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Non-weird (psycho)linguistic endeavors: theoretical and metacognitive research with the Karajá of Central Brazil

Em busca de uma (psico)linguística não-weird: pesquisa teórica e metacognitiva com os Karajá no Brasil Central

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ABSTRACT

Cognitive psychology and psycholinguistics have historically been dominated by research conducted within Western, Educated, Industrialized, Rich, and Democratic (WEIRD) societies, resulting in a disproportionate representation of this demographic in scholarly investigations. In this article, we report basic and applied research investigating order of constituents and morphological representation and processing conducted with speakers of Karajá, a non-european language of Central Brazil. The basic research findings contribute novel insights about the Karajá language, challenging certain purported language universals while corroborating others, thereby enriching the broader understanding of human cognition. The applied research explores methodological avenues to foreground indigenous voices and perspectives into the investigation process, acknowledging the potential drawbacks of employing WEIRD analytical categories when exploring non-WEIRD languages. We invite speakers of the language to the center of the discussion in metacognitive activities in which speakers use their insights to formulate hypotheses and create a theory for the grammar of the language. In line with the discussions in Maia (2022) in which eye tracking data was used at the Middle school and University levels, in these Karajá sessions, we also used qualitative eye tracking data as an aid to help Karajá language teachers to "go meta", as put by Mahdavi (2014). We conclude by stressing that if we are to take seriously the importance of non-WEIRD science to the WEIRD world, there ought to be an increasing recentering of "participants" to more protagonist roles in research.

KEYWORDS: Lexical processing. Sentence processing. Decolonial methodologies. Language comprehension. Morphosyntactic processing.

RESUMO

A psicologia cognitiva e a psicolinguística têm sido historicamente dominadas por pesquisas conduzidas nas sociedades ocidentais, educadas, industrializadas, ricas e democráticas (WEIRD, na sigla em inglês), resultando em uma representação desproporcional desse grupo demográfico em investigações acadêmicas. Neste artigo, relatamos uma pesquisa básica e uma aplicada investigando ordem de constituintes e representação e processamento morfológico realizadas com falantes de Karajá, uma língua não europeia do Brasil Central. Os resultados da pesquisa básica contribuem com um maior entendimento sobre a língua Karajá, desafiando certos supostos universais linguísticos e corroborando outros, e possibilitando uma compreensão mais ampla

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da cognição humana. A pesquisa aplicada explora novos caminhos metodológicos para colocar em primeiro plano vozes e perspectivas indígenas no processo de investigação, reconhecendo as possíveis desvantagens de empregar categorias analíticas WEIRD ao explorar línguas não-WEIRD. Convidamos os falantes da língua para o centro da discussão em atividades metacognitivas nas quais os falantes usam sua intuição linguística para formular hipóteses e criar uma teoria para a gramática da língua. Em consonância com as discussões em Maia (2022) em que dados de rastreamento ocular foram usados nos níveis do ensino médio e universitário, nessas sessões em Karajá também usamos dados qualitativos de rastreamento ocular como um material para ajudar os professores de línguas a "go meta", como sugerido em Mahdavi (2014). Concluímos enfatizando que, se quisermos levar a sério a importância da ciência não-WEIRD para o mundo WEIRD, deve haver uma concentração crescente dos "participantes" em papéis mais protagonistas na pesquisa.
PALAVRAS-CHAVE: Processamento lexical. Processamento de frase. Metodologias decoloniais. Compreensão da linguagem. Processamento morfossintático.

Nothing for us without us[4]

1. Introduction

As reviewed in Maia (2021), it has been clearly pointed out that Western, educated, industrialized, rich and democratic (WEIRD) societies— who represent as much as 80% of study participants, but only 12% of the world's population— are not only unrepresentative of humans as a species, but on many measures, they are outliers (cf. Heinrich et al., 2010). In this respect, Rad et al. (2018) even suggest specific changes in research and even in editorial policies to make it possible that 'the study of Homo sapiens meets the goal of charting and explaining human variability and universals in cognition and behavior' (cf. Rad et al., 2018, p. 11, 403). Therefore, on the one hand, while it seems quite clear that there is indeed over-representation of data from so called WEIRD linguistic communities in current cognitive psychology and (psycho)linguistic studies, on the other hand, the exploration of non-WEIRD languages tends to be, paradoxically, confined to the application of WEIRD analytical categories.

Da Matta (1978) coined the term "anthropological blues" to refer to a state of "extreme loneliness" which befalls the WEIRD researcher in the field as a true passage rite. As we pointed out in Maia (2021), the researcher in the field faces a paradox: on the one hand the intricacies of a surrounding non-WEIRD world need to be appreciated and analyzed using all the WEIRD analytic tools available. On the other hand, "all analytical insights that may come, even if helpful to organize the chaos, may also launch the researcher to a place of extreme loneliness amidst the surrounding chaotic experience, since their elaborations are generally totally irrelevant to that reality at hand" (cf. Maia, 2021).

Very few psycholinguistic studies have been conducted so far with the Karajá population. The present article reports investigations in syntactic constituent order and in morphology computation

[4] More than 500 participants from 50 countries, including government ministers, indigenous leaders, researchers, public and private partners, and other stakeholders and experts, adopted the Los Pinos Declaration, at the end of "Making a decade of action for indigenous languages," a two-day event in Mexico City, organized by Unesco and Mexico. The declaration places indigenous peoples at the center of its recommendations with the slogan: "Nothing for us without us." (https://www.languagemagazine.com/2020/04/21/nothing-for-us-without-us-roadmap-for-decade-of-indigenous-languages/).

in the Karajá language. We included these studies to cover distinct levels of representation in the language. The idea is to move from the report of two psycholinguistic studies to an example of a novel attempt of participation of the Karajá in the scientific process. To this end, our objective is to 1) report findings that contribute to characterizing language representation and processing, providing data from a non-European language and 2) bring speakers of the language to the center of the discussion in metacognitive activities in which speakers use their insights to formulate hypotheses and ultimately produce investigations that may lead to a non-WEIRD full-fledged theory for the grammar of the Karajá language in the future, if they so desire[5].

