

# Third language phonological acquisition: Understanding sound structure in a multilingual world

Di Wang  | Claire Nance 

Department of Linguistics and English  
Language, Lancaster University,  
Lancaster, UK

## Correspondence

Di Wang.

Email: [d.wang16@lancaster.ac.uk](mailto:d.wang16@lancaster.ac.uk)

## Abstract

The field of third language acquisition has gathered increased attention over the last three decades. However, phonological acquisition in an L3 is still relatively understudied within the field, despite there likely being over a billion people regularly using an L3 worldwide. In this paper, we review experimental and theoretical studies of sequential L3 acquisition to date and aim to give implications for future L3 phonological acquisition research, laying the groundwork for advances in this area. According to the reviewed studies, it is necessary to adapt previous second language phonology models (i.e. SLM/SLM-r, PAM/PAM-L2, L2LP) into future L3 phonological research. Additionally, it is essential to expand the research scope and time scale to reflect linguistic diversity, age and education background of participants, and the processes of learning.

## 1 | INTRODUCTION

It is estimated that over half of the worldwide population use two or more languages regularly in their daily life (Grosjean, 2010). While it is difficult to put an exact number on the total speakers using three or more languages worldwide, a European Commission study (2013) reported that 25% of EU teenagers were competent users of three languages. Globally, we know that there are many regions where large numbers of people regularly use multiple languages, as in West Africa, Malaysia, India, for example. Multilingualism is, therefore, relatively common across the world, and is likely experienced by over a billion people. It is also likely that the number of multilinguals is increasing rapidly every year (Rocha-Hidalgo & Barr, 2022). Despite the large numbers of multilingual language users

globally, much of the previous phonological research has focused on monolingual and bilingual speakers, and work on L3 phonological acquisition is limited.

Previously, the field of L3 phonological acquisition was regarded as an extension of Second Language Acquisition (SLA) research (Chen & Han, 2019). However, L3 phonological acquisition differs from SLA due to much more complicated sources of language interactions, as either the L1, L2 or both can influence L3 phonology (Cenoz et al., 2001; Gut, 2009; Liu & Lin, 2021; Murphy, 2003; Wrembel et al., 2019). Comparisons to L1 and L2 phonological acquisition alone cannot, therefore, enable us to have a comprehensive understanding of multilingual language capacity. Thus, it is necessary to investigate L3 phonological acquisition in its own right to gain a fuller understanding of this process (Flynn et al., 2004).

The phenomenon of multilingualism has only been established as an area being researched systematically in linguistic studies over the last three decades (Garcia-Mayo, 2012; Gut, 2009; Klein, 1995; Wrembel et al., 2019). However, most experimental and theoretical L3 studies have focused on morphosyntax and lexicon, whereas the area of L3 phonetics and phonology has typically gained lesser attention (Gut, 2009; Wrembel et al., 2019). For example, theoretical models such as the Cumulative Enhancement Model and the Typological Primacy Model were proposed based on syntactic data (Flynn et al., 2004; Rothman, 2010). So far, only the Phonological Permeability Hypothesis (PPH) proposed by Cabrelli Amaro and Rothman (2010) focuses exclusively on L3 phonological acquisition. Nevertheless, it does not precisely predict how multilinguals perceive and produce speech sounds (Luo et al., 2020).

Additionally, L3 linguistic and psycholinguistic studies have, so far, largely focused on larger Indo-European languages (Liu & Lin, 2021; Rocha-Hidalgo & Barr, 2022). To give some specific examples of under-researched multilingual contexts, the majority of Nigeria's estimated 201 million inhabitants are multilingual, using for example, Niger-Congo languages, English/Hausa and Nigerian Pidgin English, and most young people in China now learn English as a third language alongside their local language (usually referred to as a 'dialect') and Standard Mandarin. Where L3 phonological work focuses on larger Indo-European languages, it is likely to under-theorise the acquisition or influence of tone, non-pulmonic sounds, phonation distinctions, and other features that are uncommon in Indo-European languages, and is also likely to underestimate power dynamics between majority and minority languages.

We hope that the current work, alongside specific studies such as those contained in the recent special issue of *Languages* (edited by Gut and Kopečková), can lead the field in new and underexplored directions.

## 2 | OUR FOCUS

In this paper, we aim to review progress to date in third language acquisition (3LA) studies of phonology and lay the groundwork for future research. The earliest academic evidence of multilingual phonological acquisition research can be traced back to studies nearly 50 years ago (Cabrelli Amaro & Wrembel, 2016), for example, work such as Chamot (1973), Rivers (1979), Singh and Carroll (1979). These early studies mostly relied on impressionistic analysis, but inspired more academic interest in this field and led to the area being more systematically researched currently (Cabrelli Amaro & Wrembel, 2016). Well-known developments in the study of SLA such as cross-linguistic influence (CLI) (Sharwood-Smith & Kellerman, 1986) and diary studies for example, Williams and Hammarberg (1998) laid the foundations for advances in 3LA (Cabrelli Amaro & Wrembel, 2016; Cal & Sypiańska, 2020).

