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Beyond binary pathways: configurations of first language, hearing-aid use, and school placement among college-educated deaf adults in China

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Abstract. Deaf learners' language histories are often described in terms of two broad pathways. One is a spoken-language pathway associated with hearing technology and mainstream education, and another one is a sign-language pathway associated with limited technology use and schooling in schools for the deaf. This study examined how well this binary distinction represented the experiences of 48 college-educated deaf adults in Chinese mainland. Questionnaire data were used to examine associations among self-reported first language, hearing-aid use, school-placement history, and sign-language repertoire. A timed Chinese sentence-reading task was included as an auxiliary measure. Self-reported first language, hearing-aid use, and school placement were significantly associated, but their joint distribution did not separate participants into two discrete groups. Two aligned configurations were relatively common, whereas 41.7% of participants reported cross-cutting combinations of linguistic, technological, and educational experience. Nearly all participants reported using a natural sign language, and the two first-language groups did not differ significantly on the auxiliary reading measure. The findings indicate patterned but substantial heterogeneity within this college-educated deaf sample and caution against using any single category as a proxy for language proficiency, language access, or educational need.

Keywords: college-educated deaf adults, language experience, sign language, hearing aids, school placement, China

1. Introduction

Discussions of deaf education are often organized around paired alternatives: spoken versus signed language, mainstream versus deaf-school education, and hearing technology versus visually accessible communication. These categories may be administratively useful, but they become reductive when treated as complete descriptions of individual experience. Language, technology, and schooling do not enter deaf people's lives through a single, irreversible choice. Communicative resources may change as families make decisions, hearing technologies become available or cease to meet individual needs, educational settings shift, and relationships with peers and communities expand. Research on deaf and hard-of-hearing learners likewise

documents substantial developmental and educational heterogeneity. Language development and academic attainment reflect interacting individual, family, communicative, and educational factors rather than hearing status alone [1, 2]. School placement is also selective rather than random. Students with general-education, special-education, and mixed-placement histories may differ in hearing level, communication background, family resources, and prior academic achievement before entering those settings [3]. Variation also exists within mainstream education, where academic progress depends partly on the quality and accessibility of support [4]. Apparent placement effects may therefore partly reflect the characteristics and opportunities that shaped placement in the first place.

The timing and accessibility of language experience are central to this heterogeneity. Early acquisition of a fully accessible first language has lasting consequences for subsequent language learning [5]. The relevant distinction is therefore not simply whether a child's first language is spoken or signed, but whether the child can participate in rich, sustained, and comprehensible interaction during early development. Reviews of deaf children's language and literacy development similarly emphasize variation in identification and intervention, access to hearing technology, and the availability of perceptually accessible language models [1]. As Hall et al. [6] argue, access to speech should not be equated with access to language. Amplification and speech training do not by themselves guarantee reliable access to a complete language, whereas a natural sign language can provide direct linguistic access through the visual modality. Recognizing the importance of language access does not require hearing technology and sign language to be treated as mutually exclusive. Studies of signing children with cochlear implants indicate that exposure to a natural sign language does not, in itself, impede spoken-language development [7, 8]. From a public-health perspective, bilingual opportunities may also reduce the risk that a child remains without an accessible language while spoken-language outcomes are still uncertain [9]. Language planning for deaf learners can therefore accommodate changing combinations of linguistic and communicative resources rather than requiring commitment to a single pathway [10].

A repertoire perspective provides a useful framework for describing such combinations. Communicative practices do not necessarily remain within discrete, self-contained language systems. Individuals may draw on signed and spoken languages, print, mouthing, gesture, spatial organization, and other visual resources according to context [11]. In deaf education, this perspective directs attention to the resources learners already use while retaining a focus on unequal language access and the marginalization of natural sign languages [12]. Coexisting resources need not be equally accessible, developed, or valued. The relevant questions are therefore which resources became available, when they became available, with whom they were used, and how their functions changed across educational and social settings.

