Near-Merger in Hong Kong Cantonese Tones: A Behavioural and ERP Study

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Abstract

Near-merger is a recalcitrant phenomenon in sound change in which speakers are able to differentiate two sounds in production but consistently report that they are the same in perception. This phenomenon challenges the dominant models of phonological processing, and raises methodological questions whether speakers' judgment can truly reflect their ability to discriminate speech sounds. The present study attempts to provide a thorough assessment of this intriguing phenomenon through performing behavioural and ERP studies on the perception of a tonal contrast (T4/T6) in Hong Kong Cantonese which has been reported to exhibit near-merger in previous studies. The behavioural study adopts auditory discrimination and oral production tasks, whereas the ERP study employs passive oddball task to elicit MMNs. Preliminary findings showed that the results of ERP measures were consistent with that of the behavioural measures. MMNs were found in participants who could discriminate the two tones whereas no MMN was found in participants who failed to discriminate them behaviourally. These initial observations are not only consistent with the existence of near-merger, but also mark the beginning of research efforts into understanding this baffling phenomenon.

Index Terms: mismatch negativity, merger, tone perception, tone production, Cantonese

1. Introduction

Hong Kong Cantonese (HKC) stands out from other tone languages in the world by having a rich system of tonal contrast. There are six contrastive tones for non-checked syllables in standard HKC, namely T1 (high level tone), T2 (high rising tone), T3 (mid level tone), T4 (low falling/extra low level tone), T5 (low rising tone) and T6 (low level tone). The pitch contours of these six tones are shown in Figure 1. However, this highly complex system is in the process of merging. It has been reported that some speakers in the community did not consider some of the tonal pairs contrastive.

[1] and [2] have recently investigated how extensive the mergers are by administering both discrimination and production tasks to 120 local native Cantonese speakers. The results confirm the suspected merger of T2 and T5 since a significant number of subjects were noted to fail to contrast these two tones in both perception and production tasks. The dissociation of perception and production of tonal contrast was also observed. The more interesting finding was the identification of a group of speakers whose tone production distinguishes all tone categories in the language, but who fail to distinguish just one particular tonal contrast in perception. Among all the tonal contrasts, T4/T6 contrast exhibited the strongest dissociation effect. In fact, this dissociation between (non-distinctive) perception and (distinctive) production has also been found among other languages at the segmental level [3,4]. Labov named this phenomenon near-merger. Since then, "near-merger" has puzzled linguists because it challenges the dominant models of phonological processing, and raises methodological questions whether speakers' judgment can truly reflect their ability to discriminate speech sounds.

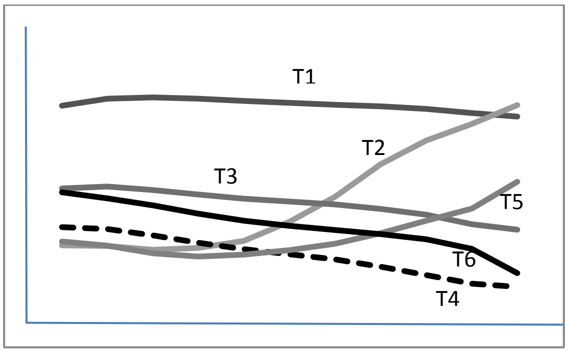

Figure 1: *The pitch contours of the six contrastive tones in Hong Kong Cantonese*

1.1. Theoretical implications

The classic motor theory of speech perception has maintained its essential claims that speech perception and production are biologically linked and that speech perception must involve access to the motor system through various revisions of its original tenets over decades [5-7]. Although conceptualized in a different way, many models of speech perception and production assume one phonological lexicon containing phonological forms of lexical items in a language that supports both perception and production [8]. These models predict that mismatch between production and perception may occur, but only the pattern of poor production and good perception is possible, as production involves motor programming of articulatory representations subsequent to access to target phonological representations. This means that good production must presume the existence of relevant phonological representations that support good perception. Hence, good production vis-à-vis poor perception involving the same phonological forms is apparently a conundrum.