Karajá is a Brazilian indigenous population whose language has been classified in the Amerindian Macro-Je stock (cf. Davis, 1968). The Karajá population comprises approximately 4000 people, distributed in about 20 villages on and around the Bananal Island, in the state of Tocantins in Central Brazil (Latitude: - 11_ 190 60.0000 S; Longitude: - 50_ 240 59.9900 W). The Karajá language is usually the first language acquired by the children in most villages and has been classified as vulnerable, but not endangered in the UNESCO's Atlas of World Languages in Danger (http://www.unesco.org/languages-atlas/index.php).

The article is organized as follows. After this brief introduction, which summarizes our aims and includes our positionality statement, the second section reports psycholinguistic experiments conducted with Karajá participants, in which the analytical tools and categories were those established by the literature with WEIRD populations. We describe non-chronometric and chronometric *off-line* acceptability judgment tests preliminarily applied to Karajá participants in order to explore the placement of adverbs in a sentence, taking as a theoretical framework the universal hierarchies proposed in Cinque (1999) for low adverbs. Results show that Karajá displays violations of the relative order proposed by Cinque (1999) for low AdvPs. However, the results still corroborate the ideas suggested by Cinque (1999), since constraints were found in the order of the adverb phrases. We also report an experiment that examines morphological effects in earlier stages of visual word recognition, in a study that collects and analyzes ERPs in a lexical decision task performed by 27 Karajá participants. The study compares morphologically complex words to simple words of the same size. Results are in line with decompositional models of word recognition in that they show differences in cortical activity for morphologically complex words when compared to the simple words.

These experiments are relevant as an attempt to probe categories posed to be language universals, since determining these categories depend on looking at languages that are as different as possible from

[5] Concerning the possible theoretical and/or methodological contributions that can be fostered with the protagonistic participation of interested members of indigenous communities, we would like to refer the reader to three cases of basic and applied linguistic research which have been carried out in our LAPEX research group. One is the discovery of a very productive empathetic deixis system in Karajá (cf. Maia, 2021; Oliveira & Maia, 2011); a second is a study about the role of prosody in recursive construction in Karajá (Gomes et al., 2017), both of which could hardly have been discovered without the co-participation of indigenous native speakers, such as Lucirene Behederu Javaé, Ijeseberi Karajá and Leandro Lariwana Karajá, among several others. An important theoretical discovery also carried out in LAPEX was the description of a tonal tense inflection system in Kaingang (cf. Nascimento, Maia & Couto, 2016), a Macro-Jê language, such as Karajá.

the ones used to generate the claims. However, a truly non-WEIRD psycholinguistic endeavor could not succeed if it perpetuates a narrow research agenda whose aim is to test non-WEIRD languages against WEIRD standards.

The third section of the article describes an attempt to give one more step in this direction. It presents qualitative eye tracking dynamic and static gazeplots and heatmaps that were informally collected and displayed to Karajá teachers in metacognitive problem-solving based sessions (cf. Mahdavi, 2014) in a teachers' training program in the Karajá village of Hawalò, in 2019. The sessions focused on word order constructions, including order of adverbs, and on the morphology of wh-words. The data were presented to the teachers in lively active problem-based workshops in order to develop language awareness and science forming capacity (cf. Honda & O'Neil, 2008; Carton & Castiglione, 1976). In these sessions, we had the opportunity to talk about linguistic categories with the Karajá community, not as a default for their language to be tested against, but as a conversation starter[6].

Finally, our conclusions and final considerations are offered in the last part of the article. However, we should state from the outset that if we are to take seriously the importance of non-WEIRD science to the WEIRD world, there ought to be an increasing *recentering* of participants to more protagonist roles in research.

1.1. Positionality Statement

The three authors of this study are white, non-indigenous and with different levels of engagement with the Karajá of Central Brazil. The first author took his first field trip to the Karajá in July–September 1983, when he first visited the Javaé Boto Velho village in the northern part of the Bananal Island for a three-month stay. The Javaé is a Karajá subgroup which have traditionally inhabited the Javaés river and the more interior areas of the island. In Karajá contact narratives with the nonindigenous "white" people (*tori*, in the Karajá language), the Javaé are usually described as more conservative, having had contact with the tori through their Karajá proper relatives. During this first field trip, Maia was asked by the Javaé village chieftain, João Wataju and his daughter, Lucirene Behederu to help develop a Javae primer that could be used at the school. He was then working for the Museum of the Indigenous Peoples, in Rio de Janeiro, and applied for an OXFAM grant to develop this Javaé language primer. After this first project, Maia visited the northernmost Karajá village in the state of Tocantins and also the southernmost Karajá village in the state of Goias, developing linguistic studies and also taking part in a language revitalization project directed by the Federal University of Goiás. Starting in 1988, he has been working in the Karajá village of Hawalò, in the Bananal Island, near the city of São Félix do Araguaia, in the state of Mato Grosso. He has taken part in different language documentation and educational projects based on this village, such as the PRODOCLIN project financed by UNESCO, which developed a Pedagogical Grammar and a Dictionary with

[6] The data from the EEG/ERPs and Eyetracking experiments are available at: https://osf.io/gstn9/?view_only=5d05171f00984279a32195bc69a7e7f5.

active participation of the indigenous community. The other authors have experience in the areas of psycholinguistics and cognitive neuroscience In January 2015, they participated in a 2-week field trip to the Karajá village of Hawalò in which they immersed themselves in Karajá activities, got acquainted with their language, traditions and craftwork. This was the first time we brought the laboratory to the field and conducted a series of psycholinguistic experiments, using different protocols, including eye tracking and electroencephalography. The three authors are Professors and Psycholinguistic researchers with focus on morphological and sentence processing. Therefore, the insights that we bring are of outsiders to the language and to the community and the questions we ask are based on the canon of theoretical linguistics and psycholinguistics research.

The research questions asked in the basic science studies reported here were motivated by leading questions in the area, as a means to increase the repertoire of languages in which the theories can be tested. The applied studies were integrated in a decade long project, carried out by one of the authors, in which Karajá teachers have been actively developing language materials to use in the teaching of Karajá at the village schools. Maia has also taken part in indigenous teacher-training programs with the Karajá and several other indigenous groups in Brazil, using active methodologies (cf. Maia, Franchetto, Sândalo, Storto, 2002).

2. Expanding the typological inventory

2.1. Adverbs in Karajá

As we mentioned in the introduction, expanding the inventory of languages is a necessary step to probe claims about language universals. Here, we confronted constraints in the order of adverbs found in Karajá with the universal hierarchy proposed by Cinque (1999) for low adverbs, based on tests of acceptability judgment. In this way, this work aligns with others that have proposed to study indigenous languages from an approach that unites grammar theory, fieldwork and psycholinguistic methodologies (Amaral et al., 2018).