To date, the vast majority of 3LA phonology work has considered adult sequential multilinguals. In this review, we focus particularly on this age group and specifically address quantitative, experimental approaches to the field whilst acknowledging the extremely important contributions to understanding made by qualitative studies of multilingual contexts. In Section 3, we discuss some previous dominant L2 and L3 acquisition models and explain how those models could be applied to L3 phonological acquisition. Section 4 reviews several of the most recent L3 phonological acquisition studies and discusses the factors contributing to cross-linguistic transfer onto L3 phonological behaviour. Section 5 focuses on the methodology used in recent L3 phonological studies. Section 6 concludes our review and provides implications for future research. Our work considers spoken language multilingual phonological acquisition. Multilingual research in sign languages has so far mainly considered lexical and grammatical aspects, or bilingualism, rather than multilingual phonology. See Zeshan and Webster (2020) and Brentari (2019, Chapter 7) for more information.

### 3 | THEORETICAL MODELS OF L2 AND L3 ACQUISITION

This section considers theoretical approaches to L2 and L3 acquisition of phonology. Early models in this area built on the dominant linguistic theoretical approaches of the time, for example, Archibald (1994), Brown (1998, 2000) both consider L2 learning through the lens of Universal Grammar. On the other hand, models such as the Speech Learning Model (SLM), Perceptual Assimilation Model (PAM), and the Second Language Linguistic Perception model (L2LP) provide various hypotheses for language phonological acquisition and have become more prominent in this field more recently due to their wide applicability.

Here, we first focus in detail on the current most dominant models proposed for L2 phonological acquisition: the SLM and its revised version (SLM-r) (Flege, 1995; Flege & Bohn, 2021), the PAM, and its extension to advanced L2 learners, PAM-L2 (Best, 1994; Best & Tyler, 2007), and the L2LP (Escudero, 2005; Van Leussen & Escudero, 2015). Our reason behind discussing these L2 models is because it has been suggested that L3 acquisition could be an extension of L2 acquisition (Wrembel et al., 2019). We discuss this possibility and how L2 models could potentially be expanded in scope. Finally, we explore several previous L3 acquisition models, and discuss how these models can shed light specifically on phonology.

#### 3.1 | L2 acquisition models

##### 3.1.1 | The Speech Learning Model

The SLM proposes equivalence classification, which suggests that bilinguals tend to initially identify tokens of different categories in the L2 as instances of L1 categories (Flege, 2018). The more similar L2 segments are perceived to be to those of L1 segments, the harder it is for L2 learners to acquire L1-like L2 pronunciation. This is because L2 learners tend to assimilate L2 sounds as existing similar L1 sounds and to reduce learning the new segments in the L2. Namely, L2 learners are more likely to notice the differences between L2 sounds and L1 phones and establish new categories for L2 sounds if those L2 sounds are more dissimilar to L1 sounds (Flege, 1995). The revised Speech Learning Model (SLM-r) further suggests that both mechanisms and processes that speakers use to acquire their L1 can still be used in L2 acquisition, without any change or exception in the lifetime (Flege & Bohn, 2021). Indeed, it agrees with the view of PAM-L2 (Best & Tyler, 2007) that L2 phonological acquisition is deeply influenced by perceptual biases caused by L1 (Flege & Bohn, 2021).

However, the SLM-r has some different hypotheses from the SLM (Flege, 1995). For example, the SLM-r argues that it is impossible for L2 users to resemble L1 speakers because of the essential interactions between the L1 and L2 phonetic systems, and the inequality of the L2 input in L2 acquisition compared to L1. Also, it argues that the age of first exposure to L2 does not prevent L2 phonetic category formation. Specifically, it suggests that the more precise the L1 phonetic categories that bilinguals have, the more likely they can distinguish phonetic differences between L2 sounds and L1 sounds (Flege & Bohn, 2021). The SLM-r proposes that perception and production evolve together rather than perception preceding production. Namely, the L2 production accuracy is not limited by how accurate L2 sounds are perceived by L2 learners (Flege & Bohn, 2021). Though the SLM-r is proposed based on substantial published research so far, it is acknowledged that this model still requires testing (Flege & Bohn, 2021).

### 3.1.2 | The Perceptual Assimilation Model

PAM proposes that bilinguals tend to perceive L2 contrasts based on the phonetic similarity between the phonological categories of L1 and L2 (Best, 1994; Chan, 2013; Chen & Han, 2019). Namely, naïve listeners are likely to perceptually assimilate L2 phones to L1 phonemes according to the common ground in articulators, constriction locations and degrees. Theoretically, the PAM is explicitly couched in Articulatory Phonology (Browman & Goldstein, 1992), and Direct Realist approaches to speech perception (Best, 1995). These approaches state that listeners learn to directly perceive speech gestures as the minimal underlying units of phonology.

