Distinct neural responses to number signs and number gestures in hearing second language signers.

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Abstract

Understanding the distinction between signs in sign language and gestures has been a topic of interest among researchers over the past decade. Recent arguments emphasize that sign languages exhibit syntactic, semantic, morphological, and phonological features while gestures are considered external to language. This theoretical distinction is importantly reflected at the brain level, with distinct brain regions being involved in sign language comprehension and gesture processing. Using a Fast Periodic Visual Stimulation (FPVS) EEG design, the present study investigated whether this distinction is modulated by sign language knowledge in hearing adults. We compared neural responses of late hearing signers and hearing non-signers to finger-number configurations presented either as number signs (finger-montring) or number gestures (finger-counting). Results revealed that hearing signers showed significantly stronger neural discrimination responses to number signs than hearing non-signers, whereas both groups exhibited similar responses to number gestures. These findings demonstrate that number signs and number gestures elicit distinct neural responses as a function of linguistic experience. Crucially, they show that even late acquisition of sign language is sufficient to modulate neural processing of manual number representations, supporting the view that sign language recruits language-specific neural mechanisms. More broadly, these results provide neurophysiological evidence that manual configurations can be processed either as linguistic signs or as gestures depending on the observer's language knowledge, thereby underscoring the linguistic status of sign languages.

Keywords : Electroencephalography (EEG), canonical representations, finger-number configurations, frequency tagging, sign language, gestures

List of abbreviations

ASL – American Sign Language

CMS – Common Mode Sense

DRL – Driven Right Leg

EEG – Electroencephalography

ERP – Event-Related Potential

F – Frequency (in Hz)

FPVS – Fast Periodic Visual Stimulation

Hz – Hertz

L1 – First Language

L2 – Second Language

LMM – Linear Mixed Model

LSFB – Langue des Signes Francophone de Belgique

mV – Millivolt

ms – Millisecond

n.s. – Non-significant

ROI – Region of Interest

SD – Standard Deviation

SE – Standard Error

SNR – Signal-to-Noise Ratio

VGT – *Vlaamse Gebarentaal*

μV – Microvolt

Fpz / PO8 / O2 – Specific electrode positions (10–20 system)

1. Introduction

Over the last decade, researchers have sought to determine whether a clear distinction can be drawn between signs used in sign languages and gestures that accompany spoken language. Although no consensus has been reached, recent work argues that such a dissociation is essential (Goldin-Meadow & Brentari, 2017). Sign languages exhibit syntactic, semantic, morphological, and phonological structure (Brentari, 1998; Sandler, 2009; Sandler & Lillo-Martin, 2006; Stokoe et al., 1965), whereas gestures are generally considered to lie outside the linguistic system (Goldin-Meadow & Brentari, 2017; Kendon, 2004). This distinction is not only theoretical (Fenlon et al., 2019), but is also reflected at the neural level (Buyle et al., 2023; Deng et al., 2020; Emmorey, 2021; Emmorey et al., 2011; Newman et al., 2015). For example, sign language comprehension recruits left inferior frontal regions, while action gestures engage more right-lateralized frontal areas (Trettenbrein et al., 2021). Similarly, during sign comprehension, hearing signers activate the left inferior frontal cortex, whereas hearing non-signers do not (Liu et al., 2017). Together, these findings indicate that *signs* versus *gestures* engage partially distinct neural systems.

A domain in which this distinction becomes particularly evident is the manual representation of numbers. Sign languages possess a fully linguistic counting system, in which specific hand configurations serve as number words. Interestingly, for numbers 1-4 in Belgian Sign Languages (i.e., "Vlaamse Gebarentaal", VGT, and "Langue des Signes Francophone de Belgique", LSFB), these lexicalized number signs visually resemble configurations that hearing individuals use to represent quantities. This manual strategy corresponds to finger-montring**,** which involves the simultaneous extension of multiple fingers to visually display a quantity (e.g., showing "3" by extending three fingers at once ; Di Luca & Pesenti, 2006).

Finger-montring is typically used in communicative contexts to indicate a final amount rather than during the act of counting. In contrast, finger-counting consists of the sequential extension of fingers while reciting number words**,** and supports counting routines and arithmetic development. Crucially, finger-montring configurations are lexicalized *number signs* in Belgian Sign Languages (in VGT and LSFB), while finger-counting routines are not part of the sign language system and remain *gestures* for both signers and non-signers.