Chinese mainland provides a particularly relevant context for examining these histories. Oral training, written Chinese, natural varieties of Chinese Sign Language, and forms of signing organized around Chinese word order have long coexisted across regions and schools, although their institutional recognition and educational status have varied [13, 14]. Deaf stakeholders have called for stronger sign-language research and infrastructure, teacher preparation, interpreting services, educational accessibility, and meaningful deaf participation in decision-making [15]. National special-education action plans for the 14th and 15th Five-Year Plan periods have likewise emphasized expanded special-education provision and the continued development and evaluation of National Common Sign Language [16, 17]. These developments make it increasingly important to understand learners' actual language repertoires rather than infer support needs from school placement or hearing-device history alone. Despite this complexity, research descriptions can still imply two internally coherent trajectories. Regular hearing-aid use, Chinese as a first language, and mainstream schooling may be read as markers of a spoken-language-oriented pathway, whereas less frequent hearing-aid use, sign language as a first language, and exclusive deaf-school attendance may be read as markers of a sign-

language-oriented pathway. These characteristics may cluster without defining two bounded types of deaf learner. A person who reports Chinese as a first language may also use natural sign language, while a sign-first person may regularly use hearing aids or have experience in mainstream education. Educational histories may also include movement between settings.

Against this background, the present study examined questionnaire data from 48 college-educated deaf adults in Chinese mainland. Three questions guided the analysis: (1) Are self-reported first language, hearing-aid use, and school-placement history associated? (2) How do these dimensions combine within individual participants? (3) Do their joint distributions support a simple distinction between two conventional pathways, or do they reveal substantial cross-cutting experience? A timed Chinese sentence-reading score was included only as an auxiliary indicator of whether the two self-reported first-language groups showed clearly different performance distributions. The study was descriptive and cross-sectional. It aims to characterize patterned relationships and the limits of categorical descriptions, not to establish causal or developmental sequences among language experience, hearing technology, and schooling.

2. Method

2.1. Participants, recruitment, and ethics

Participants were recruited through in-person outreach at Beijing Union University between August and October 2025 during background-data collection for a larger electroencephalography study. Sixty deaf participants completed the questionnaire. Eligibility for the parent study was assessed using criteria related to cochlear-implant status, hearing status, and handedness, and questionnaires missing any required response were excluded. After eligibility screening and data-quality checks, 48 complete records were retained. Participants were 19–51 years old (M = 26.67, SD = 5.65); 25 were women and 23 were men. Forty-five held Grade I hearing-disability certificates (≥ 91 dB), and three held Grade II certificates (81–90 dB). All had received higher education.

All participants provided written informed consent. The questionnaire component and its use in the parent study were approved by the Ethics Committee of the Artificial Intelligence and Human Languages Lab at Beijing Foreign Studies University. The questionnaire did not assess cultural or linguistic identification with the Deaf community. Accordingly, deaf is used throughout as a broad descriptor rather than as an assigned cultural or linguistic identity.

2.2. Language-history questionnaire

The questionnaire was developed for the parent study to document demographic, linguistic, audiological, and educational history. Its organization was informed by the language-history questionnaire tradition, which treats age and order of language exposure, patterns of language use, and educational experience as distinct dimensions of linguistic background [18]. For the present study, the questionnaire also recorded certified hearing-disability grade, hearing-aid use, school placement during basic education, and sign-language repertoire.

For the first-language item, participants identified the language they had encountered and acquired first after birth. First language was therefore operationalized as self-reported order of language contact, not as current proficiency, frequency of use, or cultural identification. Because retrospective language-history labels compress complex developmental experiences, this variable was treated as a historical classification rather than an objective measure of modality-specific language access or competence. In particular, the response category Chinese did not distinguish spoken Chinese from written Chinese or participants' combined

experience of the two and should not be interpreted as a direct measure of auditory access, literacy, or current Chinese proficiency.

