OVERVIEW OF LANGUAGE ACQUISITION FOR AN EFFICIENT INCLUSION

VISÃO ABRANGENTE SOBRE AQUISIÇÃO DE LINGUAGEM PARA UMA INCLUSÃO EFICAZ

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ABSTRACT: *Language Acquisition is a developmental science that advances our knowledge about how we describe, explain, and predict linguistic phenomena to plan effective interventions. Knowing where dissension and consensus lie is adamant for documenting further progress. Establishing what we know and where challenges lie for more inclusive practices implicates on deepening our understanding about genetic endowments and implications on neural development and social cognition at the base of language acquisition. This narrative review includes recent advances on oral language acquisition and development, genetic profiles and neurobiological aspects that we need to acknowledge for better and more inclusive practices to enable acquisition of reading and writing skills.*

KEYWORDS: *language; acquisition; development; genetics; inclusion.*

RESUMO: *A Aquisição da Linguagem é uma ciência do desenvolvimento que avança nosso conhecimento sobre como descrevemos, explicamos e prevemos fenômenos linguísticos para planejar intervenções eficazes. Saber onde estão as dissensões e os consensos é crucial para documentar novos progressos. Estabelecer o que sabemos e onde estão os desafios para práticas mais inclusivas implica em aprofundar nossa compreensão sobre nosso arcabouço genético e suas implicações para o desenvolvimento neural e a cognição social que embasam* *a aquisição da linguagem. A presente revisão narrativa inclui avanços recentes sobre aquisição e desenvolvimento da linguagem oral, perfis genéticos e aspectos neurobiológicos que precisamos reconhecer para estabelecermos práticas melhores e mais inclusivas com vista à aquisição de habilidades de leitura e escrita.*

PALAVRAS-CHAVE: *linguagem; aquisição; desenvolvimento; genética; inclusão*.

1 Introduction

In reviewing advances in any scientific realm, we should strive to find where consensus and dissension lie, and where assertion is being replaced by documentation (BORNSTEIN; LAMB, 2015). This review article seeks to point where consensus (what is already known and agreed upon) and challenges (due to confounds in the literature or because documentation is lacking) lie.

Our area of science is language acquisition and our review is focused on speech perception and oral language. In reviewing literature, we plan on delivering a more precise idea about endogenous (genetic) and exogenous (interaction) factors that might configure risk or protection in informing practices (translational view). Our ultimate aim lies with a more inclusive education that sustains efficient reading and writing development. In covering each aspect, we will provide definitions, scope and an overview of research pointing towards consensus and challenges.

1.1 Some aspects of language acquisition from different standpoints

We know that early factors, like the initial stages of motor development, attention and social cognition, are linked to later difficulties (KOMESIDOU; HOGAN, 2020; BISHOP *et al.*, 2016). This stems from the developmental stance of language acquisition. Developmental science implicates on describing a phenomenon, explaining its origins, predicting certain outcomes, and planning interventions in view of better well-being (BORNSTEIN; LAMB, 2015; more in BOX 1).

Box 1 - Language acquisition as a developmental science

Time is crucial - for development and for language. And the crux lies on two levels that bears on thoughts, feelings and behaviors. These levels correspond to how individuals and their stability may come to be affected, and how groups and their continuity may be impacted (BORNSTEIN; LAMB, 2015).

Central to developmental science and to language acquisition is growth and change. Concerning language, these two tenets mean better adaptation, contextual specificity and skill building (BORNSTEIN; LAMB, 2015). Aligned with brain development, language progresses from lower-to-higher levels (TOKUHAMA-ESPINOSA; BORJA, 2023).

In tandem with development, language implies knowing the norm – or pattern – to understand individual differences at the crossroads between genes and environment. Regularities in the environment are part and parcel of statistical learning abilities that underscore language acquisition (EGHBALZAD *et al.*, 2021).

When individuals interact, what is ultimately happening is selection of experiences which are then appraised to affect development and acquisition. This explains why development and language are dynamic and reciprocal processes that exponentiate throughout the lifespan (BORNSTEIN; LAMB, 2015).

Source: The authors based on Bornstein and Lamb (2015), Eghbalzad *et al.* (2021) and Tokuhama-Espinosa and Borja (2023).