The traditional approach of Generative Grammar classifies adverbs as adjuncts. What is alleged for such a classification is the fact that these can be attached to any intermediate projection, not considering semantic properties. This proposal, however, does not predict the restriction of certain positions of adverbs in the sentence, a fact that motivated Cinque (1999) to classify them as specifiers. This proposal emerges from the observation that the same classes of Adverb Phrases (AdvPs) are linked to the same types of projections, constituting a hierarchy. On a different perspective, AdvPs are classified according to the type of functional heads, taking into account semantic aspects. The AdvPs occupy positions projected by different functional heads, the order of the adverbs corresponding to the order of these heads, which is a response to the constraints in position.

The choice of one among the hypotheses highlights different characteristics of adverbs, so that the first seeks to stick to optionality and free distribution, while the second assigns a fixed and universal hierarchy of positions, which will be occupied by certain types of adverbs. By the

hypothesis of adjunction, adverbs are classified from domains of modification and scope delimited in the sentence. In the *specifier* hypothesis, on the other hand, adverbs are classified according to information contained in the head to which they are associated.

Low adverbs, according to Cinque (1999), are those that occupy the lowest position in the sentence, that is, adverbs of VP. These adverbs would be found in the space determined on the left by the leftmost position that a past participle can occupy and, on the right, by a complement of the past participle. When certain classes of AdvPs can co-occur in this space, a fixed relative order is observed, expressed by the following sequence: Habitual (usually) > negative (not) > repetitive (again) > frequentative (repeatedly) > celerative (rapidly) > continuative (still) > perfective (already) > retrospective (lately) > approximative (lately) > generic/progressive (typically) > prospective (almost) > completive (completely) > celerative 2 (rapidly) > frequentative 2 (often).

Most of the studies in generative linguistics rely on the use of one or a few speakers of the language as consultants – previously more generally referred to as "informants", the rationale being that "a representative speaker has built into him all the linguistic rules needed for interacting efficiently with the other members of the speech community" (Samarin, 1967; p. 28). Over the past 50 years, however, there has been some criticism of the reliability of these acceptability judgment tests. Sprouse and de Almeida (2013), however, have convincingly shown that chronometric judgment studies confirmed results of previous non-chronometric research, which have thus not committed type I errors, but does not prevent type II false negative errors.

In this study, we conducted a traditional acceptability judgment to check the hierarchy of adverbs in Karajá, the results of which are outlined in Table 1 (Non-chronometric participant). This participant was thoroughly experienced in working as a language informant and could be regarded as a reliable representative of the speech community. His acceptability judgments enabled us to establish the preferred order for Karajá adverbs.

In addition, we explored a preliminary version of a psycholinguistic test of immediate judgment of acceptability, which allows for monitoring response times. Even though the amount of participants makes the study quantitatively underpowered, we decided to report the results here, firstly, as an appreciation for the valuable contribution of the Karajá participants and, secondly, because it contributes with one more layer of information. The chronometric differences in response times serve as an indication of the hesitation from the speakers.

To create the stimuli for this chronometric test, we manipulated the order of the adverbs to check if Karajá speakers would reject some of the orders, as exemplified in (I) below. This was the material used in the chronometric acceptability test that we conducted later.

I. Cinque order: Habitual (usually) precedes Negative (not)

A) Cinque order:

Tii obitimy utura r-i-rò-õ-myhy-re

He usually fish 3-theme-eat-NEG-ASP-PRES

"He does not usually eat fish"

B) Cinque's order reversed:
Tii utura r-i-rò-õ-myhy-re obitimy
He fish 3-theme-eat-NEG-ASP-PRES usually
"He does not usually eat fish"

We used the software Psyscope, version for Macintosh IMAC G3 for an immediate judgment of acceptability, which consisted of the appearance of 20 sentences on the screen, one by one, remaining for 4.5 seconds. When finished reading, the participant should press – on a button-box connected to the computer – the YES button for sentences they judged to be grammatical, or NO for ungrammatical ones. Two Karajá-speaking volunteers participated in this task.

The results are shown in Table 1, which displays the expected order, according to Cinque (1999), the acceptability parameter for Karajá, according to the volunteer who helped us preparing the stimuli, and the acceptability judgements and response times (RTs) for the two participants who took the chronometric test.

Table 1: Acceptability judgements confronted to the universal order proposed by Cinque (1999).

	Order of Adverbs	Non-chronometric participant	Chronometric participant 1	RT (ms)	Chronometric participant 2	RT (ms)
Cinque	Habitual - Negative	YES	YES	657	NO	52662
Cinque reversed	Negative - Habitual	NO	YES	1992	NO	44710
Cinque	Habitual - Repetitive	YES	YES	1520	NO	11092
Cinque reversed	Repetitive - Habitual	YES	YES	1259	NO	10895
Cinque	Habitual - Celerative	NO	NO	761	NO	143
Cinque reversed	Celerative - Habitual	YES	YES	2234	YES	8442
Cinque	Repetitive - Celerative	YES	YES	1691	YES	12509
Cinque reversed	Celerative - Repetitive	NO	NO	963	YES	916
Cinque	Repetitive - Continuative	YES	YES	1465	NO	15929
Cinque reversed	Continuative - Repetitive	NO	NO	987	YES	10396
Cinque	Habitual - Imperfective	NO	YES	3466	NO	1336
Cinque reversed	Imperfective - Habitual	YES	YES	1336	YES	3466
Cinque	Proximative - Completive	YES	NO	3843	NO	1407
Cinque reversed	Completive - Proximative	NO	YES	654	YES	5511

Source: the authors

As stated before, due to the reduced number of participants, the response times serve more as a qualitative parameter for hesitation, which represents one more source of evaluation for the data. For example, chronometric participant 1 took longer – relatively to his average response time – to accept the habitual-imperfective order.

Even though there were inconsistencies in the responses, the fact that some orders of adverbs were rejected by the participants corroborates the idea suggested by Cinque (1999) – that there are constraints in the position of adverbs. This study therefore contributed with data from one more language that point to the fact that different classes of AdvPs correspond to certain functional heads. The functional projection, even if not realized morphologically, would be present in the structure.