The neural consequences of this linguistic distinction were recently examined by Buyle et al. (2023), who compared brain responses to finger-number configurations in deaf signers and hearing non-signers using an EEG paradigm that combines frequency-tagging with Fast Periodic Visual Stimulation (FPVS; Retter & Rossion, 2016; Rossion, 2014). In FPVS, stimuli from one category (e.g., non-canonical configurations) are presented rapidly at a base frequency (6 Hz), while stimuli from a second category (e.g., canonical configurations) appear at a slower deviant frequency (1.2 Hz). When the brain discriminates the deviant category, a selective neural response emerges at that frequency, providing an objective marker of category discrimination. Using this implicit and highly sensitive method, Buyle et al. (2023) showed that deaf signers exhibit enhanced discrimination responses for canonical *number signs* (i.e., finger-montring configurations) relative to hearing non-signers. Importantly, no group differences were observed for finger-counting configurations. Thus, finger-number configurations are processed differently by deaf signers, but only when they function as lexical items within a known language.

As deafness is known to induce cross-modal changes in the brain (for a recent review, see Alencar, Butler, & Lomber, 2019; Kral & Sharma, 2023), it is however still unknown whether the findings mentioned above are related to deafness or to the knowledge of sign language. The aim of the present study is therefore to assess this question by investigating if the differential processing of *number signs* can similarly be highlighted in hearing signers. The same FPVS design described in Buyle et al. (2023) was therefore used to examine whether finger-number configurations are processed differently by hearing signer adults compared to hearing non-signer adults when presented as *number signs* versus *number gestures*. Importantly, most hearing signers tested in the present study acquired sign language as a second language in adolescence or adulthood. This population is therefore not matched with the deaf signers tested in Buyle et al. (2023) in terms of age of exposure, modality dominance, or linguistic dominance. In light of these considerations, the present study does not aim to contrast native signers with matched hearing controls, nor to isolate the consequences of deafness. Instead, we focus on whether knowledge of sign language, even when acquired late as an L2, modulates neural responses to numerical hand configurations. By testing hearing signers without auditory deprivation, this design allows us to assess whether increased neural sensitivity to *number signs* can emerge from linguistic experience alone.

2. Material and Methods

2.1 Participants

Two groups of Dutch and French-speaking adults were recruited in Belgium: a group of 21 hearing signer adults (5 males, 11 French, M_{age} = 37.6 years ± 3.05), and a control group of 21 hearing adults who did not know sign language (9 males, 10 French, M_{age} = 38.8 years ± 3.05) (see Table 1 for a detailed description of the participants). This sample size was chosen to match the sample size of Buyle et al. (2023). All participants had normal or corrected-to-normal vision and no neurological problems. All signers in our sample acquired sign language as a second language and none were native signers. Age of acquisition ranged from adolescence to adulthood (M ± SD = 19.8 years ± 8.5, range = 0-32), and use frequency varied from weekly to daily. For all participants, sign language was not the dominant language in daily communication, and spoken language (French or Dutch) remained the primary modality. Hearing controls were matched to hearing signers for age [$F(1, 40.0) = .070; p = .79, n^2 = .002$], gender [$X^2 (1, 42.0) = 1.71, p = .19$], handedness [$X^2 (1, 42.0) = .36, p = .55$], educational level [$F(1, 39.0) = 2.00; p = .17, n^2 = .049$] and mother tongue (French versus Dutch) [$X^2 (1, 42.0) = .095, p = .76$]. Both oral and written instructions in Dutch and in French were given. Participants provided their written informed consent and the procedures were in line with the Declaration of Helsinki. The study was approved by the "Comité d'Ethique hospitalo-facultaire Saint-Luc-UCLouvain" (2019/19AOU/357).

2.2 Stimuli and procedure

Stimuli, procedure (see figure 1), EEG data acquisition and analysis were similar as described in (Buyle et al., 2023). The stimuli consisted of drawings of hand configurations representing numbers 1 to 4. Non-canonical (atypical) finger-number configurations served as base stimuli, while canonical configurations served as deviants. Each set included 48 images, obtained by combining four numerosities, three drawing styles, and their mirror versions. Visual sequences lasted 60 s, with a 2-s fade-in and 2-s fade-out. Stimuli were presented centrally at 6 Hz (six images/s) using sinusoidal contrast modulation. Canonical configurations (finger-montring/ signs vs. finger-counting configurations) appeared as deviants every fifth item, yielding a deviant frequency of 1.2 Hz (see figure 1). Stimuli were randomly ordered within each category without immediate repetitions, and each condition (finger-montring/signs vs. finger-counting) was repeated three times. Participants fixated a central cross throughout and performed an orthogonal colour-change detection task to maintain attention. The experiment was programmed in JavaScript and conducted in a quiet, dimly lit room, with participants seated ~1 m from an 800×600 resolution monitor.