From a neurobiological perspective, Poeppel (2012) made clear how foundational perspectives gathered from the neurophysiology of vision (after HUBEL, 1995) might furnish language with a generalist framework based on localization of function (FRIEDERICI, 2011), hierarchical processing (HUMPHRIES *et al*., 2014) and concurrent pathways (ARSENAULT; BUCHSBAUM, 2015). In relation to the first, mapping functions to structures and pathways led to consensus on four aspects: (i) localizationism (such as Broca's and Wernicke's areas), which provided a well-established starting point to discuss certain functions; (ii) processing (such as the dorsal stream – an articulatory network concerned with sensorimotor processing – and the ventral stream – a combinatorial network concerned with lexical interface); (iii) hemispheric asymmetries in processing (such as the lateralization of language being connected to the dominant hemisphere, and the left auditory cortex more attuned to phonological contrasts while the right auditory cortex displays better spectral resolution (TALLAL, 2012)); and (iv) putative networks (such as those favoring lateralized specializations).

We also know that language is a learned behavioral system (FINN *et al.*, 2013) that sets the stage for literacy (SNOWLING; HULME, 2021). When difficulties arise in language acquisition, they are not all the same; speech difficulties relate to the production of sounds, while language difficulties, which relate to expressing thoughts and feelings (expressive language), understanding others (receptive language), and producing correct sentences, and are not obvious by nature, tend to remain hidden till consolidated (SNOWLING *et al.*, 2019; SNOWLING *et al.,* 2022). Striking though is noticing that, when successful, children outperform adults (MAYBERRY; LOCK, 2003) contrary to what is seen in other realms as in memory development in relation to working memory (GATHERCOLE *et al.*, 2004) and to recollection and familiarity (GHETTI; ANGELINI, 2008)).

While speech tends to be related to endogenous factors (genetics and neurodevelopment), language difficulties are strongly associated with social disadvantages (GÂNDARA *et al.*, 2023). Scrutinizing oral language acquisition is key – and that is where we start.

1.2 What we know about oral language development

Oral language relies on perception for production to happen (KUHL, 2004; GOSWAMI, 2022). A focus on language-specific phonemic discrimination enhances later language abilities (KUHL *et al.,* 2005). Infant speech perception sets the stage for later language acquisition, and babies start the process by noticing the rhythmic pattern of languages (GOSWAMI, 2022).

For an understanding of language acquisition at the spoken level, i.e., as a learned behavioral system, we need to grasp what possible phonological difficulties might be related to rhythmic disparities affecting phonology. This is a different level – from the spoken level that implies behavior – of analysis as it encompasses sensory processing as well as auditory, visual and motor signals. At the neural level, the different strands that answer for rhythm get entrained in oscillatory patterns (GOSWAMI, 2022).

However, as the brain processes sensory oscillations in *snapshots*, perception is not a continuous process (GOSWAMI, 2022). This is akin to what our eyes do when processing visual input; they take snapshots of the whole to code the different elements into multilayered pixels of information about form, depth and color. With speech, our brain also samples multilayered maps of different time resolutions. And that may present some problems.

Take, for instance, hierarchy. Oscillations do not happen at random nor are sampled without some pattern that relates to the importance of the information that is being encoded (AINSWORTH; GREENBERG, 2006). This is related to how languages are hierarchically organized, and the process rests on syllable stress. Across all languages, stressed syllables happen twice every second (GOSWAMI, 2022). That means each syllable is roughly correlated to a delta oscillation of around 2 Hz (DING *et al.*, 2017; GOSWAMI, 2022). Of note, auditory processing of syllable-length oscillations are key for speech processing (AINSWORTH; GREENBERG, 2006).

To every stressed syllable there is an onset and a rime. The first relates to the initial consonant sound or blend (as *h-* in *hat* and *dr-* in *draw*) whereas the second answers for the vowel and whatever rests in that syllable (*-at* in *hat* and *-aw* in *draw*). Phonemes lie at the level of individual sounds, being the abstract representation of *phones*, the constituent sound of words (AINSWORTH; GREENBERG, 2006).

When stress is placed, there is an onset of speech signal. It means that there will be a rise time. Rise times serve the purpose of resetting oscillating networks in the auditory cortex (GOSWAMI, 2022). In other words, the different phases of oscillations (amplitude modulations) of encoding for the different energy patterns that the brain encodes simultaneously are set using rise times. When different brain rhythms are in perfect synch, there is accurate speech perception, the equivalent of perfect phase synchronization. When rhythms are not perceived well, problems ensue.

