The Evidential Value and Pitfalls of Extant Language Development Research Methods

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I have no conflicts of interest to disclose.

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Abstract

Several research methods have been developed with an aim to uncover the underlying cognitive and neural mechanisms behind child language acquisition. While these methods continue to generate promising empirical evidence, language researchers need to carefully examine the evidential value and limitations of findings that were derived from these methods before building on them. Similarly, language practitioners (e.g., speech-language pathologists/therapists, teachers) need to be aware that while these methods may form or resemble the foundations of language assessment and intervention practices (Seiger-Gardner & Almodovar, 2017; Deevy, 2017), no single paradigm can comprehensively account for the multifaceted nature of “typical” and “atypical” language development that we see in real-world settings, especially in multilingual contexts. If such is the case, how can we utilise the evidence that these methods generate in practical and clinical settings? To answer this question, this paper reviews and evaluates select language acquisition research methods based on the following criteria: (1) ecological validity of stimuli, (2) sensitivity of cognitive-linguistic measure, (3) suitability of comparison groups, (4) procedural suitability, (5) precision of response classification, (6) communicative sense (Ambridge & Rowland, 2013), and (7) practical implications (e.g., evidential value for bi/multilingual populations and in practitioner settings).

Keywords: language development, research methods, metascience, evidence, Philippines

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Language Production Paradigms

As with any human cognitive ability that has been subject to scientific investigation, observable behaviours (Ambridge & Rowland, 2013) provide the widest window for measurement. For child language, spoken language production is perhaps the most conventionally observable modality that can facilitate straightforward paradigms for data collection and analysis. One of such paradigms is **naturalistic/spontaneous language sampling**. Spontaneous language sampling can be done by recording, transcribing, and analysing children’s naturalistic speech during typical family/caregiver interactions (Marzan, 2013; Ambridge & Rowland, 2013; Seiger-Gardner & Almodovar, 2017). This method holds stronger ecological validity, communicative sense, and procedural suitability compared to experimental and neurophysiological methods due to the fact that it affords real-world data with the least interference from the researcher/s and their equipment. With respect to sensitivity of its linguistic measures and evidential value, spontaneous language sampling has been successfully used to profile the phonological skills (e.g., phonetic repertoire), lexical growth (e.g., type-token ratio to measure lexical diversity), morphosyntactic abilities (e.g., argument structure, mean length of utterance indices, grammatical variety), and pragmatic skills (e.g., interchange type analysis) of, for example, typically-developing bilingual Filipino children (see Marzan, 2013) as well as of monolingual children with language disorders (see Roberts et al., 1998; Owen & Leonard, 2002).

The resulting datasets from spontaneous language sampling studies (e.g., <https://sites.google.com/a/post.upm.edu.ph/felcdd/home>) can provide the basis for establishing

developmental language norms that can be used to guide assessment and intervention practices for both multilingual and monolingual populations in various learning settings (e.g., home, therapy services, schools). For instance, a longitudinal naturalistic language sampling study (Marzan, 2013) revealed that typically developing Filipino children (ages 1;2-5;0) equally use Tagalog and English verb stems (e.g., in Tagalog-English structure, “*mag-wawash lang ako ng hands, okay?*”), that is equivalent to the English structure, “*I will just wash my hands, okay?*”) but predominantly prefer to use English nouns (e.g., *baby, ball, fish, book, girl, dog, tree, shoe*) in daily conversations. Marzan (2013) also reported that these bilingual children use more pronouns (e.g., Tagalog: *ito, ko, iyan, ako, mo*; English: *I, it*) than nominals when producing contingent *nonverbal predicate + topic* syntactic structures (e.g., Tagalog structure, “*akin iyan*”, that is equivalent to the English structure, “*that is mine*”). Moreover, Marzan (2013) reported that this Filipino cohort exhibited higher language productivity when they share their experiences compared to their productivity with other pragmatic functions such as when regulating (e.g., directing action, obtaining an object). These findings can then better inform practitioners in selecting appropriately normed language learning and communicative targets for Tagalog-English bilingual children.

However, spontaneous language sampling involves a tremendously lengthy process of manual transcription that can only allow for longitudinal within-subject and between-subject designs with a small population size. While natural language processing technology (e.g., automatic speech recognition systems) can be used by generously-funded researchers, current automated annotation systems are not yet robust enough and would still require intensive human input in deconstructing complex human language data. Hence, naturalistic language sampling may not be the most suitable method for comparing, for example, typical and clinical populations that would require a large sample population size within a single study. In addition, naturalistic paradigms can have limited response classifications as spontaneous sampling cannot always capture children’s ability to learn low frequency words and novel grammatical structures (Ambridge & Rowland, 2013). Nevertheless, the resulting naturalistic child language datasets, such as those found in existing repositories (e.g., <https://childes.talkbank.org/>), can be used to develop ecologically valid language tasks, targets, and/or stimuli for experimental and neurophysiological studies.