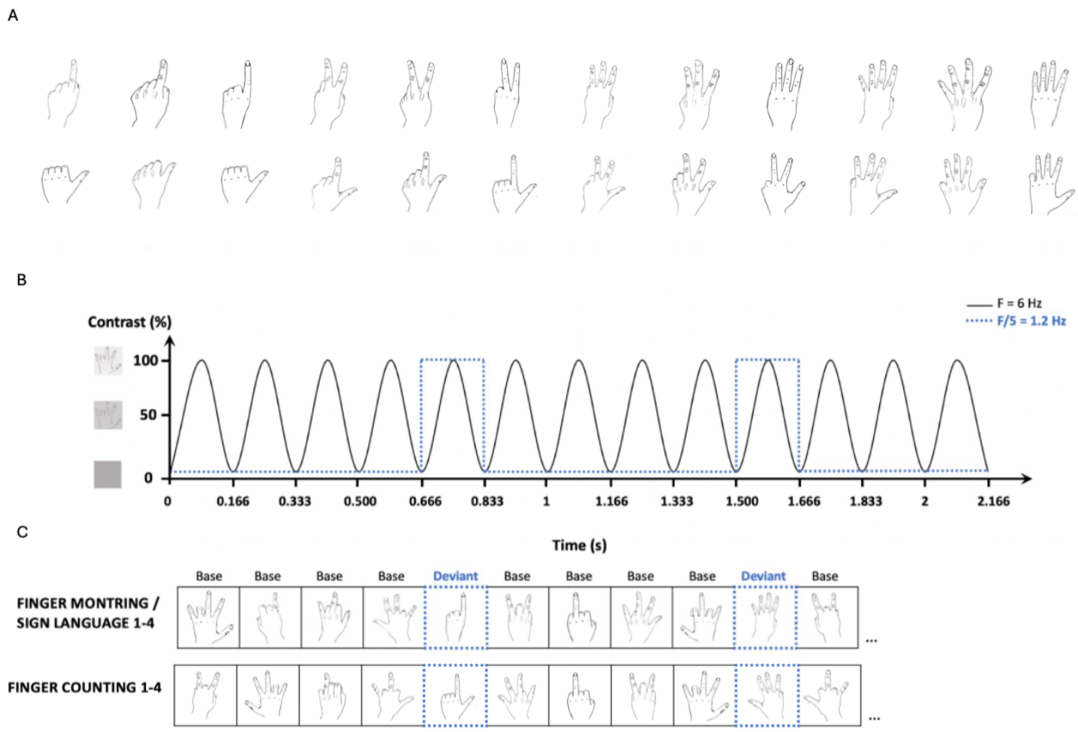

Figure 1. (A) Finger-montring configurations 1 to 4 (first line) corresponding to signed numbers 1 to 4 in LSFB and VGT. Finger-counting configurations 1 to 4 (second line). Three drawing designs were used for each numerosity representing the canonical stimuli of the experiment (i.e., presented at 6 Hz / 5 = 1.2 Hz). Non-canonical configurations of these numerals were presented at 6 Hz (i.e., base stimuli). (B) Stimulation over time of six stimuli per second (6 Hz), with deviant stimuli presented at 6 Hz/5 = 1.2 Hz. (C) Examples of the 2 conditions of the experiment. In the finger-montring/number signs' conditions, non-canonical finger representations (base stimuli) are presented at the base frequency and canonical number signs (deviant stimuli framed with blue dotted lines) are periodically inserted every fifth item. In the finger-counting condition, finger-counting configurations are presented as deviant stimuli every fifth item. Base stimuli are the same as the ones used in the number signs condition.

2.3 EEG acquisition and preprocessing

EEG was recorded at 2048 Hz using a 64-channel BioSemi ActiveTwo system arranged according to the 10–20 layout, with four additional posterior electrodes (PO9, I1, I2, PO10). CMS and DRL electrodes served as reference and ground. Electrode offsets were maintained below 50 mV. Preprocessing was performed in Letswave 5 (MATLAB), including resampling to 512 Hz, 0.1–100 Hz band-pass filtering, and removal of line noise using a 50 Hz multi-notch filter. Fade-in/fade-out periods were excluded, and up to 10% of noisy channels were interpolated. Data were segmented from stimulation onset to 60 s, re-referenced to the common average, and averaged across repetitions per condition.

Fast Fourier Transforms (FFT) were applied to obtain amplitude spectra (resolution: 0.017 Hz). Base responses were expected at 6 Hz and deviant responses at 1.2 Hz and harmonics. Z-scores were computed at each frequency bin relative to 20 neighbouring bins (excluding adjacent bins), and harmonics with $Z > 1.64$ ($p < 0.05$, one-tailed) were considered significant. Signal-to-noise ratios (SNR) were computed as amplitude / mean noise. For visualization and statistics, baseline-corrected amplitudes at the deviant frequency and significant harmonics (excluding the base frequency) were summed.