The sign-language repertoire item allowed multiple responses: natural sign language, Chinese-order signing (labelled "grammatical sign" in the original questionnaire), International Sign, and foreign sign languages. Multiple selections were retained because multilingual and multimodal repertoires are not necessarily well represented by mutually exclusive categories. This approach is consistent with repertoire-oriented accounts of communicative resources as heterogeneous and context dependent rather than as membership in discrete linguistic types [11, 12].

The questionnaire documented distinct historical dimensions rather than multiple indicators of a single latent construct. First language, school placement, hearing-aid use, and sign-language experience were therefore analyzed separately rather than combined into a composite scale, and internal-consistency coefficients were not calculated [19].

2.3. Auxiliary timed sentence-reading task

The task contains 80 short Chinese sentences. Participants read silently for three minutes and judged each sentence as semantically true or false. Example items were "花粉过敏导致鼻塞。" (Pollen allergy causes nasal congestion; true) and "姐姐早饭吃打火机。" (My older sister eats a lighter for breakfast; false). Five points were awarded for each correct response and zero for each incorrect response; the total score was the sum of points for correct responses. The measure is therefore not a words-per-minute score.

The task was developed in research on Chinese children's reading [20], and related three-minute sentence tasks have been used with Chinese deaf students to examine sentence-level fluency and passage comprehension [21]. Here, the score was used only as an auxiliary descriptive indicator. It was not a primary outcome and was not interpreted as an age-normed measure of adult reading ability.

2.4. Variable coding

Original questionnaire responses were retained before recoding, and analytical categories were defined before the focal association tests. First language was coded as self-reported Chinese or sign language, following responses to the item asking which language participants had encountered and acquired first.

School placement was originally recorded as deaf-school only, mainstream-school only, or experience in both settings. Because only three participants reported mainstream-only schooling, retaining three categories would have produced sparse contingency tables. Mainstream-only and mixed-placement histories were therefore combined as "any mainstream-school experience" and contrasted with "deaf-school only." This recoding captured whether participants had experienced a mainstream educational environment while permitting interpretable analysis in a modest sample. It does not imply equivalence between exclusively mainstream and mixed-placement histories, nor does it capture the timing, duration, direction, or quality of transitions between settings.

Hearing-aid use was coded as regular when participants reported sustained daily use or routine daily use with removal when the device was not needed. Infrequent use, non-use, and other non-routine patterns were combined as irregular or no use. The resulting variable indexes reported regularity of use, not aided audibility, benefit, age at fitting, or cumulative duration of hearing-aid use.

Sign-language repertoire options were analyzed independently because multiple responses were permitted, so that percentages across sign varieties could therefore exceed 100%. The three binary focal variables—first language, school placement, and hearing-aid use—produced eight possible configurations. The two most frequent configurations aligned across all three dimensions were termed aligned configurations, and the other

six were termed cross-cutting configurations. These labels summarize observed combinations in this sample and do not denote latent classes, stable identities, or developmental diagnoses.

2.5. Statistical analysis

Descriptive statistics were used to characterize participants' linguistic, technological, and educational histories. Frequencies and percentages were reported for categorical variables, and the auxiliary reading score was summarized using measures of central tendency and dispersion.

Pairwise associations among self-reported first language, school placement, and hearing-aid use were tested using two-sided Fisher's exact tests. Exact tests were preferred to asymptotic chi-square tests because of the modest sample and small cell counts in several 2 × 2 tables [22]. Cramér's V was reported as an effect-size index of association. Because the analysis included three pairwise tests among the focal variables, p values were adjusted using the Benjamini–Hochberg procedure to control the false discovery rate within this family of comparisons [23]. Both unadjusted Fisher p values and adjusted q values are reported.

The three focal variables were then cross-classified to show how the pairwise associations appeared at the level of individual configurations. This step was descriptive rather than model based: no latent classes or developmental pathways were estimated. Configuration frequencies were used only to determine whether associated characteristics nevertheless co-occurred in cross-cutting combinations within individual participants.