On the other hand, lexical models that assume two sets of representations with one underlying perception (input lexicon) and one production (output lexicon), may account for the dissociation. Thus far, such frameworks have been motivated by observations from individuals with acquired language impairment subsequent to brain injury who cannot comprehend language (i.e. word deafness) but can express his/her ideas in spoken form [9], as well as those with the opposite pattern [10]. Nonetheless, it has been argued that the double dissociation between comprehension (input) and production (output) is subject to an alternative account. Rather than postulating separate lexicons for input and output, one may explain the phenomenon by assuming functionally distinct access to the phonological lexicon for comprehension vs. production, that is, preserved access for input in the presence of impaired access for output, and vice versa [11].

1.2. Methodological implications

Speakers' poor perception is almost always based on behavioural measures of an auditory discrimination task, which involves not only processing of auditory information, but also the participants' judgments and decisions. Judgments, however, may not necessarily reflect our ability to distinguish two auditory stimuli. A far more accurate assessment of the subject's ability to perceive differences is to observe responses at the brain level.

Among currently available neuroimaging methods, the event-related potential paradigm (ERP), an electrophysiological technique, is uniquely suitable for investigating the issue in hand. It has exquisite temporal resolution in the order of milliseconds which can capture brain responses to detection of differences in auditory input. ERP measures can provide a window into the online processing between a stimulus and its response, reflecting effects at different temporal stages and at several levels of cognitive processing. ERPs also have a significant advantage over behavioural studies in that they may reveal differences in brain activity despite comparable behavioural performances. In the present context, it is possible that subjects' failure to distinguish two tones as indicated by a decision may be accompanied by distinctive responses to the same stimuli at the neural level.

Of the various ERP components associated with different stages of auditory/phonological processing, the mismatch negativity (MMN), which reflects a pre-attentive comparison process in passive oddball paradigms and can be elicited independently of bias of any experimental task or participant's strategy [12,13], has been used extensively to examine the sensitivity of individuals to speech sound contrasts, including place of articulation, voicing, and vowel, as well as changes in pure tones, complex tones and repetitive tone patterns (see [14] for review). Studies successfully elicited MMN to tone contrasts among native speakers of Mandarin [15] and Cantonese [16] have been reported. Both [15] and [16] found greater MMN amplitude and earlier onset in response to tonal contrasts which are larger in height and contour.

1.3. Significance of the present study

To the extent that MMNs are observed in response to tonal contrasts which the participants fail to discriminate behaviourally, the ERP technique not only provides a more accurate picture of the phenomenon of tone near-merger, but also raises important questions about the reliance on decision making on the part of the listener to indicate perceptual differences in auditory input. In contrast, if the MMN patterns are consistent with the behavioural results, i.e. absence of MMN to merging tones, the phenomenon of near-merger is confirmed. The potential significance of this confirmation is that it challenges widely accepted models that assume a single phonological lexicon and theories arguing for the position that speech production underlies speech perception.

2. Methods

2.1. Behavioural experiment

The discrimination and production tasks of tonal contrasts were identical to those developed by [1] and [2].

2.1.1. Participants

Randomly chosen native speakers of Cantonese were recruited for the experiment. After administrating questionnaire to check for language experience, educational level, and socioeconomic background, 140 participants with normal hearing ability were invited to take part in the behavioural experiment.

2.1.2. Stimuli

The stimuli included 48 syllables generated by eight CV roots. As shown in Table 1, the first four roots: [fu], [sɛ], [si], and [ji] derived 24 real syllables for all the six tonal contrasts; whereas the latter four roots: [ku], [p^hɔ], [ja], and [jɛ] derived only 12 real syllables. The 48 syllables (real and pseudo) were produced and recorded by a native Cantonese female speaker and served as the auditory stimuli of the perception task. The 36 real syllables were represented by a frequently used Chinese character and served as the visual stimuli of the production task.

2.1.3. Procedures

The perception and production tasks took place in the sound attenuated labs either at the Hong Kong Polytechnic University or at the University of Hong Kong. Both tasks were administered by a computer program developed in Visual Basic. The total length of the behavioural experiments was around one hour with breaks in between.