2.4 Statistical Analyses

Statistical analyses were carried out using IBM SPSS statistics 26 software for Mac OS Ventura 13.0 (Armonk, NY). Statistical significance was set at $p < 0.05$ for all computations. Data were checked for normality of distribution and presented as Mean ± Standard Error (SE). As amplitude values were not normally distributed, they were square-root transformed. Results were analysed using a Linear Mixed Model with *Amplitude* as dependent variable, *Group* (hearing signers, hearing controls), *Condition* (finger-montring, finger-counting) and *Hemisphere* (left, right) as fixed factors. *Subject* was indicated as random effect, to control for any variability within the groups. First, base rate amplitudes (in μV) were analysed, and then the amplitude values (in μV) of the deviant rate were analysed by considering the amplitudes of the base rate as covariate. Bonferroni post hoc analysis was applied when appropriate.

3. Results

3.1 Base Rate Responses

Responses synchronized with the base frequency (6 Hz) were significant up to 5 harmonics (from 6 Hz to 30 Hz) across both conditions. The baseline-corrected amplitudes were summed and then the responses of the 68 electrodes were ranked. The electrodes showing the highest responses were all located in the parieto-occipital region (see Figure 2). The amplitudes of the channels PO8, O2 and contralateral channels PO7, O1 were averaged into two ROIs. The LMM analysis only showed a significant effect of *Hemisphere* [$F(1, 120) = 48.2, p < .001$], but no main *Group* effect [$F(1, 40.0) = .005, p = .94$], nor *Condition* effect [$F(1, 120) = .087, p = .77$], and no significant interactions. The final model without all interactions resulted in similar conclusions. The right hemisphere showed stronger responses ($M \pm SE = 1.21 \pm .039\ \mu V$) compared to the left hemisphere ($M \pm SE = .99 \pm .039\ \mu V$). Response amplitudes in hearing signers ($M \pm SE = 1.10 \pm .051\ \mu V$) were equal to the responses in hearing controls ($M \pm SE = 1.11 \pm .051\ \mu V$). The finger-montring ($M \pm SE = 1.10 \pm .039\ \mu V$) condition had similar amplitude responses compared to the finger-counting condition ($M \pm SE = 1.11 \pm .039\ \mu V$). The *Subject* intercept was significant ($p < .001$). Nevertheless, the inclusion of *Subject* as random effect in the model already controlled for its potential influence on the fixed effects.