The timed sentence-reading scores were analyzed separately as an auxiliary outcome. Because the score distribution did not meet the assumptions of a conventional independent-samples t test, the Chinese-first and sign-first groups were compared using a two-sided Mann–Whitney U test. This analysis was not included in the family of three focal association tests because it addressed a separate secondary question. Statistical significance was evaluated at $\alpha = .05$. Given the retrospective, cross-sectional design, inferential results were interpreted as associations rather than evidence of causal or developmental ordering.

3. Results

3.1. Overall language and educational profiles

Of the 48 participants, 29 (60.4%) reported Chinese as their first language and 19 (39.6%) reported sign language as shown in Table 1. Twenty (41.7%) reported first contact with their first language at ages 0–3 years, 23 (47.9%) at ages 4–8 years, and five (10.4%) at age 9 or later. For second language, 30 selected sign language, 14 Chinese, two English, one both Chinese and sign language, and one could not remember. Because a small number of respondents used the same broad category for both first and second language, second-language responses are reported descriptively and are not treated as evidence of a strict acquisition sequence.

Sign-language experience was widespread. Forty-five participants (93.8%) reported using a natural sign language, 26 (54.2%) Chinese-order signing, eight (16.7%) International Sign, and two a foreign sign language. During basic education, 23 participants (47.9%) had attended only schools for the deaf, three (6.3%) only mainstream schools, and 22 (45.8%) both settings. After recoding, 25 participants (52.1%) had some mainstream-school experience. Twenty-nine participants (60.4%) were classified as regular hearing-aid users and 19 (39.6%) as irregular users or non-users.

Table 1. Participant background and language experience ($N = 48$)

Variable	Category	n	%
Gender	Women	25	52.1
Gender	Men	23	47.9
Education	Associate degree	5	10.4
Education	Bachelor's degree	40	83.3
Education	Postgraduate education	3	6.3
Certified hearing-disability grade	Grade I (≥ 91 dB)	45	93.8
Certified hearing-disability grade	Grade II (81–90 dB)	3	6.2
Self-reported first language	Chinese	29	60.4
Self-reported first language	Sign language	19	39.6
Age of first-language contact	0-3 years	20	41.7
Age of first-language contact	4-8 years	23	47.9
Age of first-language contact	9 years or later	5	10.4
Basic-education placement	Deaf school only	23	47.9
Basic-education placement	Any mainstream experience	25	52.1
Hearing-aid use	Regular	29	60.4
Hearing-aid use	Irregular or none	19	39.6
Sign repertoire (multiple response)	Natural sign language	45	93.8
Sign repertoire (multiple response)	Chinese-order signing	26	54.2
Sign repertoire (multiple response)	International Sign	8	16.7

Note. Sign-repertoire categories were multiple-response options; their percentages do not sum to 100%. The two respondents reporting a foreign sign language are described in the text but omitted from the table for compactness.

3.2. First language and school placement

Among participants reporting Chinese as their first language, 20 had some mainstream-school experience and nine had attended only schools for the deaf. Among sign-first participants, five had some mainstream-school experience and 14 had attended only schools for the deaf. Thus, mainstream-school experience was reported by 69.0% of the Chinese-first group and 26.3% of the sign-first group. The association was statistically significant, Fisher $p = .007$, Cramér's $V = .418$. This result indicates co-occurrence within the sample; it does not establish a causal direction between first-language history and school placement.

3.3. First language and hearing-aid use

Twenty-three of the 29 Chinese-first participants were regular hearing-aid users, compared with six of the 19 sign-first participants. Regular use was therefore reported by 79.3% of the Chinese-first group and 31.6% of the sign-first group. The association was statistically significant, Fisher $p = .002$, Cramér's $V = .477$.

3.4. School placement and hearing-aid use

Among the 25 participants with some mainstream-school experience, 20 were regular hearing-aid users and five were irregular users or non-users. Among the 23 participants who had attended only schools for the deaf, nine were regular users and 14 were irregular users or non-users. Regular use was therefore reported by 80.0%

and 39.1% of the two groups, respectively. School-placement history and hearing-aid use were significantly associated, Fisher p = .007, Cramér's V = .418. All three focal associations remained significant after Benjamini–Hochberg correction (all q < .01) as shown in Table 2.

