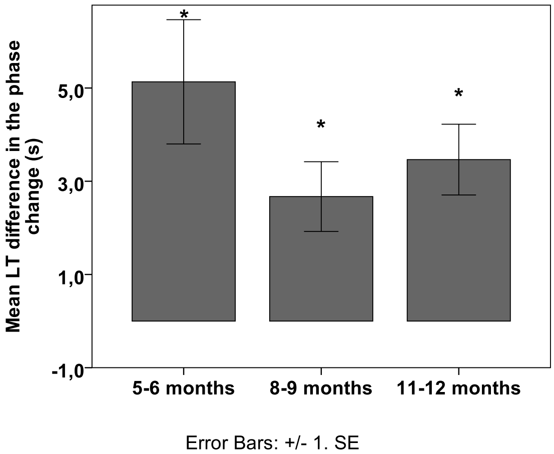
Fig. 5 (right) T1-T4 [A] and contracted T1-T4 [B] contrasts

4.3 Procedure

The infants were tested using the same procedure as in Experiment 2.

4.4 Results

The log_{10} transformed mean LTs during the phase change were compared using a repeated measures ANOVA with age as the between-subjects factor. For the T1-T4 contrast, the main effect of phase change was significant ($F(1, 81) = 47.743$, $p < .001$), but the interaction of age and phase change was not ($F(2, 81) = 0.780$, $p = .462$) (Fig. 6). Infants at all ages discriminated the contrast. For the contracted T1-T4 contrast, both the main effect of phase change ($F(1, 81) = 2.470$, $p = .120$) and the interaction of age and phase change ($F(2, 81) = 4.688$, $p = .012$) were significant (Fig. 7). Pairwise comparisons showed that the LT difference during the phase change was significantly different between 5-6 and the older ages ($p = .013$). Looking at the individual age groups, only infants in the 5-6 month group ($p = .004$) but not the other age groups ($p = .518$) discriminated the contrast during the phase change.



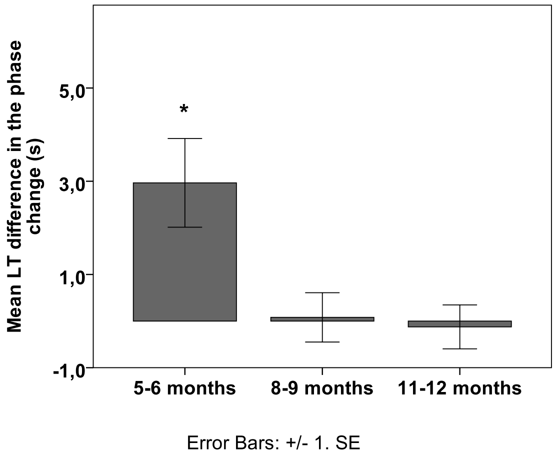


Fig. 6 (left) Mean LT differences of the T1-T4 contrast during the phase change
Fig. 7 (right) Mean LT differences of the contracted T1-T4 contrast during the phase change

4.5 Discussion

All age groups displayed successful discrimination of the Mandarin T1-T4 contrast, providing evidence for a tonal contrast to which non-tone-learning infants' sensitivity was retained during and even after the language-specific perceptual tuning period established by previous studies (at 9 months). In addition, only infants of 5-6 months discriminated the contracted T1-T4 contrast. The tonal sensitivity decline provides evidence for perceptual tuning, and the current results suggested that infants' perceptual patterns were contrast-dependent, and the strength of discrimination seemed to be influenced by contrast salience.

5. General discussion

The three experiments provide a general picture of the language-specific perceptual tuning process. Initial sensitivity appeared in all but one of the vowel contrasts tested at 5-6 months. Then, the infants tuned in to their native phonological categories with accumulated exposure. Sensitivity to native contrasts was maintained (e.g., /b/-/p/) and/or improved (e.g., /i/-/ɪ/), whereas sensitivity to some non-native contrasts declined (e.g., /p/-/p^h/; contracted T1-T4).