Tackling problems in science implies decomposing levels of analysis, what is known as the Marr-style approach (after MARR, 1982 as posed by POEPPEL, 2012). This may pave the way for later reflection and advancement.

To start at the broader level, i.e., of cognitive processing, recognizing that phonological awareness is adamant for language acquisition makes it possible to advance interventions at an early stage (GÂNDARA *et al.*, 2023). Secondly, at the sensory level, recognizing that rhythm is at the heart of processing difficulties (GOSWAMI, 2022) may pave the way for investments on social activities that encourage and promote rhythmic training, such as dance and music lessons. At the neural level, understanding neural processing of acoustic patterns for language encoding subserving language representation in the brain (DEHAENE-LAMBERT *et al.*, 2005; SUGA *et al.*, 2000; SUGA, 2006) will possibly unlock coding mechanisms that are essential to tackle challenges faced by neurodiverse learners.

2 Neurobiological profiles and neurodiversity

Language acquisition, as described, is a complex developmental process that involves the interaction of various genetic, neural, and environmental factors (see BOX 2 for more). While specific genes related to language acquisition have not been definitively identified, researchers have found associations between certain genes, language development and cognitive functions that are part of language decoding and encoding (FISHER *et al*., 2003; NEWBURY; MONACO, 2010; SMITH, 2007). Some of the genes that have been studied in this context include FOXP2, CNTNAP2, ROBO1, ROBO2, ATP2C2, KIAA0319 genes (MARTINELLI *et al.*, 2021; MASCHERETTI *et al.*, 2014; MORGAN *et al.*, 1993; PANIAGUA *et al*., 2022; ZIMMERMAN; MARON, 2016).

Box 2 - Definitions concerning genes and their alterations

Genetic conditions refer to medical conditions that arise due to abnormalities or mutations in an individual's DNA, i.e., the genetic material that carries instructions for the development, functioning, and maintenance of the body. They range from chromosomal to gene alterations.

Genomic mutations refer to alterations in the number of chromosomes in the cell, which could virtually mean the number of chromosomes of another species. For that reason, some may lead to miscarriages.

Chromosomal alterations, also known as chromosomal abnormalities or mutations, refer to changes in the structure or number of chromosomes in a cell nucleus whereas genic alterations refer to changes in the DNA sequence of a specific gene. Both alterations, i.e., chromosomal and genic, may contribute to the neurobiological basis of some difficulties in language acquisition.

Structural abnormalities change the structure of individual chromosomes including: (i) deletions of parts of a chromosome; (ii) duplication of segments of a chromosome resulting in extra genetic material; (iii) inversion of chromosomic segments; and (iv) translocation of chromosomic segments.

Genic alterations encompass changes in the structure of the gene such as mutations, polymorphisms (mutations that occur in more than 1% of the population) (KARKI *et al.*, 2015), insertions and deletions, repeat expansions, splice site mutations, gene duplication, gene deletion, and gene translocation.

Source: The authors based on Karki *et al.* (2015)

Genes contain the instructions for building proteins. When a gene is expressed, its expression results in a protein. The resulting protein is then folded into its functional form and performs its designated role in the cell. Any alterations in full chromosomes or individual genes will change the final synthetized protein. Consequently, the tissue associated with it and its function will be altered.

FOXP2 and CNTNP2 are well-known genes associated with language development. FOXP2 is involved in the development and function of neural circuits that are critical for language processing, including those in the basal ganglia and cortex (FISHER, 2019). Mutations in this gene have been linked to speech and language disorders, particularly in the areas of language and grammar (MORGAN *et al.*, 1993; ZIMMERMAN; MARON, 2016). ROBO1 and ROBO2 genes play a role in neural development and have been linked to language and reading skills. Polymorphisms in those genes have been associated with deficits in the phonological buffer and expressive vocabulary in infancy (BATES *et al.*, 2011; ST POURCAIN *et al.*, 2014). Speech sound processing and dyslexia – a neurodevelopmental disorder in decoding – have been associated with polymorphisms of the ATP2C2 gene (MARTINELLI *et al.*, 2021). Dyslexia has also been associated with polymorphisms in the KIAA0319 gene (MASCHERETTI *et al.*, 2014; PANIAGUA *et al.*, 2022).