Generally, L2 sounds can be perceived as poor or good exemplars of the L1 sound (categorised), or different from any L1 sounds (uncategorised), or non-speech sounds (non-assimilable). PAM proposes four modes of assimilation which can be used to indicate how well bilinguals discriminate different foreign sounds at the beginning of L2 phonological acquisition (Best, 1994): Two Category assimilation (TC), Single Category assimilation (SC), Category Goodness assimilation (CG), and Non-Assimilable assimilation (NA). More specifically, TC refers to the case where two L2 phones are assimilated into two different L1 phonological categories. In such instances, the discrimination of such contrasts should be excellent. SC refers to the case where two L2 phones are assimilated into one L1 phonological category. Consequently, these two phones are regarded as equally good or bad exemplars of the L1 phonological category, and discrimination performance is predicted to be poor. CG refers to the case where two L2 contrasting phones are assimilated into one L1 phonological category while being different from each other in terms of the goodness of fit to that category (e.g. phoneme) and the discrimination of such contrasts should be intermediate.

The PAM-L2 expands the original PAM to contexts of more advanced L2 learning (Best & Tyler, 2007). According to PAM-L2, advanced multilinguals may adapt to L2 perceptual cues as their L2 learning experience increases. They can perceive contrasts between L2 sounds that are not present in the L1 and will then develop two separate phonological categories, especially when the two sounds are very frequent in L2. While the SLM predicts that similar sounds in the L1 and L2 are likely to be very difficult to acquire, this final point about the PAM(-L2) suggests that similar sounds are not that difficult to acquire as the SLM predicts. Here, there is a contrast in focus between the models: the SLM is focusing on the specifics of phonetic production, but the PAM on whether two sounds can be perceptually discriminated.

### 3.1.3 | The Second Language Linguistic Perception model

The L2LP is an extension of the Linguistic Perception model proposed by Escudero (2005), which focuses on the entire development process of L2 perception, including the initial state, development

state, and end state. This model is proposed based on the optimal perception hypothesis (Escudero, 2005) which suggests beginner L2 learners tend to perceive L2 phones as instances of categories they acquire in the L1. L2 learners will then adjust their L1 perceptual boundaries in the direction of L2 perceptual boundaries and attain optimal L2 perception (Escudero, 2009). Thus, the acoustic differences and similarities between L1 and L2 will shape the development process of L2 perception. Three scenarios have been proposed: the new scenario, the similar scenario, and the subset scenario. In the new scenario, speakers must learn a sound not present in their L1 (predicted to be difficult for learners). In the similar scenario, L2 sounds resemble existing L1 categories (predicted to be less difficult for learners). In the subset scenario, learners must learn to fit a larger L1 phonology into a smaller L2 phonology (predicted to be of medium difficulty for learners) (Escudero, 2005). L2LP suggests that the L2 perception development (i.e. from the initial state to the development state and to the end state) is driven by the L2 learning experience, and L2 learners will ultimately obtain monolingual-like perceptions of L1 and L2 since they are handled by two separate perception grammars (Escudero, 2009).

The revised L2LP model suggests that the change in the number of L1 perceptual categories is a meaning-driven process influenced by lexical items, instead of L2 learners' perception of the number and type of phonemes that are relevant in their L2 (Van Leussen & Escudero, 2015). It proposes two versions of the model on phonetic perception and lexical recognition. For instance, sequential L2 learners are suggested to maintain an L1 phonetic category for certain L2 stimuli while interactive L2 learners fully adapt their L1 vowel categories to the L2 at the end.

### 3.1.4 | Extending the models to L3 contexts

Though L2 phonological acquisition models do not make predictions about the development of multilinguals, it is still possible that L3 learners can change the existing L1 and/or L2 boundaries to incorporate realisations of similar phonetic properties in L1, L2 and L3, as well as to develop new categories for their L3 (Wrembel et al., 2019).

Some studies have therefore tried to investigate L3 phonological acquisition based on adapting previous L2 acquisition models. For example, Wrembel et al. (2019) aim to adapt PAM and PAM-L2 to investigate L3 phonological acquisition. Results suggested that multilinguals, even at the beginning of L3 acquisition, tend to assimilate L3 sounds to both L1 and L2 phonological categories first, and then establish separate L3 phonological categories as their L3 learning experience increases. This pattern follows the pattern of SC proposed by the PAM-L2, that is, multilinguals behave similarly to advanced L2 learners (Best & Tyler, 2007; Wrembel et al., 2019).