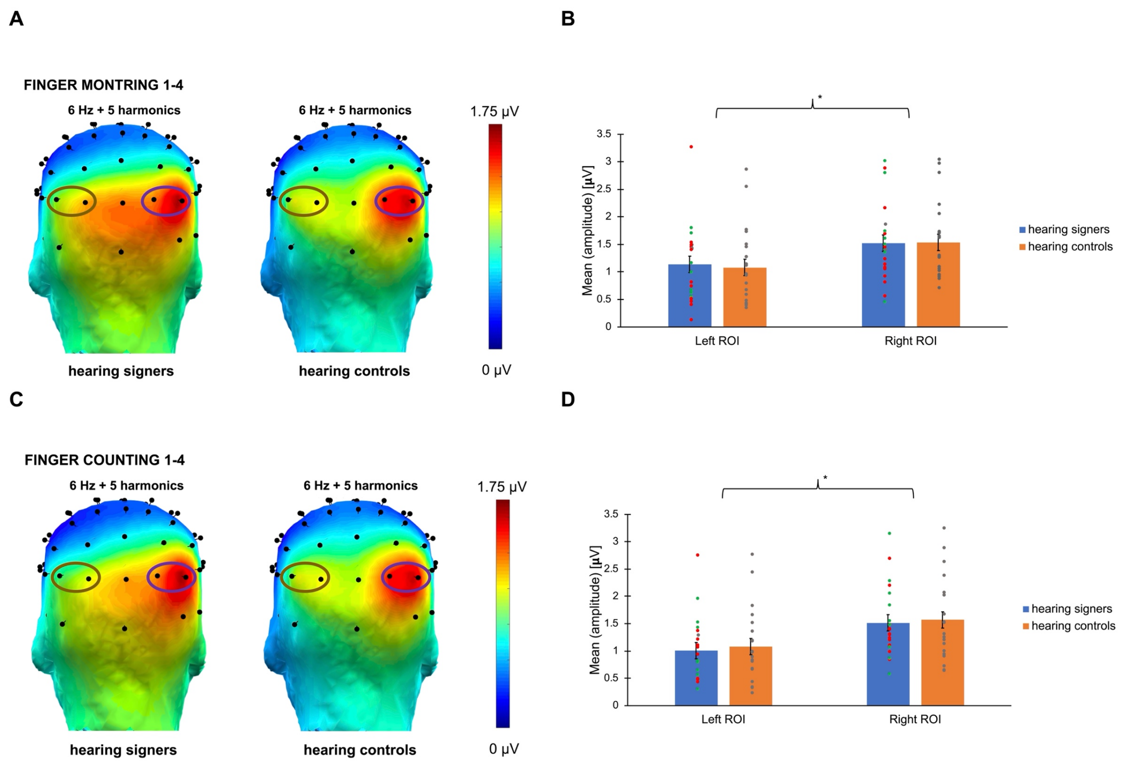

Figure 2. Base responses: Responses elicited at the base rate (i.e., 6 Hz) in the first condition **(A)**, and the second condition **(C)** for hearing signers and hearing controls. Topographies display the sum of amplitude responses for the significant (Z > 1.64) harmonics (from 6 Hz to 30 Hz). The ROIs (right: PO8, O2; left: PO7, O1) are circled on the topographic maps. Bar plots showing the mean amplitudes for hearing signers (in blue), and hearing controls (in orange) per ROI for finger-montring **(B)**, and finger-counting **(D)**. Untransformed amplitude values are presented for the sake of clarity. Error bars represent the standard error of the means. Asterisks represent significant difference. Grey points represent individual hearing controls mean scores. For hearing signers, green data points represent participants who use sign language daily, whereas red data points represent those who use it weekly.

3.2 Categorical Discrimination Responses

Categorical responses elicited by the presentation of canonical configurations at 1.2 Hz were significant from 1.2 Hz to 14.4 Hz among conditions (10 harmonics excluding the base stimulation frequency). Scalp topographies of the sum of significant harmonics suggested posterior bilateral responses (see Figure 3), in line with the results reported for deaf signers versus hearing non-signers (Buyle et al., 2023). Baseline-corrected amplitudes were summed and ranked for the 68 channels to identify the channels with the highest responses. Channels O2, PO8 and contralateral channels O1, PO7 were averaged to create right and left ROIs, respectively. Statistical analysis indicated no significant *Hemisphere* difference [$F(1, 139) = .000, p = .99$], nor a significant *Group* difference [$F(1, 39.6) = 2.31, p = .14$]. There was a significant contribution of the Base Rate amplitudes [$F(1, 102) = 40.5, p < .001$], and a significant effect of *Condition* [$F(1, 119) = 21.5, p < .001$]. Only the *Group x Condition* interaction was significant [$F(1, 119) = 7.42, p = .007$], the others were not. The final model lead to the same conclusion after removing the non-significant interactions from the analysis: Response amplitudes in the finger-counting condition ($M \pm SE = .53 \pm .030\ \mu V$) were higher compared to the ones in the finger-montring condition ($M \pm SE = .35 \pm .031\ \mu V, p < .001$). Importantly, response amplitudes of hearing signers ($M \pm SE = .44 \pm .043\ \mu V$) were significantly higher from those of hearing controls ($M \pm SE = .27 \pm .043\ \mu V$) only in the finger-montring condition ($p = .004$), and not in the finger counting condition ($M \pm SE = .52 \pm .042\ \mu V$ *for hearing signers;* $M \pm SE = .55 \pm .043\ \mu V$ *for hearing controls,* $p = .52$). Note that amplitudes are displayed for a base rate reference at 1.00 µV, and that the *Subject* intercept was not significant ($p = .34$).

