

Multilingual experience predicts attentional control in dichotic listening among older adults: the moderating role of socioeconomic status

Yuqi Wang¹, Jiayu Liang¹, Andriy Myachykov², Quentin Zhen Qin¹

¹The Hong Kong University of Science and Technology; ²University of Macau

Attentional control, the ability to focus on targets, can be strengthened through experiences that build cognitive reserve (e.g., music training and lifelong learning). Bi-/multilingualism is proposed as one resource of reserve because managing two or more languages requires continuous selection of the target language. Research has documented a bilingual advantage effect in visual attention tasks (e.g., Flanker), especially among older adults. Decades of language experience and age-related declines in attentional control may make bilingual experience detectable [1]. Compared with the well-established findings in visual attention, bilingual effects in the auditory domain are less studied and yield mixed findings. Forced-attention dichotic listening (FADL) is an auditory task measuring attentional control [2]. Two distinct stimuli are presented to each ear at the same time, creating a competition for attention. Participants complete three conditions (Fig 1): non-forced (NF), forced-left (FL), and forced-right (FR). Attentional control is indexed by increased accuracy for the forced ear from NF to forced conditions, especially the incongruent condition that overrides the neutral ear preference. Previous research using binary comparisons (older bilinguals vs. monolinguals) found no group differences in these accuracy increases [2], suggesting that bilingual effects may be sensitive to how bilingualism is operationalized. Recent approaches recommend defining bilingualism as a continuum to capture individual variance in language experience (e.g., multilingual diversity [3]). Moreover, socioeconomic status (SES) may moderate the cognitive benefits of bilingualism (e.g., only for low SES people [4]). Therefore, the present study investigated (1) how gradient bilingualism influences auditory attentional control in the FADL task and 2) how SES interacts with the bilingual effect to shape attentional control in older adults.

We recruited 86 older adults (aged 50-72) who were Cantonese-dominant bilinguals or multilinguals. Language profiles were assessed using the Language History Questionnaire-3 [5]. From this questionnaire, we derived the multilingual language diversity (MLD, Table 1) and other scores (e.g., L2-English proficiency). SES was assessed using Hollingshead's scores [6], which considered education and occupation levels (Table 1). In the FADL task, participants heard dichotic tones from their L1-Cantonese and identified tones from either ear across three conditions (Fig. 1): NF (presented first), followed by FL and FR (order counterbalanced). Each condition comprised 108 trials, with tone pairs and ear-of-presentation balanced.

A generalized linear mixed-effects model on right ear accuracy (the instructed ear of the incongruent, namely the most cognitively demanding, condition) revealed a left ear advantage in the NF-neutral condition, a larger left ear advantage in the FL-congruent condition, and a right ear advantage in the FR-incongruent condition (Fig. 2). The redirection of ear advantage (neutral vs. incongruent) showed the successful attentional control. For the bilingual effect, an interaction between Condition, MLD, and SES was observed (Fig. 3) in the incongruent (but not congruent) condition ($\beta=-0.70$, $SE=0.10$, $z=-6.93$, $p<.001$). For participants with lower SES scores (-1 SD) only, higher MLD predicted a greater increase in right ear accuracy from the neutral to incongruent condition ($\beta=-0.53$, $SE=0.29$, $z=-1.79$, $p=.073$).

Our results have implications for understanding how lifelong language experiences support auditory attentional control in aging. Findings suggest multilingualism as a key contributor to better attentional control among older adults with lower SES [3]. MLD may be effective at capturing the variance in this population because it more comprehensively reflects language experiences than simple measures (e.g., proficiency) alone. The results further identify specific conditions under which multilingual effects emerge [4]. Lower-SES older adults may rely on daily use of multiple languages as an easily accessible form of cognitive reserve because they lack access to diverse cognitively intensive activities compared with higher-SES older adults.

Table 1. The calculation and interpretation of the key independent variables.

	Dimensions Measured	Calculation Logic	Interpretation
MLD	Proficiency: 1-7 scale (low to high)	1. Proficiency and frequency to calculate the language dominance score for each language and proportion of dominance (PD) 2. Shannon Entropy to aggregate MLD $MLD = - \sum_{i=1}^n PD_i \log_2(PD_i)$ (See [5] for details)	Ranges from 0 to 2; higher scores reflect a more diverse (more languages are used) and balanced (equal proficiency and usage) multilingual usage.
	Frequency of usage time: hours per day for each language		
SES	Education: 0–7 scale (no formal education to post-graduates)	1. Weighted sum: Education * 3 + Occupation * 5 2. Averaged across the participant and his/her partner	Ranges from 0 to 66; higher scores indicate higher SES
	Occupation: 0-9 scale (unemployed to high executive)		

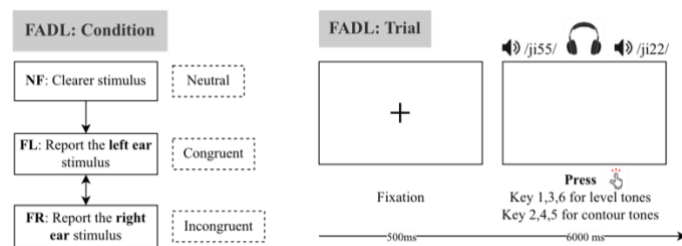


Fig. 1. Left: The overview of the procedure of FADL: participants finished the NF first, followed by FL and FR in a counterbalanced order. FR is believed to be the incongruent condition, as previous studies found the left ear advantage in the neutral condition. Right: The illustration of a trial: participants identify the tone in the ear according to the instruction.

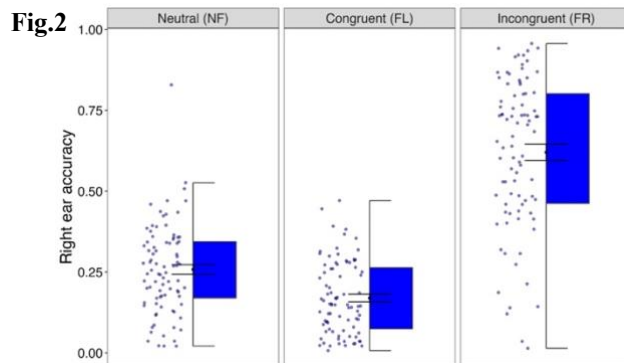


Fig. 2. The right ear accuracy (the rate of identifying a tone presented in the right ear) of each ear in neutral, congruent, and incongruent conditions of the FADL task; right ear accuracy with lower than 50% indicated a left ear advantage (i.e., more accurate report of tones presented in the left ear). Neutral vs. Congruent (dummy coding with neutral condition as the reference): $\beta=-0.70$, $SE=0.10$, $z=-6.93$, $p<.001$; Neutral vs. Incongruent: $\beta=2.05$, $SE=0.17$, $z=11.78$, $p<.001$.

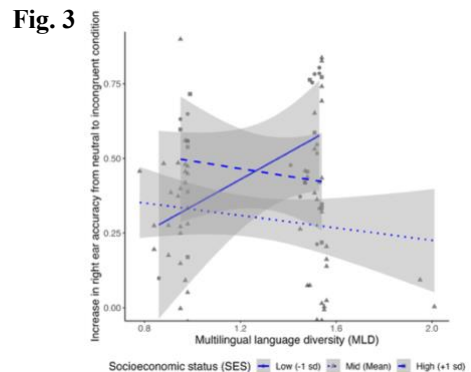


Fig. 3. The relationship between multilingual language diversity (x-axis: higher scores, more diverse language experience) and attentional control performance in the FADL (y-axis: larger increase, better attentional control), mediated by socioeconomic status (line types for SES scored low to high).

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