The continuity of studies in this direction may contribute to a deeper understanding of the systematic correspondence between the hierarchy of AdvPs and the functional heads. According to Cinque (1999), this correspondence would be in accordance with the idea that linguistic variation is related to differences in the morphological and lexical realization of fixed structural factors. Therefore, investigations in this direction become relevant as important tools in the understanding of Universal Grammar.

2.2. Visual word recognition: ERPs

Karajá, as an agglutinative language (Amerindian Macro-Je stock, cf. Davis, 1968), may provide important material to test hypotheses about the mechanisms underlying our human language processing, particularly morphological systems.

Gomes et al. (2022) investigated the morphological computation in Karajá by registering event-related brain potentials (ERPs) during a lexical decision task. To test possible differences in processing they compared *complex words* (rihonymyhyre *he leaves* – complex) with *simple words* (telukumakari *proper name* – simple) of the same size in the early stages of visual word recognition using the N170 component as a measure of pre-semantic morphological decomposition (Lewis et al, 2011). The conditions were created by crossing the two independent variables - *word size* and *morphological complexity*: i) Simple Small, ii) Complex Small (2 affixes), iii) Simple Medium, iv) Complex Medium (3 affixes), v) Simple Large, vi) Complex Large (4 affixes). A total of 120 experimental items were used (20 stimuli in each condition), besides 240 distracting words and 120 non-words to complete the lexical decision task. From these stimuli 6 lists were constructed, each containing 120 experimental items and 240 filler items. No item appeared in more than one condition in any given list. In a testing session each participant was given 1 of the six lists. Thus, each participant saw each item once.

Previous studies with MEG and with EEG investigating word processing (Zweig, Pylkkanen, 2009; Lewis, Solomyak, Marantz, 2011) have highlighted the M170/N170 as an index of the early visual stage of morphological decomposition, regardless of the nature of the morphological complexity of the words, whether regular or irregular, derived or inflected (Fruchter and Marantz, 2015), so the authors expected the N170 to behave as an index of increasing activity for complex words, indicating a stage of affix stripping during word recognition.

The authors reported EEG data from twenty-seven native speakers of Karajá from the Hãwalò and Btoiry Villages (12 males, aged 17–35, mean = 24.3). The data from two subjects were excluded from analysis – for excessive eye movement artifacts. Participants were right-handed and with normal or corrected-to-normal vision, with no reported linguistic or neurological impairment.

The EEG was acquired from a 64 (58 scalp electrodes) active electrodes system (actiCHamp Brain Products), which digitizes the EEG signals and captures the triggers (sent by the E-prime software) synchronized to the stimuli (time-locked stimuli) – sampling rate, 1000 Hz; bandpass, 0.01-499 Hz; reference, Cz; ground, AFz; impedance < 10 kOhms.

In addition to the 64 scalp sites, additional electrodes were attached to below the left eye (to monitor for vertical eye movement/blinks), to the right of the right eye (to monitor for horizontal eye movements), over the left mastoid bone (reference) and over the right mastoid bone (recorded actively to monitor for differential mastoid activity). All EEG electrode impedances were maintained below 10 kOhms. The EEG was amplified (bandpass of 0.01 and 30 Hz) and it was continuously sampled at a rate of 1000 Hz throughout the experiment. ERPs time locked to the onset of target words in each category were formed *off-line* from trials free of excessive artifact or response error (EOG > 70 mV were rejected). This percentage did not vary significantly across experimental conditions ($p > 0.9$). In addition, any trials with incorrect behavioral responses were also excluded from the averages.

All trials were baselined to the average of activity in the 200 ms pre-target period and were low-pass filtered at 30 Hz. We calculated the mean voltage in different time windows (Gomes, Garcia & Maia, 2022). The data were later digitized at a sampling frequency of 500Hz by a 24-bit analog-to-digital converter with 8 dB/oct and filtered with a low-pass (high-cut) of 30 Hz and a high-pass (low-cut) of 0.01 Hz, re-referenced to the average of the earlobes and segmented into 800 ms epochs with a pre-stimulus baseline of 200 ms. The baseline correction of 200 ms (-200 to 0 ms) was applied, and segments containing ocular, muscle, and other artifacts were removed after visual/semi-automatic inspection. These time epochs were chosen because they correspond to peaks in the waveforms elicited by the stimuli that were identified by visual inspection and also to the latency ranges that have been found for the N170 (Zweig, Pylkkanen, 2009; Lewis, Solomyak, Marantz, 2011; Holcomb and Grainger, 2009). All ANOVAs were run using the general linear model approach in R, and subjects were a random factor in all analyses. Fixed factors were *Type* (Simple/Complex) x *Affix Complexity* (Small/Medium/Big) and, *Condition* (6) x *Region* (5) x *Hemisphere* (2), and all factors were crossed in the model. Authors analyzed the mean amplitude difference scores by selecting areas of interest (ROI) distributed across the scalp. The N170 was analyzed with a specific set of ROI – the occipito-temporal (O1, Oz, O2, POZ, PO1, PO2), selected because previous ERP studies have indicated that N170 effects are largely restricted to occipital sites (Chauncey, Holcomb, & Grainger, 2008; Morris et al., 2008). Voltage amplitudes vary considerably over the topography of the head, but in the absence of interactions with the experimentally manipulated variables, these differences mean little, so we report only results concerning the main effects of the experimentally manipulated factors.

The results[7] partially reported in Gomes, Garcia & Maia (2022) show overall different cortical activity for morphologically complex words as opposed to simple words ($F(1,19) = 153$ $p<0.000001$), which is in line with decompositional models of word recognition.