The perception task included an AX discrimination test. Two hundreds and twenty-one pairs of syllables (10 trials x 21 tonal contrasts) were presented. The participants have to indicate whether the two syllables presented on a trial were identical or not by clicking a button on the computer screen.

In the production task, the 36 real syllables in the stimuli were embedded in different sentential positions in the following two carriers: /ŋɔ23 ji11 ka55 duk2 ____ ji22/ 'I am now reading the ____ character' and /ni55 kɔ33 ji22 hɐi22_____/ 'This character is _____'. The 72 trials (36 syllables x 2 carriers) were presented to the participants in written form for them to read out aloud. The speech outputs were recorded digitally for transcription by two native speakers. Acoustic analysis was also performed. The fundamental frequency (F0) values of the target syllables were extracted at ten equal distant points using a Praat script. The F0 values measured were normalized using the T-formula.

2.2. ERP experiment

2.2.1 Participants

Forty participants were selected for the ERP experiment based on their perception and production scores in the behavioural tasks. All participants must be able to produce the three tones of interest distinctively. Twenty of the participants exhibited possible near-merger of T4/T6 and clear discrimination of T1/T6 (the near-merger group), while the other 20 participants could distinguish both tone pairs and served as controls (the non-merger group). The recruitment criteria of the each group are shown in Table 2. For participants who failed to achieve 100% correct in T6 production, the errors must not involve T6/T4 confusion.

Table 2. *Recruitment criteria of participants in percentage-correct.*

	Perception		Production		
	T1/T6	T4/T6	T1	T4	T6
Near-mergers	100%	62.5% or below	100%	100%	over 90%
Non-mergers	100%	100%	100%	100%	100%

2.2.2. Stimuli

The stimuli included the recordings of a native Cantonese female speaker pronouncing the real syllable [fu] and the pseudosyllable [lu] carrying T1, T4, or T6. Combining these elements resulted in eight blocks in the experiment. Two blocks presented the T1/T6 and T4/T6 contrasts of [fu], respectively, with T6 as the deviant stimulus. Two other blocks presented these contrasts with T6 as the standard stimulus. The same arrangement applied to the other four blocks with the pseudosyllable [lu]. Each block contained 535 trials, of which 80 trials (or 15%) were deviant trials. The trials were randomized with the constraint that there would be at least five and a maximum of 11 standards between consecutive deviants. Each trial had a duration of 1200 ms, including a syllable of 400ms in length and an inter-stimulus interval (ISI) of 800ms (similar to the ISI of 825ms in [17] and [18]). The intensity of all syllables were normalised to 70 dB SPL using Audacity (http://audacity.sourceforge.net/; see Figure 2, 3 and 4 for the spectrograms of syllables [fu1], [fu4] and [fu6]) and all syllables were aligned to have the same onset and vowel duration. This was critical for defining the divergence point—where two identical stimuli begin to deviate—and for identifying the MMN as MMN is highly sensitive to minor acoustic differences. The divergence point was different for the two pairs of tone contrasts due to the difference in pitch. T1 and T6 diverged at the vowel onset (100ms post-stimulus onset; see Figure 5) as they have different pitch heights. In contrast, T4 resembled T6 in the early part of the pitch contour, the divergence point of T4/T6 was later than that of T1/T6 and was also slightly different for the syllable [fu] and [lu]. [fu4] and [fu6] began to diverge at 294 ms (see Figure 5) whereas [lu4] and [lu6] started to diverge at 219 ms.