Several previous studies also suggest that the SLM could be used to predict L3 phonological perception patterns (Liu & Lin, 2021; Liu et al., 2019; Sypiańska, 2016a). For example, Liu and Lin (2021) demonstrate that multilinguals perceptually acquire L3 voiceless and voiced stops in a way predicted by the SLM (Flege, 1995). More specifically, L1 Chinese speakers were likely to equate voiceless stops in L3 Spanish or Russian (i.e. /p, t, k/) with the L1 Chinese voiceless unaspirated stops and L2 English voiced stops, causing difficulties in their perception of L3 voiceless stops. Instead, they were better able to perceive the differences in voiced stops between L3 and L1 or L2 since the pre-voicing feature of word-initial stops was basically absent in their L1 and L2 while being present in their L3. Thus, they performed better in perceiving voiced stops than voiceless stops in the L3.

## 3.2 | L3 acquisition models

Although models such as the SLM(-r) and PAM could potentially be extended to the context of L3 phonological acquisition, L3 perception and production still differ from those of L2 due to complicated

sources of language interactions (Gut, 2009; Wrembel et al., 2019). For example, Chen and Han (2019) find that participants' L3 Mandarin production is modulated by both L2 English and L1 Cantonese while Cal and Sypiańska (2020) find that participants' L3 Spanish production is only influenced by L2 English. It is therefore possible that 3LA is influenced by the L1, L2, or both. Also, there are many more possibilities for learning third languages than learning second languages in terms of the order of language acquisition (Lipińska, 2015).

So far, there have been several explanatory models proposed for L3 acquisition of morphosyntax, such as the Cumulative-Enhancement Model (Flynn et al., 2004), the L2 Status Factor Model (Hammarberg, 2001; Williams & Hammarberg, 1998), the Typological Primacy Model (Bardel & Falk, 2012; Rothman, 2010), the Scalpel Model (Slabakova, 2017), and the Linguistic Proximity Model (Westergaard, 2019; Westergaard et al., 2016). At present, only the PPH focuses specifically on L3 phonological acquisition (Cabrelli Amaro & Rothman, 2010). The PPH suggests that the L3 is more likely to influence the L2 than the L1 when the L2 is acquired after the 'critical period' (pre-puberty) and the effects of L3 on L1 or L2 sound systems are different as L1 and L2 are not represented in the same manner cognitively (Cabrelli Amaro & Rothman, 2010; Luo et al., 2020). Namely, the PPH argues that there is significant difference in phonological acquisition in terms of the age of L3 acquisition (AOA). However, this hypothesis does not give concrete predictions on how speech sounds would be perceived and produced by multilingual speakers. It only generally focuses on the directions of CLI (Luo et al., 2020).

## 4 | FACTORS CONTRIBUTING TO CROSS-LINGUISTIC TRANSFER

All the models identified above suggest that some cross-linguistic transfer will happen, as is natural and expected when someone uses more than one language. In this section, we discuss the factors which have been shown to contribute to cross-linguistic transfer in contexts of L3 phonological acquisition focusing on the most recent research from 2010 until present.<sup>1</sup> We especially aim to identify and include studies of L3 phonology in non-Indo-European contexts, as this setting has received lesser attention in the literature to date.

There are two kinds of linguistic transfer: progressive and regressive. Here, we focus on progressive transfer from the L1/L2 or both to L3 phonological acquisition in terms of speech perception and production as they are relatively common (Chen & Han, 2019). For a recent example of regressive transfer, see Nelson (2022). In early studies, the L1 was proposed as the primary influence source of transfer onto the L3 speech perception (Ringbom, 1987). More recently, we now have a better understanding of the important role of the L2 in this process (Wrembel, 2010). Tables 1 and 2 present the source of transfer onto L3 speech perception and production suggested in the most recent literature. As shown in the tables, almost all studies recorded transfer from the L2 to the L3, and over half reported hybrid transfer from the L1 and L2. However, Grünke and Gabriel (2022) find that neither L1 nor L2 has transfer onto L3 production in terms of intonational patterns.

Previous studies have proposed factors contributing to cross-linguistic transfer in L3 phonological acquisition such as the L2 status (Llama et al., 2010; Wrembel, 2010), the L3 experience (Luo et al., 2020), typological proximity (Cabrelli Amaro & Rothman, 2010; Liu et al., 2019), and the level of proficiency (LoP) (Cal & Sypiańska, 2020). The following sub-sections discuss these factors separately.

TABLE 1 Source of transfer onto L3 speech perception.