Experimental methods can provide evidence of cognitive mechanisms behind children’s language production, which naturalistic paradigms cannot directly measure. For instance, lexical access has been investigated using **picture-word interference (PWI) paradigms** in order to determine when semantic and phonological information becomes accessible during word production (Seiger-Gardner & Almodovar, 2017). In a PWI paradigm, children are shown pictures of common objects and are asked to immediately name them while interfering stimuli (e.g., semantically- or phonologically-related pictures/words to the target pictures) are either visually or auditorily presented at different timepoints (Seiger-Gardner & Almodovar, 2017). Children are instructed to disregard the interfering stimuli, which

may precede, follow, or simultaneously appear with the target pictures (Seiger-Gardner & Almodovar, 2017). The effects of the interfering stimuli to children's naming are then measured by comparing response latencies during related and unrelated conditions (Seiger-Gardner & Almodovar, 2017).

Consistent findings from studies (e.g., Brooks & MacWhinney, 2000; Jerger et al., 2002; Jescheniak et al., 2006) that used PWI paradigms have revealed that typically developing children exhibit early facilitative and interactive processing (e.g., semantic-phonological mediation priming) of both phonological and semantic information prior to naming. This finding has then been used to test whether phonological or semantic deficits cause word-finding difficulties in children with Developmental Language Disorder (DLD). Results from later PWI studies (e.g., Seiger-Gardner & Schwartz, 2008; Brooks et al., 2014) aimed to answer this and concluded that while children with DLD also exhibited phonologically facilitated lexical access, the priming effect occurred later as they processed phonological information longer than typically developing controls did. In addition, children with DLD exhibited persisting semantic interference instead of priming effects (Seiger-Gardner & Schwartz, 2008), which suggests that semantic deficits (e.g., weak word association) potentially cause word-finding difficulties (Brooks et al., 2014).

As described earlier, PWI is one experimental paradigm that can offer sensitive measures and precise response classifications for understanding lexical access mechanisms behind word production. PWI tasks can also ensure ecological validity if the linguistic stimuli are carefully designed based on norming data that are applicable to the intended participants and comparison groups. However, the procedures involved in PWI tasks compromise communicative sense as rapid naming is rarely expected from children in their daily conversational environments. With respect to practical implications, most PWI studies have thus far only accounted for lexical access mechanisms in monolingual populations and, therefore, can only directly inform focused intervention for monolingual clinical populations. While practitioners who work with multilingual children can certainly infer possible translation of these PWI findings in their contexts, there is still a need to improve the research evidence base for multilingual populations.

If PWI paradigms have been used to investigate lexical access mechanisms for word production, **syntactic priming paradigms** have been used to investigate how children learn to use novel or complex grammatical constructions (e.g., double object dative) and whether there are lexical or syntactic priming mechanisms that facilitate this process (Ambridge & Rowland, 2013). In a syntactic priming paradigm, children are auditorily primed with a specific construction (e.g., *The teacher gave the child a sticker.*) to eventually elicit a similarly structured target utterance (e.g., *Ana read Ben a book.*) that has no lexical overlap with the primed utterance (Pickering & Ferreira, 2008). Some studies (e.g., Akhtar, 1999; Matthews et al., 2007) have also modified this paradigm to test whether typically developing children can learn novel word order constructions (e.g., weird word order). These syntactic

priming studies have revealed that whereas 2-year-old children gradually learn to use novel word orders if they hear low frequency verbs, the controls who hear high frequency verbs as well as the older children (ages 3:0-4:0) in the comparison groups tend to correct the ungrammatical primes (Akhtar, 1999; Matthews et al., 2007). These findings support Tomasello's (1992) theory that individual verbs are linked to children's initial word order knowledge. Additionally, other studies (e.g., Leonard et al., 2000; Leonard et al., 2002) reported that syntactic priming helps children with DLD improve their sentence-level productions (e.g., formulating sentences with auxiliary verbs *is* and *are*).