Genetic conditions such as Down Syndrome involve an extra copy of a full chromosome, i.e., chromosome 21, which makes phenotypes more visible and features more stable. Another genetic condition is the Fragile X syndrome, which involves parts of a chromosome (X) and therefore, many genes. Both conditions often implicate delays in language development and with expressive language skills. They present genetic profiles that interact with the final reception and production of language through the synthetization of specific proteins – necessary for the neurobiological basis of language processing. However, genetic alterations are not the only biological basis for language acquisition. A rich social environment is also necessary for language acquisition (ONNIS; TRUZZI; MA, 2018). And that is when inclusion needs appraisal.

2.1 Neurobiological profiles that may display difficulties regarding language acquisition

In this section, our focus lies on what happens in the brain when reception of the stimulus is intact before reaching the thalamus. Language acquisition happens due to a combination of genetic and congenital conditions – the first implicating on alterations exclusively controlled by genes and the latter implicating on conditions present at birth via genetic alterations or due to environmental influences during fetal development – with environmental variables, epigenetic mechanisms, critical periods of brain maturation and social cognition. They all act in parallel and play important roles. They implicate in variables that interact and subsidize changes in neurobiological profiles from birth to adolescence through brain development and the construction of neural pathways. We will briefly discuss each in turn.

2.2 Genetic and congenital conditions

As previously defined, genetic conditions that involve chromosomic trisomy and alterations contribute to the shaping of a neurobiological profile with clearer implications on language acquisition and development as they may suffer less influence from environmental variables when compared to global developmental disorders. These, on the contrary, usually present a set of associated genes but suffer greater influence of environmental variables throughout development. Some disorders in this category include Autism Spectrum Disorder (ASD), Attention Deficit and Hyperactivity Disorder (ADHD), Intellectual Disability, Auditory Processing Disorder (APD), Developmental Language Disorder (DLD) or mutations in one gene such as in Rett Syndrome.

Some genetic and congenital conditions result in sight or hearing impairment such as the ones affecting blind or deaf and hard of hearing (DHH) individuals who will probably display major difficulties for language acquisition. That happens because such conditions block primary channels of stimulation, i.e., sight and hearing, related to language.

The primary (V1) visual cortex and secondary visual cortex (V2) receive light stimuli whereas the superior temporal gyrus and Broadman areas 44 and 45 receive sound stimuli from the environment and process the decoding of that information (CAFFARRA *et al*., 2021; FRIEDERICI, 2011). When tissue alterations in those cortical areas occur, as in the case of blind and DHH individuals, language is also altered because cortical tissues are the basis for the formation of neural pathways.

2.3 Environmental variables and epigenetic mechanisms

Both brain maturation and environmental variables may be associated with epigenetic mechanisms – those heritable changes in gene expression without any alteration in the underlying DNA sequence (YAMADA; CHONG, 2017). Several epigenetic mechanisms are known to occur during the development of all species through cell specialization. As cells differentiate, they acquire specific epigenetic marks. Some such marks are methylation, i.e., the binding of a methyl group to the chromosome; deacetylation, i.e., the removal of an acetyl group from the chain of histones; and binding of non-coding RNAs that interfere with DNA to RNA transcription. Taken together, epigenetic marks determine cellular fate and function. The epigenetic changes occurring during differentiation help establish and maintain cell identity by selectively activating or expressing genes necessary for the specific cell type.

To understand epigenetics and how important it is for our phenotypes, Waddington, in 1957, proposed the famous epigenetic landscape, in which a ball, symbolizing a cell, could follow different paths due to the roughness of the surface (which means intra and extracellular environmental influences) (PEIXOTO *et al*., 2020). In other words, epigenetic mechanisms promote a bridge between genes and environment; an *agreement* that will result in adaptation and, ultimately, enhance chances of survival.

2.4 Brain maturation

The development of language is closely tied to brain maturation. During early childhood, specific brain regions, such as the left hemisphere areas (Broca's and Wernicke's areas), undergo significant growth and specialization (WEISS-CROFT; BALDEWEG, 2015). Neuroplasticity allows these brain regions to adapt and reorganize in response to language exposure and learning.

Language processing also involves the activation of various neural pathways responsible for different aspects of language, including phonology (sound processing), syntax (grammar), semantics (meaning), and pragmatics (social use of language) (FELDMAN, 2019). Besides neural pathways for processing language itself, neural pathways need to be constructed in the motor cortex and in subcortical areas associated to emotional cognition such as the basal ganglia and amygdala to promote language acquisition (BZDOK *et al*., 2016; NADEAU, 2021). The efficiency and connectivity of these neural pathways can influence language acquisition abilities as they are tied to social cognition (BZDOK *et al*., 2016; LIÉGEOIS; MAYES; MORGAN, 2014).