Table 2. Pairwise associations among first language, school placement, and hearing-aid use

Association	Fisher p	Cramér's V	Adjusted q
First language × school placement	.007	.418	.007
First language × hearing-aid use	.002	.477	.006
School placement × hearing-aid use	.007	.418	.007

Note. All tests were two-sided. Adjusted q values were obtained with the Benjamini–Hochberg procedure across the three focal tests.

3.5. Frequent and cross-cutting configurations

As shown in Table 3., the three-way cross-classification did not separate the sample into two complete, non-overlapping groups. The most frequent configuration was Chinese first language, some mainstream-school experience, and regular hearing-aid use (n = 16, 33.3%); the second was sign language first language, deaf-school-only experience, and irregular or no hearing-aid use (n = 12, 25.0%). Together, these two aligned configurations accounted for 28 participants (58.3%). The remaining 20 participants (41.7%) were distributed across six cross-cutting configurations.

The cross-cutting configurations were not confined to a single exception pattern. Seven Chinese-first participants had attended only schools for the deaf while regularly using hearing aids, and four had mainstream experience without regular hearing-aid use. Four sign-first participants had both mainstream experience and regular hearing-aid use, while two had attended only schools for the deaf and regularly used hearing aids. The pairwise associations in Table 2 therefore describe tendencies rather than two mutually exclusive types of deaf learner.

Table 3. Cross-classification of the three focal experiences

First language	School placement	Hearing-aid use	n	%
Chinese	Any mainstream experience	Regular	16	33.3
Chinese	Any mainstream experience	Irregular or none	4	8.3
Chinese	Deaf school only	Regular	7	14.6
Chinese	Deaf school only	Irregular or none	2	4.2
Sign language	Any mainstream experience	Regular	4	8.3
Sign language	Any mainstream experience	Irregular or none	1	2.1
Sign language	Deaf school only	Regular	2	4.2
Sign language	Deaf school only	Irregular or none	12	25.0

3.6. Auxiliary timed sentence-reading scores

Across the 48 participants, the mean three-minute sentence-reading score was 337.08 (SD = 38.67), with a median of 347.50 and a range of 200–390. The Chinese-first group had a mean of 337.07 (SD = 30.40; median = 345), and the sign-first group a mean of 337.11 (SD = 49.67; median = 350). The Mann–Whitney U test did not detect a significant group difference, U = 242.50, p = .492. This null result does not establish equivalence.

Given the small sample, unequal variability, and absence of adult norms for the task, the narrower conclusion is that the broad first-language categories did not separate participants into clearly different distributions of timed Chinese sentence-reading performance.

4. Discussion

4.1. Patterned associations without a single causal route

The central finding was a pattern of association across three aspects of participants' histories. Chinese-first participants were more likely to report regular hearing-aid use and some mainstream-school experience, whereas sign-first participants were more likely to report irregular or no hearing-aid use and deaf-school-only experience. School placement and hearing-aid use were also associated. Cramér's V values of .418–.477 indicate that these dimensions were related but far from interchangeable.

These associations should not be converted into a developmental chain. Hearing technology may shape access to spoken language, and early auditory access may influence later educational placement, but the reverse and common-cause pathways are also plausible. Family expectations about mainstream education may influence investment in amplification and spoken-language intervention, while regional resources, socioeconomic conditions, and early language performance may affect both technology use and placement. Shaver et al. [3] for example, showed that placement groups differ on multiple characteristics before the educational consequences of placement can be isolated. In the present study, pathway therefore refers to the accumulation of experience, not to a one-directional causal mechanism.

4.2. Cross-cutting configurations qualify the binary account

The pairwise results alone could be read as support for two conventional pathways. The three-way cross-classification complicates that interpretation. Although the two aligned configurations accounted for 58.3% of the sample, 41.7% of participants occupied six other combinations. The sample was therefore patterned without being cleanly partitioned. These less frequent configurations are not statistical noise; they show that group-level associations can coexist with substantial heterogeneity at the individual level.