Publication	L1 transfer?	L2 transfer?	Hybrid transfer (L1 and L2)?
Liu et al. (2019)	✓	✓	✓
Liu and Lin (2021)	✓	✓	✓
Luo et al. (2020)		✓	
Onishi (2016)	✓	✓	✓
Qin and Jongman (2016)	✓	✓	✓
Wrembel et al. (2019)	✓	✓	✓

#### 4.1 | L2 status

'L2 status' refers to the impact of previously learnt languages on L3 phonological acquisition, which has been demonstrated as a factor influencing the source of cross-linguistic effects on L3 perception and production (Hammarberg, 2001; Wrembel, 2010). According to Wrembel (2010), L2 transfer is greater than L1 transfer at the beginning of L3 phonological acquisition. However, the influence of L2 on L3 phonological acquisition diminishes as L3 experience increases (Hammarberg, 2001; Luo et al., 2020; Wrembel, 2010).

#### 4.2 | L3 experience

L3 experience generally refers to exposure to the L3, such as the Length Of Residence in the L3-speaking environment (Luo et al., 2020). Increased L3 experience is suggested to facilitate sound discrimination, especially in the early stage of L3 acquisition. Luo et al. (2020)'s study investigates the role of experience in depth comparing L1 Mandarin, L2 English and L3 Cantonese participants' perception of Cantonese vowels. Participants were divided into naïve listeners, listeners with less than 1 year of Cantonese experience, and listeners with over 5 years of Cantonese experience. Multilingual speakers' perceptual accuracy of L3 Cantonese contrastive vowel pairs increased rapidly at the early stage of L3 acquisition. However, the perceptual accuracy of L3 Cantonese contrastive vowel pairs did not benefit much from increased exposure to L3 Cantonese at later stages of L3 acquisition.

#### 4.3 | Typological proximity

Typological proximity typically refers to the relationship between languages and language families that linguists can formally and objectively define and identify (De Angelis, 2007). Previous studies agree that CLI is more likely to occur between languages that are closely related (Wrembel, 2015). Specifically, L3 learners are likely to establish links between the L3 and prior languages they have acquired. They tend to establish links between languages that have more similarities rather than differences (Ringbom & Jarvis, 2009), and the similarities between the L3 and L1/L2 can hinder multilinguals' ability to learn an L3. As well as the diachronic links between language families for example, between



TABLE 2 Source of transfer onto L3 speech production.

Publication	L1 transfer?	L2 transfer?	Hybrid transfer (L1 and L2)?
Cal and Sypiańska (2020)		✓	
Chen and Han (2019)	✓	✓	✓
Garcia (2013)	✓	✓	✓
Geiss et al. (2022)		✓	
Grünke and Gabriel (2022)			
Gut (2009)		✓	
Kopečková (2014)	✓	✓	✓
Liu and Lin (2021)	✓	✓	✓
Lloyd-Smith (2021)	✓	✓	✓
Llama et al. (2010)	✓	✓	✓
Patience and Qian (2022)	✓	✓	✓
Sypiańska (2016b)	✓	✓	✓
Sypiańska (2022)	✓		
Wrembel (2010)	✓	✓	✓
Wrembel (2015)	✓	✓	✓
Zhang and Levis (2021)	✓		

Spanish and Portuguese, research has also noted effects on L3 learning stemming from structural similarities and differences between unrelated languages. For example, in Liu et al. (2019), L3 learners of Japanese/Russian/Spanish had higher accuracy in perceiving voiced stops than voiceless stops, which was due to significant differences between L3 and L1 or L2 in terms of the differences between voiced stops rather than voiceless stops.

#### 4.4 | Level of proficiency

Previous studies have also demonstrated that LoP played an influential role in L3 vowel production (Cal & Sypiańska, 2020; Hammarberg & Hammarberg, 2009; Wrembel, 2010). LoP refers to both L2 and L3 if multilinguals are assumed to have a uniform level of L1 (Cal & Sypiańska, 2020). Previous research suggests that the lower the level of L3 proficiency, the greater the CLI from L2 to L3 (Gut, 2009; Hammarberg, 2001). This implies that learners at the initial stage of L3 acquisition are likely to transfer L2 phonology directly into their L3 production. However, the influence of the L2 decreases as L3 proficiency increases, and L3 phonological categories are more likely to be influenced by input from the L3 (Hammarberg, 2001; Hammarberg & Hammarberg, 2009; Wrembel, 2010).

In other words, lower proficiency in either the L2 or L3 makes (input of) the other, more proficient language, become the source of transfer onto L3 phonological categories (Cal & Sypiańska, 2020). Moreover, the interactions between L2LoP and L3LoP are also likely to influence part of L3 production. For example, the production of the L3 Spanish vowel /a/ was conditioned by both L2LoP and L3LoP in Cal and Sypiańska (2020). Additionally, L3 phonological categories are likely to be influenced by L2 and input from the L3 equally if L2LoP and L3LoP are at the same level. For instance, the first formant value of a Spanish vowel was at an intermediate value between L2 English and L3 Spanish vowel properties in Cal and Sypiańska (2020).