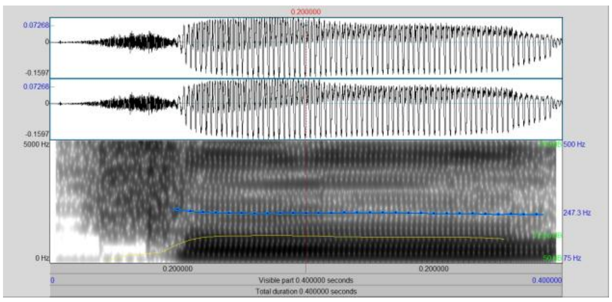
Figure 2: *Spectrogram of syllable [fu1].*

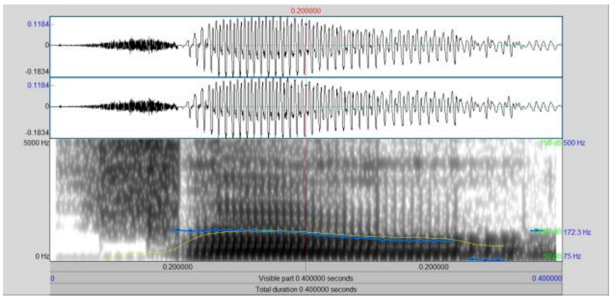
Figure 3: *Spectrogram of syllable [fu4].*

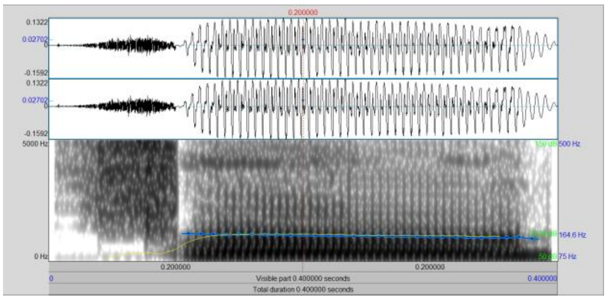
Figure 4: *Spectrogram of syllable [fu6].*

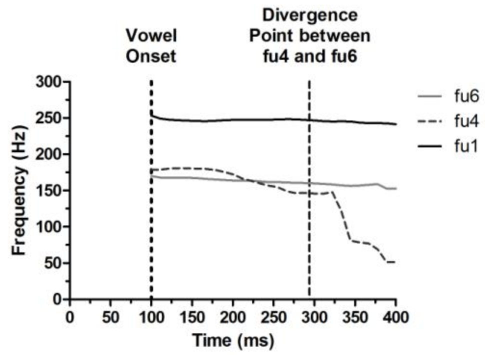

Figure 5: *Pitch contours of syllables fu[fu4] and [fu6]. The divergence point of [fu4] and [fu6] is at 294 ms.*

2.2.3. Procedure

The passive oddball task took place in the Laboratory for Communication Science in the Division of Speech and Hearing Sciences at the University of Hong Kong. The participants were seated comfortably in front of a computer screen approximately 1 m away. During the passive oddball task, participants were asked to watch a silent movie played via the computer screen. Auditory stimuli were binaurally presented through headphones simultaneously. The participants were told to pay attention to the movie and ignore the sounds they hear. The task consisted of eight blocks and a two-minute rest was given between blocks. The entire experiment lasted about 100 minutes.

2.2.4. Data acquisition and analysis

Electrocephalography (EEG) was recorded using SynAmps2 Neuroscan Inc. system (Compumedics Ltd., USA) in an electrically and acoustically shielded booth. The EEG activity was recorded from 64 silver-silver-chloride (Ag/AgCl) electrode sites (FPz, Fz, FCz, Cz, CPz, Pz, POz, Oz, FP1/2, F7/5/3/1/2/4/6/8, FT7/8, FC5/3/1/2/4/6, T7/8, C5/3/1/2/4/6, M1/2, TP7/8, CB1/2, CP5/3/1/2/4/6, P7/5/3/1/2/4/6/8, PO7/5/3/4/6/8, O1/2) arranged in an extended montage based on the International 10-20 system (using a Neuroscan 64-channel Quik-cap (Compumedics Ltd., USA). The vertex functioned as the reference and AFz served as the ground electrode. The impedance was kept under 10 kΩ whenever possible. Additional electrodes were placed above and below the left orbit and on the outer canthus of each eye to monitor electro-oculographic (EOG) activity with a bipolar recording. Continuous data were digitized at a sampling rate of 500Hz with a bandpass of 0.05 Hz to 200 Hz.