The main finding of the current study is the role of the acoustic salience of a contrast in infant phonological acquisition. It affects infants' discrimination during the perceptual tuning period. On the one hand, some native contrasts, like the tested vowel contrast, cannot be discriminated until a relatively late stage. English infants displayed difficulty in discriminating the native stop-fricative /d/-/ð/ contrast in the first year after birth (Polka, Colantonio and Sundara 2001). Tagalog infants of 10-12 but not 6-8 months discriminated the native /na/-/ŋa/ contrast (Narayan, Werker and Beddor 2010). Japanese infants did not acquire the single vs. geminate obstruent /pata/-/patta/ and vowel length differentiation until 9.5 and 10 months (Sato et al. 2010; Sato, Kato and Mazuka 2012). On the other hand, infants retain sensitivity to some non-native contrasts, including the tested T1-T4 contrast. 12-14-month-old English infants discriminated the Zulu click contrast (Best, McRoberts, LaFleur and

Silver-Isenstadt 1995) and the German front-back high vowel /y/-/u/ contrast (Polka and Bohn 1996).

Governed by native language experience, the native sound system is fairly stable at 18 months of age (Dietrich, Swingley and Werker 2007). Our data suggest stabilization as early as 12 months of age. In addition, we hypothesize that the language-specific perceptual tuning process is an indispensable element of native phonological acquisition.

Notes

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[1] As no re-presentation of habituation stimuli appeared in test trials, the results could be due to regression to the mean following attainment of the habituation criterion. However, this interpretation is unlikely given infants' performances across age.

References

Aldridge, Michelle A., Robert D. Stillman and Thomas G. R. Bower. 2001. Newborn categorization of vowel-like sounds. *Developmental Science* 4(2).220–232.

Anderson, Jennifer L., James L. Morgan and Katherine S. White. 2003. A statistical basis for speech sound discrimination. *Language and Speech* 46(2-3).155–182.

Aslin, Richard N. and David B. Pisoni. 1980. Some developmental processes in speech perception. *Child Phonology* 2.67–96.

Best, Catherine T., Gerald W. McRoberts, Rosemarie LaFleur and Jean Silver-Isenstadt. 1995. Divergent developmental patterns for infants' perception of two nonnative consonant contrasts. *Infant Behavior and Development* 18(3).339–350.

Boersma, Paul and David Weenink. 2012. Praat, version 5.5.

Bosch, Laura and Núria Sebastián-Gallés. 2003. Simultaneous bilingualism and the perception of a language-specific vowel contrast in the first year of life. *Language and Speech* 46(2-3).217–243.

Burns, Tracey, Katherine A Yoshida, Karen Hill and Janet F. Werker. 2007. The development of phonetic representation in bilingual and monolingual infants. *Applied Psycholinguistics* 28.455–474.

Cheour, Marie, Rita Ceponiene, Anne Lehtokoski, Aavo Luuk, Jüri Allik, Kimmo Alho and Risto Näätänen. 1998. Development of language-specific phoneme representations in the infant brain. *Nature Neuroscience* 1(5).351–353.

Curtin, Suzanne, Christopher Fennell and Paola Escudero. 2009. Weighting of vowel cues explains patterns of word–object associative learning. *Developmental Science* 12(5).725–731.

Dietrich, Christiane, Daniel Swingley and Janet F. Werker. 2007. Native language governs interpretation of salient speech sound differences at 18 months. *Proceedings of the National Academy of Sciences* 104(41).16027–16031.

Galle, Marcus E. and Bob McMurray. 2014. The development of voicing categories: A quantitative review of over 40 years of infant speech perception research. *Psychonomic Bulletin & Review* 1–23.

Garcia-Sierra, Adrian, Maritza Rivera-Gaxiolaa, Cherie R. Percaccio, Barbara T. Conboy, Harriett Romo, Lindsay Klarman, Sophia Ortiz and Patricia K. Kuhl. 2011. Bilingual language learning: An ERP study relating early brain responses to speech, language input, and later word production. *Journal of Phonetics* 39(4).546–557.

Harrison, Phil. 2000. Acquiring the phonology of lexical tone in infancy. *Lingua* 110(8).581–616.

Hoonhorst, Ingrid, Cécile Colin, Emily Markessis, Monique Radeau, Paul Deltenre and Willy Serniclaes. 2009. French native speakers in the making: From language-general to language-specific voicing boundaries. *Journal of Experimental Child Psychology* 104(4).353–366.

Houston, Derek, M., David L. Horn, Rong Qi, Jonathan Y. Ting and Sujuan Gao. 2007. Assessing speech discrimination in individual infants. *Infancy* 12(2).119–145.