Having identified potential factors contributing to cross-linguistic transfer, we now turn to methodology in recent approaches to L3 phonological research and aim to indicate future directions the field could take.

## 5 | METHODOLOGICAL CHALLENGES AND FUTURE DIRECTIONS

This section reviews the methodological challenges in terms of research scope and design in recent L3 phonological research. In identifying challenges from previous work, we hope to indicate gaps for future directions in the field.

### 5.1 | Research scope

The works surveyed in Tables 1 and 2 indicate that recent experimental approaches in this area have focused on L3 speech production (e.g. Cabrelli Amaro & Wrembel, 2016; Garcia, 2013; Llama et al., 2010) and comparatively less on perception (e.g. Liu & Lin, 2021; Luo et al., 2020; Wrembel, 2010; Wrembel et al., 2019). Thus, the next logical stage for the field should be to investigate the perception-production interface for L3 phonological acquisition (Best, 1994; Cabrelli Amaro & Wrembel, 2016).

Table 3 shows the linguistic focus of recent L3 phonology studies. This table indicates that most of the research has focused on Indo-European languages as the target language (i.e. L3), especially Germanic and Romance languages such as German, English, French, Spanish and Portuguese, whereas Slavic languages were less studied for example, Russian and Polish (Cabrelli Amaro & Wrembel, 2016; Liu & Lin, 2021). Non-Indo-European languages as the target language in L3 phonological research were much less frequent, such as Arabic (Benrabah, 1991, reanalysed in Archibald, 2022), Mandarin Chinese (Gabriel et al., 2016), and Japanese (Tremblay, 2007). On the other hand, most of the previous research shown in Table 3 has focused on language trios where L1, L2 and L3 are all Indo-European languages, especially Germanic and Romance languages for example, Llama et al. (2010), Wrembel (2015), whereas L3 phonological research focusing on language trios where L1 and L3 are non-Indo-European languages and L2 is Indo-European languages was less frequent for example, Onishi (2016). Non-Indo-European languages as L1 (and L2), or as L2 and L3 in L3 phonological research were much less frequent for example, Qin and Jongman (2016), Grünke and Gabriel (2022), Zhang and Levis (2021). It is clear that there is a vast gap in the literature with regard to multilingualism in western and southern Africa, and L3 acquisition of minority and indigenous languages.

In the L3 phonology and phonetics studies outlined in Table 3, segmental properties have received more attention than suprasegmental properties. Studies of segmental properties mainly focused either on acoustic measurements of Voice Onset Time or on vowel formants. This research focus is in line with trends in SLA studies (Cabrelli Amaro & Wrembel, 2016). Previous L3 studies which have investigated suprasegmental features considered things such as word stress (Louriz, 2007), speech rhythm (Gabriel et al., 2015), vowel neutralisation (Gut, 2009), and vowel reduction (Cabrelli Amaro, 2013, 2016; Cabrelli Amaro & Wrembel, 2016).

### 5.2 | Time scales

According to Cabrelli Amaro and Wrembel (2016), most L3 phonology studies focus on a single time point, whereas longitudinal investigations are much rarer. A pioneering instance of longitudinal investigation studies is a case study conducted by Williams and Hammarberg (1998), and Hammarberg

TABLE 3 Language involved in previous studies.

Publication	L3 language	L2 language	L1 language/heritage language <sup>a</sup>
Cal and Sypiańska (2020)	Spanish	English	Polish
Chen and Han (2019)	Mandarin	English	Cantonese
Garcia (2013)	Portuguese	Spanish	English
Gut (2009)	German/English	German/English	Polish/Russian/Hungarian/Spanish
Geiss et al. (2022)	English	German <sup>b</sup>	Italian
Grünke and Gabriel (2022)	French	German	Turkish
Liu et al. (2019)	Japanese/Russian/Spanish	English	Mandarin
Kopečková (2014)	Spanish	English	German
Llama et al. (2010)	Spanish	English/French	English/French
Liu and Lin (2021)	Japanese/Russian	English	Mandarin
Lloyd-Smith (2021)	English	German <sup>c</sup>	Italian
Luo et al. (2020)	Cantonese	English	Mandarin
Onishi (2016)	Japanese	English	Korean
Patience and Qian (2022)	Spanish	English	Mandarin
Qin and Jongman (2016)	Cantonese	Mandarin	English
Sypiańska (2016b)	English	Danish	Polish
Sypiańska (2022)	Polish	Russian	Ukrainian
Wrembel (2010)	English	German	Polish
Wrembel (2015)	French	English	German
Wrembel et al. (2019)	Polish	English	German
Zhang and Levis (2021)	English	Standard Mandarin	Southwestern Mandarin

<sup>a</sup>L3 participants in Lloyd-Smith (2021), Geiss et al. (2022), Grünke and Gabriel (2022) acquired L1 as their heritage language, and L2 as their majority language.