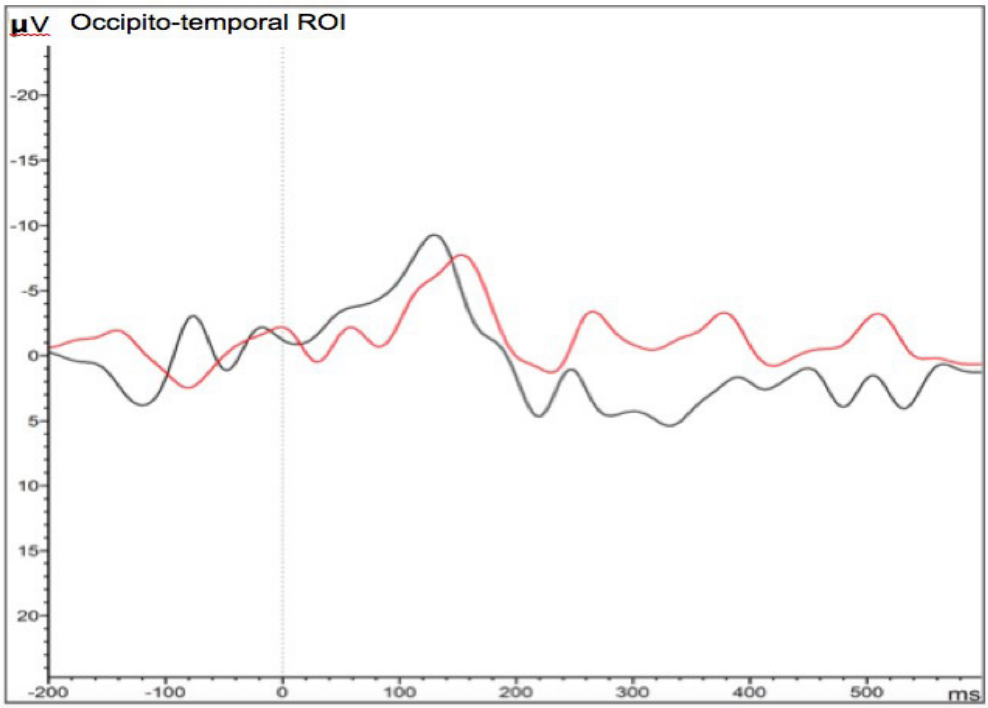
As can be seen in figures 1, 2 and 3, the authors reported that morphologically complex words display larger amplitudes in the N170 time-window. Results revealed greater activity in the N170 component for the comparisons in medium and large conditions (3-4 affixes) ($F(2,38) = 7.89$ $p<0.001365$), which is also in tune with the literature on decomposition (figures 2 and 3). However,

[7] Statistical analysis of the ERP data included a repeated- measures analysis of variance (ANOVA) with the factors: Type (Simple/Complex) x Affix Complexity (Small/Medium/Big) and, Condition (6) x Region (5) x Hemisphere (2).

there was no significant N170 effect between the two conditions with two affixes (t(19)=0.15 p< 0.8826). The lack of difference between small simple and complex words (in figure 1) can perhaps be explained by the smaller graphic salience between them - requiring further testing to verify this result.

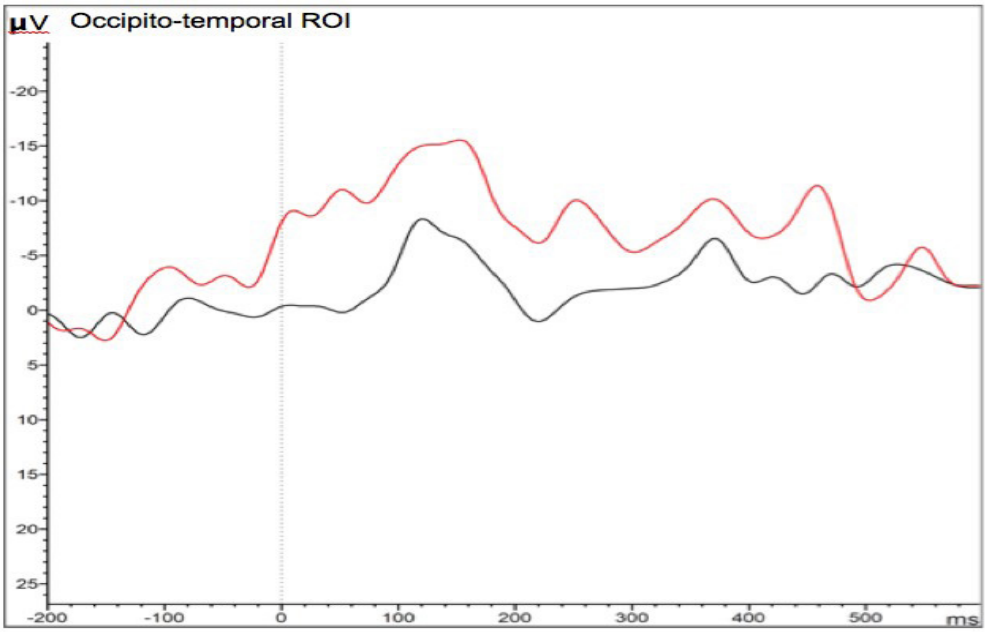
Moreover, ERP source analyzes found latency and topography effects on occipito-temporal regions (N170), which is described in the literature as the so-called visual word form area (VWFA, see McCandliss, Cohen, Dehaene (2003) for a review).

Figure 1: Mean ERP in the occipito-temporal region of interest (ROI) comparing Simple words (black-line) and complex words (red line) with two affixes (P), such as *Kurina* vs. *Rirore*, which are respectively an indecomposable proper name and a multimorphemic verb form) [Simple_P]vs[Complex_P] t(19)=0.15 p< 0.8826, indicating that there were no amplitude differences in the N170 window for this comparison.