A repertoire perspective helps make sense of this pattern. Communicative repertoires consist of resources acquired at different times, used with different people, and serving different functions rather than bundles of equally developed languages [11]. A Chinese-first participant may later use natural sign language extensively, while a sign-first participant may develop spoken and written Chinese, use hearing technology, or move into mainstream education. Swanwick's [12] account of translanguaging in deaf education similarly treats movement across linguistic resources as ordinary while cautioning that flexibility should not be used to justify reduced access to natural sign language.

The near-universal report of natural sign-language use (45 of 48 participants) reinforces this point. Sign-language experience was not confined to sign-first participants or to those educated exclusively in schools for the deaf. Within this sample, it was a widely shared resource across otherwise different auditory and educational histories. A single first-language label therefore captured only one dimension of participants' broader repertoires.

4.3. Hearing technology and sign language are not opposites

The association between first language and hearing-aid use might be taken to imply that hearing technology and sign language represent competing orientations. The individual configurations argue against that

interpretation: six sign-first participants were regular hearing-aid users, six Chinese-first participants were irregular users or non-users, and natural sign-language use was nearly universal. Hearing aids and sign languages also address different dimensions of access. Hearing-aid benefit depends on factors such as hearing profile, fitting, age at first use, consistency of use, rehabilitation, acoustic conditions, and communicative context; sign language provides a visual linguistic resource. Device use therefore cannot be treated as an inverse measure of sign-language access or experience.

Evidence from deaf children exposed to both signed and spoken language likewise does not support a necessary trade-off. Native signing children with cochlear implants can develop spoken language without sign exposure functioning as an obstacle [7], and learning sign vocabulary has not been shown to harm spoken-vocabulary acquisition [8]. Hall et al. [6] and Wilkinson and Morford [9] frame the issue in terms of ensuring access to at least one fully accessible language while allowing additional resources to develop. The present adult histories are consistent with this non-zero-sum account, although the cross-sectional data cannot test developmental effects.

4.4. Placement is not the same as language access

Mainstream experience was associated with regular hearing-aid use and a Chinese-first history, but placement alone reveals little about what participants could access in the classroom. Attendance in a mainstream school does not guarantee access to teacher talk, peer interaction, assessment instructions, or informal social learning. Longitudinal evidence shows that deaf and hard-of-hearing students can make strong academic progress in general education, but outcomes and support needs remain variable [4]. Research on interpreted education further illustrates that an accommodation may be useful without, by itself, resolving earlier or continuing barriers to language access [24].

The same caution applies to schools for the deaf. Such settings may provide deaf peers and a visually accessible communication environment, but the availability and status of natural sign language, written-language instruction, and auditory support vary across schools and historical periods. The analytically relevant question is therefore not simply where a student was placed, but what linguistic access and continuity that placement afforded.

4.5. What the auxiliary reading result does and does not show

The auxiliary reading result provides an important boundary on interpretation. Mean scores were almost identical in the Chinese-first and sign-first groups, and the nonparametric comparison was not significant. This finding does not establish equivalence or show that early language experience is irrelevant to literacy. The first-language categories were broad, variability was greater in the sign-first group, the task was developed for school-age readers, and the sample was selected for participation in higher education.

Its more limited implication is that self-reported first language did not function as a direct proxy for timed Chinese sentence-reading performance in this sample. Chinese deaf students' reading fluency is related to character recognition, vocabulary, syntax, and sentence-level comprehension, with the contribution of these skills changing across development [21, 25]. In bilingual contexts, sign-language proficiency has also been positively associated with reading and broader academic outcomes [26]. Reading performance is therefore better treated as a multidimensional outcome than inferred from a broad first-language label.

4.6. Educational implications

First, the findings support the use of individual language-history profiles rather than reliance on hearing level, technology use, or first-language label alone. Such profiles could document age of exposure to each language,

current proficiency, communication partners, contexts of use, access barriers, and changes over time. Because communicative resources may change with school transitions, peer networks, higher education, and employment, these profiles should be revisable rather than treated as fixed classifications.