<sup>b</sup>Seven participants were exposed to German since birth, while other 13 participants were exposed to German between 2 and 6 years old (mean age = 2.7).

<sup>c</sup>Fourteen participants were exposed to Italian since birth, and to German between ages 3–6 (mean age = 3.8), while 5 participants were exposed to German since birth.

and Hammarberg (2009), about one informant's development over several years. A rare example of a longitudinal design is Kartushina and Martin (2019), who demonstrate longer term shifts in vowel production for Basque-Spanish bilinguals learning English while studying abroad. They demonstrate longer term changes associated with changing input and indicate CLI can shift over time depending on exposure. Nelson (2022) compares adult and adolescent L3 learners of Polish over the course of a year. She demonstrates that adolescents showed greater changes to their L1 and L2 than the adults, indicating that the specific outcome of acquisition can vary across age groups, and there is much yet to be understood about the plasticity of language development in different groups of multilinguals over time.

### 5.3 | Participants

Most L3 phonology studies have relied on a limited number of participants due to the complexity of multilingual participants' profiles (e.g. Garcia, 2013; Wrembel et al., 2019), which can reduce the power of statistical analyses (Cabrelli Amaro & Wrembel, 2016). As shown in Table 4, the majority of previous L3 phonological acquisition studies involve participants who were undergraduates and older

TABLE 4 L3 group participants' profiles in recent L3 phonology studies.

Publication	Age of onset of acquisition (years)	Age of test (years)	Number of participants	Length acquiring L3
Cal and Sypiańska (2020)	15 (mean); range 3–20	22 (mean); range 19–25	25	7 years (mean)
Chen and Han (2019)	~10	~18	4 <sup>a</sup>	8 years
Garcia (2013)	>18	22 (mean); range 19–31	10	~1 year
Geiss et al. (2022)	6–11	23 (mean); range 17–29	20	NA
Grünke and Gabriel (2022)	12–14	Range 15–17	6	3 years
Gut (2009)	Speaker 1: 13 Speaker 2: 18 Speaker 3: NA Speaker 4: 29	39.25 (mean); range 30–50	4	Speaker 1: 17 years Speaker 2: 32 years Speaker 3: NA Speaker 4: 2 years
Kopečková (2014)	NA	Range 11–12	20	3 months (36 h)
Llama et al. (2010)	NA	>18	22	NA
Lloyd-Smith (2021)	NA	23.3 (mean); range 17–31	19	NA
Liu and Lin (2021)	>18	Range 18–20	39	2 months (80 h)
Liu et al. (2019)	>18	Range 18–20	58	2 months
Luo et al. (2020)	Experienced: ~18 Inexperienced: ~20	Experienced: 23.15 (mean) Inexperienced: 20.85 (mean)	40	Experienced: 5.46 years (mean) Inexperienced: 0.79 years (mean)
Onishi (2016)	>18	21.4 (mean)	22	<2 semesters
Qin and Jongman (2016)	23.67 (mean)	23.67 (mean)	15	NA
Sypiańska (2016b)	NA	57 (mean); range 32–69	20	NA
Sypiańska (2022)	~19	19.7 (mean); range 17–22	21	~5–8 months
Wrembel (2010)	Intermediate: 10 Elementary: 17	>18	24	Intermediate: 12 years Elementary: 3.5 years
Wrembel (2015)	13 (mean)	29 (mean); range 22–43	18	7 years (mean)
Wrembel et al. (2019)	Chronological L3: 12 ( $n = 3$ ) Dominance L3 (heritage): 0 ( $n = 5$ )	13.8 (mean), range 13–14	8 <sup>b</sup>	10 months
Zhang and Levis (2021)	~9	19.5 (mean); range 18–21	25	10 years (mean); range 7–12 years

<sup>a</sup>There were 89 participants involved in this study, but only 4 participants finished all stages of the experiments, and the cross-linguistic influence source of transfer was analysed based on those 4 participants' data.

<sup>b</sup>Task 2 included 8 L3 Polish participants but Task 1 only included 7 L3 Polish participants due to one participant's withdrawal during data collection.

than 18 (e.g. Llama et al., 2010; Luo et al., 2020) while few of them involve participants who were children or adolescents. In terms of the AOA, few previous studies include participants who acquired their L3 before 18 (though see Wrembel et al., 2019). Instead, participants in most studies acquired their L3 as adults (Garcia, 2013; Liu & Lin, 2021; Llama et al., 2010).