Despite the informative findings that syntactic priming paradigms have generated, the sensitivity of this paradigm's cognitive-linguistic measures is not strong enough to confirm if there are lexically-dependent priming effects that facilitate syntactic productions or if adult-like knowledge of primed formulation is actually learnt from successful priming in the absence of semantic overlap (Ambridge & Rowland, 2013). Nonetheless, this paradigm can still be useful if the priming stimuli, procedures, and targets involved are ecologically valid (i.e., based on norming data). Precision of findings can also be achieved if appropriate response classifications and comparison groups are controlled for. Communicative sense of syntactic priming tasks can still be relatively preserved as long as they resemble real-world language teaching interactions. More importantly, existing evidence of the facilitative syntactic priming effects in children with DLD presents promising clinical utility for syntax-focused language interventions (Leonard, 2011). However, extant syntactic priming studies, like most PWI studies, have only accounted for monolingual populations. While the evidence base under this paradigm has yet to improve for multilingual populations, practitioners can actively consolidate the most applicable and available evidence when implementing syntactic priming interventions for multilingual children.

Language Comprehension Paradigms

Language comprehension, unlike language production, can only be measured indirectly by analysing responses (e.g., listening, looking, pointing) to linguistic stimuli (Ambridge & Rowland, 2013; Deevy, 2017). When the aim is to investigate, for example, children's sentence comprehension, researchers have used **self-paced listening paradigms**. In a self-paced listening condition, children listen to segmented sentences (e.g., on phrase- or word-level) via headphones, press a computer key to proceed to the succeeding segments, and answer comprehension questions after hearing all the segments (Deevy, 2017). The sentence stimuli are strategically designed such that the computerised listening time recordings can be compared with an aim to localise the pace at critical regions across sentence conditions and, hence, allow judgments, for instance, of processing difficulty as a function of prolonged listening time (Deevy, 2017). Recently, this paradigm has been modified by Garcia et al. (2019) to generate evidence that Tagalog-English bilingual children (ages 5:0-7:0), like other typically developing populations, find it more difficult to understand patient-initial sentences in the agent voice

(e.g., Tagalog: *Humihila ang baka ng baboy*, English: *The cow is pulling a pig*) compared to patient voice (e.g., Tagalog: *Hinihila ang baka ng baboy*, English: *The/A pig is pulling the cow*). In clinical populations, self-paced listening tasks have also been used to produce evidence indicating that English-speaking children with DLD (ages 5:0-9:0) have difficulty processing both active and passive voice sentences, which were reportedly attributed to working memory limitations instead of grammatical deficits (Marinis & Saddy, 2013; Deevy, 2017).

Further interest in language processing along with the growing availability of child-friendly and fully-automated eye-tracking equipment (Ambridge & Rowland, 2013; Deevy, 2017) have advanced **visual world paradigms** (e.g., Trueswell et al., 1999) for child language research. In a visual world paradigm, children's ability to use context in interpreting ambiguous sentences is measured by video-recording their eye movements while being presented scenes along with spoken stimuli (Deevy, 2017; Trueswell et al., 1999). These automated video-recordings generate the raw data to be analysed on the basis of proportion of fixations to specific elements in the scenes as a function of spoken stimulus timing (Deevy, 2017; Trueswell et al., 1999). Relevant to clinical populations, this paradigm has been modified to investigate the role of language ability in sentence context-processing, as evidenced by looking patterns (Deevy, 2017). For example, an eye-tracking study conducted by Brock et al. (2008) suggested that adolescents with Autism Spectrum Disorder (ASD), similar to language-matched peers and non-autistic individuals that were previously studied under similar paradigms, are indeed able to integrate context-dependent phonological and semantic information during online sentence processing and that the degree of language impairment appears to interfere with their sensitivity to sentence context. Hence, Brock et al.'s (2008) findings contradict previous accounts (e.g., Happé & Frith, 2006) of weak central coherence in individuals with ASD.

Related to Brock et al.'s (2008) investigation, Kelly et al.'s (2013) visual world paradigm study aimed to investigate the variability of looking patterns in children with language disorders. In this study, they compared 8- to 14-year-old autistic children with (ALI) and without (ANL) language impairment, children with DLD, and typically developing children. Pro-saccade, anti-saccade, and search distractor (i.e., requiring sustained fixation to a target amid the presence of distracting stimuli) tasks were used to measure reflexive and volitional eye-movement control (Kelly et al., 2013). Their results revealed that groups with language impairment (i.e., DLD and ALI groups), and not those with ASD only (i.e., ANL group), have difficulty in volitionally suppressing reflexive eye-movement towards nontargets. This finding is consistent with Brock et al.'s (2008) conclusion that language impairment is associated with context sensitivity. Thus, these studies have trailblazed future research directions towards uncovering potential causal links (e.g., verbal mediation and executive function) between language and oculomotor control during context processing (Deevy, 2017).