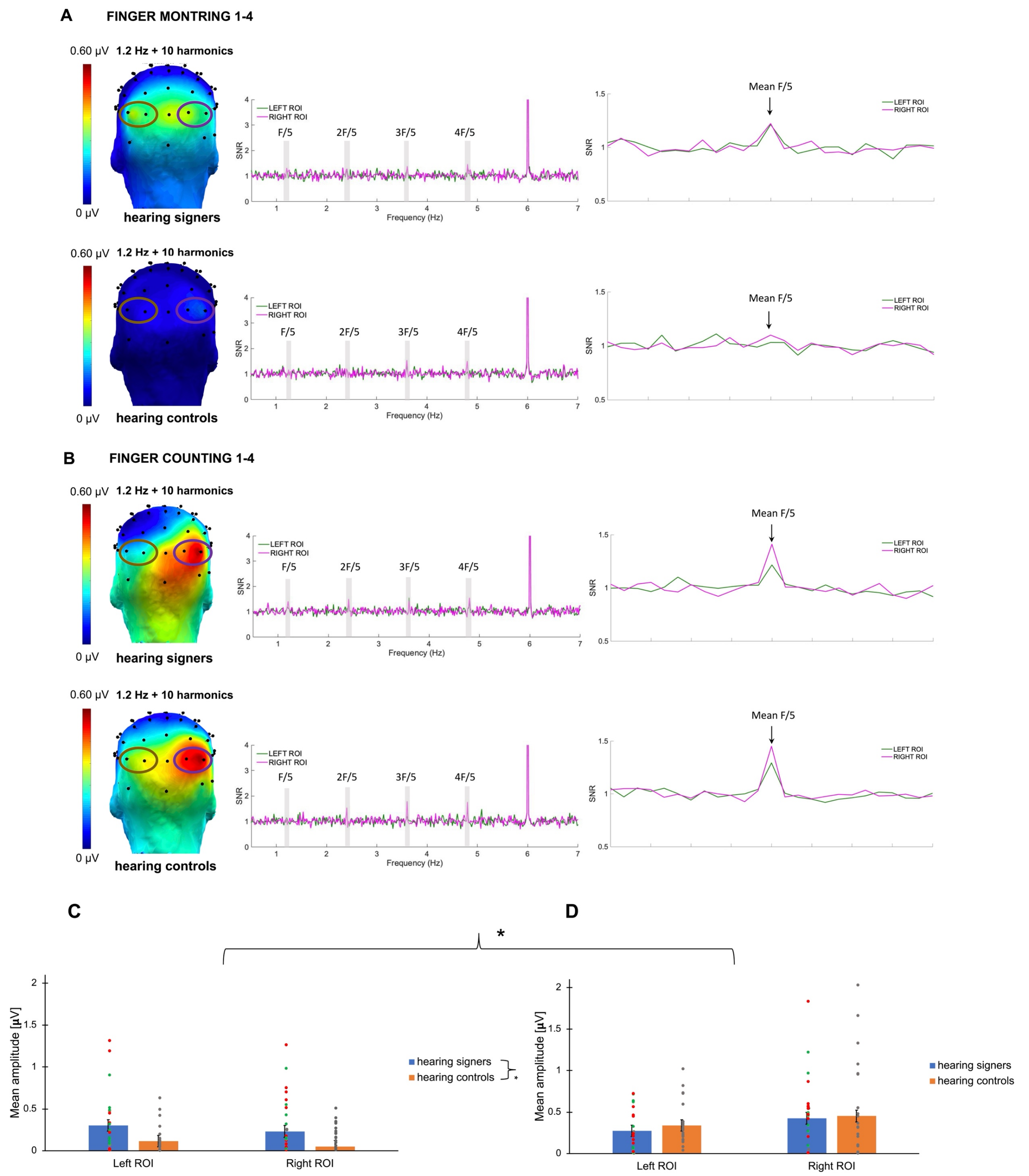

Figure 3. Categorical Responses: responses elicited by canonical detection in the **(A)** first and **(B)** second condition for hearing signers and hearing controls. Topographies (on the left) display the sum of amplitude responses for the significant (Z > 1.64) harmonics (1.2 Hz to 14.4 Hz for both conditions). SNR response spectra (middle and right figures) show the electrodes of the ROIs for both conditions: O1, PO7 (left) and O2, PO8 (right). The ROIs are circled on the topographic maps. The frequencies of significant harmonics are marked as F/5 (1.2 Hz),

2F/5 (2.4 Hz), 3F/5 (3.6 Hz) and 4F/5 (4.8 Hz). The response at 6 Hz represents the response synchronized with the base stimulation frequency. On the right figure, the averaged SNR of the significant harmonics (excluding the base) is represented centred with 12 surrounding bins on each side. Bar plots showing the mean amplitudes for hearing signers (in blue), and hearing controls (in orange) per ROI (right: PO8, O2; left: PO7, O1) for the finger-montring **(C)**, and the finger-counting **(D)** condition. Untransformed amplitude values are presented by means of clarity, for a base rate reference of 1.00 µV. Error bars represent the standard error of the means. Asterisks represent significant difference. Grey points represent individual mean scores. For hearing signers, green data points represent participants who use sign language daily, whereas red data points represent those who use it weekly.

4. Discussion

The aim of this study was to provide further insight into the proposed dissociation between signs and gestures used by signers versus non-signers. More specifically, brain responses of hearing signers and hearing non-signers to *number signs* versus *number gestures* were compared in an FPVS-EEG design. Our results first demonstrated that finger-montring and finger-counting configurations induced significant discrimination responses in bilateral parieto-occipital brain regions. These enhanced neural responses to canonical compared to non-canonical hand configurations are very well in line with previous studies suggesting that canonical finger representations automatically activate number semantics (Buyle et al., 2023; Marlair et al., 2021; Soylu et al., 2019; van den Berg et al., 2021, 2022). The observation that finger-counting configurations elicited higher brain responses than finger-montring configurations might suggest that these procedures do not completely overlap in their processes (Roesch, Moeller, & Bahnmueller, 2024). While finger-counting typically involves the successive extension of single fingers to count and facilitate arithmetic processing (Soylu et al., 2019), finger-montring in contrast involves the simultaneous extension of several fingers to represent and communicate numerical information (Di Luca & Pesenti, 2011). Importantly, recent research has demonstrated that children aged 3 to 5 years old were able to use finger-counting accurately before mastering finger-montring (Roesch et al., 2024), hence suggesting that finger-montring may require frequent use of finger-counting for proper development. An ERP study similarly demonstrated that finger-montring induced higher P1/N1 waves than finger-counting, suggesting that recognizing finger-montring configurations might require more attentional or perceptual resources than finger-counting configurations (Soylu et al., 2019). The higher brain responses observed in the present study may therefore reflect the developmental time course of finger-based representations, with finger-counting emerging before finger-montring, as well as the attentional resources required to process these configurations. Less attentional resources may specifically be required for finger-counting, thus inducing higher brain responses in the present FPVS design.