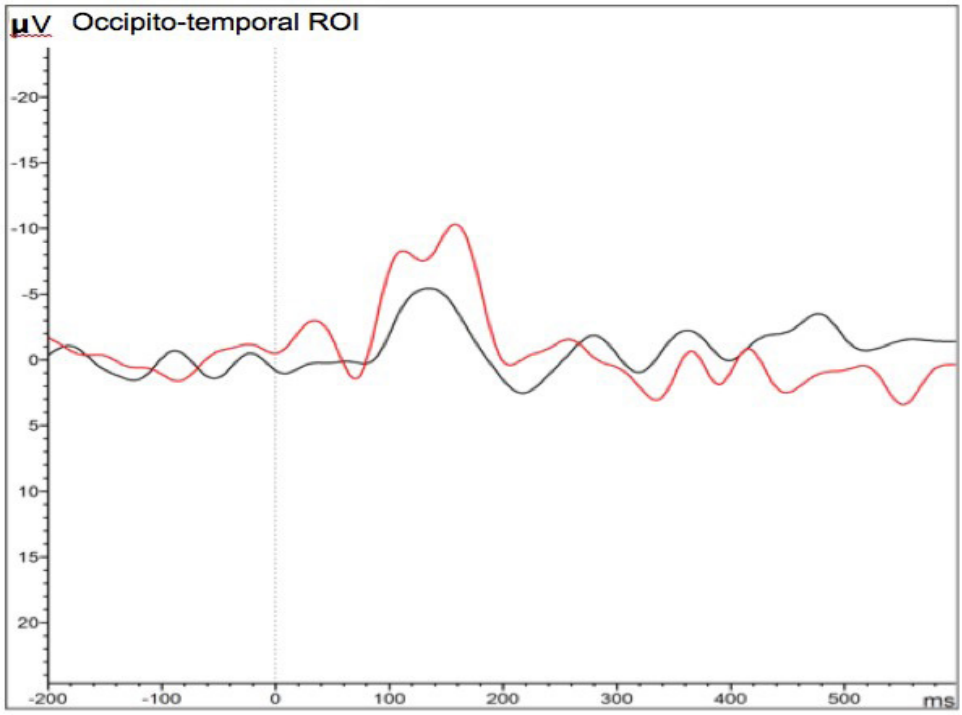
Source: the authors

Figure 2: Mean ERP in the occipito-temporal region of interest (ROI) comparing Simple words (black-line) and complex words (red-line) with three affixes (M), such as *Korihele* vs. *R-i-yriny-re*. [Simple_M] vs[Complex_M] t(19)=8.56 p< 0.0001, indicating that there are amplitude differences in the N170 window.



Source: the authors

Figure 3: Mean ERP in the occipito-temporal region of interest (ROI) comparing Simple words (black-line) and complex words (red-line) with four affixes (G), such as *Telukumakari* vs. *R-a-hiny-myhy-re*. [Simple_G] vs[Complex_G] t(19)=5.47 p< 0.0001, indicating that there are amplitude differences in the N170 window.



Source: the authors

Although letter-string effects have been reported to be left-lateralized, the authors did not find the effect of morphological complexity lateralization, suggesting that both hemispheres may be involved in early analysis of word forms.

The study partially reported in Gomes, Garcia e Maia (2022) investigates Karajá data to provide *on-line* evidence for differences in the time course of orthographic information processing and lexical access. Corroborating what is found in the literature for European languages, the results indicate that morphological complexity modulates early visual evoked activity in the N170 component. Those results demonstrate that data from Karajá speakers also exhibit an effect observed in studies with populations from WEIRD societies (including, but not limited to English) (Soto et al, 2019; Solomyak & Marantz, 2010).

3. Reentering the community: Eye tracking as a problem-based learning tool

In the present article we have explored different WEIRD theoretical frameworks and psycholinguistic methodologies to study adverb ordering and morphological computations in the Karajá language. In this section, we try to open at least part of the "research black box" to the research participants, presenting Karajá eye tracking data on adverbs and on morphology as epilinguistic metacognitive exercises that would have the potential both to trigger linguistic awareness and to share with the Karajá the researchers' lonely insights. By doing so, we hope to be exploring new venues both to overcome the so called "anthropological blues", that is the lack of understanding of the WEIRD analytical categories by the indigenous communities, which may isolate WEIRD researchers in fieldwork, and ultimately to stimulate the formulation of non-WEIRD linguistic analyses[5].

As proposed in Mason, Pluchino and Tornatora (2015), The EMME technique (Eye movement modeling example) can be developed in educational research to foster observational learning and self-regulatory processes. Considering that trackers are non-invasive, allowing not only to capture fixations and saccades, but also to display results in the form of videos, the authors showed eye tracking reading and image scanning data to students and evaluated that the visualization and discussion of the data were instrumental to develop linguistic awareness, positively impacting their reading abilities.

In a 3-week field trip to the Karajá village of Hawalò in February 2019, we had daily sessions with Karajá teachers and middle and high school students and had the chance to informally record their readings of different sentences in the Karajá language, using a portable Tobii Pro 120 eye tracker. Typically, we would record their readings of different constructions in a well formedness task during the mornings and would display videos of the readings in the form of dynamic and static gazeplots and heatmaps, in afternoon sessions, in which the proposal was basically to discuss the very intuitive eye tracking patterns. We should note that these eye tracking discussion sessions were very engaging and motivating, yielding lively participation of members of the Karajá school community, including teachers and Middle and High school students, who would enthusiastically present their hypotheses on the reading patterns, offering interesting insights on the constructions. We will present below some of the activities exploring constructions relating to adverb ordering and morphological computation.

3.1. Adverb orderings

In Maia, Franchetto, Leite, Soares and Vieira (1998), we compared a set of interrelated phenomena concerning the syntax/morphology interface in four Brazilian indigenous languages, namely, Kuikúro, Guarani, Karajá and Tikuna. Karajá data were also elicited using Pollock (1989) tests in which VP adjoined adverbs are proposed as a diagnostic to determine raising of the Verb and of the Object over the adverbs to derive the SOV order in the language. Informal acceptability judgments collected with Karajá speakers had yielded the following data which were analyzed in the article:

(4) a. ✓Kua habu hawò riwinyra ywimy.
that man canoe made slowly
"That man made the canoe slowly"

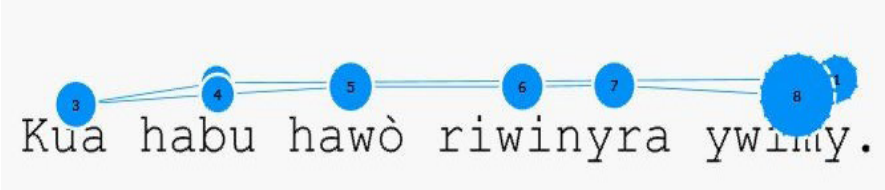
b. Kua habu riwinyra ywimy hawò.
that man made slowly canoe
"That man made slowly the canoe"

c. ?? Kua habu hawò ywimy riwinyra.
that man canoe slowly made
"That man the canoe slowly made"

The sentence in (4a) indicates the well formedness of the SOV constituent order in Karajá, having been analyzed in the terms of Pollock (1989) and Chomsky (1993) as indicating the linearization of the OV order by the raising of V and O over the adverb before spellout. In (4b), the sentence is not considered well-formed if the O is not raised and remains in the final position in the derivation. Finally, in (4c), if the verb remains in the final position of the clause, the sentence yields a doubtful acceptability judgment, being rated as not so good as (4a), but not so bad as (4b).

During our 2019 field trip we tracked the reading of these three sentences and typically obtained reading patterns as qualitatively illustrated below:

Figure 4: Static gazeplot of well formed sentence.