Kuhl, Patricia K. 1979. Speech perception in early infancy: Perceptual constancy for spectrally dissimilar vowel categories. *The Journal of the Acoustical Society of America* 66(6).1668–1679.
Kuhl, Patricia K. 1983. Perception of auditory equivalence classes for speech in early infancy. *Infant Behavior and Development* 6(2).263–285.
Kuhl, Patricia K., Erica Stevens, Akiko Hayashi, Toshisada Deguchi, Shigeru Kiritani and Paul Iverson. 2006. Infants show a facilitation effect for native language phonetic perception between 6 and 12 months. *Developmental Science* 9.F13–F21.
Kuhl, Patricia K., Karen A. Williams, Francisco Lacerda, Kenneth N. Stevens and Björn Lindblom. 1992. Linguistic experience alters phonetic perception in infants by 6 months of age. *Science* 255.606–608.
Liu, Liquan and René Kager. 2014. Perception of tones by infants learning a non-tone language. *Cognition* 133(2).385–394.
Mattock, Karen and Denis Burnham. 2006. Chinese and English infants' tone perception: Evidence for perceptual reorganization. *Infancy* 10(3).241–265.
Mattock, Karen, Monika Molnar, Linda Polka and Denis Burnham. 2008. The developmental course of lexical tone perception in the first year of life. *Cognition* 106(3).1367–1381.
Narayan, Chandan R., Janet F. Werker and Patrice S. Beddor. 2010. The interaction between acoustic salience and language experience in developmental speech perception: Evidence from nasal place discrimination. *Developmental Science* 13(3).407–420.
Nazzi, Thierry, Josiane Bertoncini and Jacques Mehler 1998. Language discrimination by newborns: Toward an understanding of the role of rhythm. *Journal of Experimental Psychology: Human Perception and Performance* 24(3).756.
Polka, Linda, and Ocke-Schwen Bohn. 1996. A cross-language comparison of vowel perception in English-learning and German-learning infants. *The Journal of the Acoustical Society of America* 100(1).577–592.
Polka, Linda, Connie Colantonio and Megha Sundara. 2001. A cross-language comparison of/d/–/ð/perception: Evidence for a new developmental pattern. The *Journal of the Acoustical Society of America* 109(5).2190–2201.
Polka, Linda and Janet F. Werker. 1994. Developmental changes in perception of nonnative vowel contrasts. *Journal of Experimental Psychology: Human Perception and Performance* 20(2).421.
Sato, Yutaka, Mahoko Kato and Reiko Mazuka. 2012. Development of single/geminate obstruent discrimination by Japanese infants: Early integration of durational and nondurational cues. *Developmental Psychology* 48(1).18.
Sato, Yutaka, Yuko Sogabe and Reiko Mazuka. 2010. Discrimination of phonemic vowel length by Japanese infants. *Developmental Psychology* 46(1).106.
Swoboda, Philip J., Philip A. Morse and Lewis A. Leavitt. 1976. Continuous vowel discrimination in normal and at risk infants. *Child Development* 459–465.
Trehub, Sandra E. 1973. Infants' sensitivity to vowel and tonal contrasts. *Developmental Psychology* 9(1).91.
Trehub, Sandra E. 1976. The discrimination of foreign speech contrasts by infants and adults. *Child Development* 466–472.
Van Alphen, Petra M. and Roel Smits. 2004. Acoustical and perceptual analysis of the voicing distinction in Dutch initial plosives: The role of prevoicing. *Journal of Phonetics* 32(4).455–491.
Veenker, Theo J.G. 2007. [computer program]. http://www.let.uu.nl/~Theo.Veenker/personal/ZEP.
Wang, Yue, Allard Jongman and Joan A. Sereno. 2001. Dichotic perception of Mandarin tones by Chinese and American listeners. *Brain and Language* 78(3).332–348.
Werker, Janet F. and Richard C. Tees. 1984. Cross-language speech perception: Evidence for perceptual reorganization during the first year of life. *Infant Behavior and Development* 7.49–63.
Yeung, H. Henny, Ke Heng Chen and Janet F. Werker. 2013. When does native language input affect phonetic perception? The precocious case of lexical tone. *Journal of Memory and Language* 68(2).123–139.

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