Effect of L1 experience on the brain's pre-attentive processing of prosodic features

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Introduction. Processing and learning of a second language (L2) are affected by language experience and most clearly, by a native language (L1). Employing mismatch negativity (MMN), an electrocortical response elicited by an unattended change in sensory input [1,2], this study investigates processing of prosodic information (e.g., duration, pitch) by asking which features of L1 and L2 are and which are not discriminated by the brain and how the L1 experience possibly moderates such process. Experiments with Mandarin Chinese and Estonian groups, and both languages as L1 and L2, will be conducted as the two languages differ in the relative importance of duration and tone cues.

Whereas Chinese features four lexical tones (T1, T2, T3, T4) that are commonly categorized by their fundamental frequencies [3,4,5], a central feature of Estonian word prosody is the three-way quantity distinction (Q1, Q2, Q3) manifested as complex prosodic structures that combine durational and tonal components [6,7]. While Chinese native speakers rely primarily on the tonal cue to categorically perceive lexical tones [8,9,10], studies have shown that Estonians use both duration and pitch cues to perceive disyllabic words [7]. To study how the brain represents prosodic information in relation to L1 experience, we compare the discrimination ability (operationalized by MMN) for a pure tone (having characteristics comparable to language stimuli) and MMNs for L1/L2 features in words.

Methods. The stimuli are disyllabic words. The Chinese stimuli are resynthesized from Mandarin words T1 JILI (*ji1li4* 'to encourage') and T2 JILI (*ji2li4* 'auspicious'), and the Estonian stimuli are resynthesized from Q2 SADA (*saada* 'to send') and Q3 SADA (*saada* 'to get') [7]. The duration of the first syllable in each word is manipulated by the length of the first vowel as either long or overlong (Tables 1 & 2). The non-linguistic stimuli are pure tones that are created to physically resemble the Chinese and Estonian linguistic stimuli using Praat [11]. Each group of participants (i.e., Chinese (CN) and Estonian (EE)) listen to all three types of stimuli, including L1 words (i.e., JILI for CN, SADA for EE), L2 words (i.e., SADA for CN, JILI for EE), and pure tones. The EEG experiments consist of seven series as shown in Table 3. The experiments follow an optimal paradigm [12], where several (N = 3) different deviant stimuli (DEV) were presented between the standard stimulus (ST) (i.e., every second stimulus being a standard) to elicit an MMN response. In each series, the standard stimulus was presented 315 times (the first 15 times to create a memory trace) and each of the three deviants 100 times. The inter-stimulus interval was 400, 425, or 450ms.

Results. The electrodes are grouped as frontal and temporal based on their locations [13]. The MMN waveforms are analyzed at an interval of every 50ms from 100ms to 600 after the stimulus onset (i.e., ten intervals in total). For each series, statistical analysis includes two parts. First, we look at the effect of stimuli role (standard vs. deviant) for each deviant by fitting linear regression models to the mean amplitude of the EEG waveform at each time interval. The results of the two groups are analyzed separately. Second, we fit linear regressions models to the MMN waves of each deviant at each time interval to examine the main effects of group (CN vs. EE) and area (frontal vs. temporal), as well as their interaction.

The preliminary results of a pilot study (N = 4 for each language group) showed significant group differences in terms of the stimuli with duration changes: **ST** T1-150 vs. **DEV1** T1-250 in **series JILI1** and **ST** Q2-170 vs. **DEV1** Q2-290 in **series SADA1** (Figure 1; Tables 4 & 5). In both JILI1 and SADA1 series, we found larger MMN responses to duration change for the Estonian subjects than the Chinese. We suggest that it is because duration is an important cue in the Estonian quantity system but not used to discriminate meaning in Chinese.

Conclusion. Experience in L1 shapes the brain to extract certain prosodic features. This study has broader implications for the development of second language learning programs.