The collected raw EEG data was preprocessed with Neuroscan 4.5 software (Compumedics Ltd., USA) and FieldTrip [17]. The data was first filtered with a bandpass 1 Hz to 20 Hz for noise reduction and was then divided into trials of 1800 ms in length including a 800 ms interval before the stimulus onset. Next, extreme trials—trials with an amplitude larger than ±300 μV—were removed before entering all trials into Independent Component Analysis (ICA). The purpose of the ICA was to identify any components resembling eyeblinks, horizontal eye movements, noisy channels and other focal artefacts. The identified components were then mathematically removed from the data and signals were reconstructed based on the remaining components. After ICA, each channel was baseline corrected using the pre-stimulus 800 ms interval and was re-referenced to the mean mastoids to remove any lateral bias [17,18]. Also, trials with artefacts that exceeded 100 μV, trends greater than 75 μV, abnormal distributions or improbable data exceeding 5 SD were rejected. The remaining trials were sorted into deviants (per tone and syllable-type), standards-preceding-a-deviant (per tone and syllable-type), and other standards (per tone and syllable-type). In the following analyses, only deviants and standards-preceding-a-deviant (which is referred to as standards hereafter) were included.

Statistical differences between the deviants and the standards were assessed by the cluster-based permutation test (see [18] for details). The test first identifies clusters of adjacent channel-time pairs, whose t-statistic exceeds a critical threshold ($p<.05$, two-tailed). Then, the maximum cluster-level test statistic (the sum of all individual t-values within a cluster) is evaluated against a null distribution of cluster-level *t*-statistics constructed from the t-statistics on multiple randomizations (10,000 in the present study). Clusters falling in the highest or lowest 2.5th percentile of the distribution are considered significant. The cluster-level permutation test was computed separately on each block for each participant.

3. Results

Preliminary results of behavioural and ERP experiments on two age-matched participants, one from each group, are reported.

3.1. Behavioural experiment

As the T4/T6 tone pair is the critical contrast in this study, the pitch contours of T4 and T6 produced by the control participant and the near-merger participant were measured and shown in Figure 2 and Figure 3, respectively. The pitch traces confirmed that both the near-merger and the control could discriminate the two tones in production.

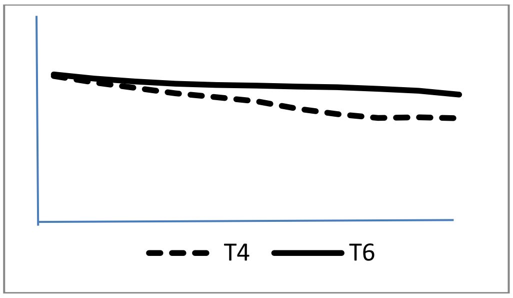

Figure 6: *Pitch contours of T4 and T6 produced by the control participant*

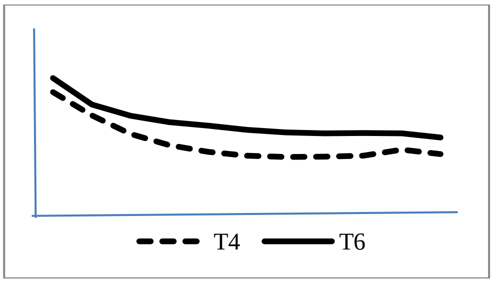

Figure 7: *Pitch contour of T4 and T6 produced by the near-merger participant*

3.2. ERP experiment

We report only the results of the analyses involving the real syllable [fu6] with T6 as the deviant in both T1/T6 and T4/T6 contrasts. The cluster analyses identified significant clusters in the T1/T6 contrast for both participants. With regard to the T4/T6 contrast, significant clusters were only observed in the control but not in the near-merger.