Most studies involved participants who had only begun learning an L3 quite recently. For instance, participants in Liu and Lin (2021) had studied their L3 for about 2 months. Also, participants in Onishi (2016) studied their L3 Japanese for less than two academic semesters. Fewer studies focus on learners who learnt an L3 for a relatively long period (e.g. around 10 years in Zhang & Levis, 2021). While these studies indicate a range of learning times, the intensity of instruction also varies across studies. For example, Liu and Lin (2021) report participants had 80 h of instruction in 2 months, whereas Onishi's (2016) participants likely received around 45 h of teaching over two semesters.<sup>2</sup>

Additionally, the language proficiency of participants is very diverse. For instance, L3 Mandarin Chinese speakers in Chen and Han (2019) were divided into different groups according to their different English proficiency levels determined by exam results. However, their English phonological ability still varied within the groups even though individuals in each group were theoretically at the same proficiency level. In such instances, it is essential to have an objective proficiency measurement for determining which group participants should belong to, especially for studies in which proficiency is a variable (Cabrelli Amaro, 2013).

## 5.4 | Data collection paradigms

According to Cabrelli Amaro (2013), it is necessary to develop instruments in all three languages (i.e. L1, L2 and L3) when choosing a property to investigate the source of transfer to the L3 due to the complexity of L3 speakers' profiles. For example, these were included in Wrembel et al. (2019). However, many studies only collected measurements of the L3 and L2 but did not include stimulus material in the L1, for example, Liu and Lin (2021). In terms of the types of tasks used, L3 phonology studies have used a variety of tasks typical of phonetics and psycholinguistics such as word lists (Llama et al., 2010) and more open-ended tasks such as story retelling (Gut, 2009) and spontaneous speech (Wrembel, 2010).

## 6 | CONCLUSIONS

In this paper, we have reviewed the development of the field of L3 phonological acquisition, focusing most closely on recent experimental approaches to this area. In this section, we highlight the gaps identified in the literature and suggest potentially fruitful future areas for the field to explore.

Theoretically, most previous models of L3 acquisition focus on morphosyntax rather than phonology, and they do not yet provide accurate predictions about L3 phonological acquisition. However, they still provide potential factors contributing to cross-linguistic transfer in phonology, such as typological proximity and language status. In addition, some L2 phonological acquisition models, such as SLM (SLM-r), PAM (PAM-L2), and L2LP can be extended to the context of L3 phonological acquisition as demonstrated in several previous studies (Liu & Lin, 2021; Liu et al., 2019; Wrembel et al., 2019).

In the last few years, the research design, and methods of L3 phonological acquisition studies have developed substantially. Many more studies have paid attention to the influence of L2 or both prior languages (i.e. L1 and L2) on L3 phonological acquisition (Liu & Lin, 2021). According to their results, most recent studies suggested that both L1 and L2 were sources of transfer onto L3 speech perception and production (Liu & Lin, 2021; Liu et al., 2019; Wrembel, 2010). Future work could further investigate the links between production and perception. In order to more fully investigate the processes behind L3 phonological learning, future work should consider more longitudinal designs

as well as work with participants who are child or receive education outside of western education systems. Finally, further analyses could focus more on L3 combinations involving non-Indo-European languages, as well as minority and indigenous language multilingualism.

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## CONFLICT OF INTEREST STATEMENT

The authors declare that they have no potential conflicts of interest.

## ORCID

Di Wang  <https://orcid.org/0000-0002-1427-2141>

Claire Nance  <https://orcid.org/0000-0001-5953-155X>

## ENDNOTES

<sup>1</sup> We firstly searched in the following journals: *International Journal of Bilingualism*, *International Journal of Multilingualism*, *Language and Speech*, *Journal of Phonetics*, *Speech Communication*, *Second Language Research*, *Studies in Second Language Acquisition*, *Bilingualism: Language and Cognition* as well as a recent special issue in *Languages* (edited by Gut and Kopečová). We then consulted as widely as possible beyond these journals in order to specifically include further studies involving non-Indo-European contexts.

<sup>2</sup> Onishi (2016) does not specify the exact number of hours received. Thank you to an anonymous reviewer for making this estimate based on Japanese university teaching schedules.

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## AUTHOR BIOGRAPHIES

**Di Wang** is a Postgraduate student majoring in Language and Linguistics at the Department of Linguistics and English Language of Lancaster University. She completed her bachelor's degree with honours in English Language and Linguistics at Lancaster University in June 2022. Her research interest involves phonetics, phonology, multilingualism, and minority languages. In particular, she focusses on third language phonological acquisition and Mandarin Chinese, especially Southwestern Mandarin.

**Claire Nance** is a Senior Lecturer in Linguistics at Lancaster University. She completed her BA in Modern and Medieval Languages at the University of Cambridge in 2005, and her PhD in

Celtic and Gaelic at the University of Glasgow in 2013. Her research interests include phonetics, sociolinguistics, multilingualism, and minority languages. Her specialisms are in Scottish Gaelic sociophonetics, and variation in English in north-west England.

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