2.5 Social cognition

Social cognition entails a complex set of mental abilities. It encompasses perception, processing, interpretation, and response to social stimuli which, in turn, undergirds the development of adequate social competence and adaptation (BEAUDOIN; BEAUCHAMP, 2020). Two types of social learning – facilitation and imitation – play important roles in language acquisition, as they involve the ability to understand and interpret the social cues, intentions, and emotions of others (LEBLANC; RAMIREZ, 2020). The combination of these variables seems to pose difficulties in language acquisition in some disorders. Below we proceed with a definition of each set of challenges presented by some specific disorders referred to in section 2.2 above.

1) Autism Spectrum Disorder (ASD): People with ASD often have challenges in language development in particular due to the social cognition required to acquire language. Poor development of neural pathways associated with the basal ganglia, the inferior frontal gyrus, the amygdala, the anterior insula, the anterior cingulate cortex, and the ventral striatum contribute to difficulties in language acquisition in ASD (SATTERSTROM *et al*., 2020; SIMMS; JIN, 2015).
2) Intellectual Disabilities: Severe intellectual disabilities can impact language acquisition due to cognitive limitations (FELDMAN, 2019).
3) Auditory Processing Disorder (APD): APD affects the brain's ability to process auditory information properly, leading to difficulties in processing and understanding spoken language. There is also presynaptic disorders affecting inner hair cell ribbon synapses; postsynaptic disorders of auditory nerve dendrites; and postsynaptic disorders of auditory nerve axons (STARR; RANCE, 2015).
4) Developmental Language Disorder (DLD): DLD is a condition where individuals have persistent difficulties in acquiring language despite having normal intelligence and no other syndromes nor psychiatric or evident neurological deficits (LIÉGEOIS, MAYES; MORGAN, 2014; STARR; RANCE, 2015).
5) Dyslexia: With a prevalence rate of around 5% (GÂNDARA *et al*., 2023), research has shown that speech processing is key for phonological awareness and reading development (ADLOF; HOGAN, 2019; CATTS; HOGAN, 2022). Dyslexic children show inability to perceive rhythm (FRASER; GOSWAMI; CONTI-

RAMSDEN, 2010; GOSWAMI *et al*., 2013). Such inability is not only felt in language, i.e., it is not domain-specific (GOSWAMI; ZIEGLER., 2006; THOMSON; GOSWAMI, 2008) and extends over the musical domain (HUSS *et al*., 2011).

Understanding the disabilities posed above is central to propitiating more successful and inclusive practices.

3 What we know about language acquisition in successful practices

Several studies have demonstrated the close relationship between phonological development and the mastery of reading and writing skills (FRANÇA *et al*., 2004; SALGADO; CAPELLINI, 2004; PESTUN, 2005). França *et al*. (2004) have found, in a longitudinal study with 71 children in Brazil, that at age 6 children who present incomplete phonological acquisition show a general tendency to display difficulties in the development of writing skills. In this context, initial stages of phonological awareness (awareness that speech can be segmented and that the segments – words, syllables, phonemes – may be manipulated) contribute to the first steps in the reading process. The skills developed during early stages of reading contribute to the development of a more complex phonological awareness, one that involves manipulation and phonemic transposition (SALGADO; CAPELLINI, 2004).

The Portuguese language presents a shallower correspondence between orthographic and phonological levels than English, for instance. The sounds of speech are represented graphically, but knowledge of graphophonological correspondence is not enough to write in Portuguese. Meireles and Correa (2005) organize empirical evidence of orthography acquisition in three groups.

The first group encompasses studies that analyzed the mistakes made by children as a sign of the elaboration level about the orthographical system at a specific moment. Such mistakes are related to speech transcription, overcorrection, no use of contextual rules, difficulties in marking nasalization, letter exchange, lack of knowledge of word origin, and difficulty in writing complex syllables that differ from the consonant-vowel pattern.

The second group includes studies that established a relationship between cognitive competences and the learning of specific orthographical aspects, thus, different competences facilitate the acquisition of different orthographical aspects.