In terms of the T1/T6 contrast, significant negative clusters were observed in both the merger and the control (see Figure 8A and Figure 8C). The MMN-like component in the near-merger had a time-window from 218ms (or 118 ms after point of divergence) to 302ms after stimulus onset (sum-T = -7642.30, $p< .001$). This component was maximal at the left fronto-central electrodes (see Figure 8A). As for the control, the negative cluster was present between 202 ms and 284 ms (sum-T = -9868.93, $p< .001$). This negative cluster was widely distributed over the fronto-central electrodes (see Figure 8C). Given their latency and the topographic characteristics, these negative clusters were taken as MMN. In addition, the control showed a positivity from 300 ms till 400 ms after stimuli onset (sum-T = 11942.10, $p< .001$). The positivity was largest at the fronto-central electrodes (see Figure 8C). Based on the time-course and topography, we classified this positivity as P3a.

As for the T4/T6 contrast, the cluster analyses yielded two significant clusters in the control but none in the near-merger (see Figure 8D and Figure 8B, respectively). The two clusters found in the control were both negative. The first negativity was marginally significant (sum-T = -4849.93, p = .05). It started from 248 ms till 314 ms covering the point of divergence and was maximal at centro-parietal electrodes (see Figure 8D). The later negative cluster was observed in the time-window between 484 ms (or 190 ms after point of divergence) and 568 ms after the stimulus onset (sum-T = -6081.69, $p< .05$). It had a fronto-central distribution. Based on the time-course and topography, the second negative cluster is considered MMN responsive to the T4/T6 contrast.

4. Discussion

The present investigation examines the puzzling near-merger phenomenon in the tonal system of HKC at both behavioural and neural levels. Our preliminary results of the ERP experiment are consistent with those of the discrimination task. MMNs to the T1/T6 contrast were observed in both the near-merger and control in roughly similar time windows. Additionally, P3a reflecting automatic attentional shift elicited by detection of deviant features was observed only in the control. In contrast, no MMN to T4/T6 was found in the near-merger. While MMN to the T4/T6 contrast was detected in the control, it was of lower amplitude and with a later onset relative to the point of divergence, consistent with [15] and [16].

To the extent that the preliminary pattern of results holds up at the group level analysis and thereby confirms the near-merger phenomenon, our initial findings taken together reveal two potentially important aspects for the understanding of the near-merger phenomenon. First, whether certain tone pairs are more susceptible to tone merging may depend on the magnitude of contrast. This is reflected in the different characteristics of the neural responses to T1/T6 and T4/T6 in the control. Second, whether a listener may fail to perceive smaller contrasts (e.g. T4/T6) and become a near-merger may be related to his sensitivity to subtle differences in acoustic/phonetic signals and/or responsiveness of his attentional mechanism. This is suggested by the different neural responses to T1/T6 between the merger and the control, in terms of the presence or absence of P3a.

5. Conclusions

Our initial behavioural and electrophysiological findings of tone perception of a Cantonese near-merger and a control demonstrated that while the discrimination and ERP results were consistent with each other, the latter provide much richer and insightful information that likely lead to important directions to our understanding of the theoretically challenging near-merger phenomenon.

6. Acknowledgements

The study was supported by the Hong Kong Polytechnic University (Project no: Z448F) and the University of Hong Kong (Project no. 10401150.14304.10010.323.01).

7. References

[1] Fung, R.S.Y. and Wong, C.S.P., "Mergers and near-mergers in Hong Kong Cantonese tones", presented at Tone and Intonation 4, Stockholm, Sweden. 2010.

[2] Fung, R.S.Y. and Wong, C.S.P., "The mechanisms of tone mergers in Hong Kong Cantonese", presented at 15th International Conference on Yue Dialects, Macau, 2010.

[3] Labov, W., Principles of Linguistic Change. Vol. 1: Internal Factors, Oxford & Cambridge, Mass.: Blackwell. 1994.

[4] Labov, W., Karen M., and Miller, C., "Near-mergers and the suspension of phonemic contrast", Language Variation and Change (3): 33–74, 1991.

[5] Galantucci, B., Folwer, C. A., and Turvey, M. T., "The motor theory of speech perception reviewed", Psychonomic Bulletin and Review, 13:361-377, 2006.

[6] Liberman, A. M., Cooper, F. S., Shankweiler, D. P., and Studdert-Kennedy, M., Perception of speech code. Psychological Review, (74): 431-461, 1967.