Our results finally and importantly demonstrated more pronounced neural responses to finger-montring configurations in signers than in non-signers, while similar neural reactions to finger-counting configurations were found among both groups. Since this amplitude modulation was not observed in the general visual responses and resembles the pattern reported in deaf signers compared to hearing controls (Buyle et al., 2023), it offers additional evidence for the impact of sign language knowledge on finger-number configuration processing. The inclusion of late hearing signers (see Table 1) notably reinforces the notion that these findings are intricately tied to the knowledge of sign language. The stronger neural responses observed in participants familiar with sign language are indeed consistent with our proposal that finger-montring configurations 1 to 4 (i.e., *number signs* for individuals knowing sign language) are processed as *linguistic signs* for those individuals, while they are processed as number gestures in non-signers (see also Buyle et al., 2023).

Importantly, many signs, including number signs, exhibit varying degrees of iconicity, meaning that their form maps visually or motorically onto their meaning (Perniss et al., 2010; Taub, 2001). Iconicity is also a feature of many spontaneous gestures produced by hearing non-signers, especially pantomimic or action-based gestures (McNeill, 1992; Hostetter & Alibali, 2008). As a result, certain number signs may overlap perceptually with gestures familiar to hearing individuals, even though they function as conventionalized lexical items within the linguistic system for signers. This overlap suggests that hearing non-signers may process number signs as action-like gestures, whereas signers process them within linguistic networks despite their iconic form. Neuroimaging and electrophysiological evidence supports this distinction. For example, Emmorey et al. (2011) showed that producing American Sign Language verbs engaged left inferior frontal language areas in deaf signers, whereas hearing non-signers producing pantomimes for the same objects did not recruit the same frontal language regions, instead activating parietal cortex associated with praxic action production. In addition, recent electrophysiological work has demonstrated differential neural responses to highly iconic signs in hearing learners versus proficient signers: hearing learners show larger N400 responses to iconic signs prior to learning, consistent with implicit gestural recognition, whereas deaf signers exhibit distinct N400 modulations reflecting integration of iconic forms into an established lexical system (Akers et al., 2025). These findings indicate that even when signs resemble pantomime, their production and comprehension recruit partially segregated neural systems that support linguistic versus gesture-based praxic functions. Integrating iconicity therefore helps explain why signs and gestures may share motoric or visual features while still engaging distinct representational systems depending on language experience.

A comprehensive comparison of the neural networks underlying finger-counting configurations across groups provides further evidence to this assumption. As this comparison did not reveal any discernible differences between signers and non-signers (see also Buyle et al., 2023), it strongly implies that finger-counting configurations are processed uniformly across both groups, with iconicity playing a negligible role in the discrimination responses.

Most hearing signers tested in this study acquired sign language as a second language (L2) and do so relatively late, often after puberty. Age of acquisition and language dominance are known to influence lexical processing, neural specialization, and representational tuning in both spoken and signed languages. Late L2 learners typically show reduced proficiency, lower automaticity, and alternative neural recruitment patterns compared to native users, reflecting both maturational constraints and competition with a dominant L1 modality (e.g., Malaia, Krebs, Roehm, & Wilbur, 2020 ; Mayberry, Chen, Witcher, & Klein, 2011). Further research must therefore delve into potential disparities between native and late hearing signers. It is conceivable that early signers may exhibit even more robust responses compared to late signers, owing to their earlier exposure to sign language (i.e., sign language as their primary language). In addition to age of acquisition, frequency of sign language use may contribute to variability among hearing signers. In the present sample, sign language exposure ranged from weekly to daily use. To explore whether use frequency modulated the observed effects, individual data points were visually distinguished according to sign language use in the figures. This inspection did not reveal a clear separation between daily and weekly users, suggesting that the enhanced neural responses to finger-montring configurations in hearing signers are not solely driven by high levels of current use, but may emerge across varying degrees of sign language exposure. A comprehensive investigation involving hearing signers with varying durations of sign language experience could shed light on the precise developmental stages at which hearing signers begin to perceive signed numbers as *linguistic signs*. Further research should also examine the influence of auditory status on the processing of these finger-number configurations through comparisons between native deaf and native hearing signers. In such instances, both signer groups should demonstrate similar brain responses. A comparative study between deaf native signers and orally educated deaf individuals could additionally elucidate the impact of sign language knowledge. Oral deaf individuals may indeed demonstrate neural responses similar to hearing non-signers, because although both groups can assign numerical meaning to finger configurations, these configurations are not part of their language and are not used as lexical items. From this perspective, finger-number configurations remain gestures rather than linguistic units, which may result in neural responses that resemble those of hearing non-signers rather than hearing signers.