As mentioned earlier, there is a growing interest in deeper investigations of children's language comprehension. However, the formerly discussed behavioural methods cannot fully capture the transient linguistic processes and neural mechanisms behind comprehension. Hence, behavioural methods have been merged into **electrophysiological paradigms** to track the temporal course of these transient neurolinguistic mechanisms. In an electrophysiological paradigm, electroencephalography (EEG) is done by placing electrodes on a child's scalp to measure voltage fluctuations associated with neuronal activation (Ambridge & Rowland, 2013). These EEG fluctuations are averaged over numerous related trials until a waveform that is temporally tied to stimulus presentation (i.e., event-related potential/ERP) emerges (Deevy, 2017). ERPs provide rich temporal resolution for lateralisation and localisation of language processing (Deevy, 2017), as indexed by signature waveforms N400 (i.e., a negative voltage that peaks approximately at 400 milliseconds post-stimulus), eLAN (i.e., early left anterior negativity that peaks at 100-500 milliseconds post-stimulus), and P600 (i.e., a positive voltage that peaks approximately at 600 milliseconds post-stimulus).

N400 has been established as an index of semantic processing in children (Deevy, 2017). To demonstrate the sensitivity of this measure, an EEG study conducted by Rämä et al. (2013) revealed that typically developing 2-year-old children, or even younger ones with higher word productivity, may have taxonomically organised words in their mental lexicon. Consistent with this finding, Torkildsen et al.'s (2008) study provided further evidence that 20-month-old children's vocabulary size appear to affect their receptive fast mapping efficiency (i.e., novel world-learning ability) as those with lower word productivity were observed to take a longer time when processing new words. Relevant to atypical populations, EEG studies have also revealed a delayed N400 effect that was interpreted to indicate semantic integration deficits specific to verbal domains in children with DLD (Cummings & Čeponienė, 2010) and ASD (McCleery et al., 2010). These reported implications of a delayed N400 effect have then been interpreted to support Kail and Leonard's (1986) storage deficit theory of language impairment. Therefore, these EEG findings provide converging evidence, albeit still open for further investigations, that has promising practical and clinical utility for designing focused semantic interventions to facilitate better vocabulary development in children.

Whereas N400 measures semantic processing, eLAN/P600 biphasic pattern (i.e., eLAN followed by P600) has been used to measure syntactic processing (Deevy, 2017). As an exemplar, Hahne et al. (2004) reported that the eLAN/P600 biphasic pattern effect was observed in typically developing 7- to 13-year-old children and in adult controls when asked to perform grammaticality judgment tasks (e.g., detecting syntactic violations). However, the eLAN effect was not observed in their 6-year-old participants, suggesting that automatic syntactic processes may not be fully acquired until age 7 but gradually develop toward adult-like processing (Hahne et al., 2004). With respect to atypical populations, the absence of the eLAN effect in children with DLD (ages 10:0-21:0) during syntactic judgment tasks and the presence of the N400 effect during semantic judgment tasks have been

interpreted as evidence of a DLD subtype specific to syntactic deficits with preserved semantic processing (Fonteneau & van der Lely, 2008). In another study done by Epstein et al. (2013), the LAN index, this time used as a measure of working memory load during sentence processing, was found to attenuate in school-aged (ages 8:5-12:4) children with DLD when processing object *Wh*- questions (e.g., *Who did the bear follow?*) relative to subject *Wh*- questions (e.g., *Who followed the tiger?*). This attenuating and less distinctive processing has then led the authors to conclude that children with DLD might also have less efficient working memory when processing object *Wh*- questions (Epstein et al., 2013).

Conclusion

This paper reviewed select language production (i.e., naturalistic/spontaneous language sampling, picture-word interference, syntactic priming) and comprehension (i.e., self-paced listening, visual world paradigm, electrophysiology) paradigms that have thus far been used to investigate cognitive and neural correlates of language development in monolingual, bi/multilingual, and atypical children. While each paradigm has its own strengths and limitations, they have all generated valuable evidence that ongoing and future research can build on or improve if strategically re/configured to facilitate robust measures for the language phenomenon, population, and/or context under investigation. Most importantly, these paradigms can also facilitate forward-reverse translation of research and practice by converging findings that are relevant to practitioners, intended populations, and their contexts.

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