[7] Liberman, A. M., and Mattingly, I. G., "The motor theory of speech perception revised", Cognition, (21):1-36, 1985.

[8] Hickok, G., "The cortical organization of phonological processing", in M. S. Gazzaniga [Ed], Cognitive Neuroscience 4th ed., 767-776, Cambridge, MA: MIT Press, 2009.

[9] Franklin, S., Turner, J., and Morris, J., "Word meaning deafness: Effects of word type", in Proceedings of the International Conference on Spoken Language Processing. Yokahama, Japan, 1994.

[10] Hillis, A. E., Boatman, D., Hart, J., and Gordon, B., "Making sense out of jargon: A neurolinguistic and computational account of jargon aphasia", Neurology (53) :1813–1824, 1999.

[11] Hillis, A. E., "The organization of the lexical system", In B. Rapp (Ed), Handbook of Cognitive Neuropsychology: What Deficits Reveal about the Human Mind, 185-210, Hove, UK: Psychology Press, 2001.

[12] Näätänen, R., Gaillard, A.W., and Mäntysalo, S. "Early selective-attention effect on evoked potential reinterpreted", Acta Psychologica, 42, 313–329, 1978.

[13] Näätänen, R., and Winkler, I., "The concept of auditory stimulus representation in cognitive neuroscience", Psychological Bulletin, 125, 826–859, 1999.

[14] Näätänen, R., Paavilainen, P., Rinne, T., and Alho, K. "The mismatch negativity (MMN) in basic research of central auditory processing: A review", Clinical Neurophysiology, 118, 2544-2590, 2007.

[15] Chandrasekaran, B., Krishnan, A., and Gandour, J.T., "Mismatch negativity to pitch contours is influenced by language experience", Brain Research, 1128: 148–152, 2007.

[16] Tsang, Y.-K., Jia, S., Huang, J., and Chen, H.-C., "ERP correlates of pre-attentive processing of Cantonese lexical tones: The effects of pitch contour and pitch height", Neuroscience Letters, (487)268-272, 2011.

[17] Bishop, D. V. M., Hardiman, M. J., and Barry, J. G., "Lower-Frequency Event-Related Desynchronization: A Signature of Late Mismatch Responses to Sounds, Which Is Reduced or Absent in Children with Specific Language Impairment", Journal of Neuroscience, 30, 15578 –15584, 2010.

[18] Bishop, D. V. M., Hardiman, M. J., and Barry, J. G., "Is auditory discrimination mature by middle childhood? A study using time-frequency analysis of mismatch responses from 7 years to adulthood", Developmental Science, 14, 402–416, 2011.

[19] Oostenveld, R., Fries, P., Maris,c E., and Schoffelen, J-M., "FieldTrip: Open Source Software for Advanced Analysis of MEG, EEG, and Invasive Electrophysiological Data", Computational Intelligence and Neuroscience, 2011, Article ID 156869, 9 pages, doi:10.1155/2011/156869, 2011.

[20] Maris, E., and Oostenveld, R., "Nonparametric statistical testing of EEG- and MEG-data", Journal of Neuroscience Methods, 164, 177–190, 2007.

[21] Snyder, E., and Hillyard, S., "Long-latency evoked potentials to irrelevant, deviant stimuli", Behavioral Biology, 16, 319-331, 1976.

[22] Sams, M., Alho, K., and Näätänen, R, "Sequential effects on the ERP in discriminating two stimul", Biological Psychology, 17, 41-58, 1983.

[23] Näätänen, R., Simpson, M., Loveless N. E.,"Stimulus deviance and evoked potentails", Biological Psychology, 14, 53-98, 1982.

[24] Sussman, E., Winkler, I., Huotilainen, M., Ritter, W., Näätänen, R., "Top-down effects can modify the initially stimulus-driven auditory organization", Cognitive Brain Research, 13, 393-405, 2002.