5. Conclusion

This study provides compelling evidence for the crucial distinction between signs and gestures. In line with the findings of Buyle et al. (2023), which compared *number signs* and *number gestures* in deaf signers and hearing controls, our investigation revealed no significant group differences in brain responses to finger-counting configurations (i.e., *number gestures*) between hearing signers and hearing non-signers. This suggests a uniform processing of these configurations across both groups. However, a striking contrast emerged in our study: hearing signers exhibited significantly more pronounced brain responses to finger-montring configurations (i.e., *number signs*) compared to hearing controls, indicating distinct processing mechanisms. These results underscore the pivotal role of sign language in shaping finger-number representations. These conclusions nevertheless apply specifically to hearing individuals who acquired sign language as a second language, and use it as a non-dominant modality. Future work including native deaf signers and native hearing signers will be crucial to determine how early exposure, modality dominance, and sensory experience jointly shape the neural representation of signed numerical forms.

Declaration

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Conflicts of interest/Competing interests: The authors declare no competing interests.

Ethics approval: The study was approved by the "Comité d'Ethique hospitalo-facultaire Saint-Luc-UCLouvain" (2019/19AOU/357).

Consent to participate: Written informed consents to participate were signed by all participants.

Consent for publication: Written consents for use of data for publication were signed by all participants.

Availability of data and materials: The study was not preregistered. Our data are freely available at the OSF link :
https://osf.io/8shar/overview?view_only=ad9a682475b9494fabcf5fb3181f74d1

Code availability : Not applicable

Authors' contributions:
Margot Buyle: Conceptualization, data curation, formal analysis, project administration, writing-review and editing
Virginie Crollen: Conceptualization, Writing- original draft, Funding acquisition, Supervision

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Tables

Table 1

Characteristics of Participants

Subject	Age	Sex	Handedness	Mother tongue	Formal school years (after primary school)	Sign language acquisition (age)	Frequency of using sign language
1	23	F	R	Fr	9	6	Daily
2	30	F	R	Fr	12	20	Daily
3	23	F	R	Fr	11	18	Daily
4	31	F	R	Fr	N/A	28	N/A
5	58	F	R	D	12	As a kid	Weekly
6	23	F	R	Fr	7	18	Daily
7	26	F	R	D	12	18	Daily
8	29	F	R	Fr	9	N/A	Daily

9	51	F	R	D	17	28	Weekly
10	32	F	R	Fr	11	26	Daily
11	41	F	R	Fr	9	18	Daily
12	23	F	R	Fr	8	22	Weekly
13	29	F	L	D	15	Implicit 10, explicit 25	Weekly
14	57	F	L	D	14	26	Weekly
15	28	F	R	Fr	16	19	Weekly
16	30	F	R	Fr	11	22	Weekly
17	50	M	R	D	10	4-5	Weekly
18	63	M	R	D	9	18	Weekly
19	51	M	R	D	10	32	Weekly
20	54	M	R	D	6	28	Weekly
21	38	M	R	D	12	As a baby	Daily
22	55	F	R	D	11	/	
23	23	M	R	D	12	/	
24	23	M	R	Fr	9	/	
25	23	F	R	Fr	10	/	
26	20	F	R	Fr	8	/	
27	38	F	R	Fr	12	/	
28	50	M	R	D	11	/	
29	57	F	R	Fr	6	/	
30	46	M	R	D	6	/	
31	66	M	R	D	11	/	
32	31	M	R	D	16	/	
33	57	M	R	D	10	/	
34	50	F	R	D	9	/	
35	39	M	R	D	8	/	
36	38	F	R	D	9	/	
37	25	F	R	Fr	14	/	

38	36	F	L	Fr	11	/
39	49	M	R	Fr	7	/
40	47	F	R	D	7	/
41	20	F	R	Fr	9	/
42	21	F	R	Fr	10	/

Note. R = right-handed; L = left-handed; F = female; M = male; D = Dutch; Fr = French.