Second, mainstream placement and regular hearing-aid use should not be assumed to indicate unrestricted access to spoken instruction. Depending on individual needs, mainstream settings may require captioning, sign-language interpreting, visual materials, accessible assessment instructions, or support for classroom and peer interaction. Schools for the deaf, in turn, can maintain natural sign-language environments while supporting written Chinese and auditory access where useful to individual learners. The relevant goal is sustained access to language, learning, and participation rather than placement in a preferred institutional category.

Third, the 22 participants who had experienced both mainstream and deaf-school settings highlight the importance of linguistic continuity during educational transitions. Moving between settings may change the language of instruction, peer networks, and forms of communication access. Transition planning may therefore benefit from attention to language and literacy needs, communication access, curriculum continuity, and orientation to the new linguistic environment rather than being treated as an administrative transfer alone.

Finally, language planning should include deaf people in the design and evaluation of services. Deaf stakeholders in China have identified sign-language research, teacher preparation, interpreting, and educational accessibility as priorities for sustained development [15]. Current policy attention to National Common Sign Language may strengthen access, but standardization should not erase natural variation or substitute for local community expertise. The mixed repertoires observed here support an approach that protects shared access while allowing individual pathways to remain plural.

4.7. Limitations and directions for future research

Several limitations constrain the scope of the findings. First, the study used a small convenience sample recruited at one university in Beijing. All participants had received higher education, and 45 of 48 held Grade I hearing-disability certificates. The findings therefore cannot be generalized to deaf people across regions, generations, educational levels, hearing profiles, or socioeconomic positions. Eligibility criteria inherited from the parent EEG study, including handedness, further narrowed the sample in ways unrelated to the present questionnaire questions.

Second, the data were retrospective self-reports. The Chinese first-language category was based on reported order of acquisition but did not distinguish spoken Chinese, written Chinese, or a combination of the two. Sign-language experience was recorded through broad response options rather than a standardized proficiency measure. Future work should distinguish exposure from receptive and expressive proficiency, frequency of use, and communicative function across modalities.

Third, the hearing-aid item did not capture age at first fitting, daily hours of use, aided audibility, fitting quality, rehabilitation, or changes in use over time. Cochlear-implant users were excluded under the parent-study criteria, so the sample does not represent the full range of contemporary hearing-technology histories. Information on family language, parental hearing status, region, and socioeconomic resources was also unavailable, although these factors may help explain why particular configurations emerge.

Fourth, school histories were collapsed into deaf-school only and any mainstream experience to avoid sparse cells. This recoding necessarily removed information about the timing, direction, duration, and quality of transitions. Future research could combine life-course timelines with semi-structured interviews to reconstruct when language, technology, and placement changed and how participants understood those changes. Longitudinal data would be needed to evaluate developmental or causal ordering.

Finally, the three-minute reading task was an auxiliary measure developed for research with children. Item-level data were unavailable for evaluating item difficulty, discrimination, reliability, or construct validity in deaf adults, and no adult norms were available. Future studies should validate the task for the intended population or use multiple measures of Chinese literacy, including untimed comprehension, character and word recognition, vocabulary, and syntactic knowledge. A null difference on a single timed task should not be treated as a comprehensive assessment of reading.

5. Conclusion

Among the 48 college-educated deaf adults in this sample, self-reported first language, hearing-aid use, and school-placement history were significantly associated, yet their joint distribution did not form two bounded groups. More than two fifths of participants occupied cross-cutting configurations, nearly all reported using a natural sign language, and the two first-language groups did not differ significantly on the auxiliary timed Chinese sentence-reading task. The findings therefore point to patterned association without categorical uniformity. Hearing technology, school type, and a single first-language label should not be treated as substitutes for actual language access or ability. A more informative account asks which linguistic and communicative resources became accessible, when they entered a person's life, how they were used across settings, and what forms of access remain necessary. For research and educational planning alike, the relevant unit is not a presumed pathway type but the individual history through which multiple resources accumulate and change.

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