Table 1. *Stimuli for the behavioural tasks. Pseudosyllables are asterisked.*

	T1	T2	T3	T4	T5	T6
[fu]	呼 'to call'	苦 'bitter'	富 'rich'	扶 'hold'	婦'woman'	付 'to pay'
[sɛ]	些 'some'	寫 'to write'	赦 'pardon'	蛇 'snake'	社 'society'	射 'to shoot'
[si]	師 'teacher'	史 'history'	嗜 'hobby'	時 'time'	市 'market'	示 'notice'
[ji]	醫 'to cure'	椅 'chair'	意'meaning'	兒 'son'	耳 'ear'	二 'two'
[ku]	姑 'aunt'	古 'ancient'	固 'stable'	*	*	*
[pʰɔ]	*	頗 'quite'	破 'worn'	婆'grandma'	*	*
[ja]	吔 '(interj.)'	*	*	*	也 'also'	廿 'twenty'
[jɛ]	*	*	*	椰 'coconut'	野 'wild'	夜 'night'

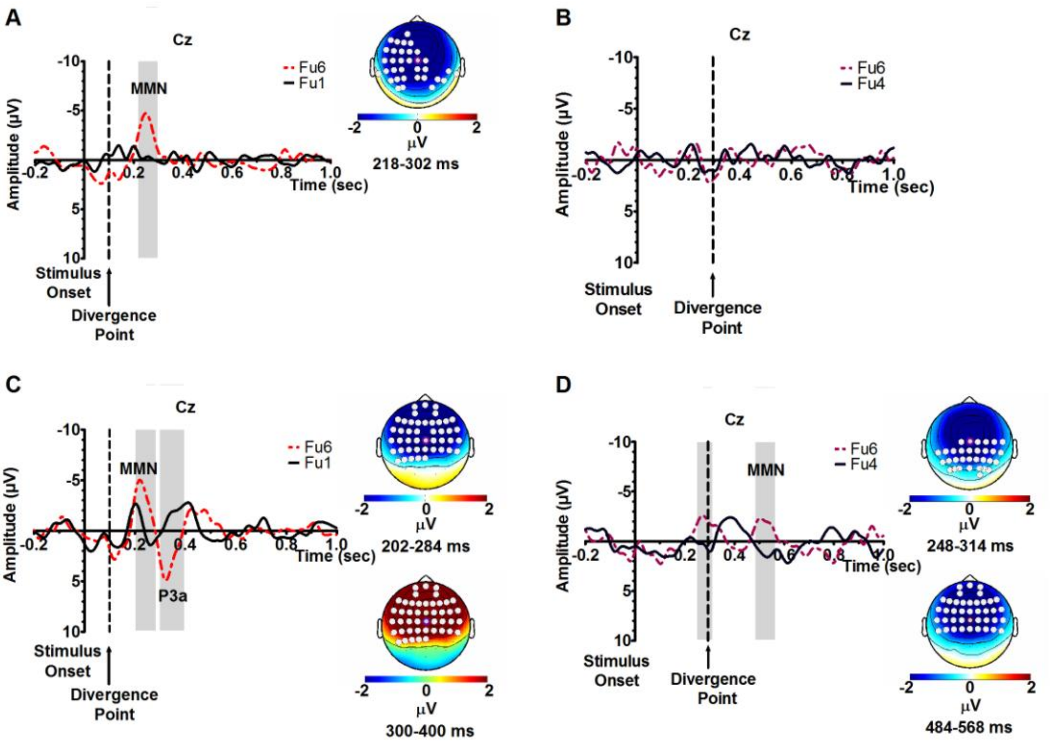

Figure 8: *Topographic maps and average waveforms time-locked to the onset of the stimulus at the electrode Cz of the merger (Panels A and B) and the control's (Panels C and D) responses to the two pairs of tone contrast—T1/T6 (Panels A and C) and T4/T6 (Panels B and D). The divergence point in Panels A and C is 100ms and the one in Panels B and D is 294 ms. Significant clusters are shaded in grey and the topography of the significant clusters are shown next to the waveforms. Significant electrodes are highlighted with a white dot on the topographic maps and the grey dot with a violet border marks the electrode Cz.*