Finally, the third group covers studies that investigated the process of acquisition of specific orthographical aspects. Such studies have shown that initially the child writes the words phonetically, thus representing the word pronunciation integrally in writing. As the child gets in contact with other possibilities of writing, s/he reconstructs previous hypotheses, which in turn generates inappropriate generalizations, affecting even words that were previously written in a correct manner. Gradually, the child learns the restrictions imposed by specific contexts and elaborates more complex knowledge about the written world.

3.1 What we need to know about language acquisition for more inclusive practices

Phonological disorders deserve attention as children may display difficulties in frequent word recognition, in the use of the phoneme-grapheme conversion mechanism in the codification and recognition of low frequent words and pseudowords, in vocabulary expansion and in subtests of phonological awareness. Even when phonological difficulties are overcome in orality, such difficulties remain present in reading and writing activities, since phonological disorders may compromise the storage of sound information (SALGADO; CAPELLINI, 2004). Thus, education professionals need to pay attention to such difficulties and how they may be tackled to minimize their impact on learning.

Education professionals need to have a clear understanding of how the acquisition of orthographical aspects takes place along with the levels of knowledge children construct about the written language since. This comprehension enables them to elaborate didactic situations that promote the acquisition of orthography, making the classroom a space for discussion and elaboration of knowledge (MEIRELES; CORREA, 2005).

Regarding children, it is fundamental that they become aware that oral and written language are different forms of expression (SCHIRMER, FONTOURA; NUNES, 2004). Also, in view of children's natural development and needs, activities need to be carried out in playful ways so that children find pleasure in experimenting with language. At home, caretakers need to encourage children to read by reading them stories, playing rhyming games with letters and drawings, and having them read labels and signs. Of note, children need to be encouraged to read a book in order to know what the story is all about, i.e., to get its meaning, rather than being forced to read and manipulate language only. A rich social environment, that encourages and sustains meaning-making instances, makes all the difference in language acquisition (GÂNDARA *et al*., 2023; ONNIS; TRUZZI; MA, 2018).

Research has for long emphasized the role that playful situations, such as nursery rhymes and games, and initial sound identification activities have in helping the development of phonological awareness (PESTUN, 2005). Children in kindergarten display and develop phonological skills that contribute to their later success in learning how to read and write. Children that reach the first year of schooling with increased awareness of phonological aspects of speech and of the syntactic-semantic structure of sentences are better equipped to learn formally how to read and write (BARRERA; MALUF, 2003).

To prevent and early remediate possible difficulties in reading and writing, children should participate in explicit and systematic instruction of phoneme manipulation (CAPOVILLA; CAPOVILLA, 2003). Early Childhood Education may be the right time for the development of metaphonological skills that encompass sound manipulation skills as well as graphophonological relationships, at the syllabic level and intrasyllabic units to favor further acquisition and development of reading and writing skills (ALVES; FINGER, 2023; PESTUN, 2005).

Pre- and in-service teachers need opportunities to understand the processes involved in language development in a way that they can design instructional interventions that foster such development (BARRERA; MALUF, 2003). By developing activities that involve playfulness, rhymes, and lullabies, teachers can contribute to later development of graphophonological rules; setting the stage for an efficient literacy process (ALVES; FINGER, 2023).

4 Where challenges lie

Challenges regarding the implementation of more inclusive practices abound. And they exponentiate for neurodivergent profiles. Here we have strived to highlight where advances in inclusiveness deserve more efforts and to delineate some profiles for whom research is already documenting advances.

For dyslexia, in particular, difficulties seem tied to impairments in rise times (GOSWAMI, 2015). We may start tackling such challenges by asking questions that challenge the *status quo*, such as the one posed by Goswami (2022). She pondered whether phonemes can be still considered the basic elements of the neural code for speech. More research in this realm could bring much needed documentation.

Another challenge lies with different contexts. Traditionally, research conducted in WEIRD (Western, Educated, Industrialized, Rich, Democratic) populations have failed in providing accurate evidence on context-specific changes created by environmental constraints (GÂNDARA *et al*., 2023; MACWHINNEY, 2011). We need to propitiate means and standards for research to breach that inequality.

A final challenge that we would like to highlight here is that which bridges levels and domains. Research in the cognitive, sensory, and neural level is adamant for analysis and depth of understanding (GOSWAMI, 2022). However, if we fall short in establishing the dots that close up the divide between levels, experts and data, we may lack the kind of overall understanding that translational science relies on (SIGMAN *et al*., 2014).

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