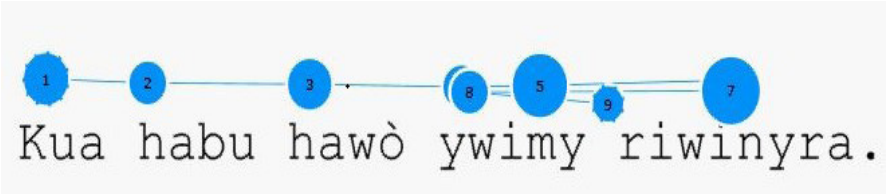


Source: the authors

Figure 5: Static gazeplot of unacceptable sentence.

Source: the authors

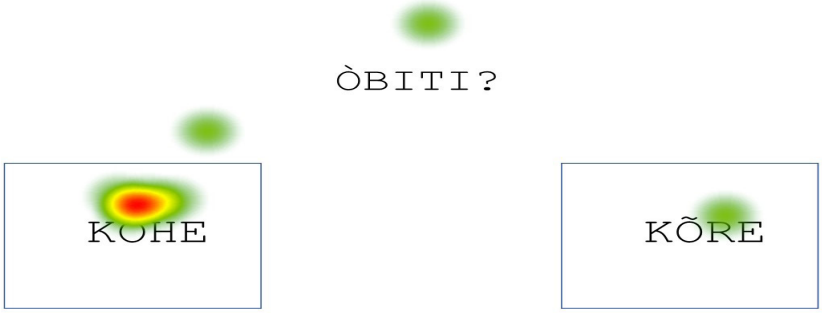
Figure 6: Static gazeplot of doubtful sentence.



Source: the authors

Eye tracking metacognitive sessions would typically start with the comparative display of dynamic and static gazeplots of the reading tests applied in the morning. A reading of a sentence as in figure 4 was completed with basically 8 fixations and did not require any regressive saccadic movements to be judged as well formed in the task, as illustrated by the heatmap below in which, after reading the sentence, the participant should judge its well formedness, answering if it was òbiti "good" by looking either at the square kohe "yes" or kõre "no":

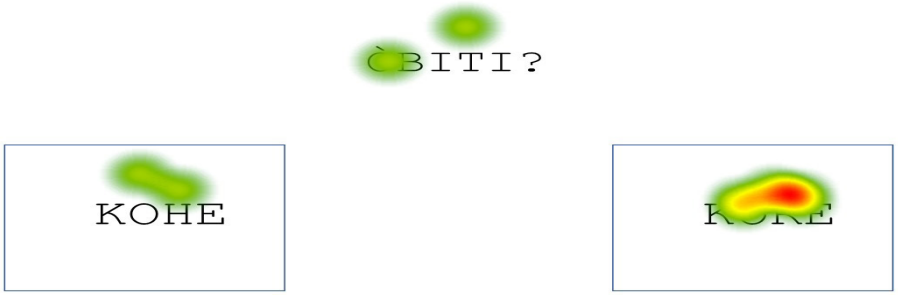
Figure 7: Judgment task of well formed sentence.



Source: the authors

The Karajá teachers readily recognized the very intuitive eye tracking patterns of fixation latencies which are represented in gaze plots by the size of the fixations. They would point how in a sentence such as in figure 5, the fixations were higher in number and in duration on the adverb *ywimy* "slowly" than in the same adverb in the other two conditions. The several regressions to the adverb area in figure 5 were also spontaneously pointed by them and explained in terms of the head final constituent orderings in the language.

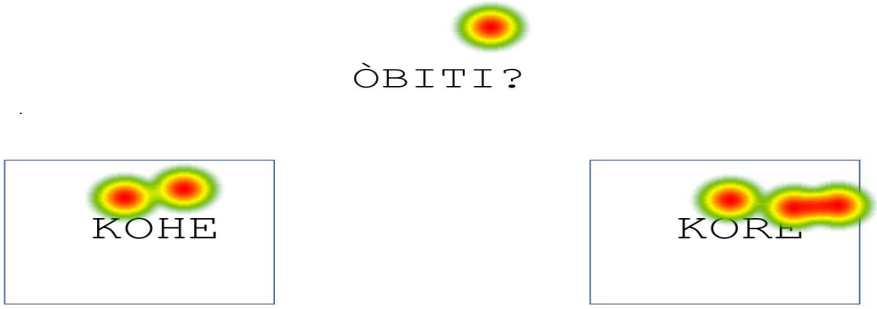
Figure 8: judgment task of ill formed sentence.



Source: the authors

The judgment task of an ill formed sentence such as in figure 5 would also be anticipated and came as no surprise when an answer pattern as figure 8 above would be displayed. They would nod, confirming the *kõre* "no" marked in dominant yellow and red colors in the heatmaps: "sure" this is no good in *iny rybè* the "karajá language". As for a doubtful sentence such as in figure 6, the hesitation patterns obtained in the judgment task were also cheerfully acknowledged by the participants:

Figure 9: judgment task of doubtful sentence.



Source: the authors

The teachers would repeat the sentences several times trying to figure out the subtle differences in pronunciation and interpretation between them. They would even advance hypotheses concerning constituent order differences which were proposed to be stricter between Verb and Objects than for adverbs, which would account for the more costly reading of figure 5 as compared to the other conditions. Other participants would propose that there would be differences in the intensity of the adverb modification, depending on its position after the verb as in figure 4 which would be less intense than in figure 6, when it is before the verb, requiring a more marked prosody. These lively discussions would allow for active problem-based sessions with spontaneous reflections on different aspects of the grammar of their language and might also lead sometimes to contrastive analyses with Brazilian Portuguese, which unlike Karajá, is a head initial language.

3.2. Morphological computation

Data on morphological computation of WH-words in Karajá, previously collected and analyzed in papers such as Maia (2010) were also eye-tracked and discussed with the indigenous teachers in the long-awaited afternoon sessions in the village. As analyzed in Maia (2010), Karajá interrogative words are invariably formed by the composition of one or more indefinite roots with the wh-feature *–bo*. The data in (5) describe some of the basic constitution properties of wh or *bo*-words in Karajá.