Table 1. Features of Chinese stimuli JILI

	J	I	L	I
T1-150	100ms	150ms	65ms	245ms
T1-250	100ms	250ms	65ms	245ms
T2-150	100ms	150ms	65ms	245ms
T2-250	100ms	250ms	65ms	245ms

Table 2. Features of Estonian stimuli SADA

	S	A	D	A
Q2-170	100ms	170ms	86ms	101ms
Q2-290	93ms	290ms	86ms	101ms
Q3-110	93ms	110ms	103ms	74ms
Q3-290	100ms	290ms	103ms	74ms

Table 3. Experimental series

		ST	DEV1	DEV2	DEV3
1	**JILI1**	T1-150	T1-250	T2-150	T2-250
2	JILI2	T1-250	T1-150	T2-150	T2-250
3	JILI3	T2-150	T1-150	T1-250	T2-250
4	JILI4	T2-250	T1-150	T1-250	T2-150
5	JILI-pure tone	toneT1-150	toneT1-250	toneT2-150	toneT2-250
6	**SADA1**	Q2-170	Q2-290	Q3-110	Q3-290
7	SADA-pure tone	toneQ2-170	toneQ2-290	toneQ3-110	toneQ3-290

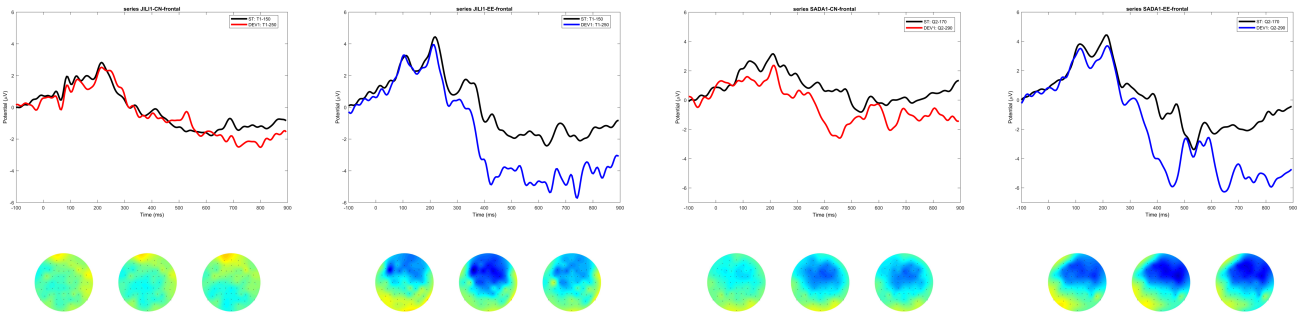

Figure 1. The average standard and deviant wave for Chinese (a) and Estonian (b) groups in series JILI1, and Chinese (c) and Estonian (d) groups in series SADA1 (black line – **ST**, red line – CN **DEV1**, blue line – EE **DEV1**). Negative amplitudes are plotted downwards. The scalp distributions in each panel are for time windows of 350-400ms, 400-450ms, and 450-500ms (from left to right).

Table 4. Effect of stimuli role (standard vs. deviant) at each time interval for Chinese (CN) and Estonian (EE)

		1		2		3		4		5		6		7		8		9		10	
		F	T	F	T	F	T	F	T	F	T	F	T	F	T	F	T	F	T	F	T
JILI 1	CN																				
	EE											**		***	**	**	*	**		***	
SADA1	CN							*						**	*	**	*				
	EE			*		*		*		*		***	***	***	***	***	***				

Notes. F-Frontal, T-Temporal; *** $p < .001$, ** $p < .01$, * $p < .05$; Results in the table only show the contrast between ST and DEV1 in series JILI1 and the contrast between ST and DEV1 in series SADA1.

Table 5. Main effects of group and area, and their interaction on the MMN waves

		Interval									
		1	2	3	4	5	6	7	8	9	10
JILI1	Group						*	*	**	***	***
	Area										
	Interaction										
SADA1	Group						***	*	**		
	Area										
	Interaction										

Notes. *** $p < .001$, ** $p < .01$, * $p < .05$; Results in the table only include the MMN of ST-DEV1 in series JILI1 and the MMN of ST-DEV1 in series SADA1.

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