(5) a. Aõ + bo
Thing wh
'What'

(6) b. Mo + bo
Person wh
'Who'

As discussed in Maia (2010), Karajá postpositions are incorporated inside the bo-words to the right of the indefinite roots mo 'person' and aõ 'thing'. Thus, postpositions must occupy this internal position either inside mobo 'who', or inside aõbo 'what', in Karajá, as exemplified in (7) and (8):

(7) Aõ-di-bo juwata temyta?
Thing-INST-wh piranha caught
'With what did you catch the piranha?'

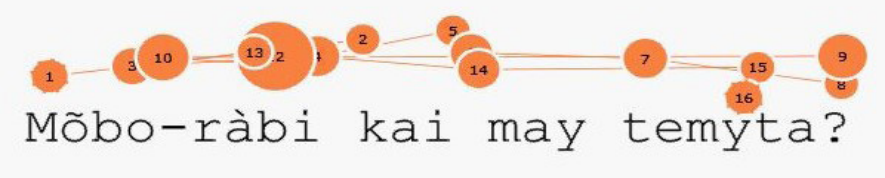
(8) Mo-ràbi-bo kai may temyta?
Person-from-wh you knife grabbed
'From whom did you grab the knife?'

We recorded readings of sentences such as (8), in which the postposition ràbi "from" is grammatically inside the *mõbo* "who" word and also created an ungrammatical sentence in which the postposition would be attached not inside, but to the right of the whole *mõbo* word:

Figure 10: Static gazeplot of grammatical *mõbo* construction, incorporating the *ràbi* postposition.

Source: the authors

Figure 11: Static gazeplot of ungrammatical *mõbo* construction, placing the *ràbi* postposition to the right.



Source: the authors

Karajá participants were quick to point that sentence in figure 10 would be read with only seven progressive fixations, in contrast with a sentence such as in figure 11 which would demand a higher number of progressive and regressive fixations with longer latencies exactly on the critical area, the *ràbi* postposition ungrammatically attached to the right of the *Mõbo* word. They even advanced hypotheses concerning language acquisition by children who might produce sentences such as in figure 11, wrongly generalizing the attachment of the postpostion to the right of names to the right of wh-words.

We also discussed sentences with postpositions to the right of indecomposable and decomposable names such as (9a) and (9b):

(9a) Kai Ijeseberi-ràbi may temyta
You Ijeseberi-from knife grabbed
"You grabbed the knife from Ijeseberi"

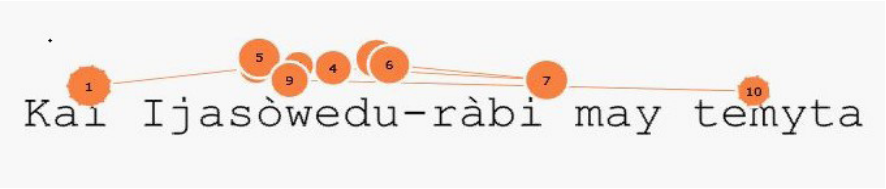
(9b) Kai Ijasòwedu-ràbi may temyta
you spirit leader – from knife grabbed
"You grabbed the knife from the spirit leader"

Note that the two sentences are very similar in terms of structure and number of words, except for the indecomposable proper name *Ijeseberi* in (9a) and the decomposable common name *Ijasòwedu* which is decomposable in terms of *ijasò* "spirit" and *wedu* "leader". The readings obtained were the point of departure of interesting discussions concerning morphological parsing, opacity and transparency of morphemes in the language:

Figure 12: static gazeplot of sentence with indecomposable name

Source: the authors

Figure 13: Static gazeplot of sentence with decomposable name.



Source: the authors

The higher number of progressive and regressive fixations on the critical decomposable name in figure 13 than on the indecomposable name in figure 12 triggered lively discussions which actually went beyond morphological parsing to semantic subtleties such as the courage required for someone to grab a knife from a spirit leader as compared to a regular person, such as Ijeseberi.

Final remarks

The aim of this article was to report basic and applied research investigating order of constituents and morphological representation and processing conducted with speakers of Karajá, a non-european language of Central Brazil. The motivation was to contribute to bridging the gap in representation found in language research, in which the majority of study participants and languages studied are largely unrepresentative of the variability found in the world. In addition, we aimed at giving one step further towards broadening the scope of methodologies to investigate language. As stated by Ribeiro (2022), embracing knowledge diversity allows us to access "different entities of the vast mental ecosystem of our species" Protecting diversity takes WEIRD populations to recognize that their understanding may also be limited and biased by the metaphors through which they conceptualize the world (cf. Franchetto, Maia, Storto & Sândalo, and also Maia (2002), for preliminary discussions in this respect).

Results from the theoretical studies are mostly in line with the results reported in the literature of European languages. The study that investigated order of adverbs in Karajá showed violations for the hierarchy proposed by Cinque (2000), which point to a necessity of further research and, if the findings are confirmed, revision of the theory. However, the bottom-line assumption that different classes of AdvPs correspond to certain functional heads holds for Karajá, since we do find restrictions in the positions of adverbial phrases.

Our data on neurophysiological markers (ERPs) provide further evidence that there are rapid perceptual processes in the brain and that they are specialized for reading, specifically modulated by morphological processing. Thus, as far as visual word recognition is concerned, we confirmed that Karajá readers resort to the decomposition of the word in morphemes at an early stage. These findings on morphological processing are consistent with a substantial range of earlier evidence, including the ones using the N170 component as an index of the early visual stage of morphological decomposition. Our results extend this general finding which is also reported for other languages.

In sum, in line with the discussions in Maia (2022) in which eye tracking data was used at the Middle school and University levels, in these Karajá sessions, we also used qualitative eye tracking data as an aid to help language teachers to "go meta", as put by Mahdavi (2014). Going meta with eye tracking has the potential not only to help participants become aware of their own *on-line* reading properties, but also offer them interesting data to exercise their science forming capacity, inspecting, and contrasting gaze plots and heatmaps to make hypotheses, establish variables, make inferences and draw conclusions on different aspects of their language. In this sense, overcoming anthropological blues seems to be possible through decolonizing and active methodologies which attempt to transform indigenous participants from the passive role of objects of research to more protagonist roles as educators and as linguists. Then again, this experience will not be effective if it does not also transform educators, linguists and scientists – if it does not serve to broaden their (our) world views, metalinguistic categories and analytical tools. We have to start with what we have, but being aware that what we have is not the whole story. Science will then significantly benefit from the more diverse non-WEIRD insights, which will be available.

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