
The Perception-Production Link in L2 Phonology

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Abstract

In a first or second language (L2), it is thought that in order to accurately produce a sound, one must be able to accurately distinguish that same sound in reception. This intuitive connection, called the perception-production link, also enjoys theoretical support from Flege's (1995) Speech Learning Model and empirical support from a considerable number of experimental studies. However, reports of perception without production and production without perception present a challenge to the perception-production link. In this brief review, the perception-production link is explained and evidence supporting and challenging the link is summarized. Additionally, empirical research on the link is critically reviewed to highlight issues with research design and interpretation. Finally, the perception-production link's current status in L2 research is discussed and directions for future research are presented.

Keywords: L2 phonology, L2 pronunciation, perception, production

In a first (L1) or second language (L2), the idea that one must first be able to perceive a sound in order to produce it is rather intuitive. This idea is referred to as the *perception-production link*, and plays an important role in the development of L2 oral production. The exact origin of the term is unknown to this author, but the idea enjoys a long history in the study of L2 phonology, dating back to at least 1934 (Polivanov, as cited in Cardoso, 2011). Infants have a well-known ability for categorizing sounds of any language regardless of prior experience (Werker & Tees, 2002), making it easy to take for granted the importance of perception in the development of L1 production. In the L2, however, perception is not a given. Perhaps the most well-known example of this is the difficulty L1 Japanese learners of English have in perceiving the English /r/-/l/ distinction (e.g., Aoyama, Flege, Guion, Akahane-Yamada, & Yamada, 2004; Bradlow, Akahane-Yamada, Pisoni, & Tokhura, 1997; Sheldon & Strange, 1982; Strange & Dittman, 1984). Concomitantly, L1 Japanese speakers famously have difficulty producing it, too (Avery & Ehrlich, 1992).

Before continuing, the two elements of the perception-production link warrant more detailed explication. *Perception* involves the recognition of sound as belonging to a phonological category during the processing of aural input. Importantly, in order to recognize a feature appropriately, the existence of a unique category for that feature in a learner's underlying phonological system is required. *Production* refers to using the oral-articulatory system to emit an auditory signal carrying a linguistically (phonologically)-encoded message (or more simply, *speaking*). The order of the two elements also carries important meaning: in the perception-production link, perception should precede production; perception of a feature is requisite for production. Consistent, accurate production preceding or completely independent of perception

would present a challenge to the link (Chan, 2014). However, perception without production would not necessarily be considered a rebuttal to the link, though it may be seen as a limit on its strength.

Although the perception-production link is both intuitively attractive and well-situated in popular theories of speech production (e.g., Perceptual Assimilation Model, Best & Tyler, 2007; Speech Learning Model, Flege, 1995), it is not without limitations or reasonable doubts. Baker and Trofimovich (2006) point out that perception and production are controlled by different mechanisms, and in that sense, the link could actually be considered counterintuitive.

Review of Research on the Perception-Production Link

This section reviews the support and challenges to the perception-production link in L2 phonology. A number of empirical studies are discussed and referred to, and to facilitate comparisons among them, these studies are summarized in Table 1. Table 1 presents the L1s, L2s (with the parenthetical *Status* to indicate the context/environment of acquisition), target features, and findings relevant to the perception-production link for each study. After the reviews of support and challenges, methodological issues present in the empirical studies are discussed. A summary then ties together the three preceding sections.

Support for the Perception-Production Link

Research has yielded strong support for the existence of the perception-production link. Work done in support of Flege's (1995) Speech Learning Model (SLM) has been particularly useful in providing a foundation for the link. In Flege's SLM, it is predicted that learners only readily create new phonetic categories when an L2 sound is sufficiently different from an existing L1 category. Without a unique category used to perceive the L2 sound, production of the L2 sound is also thought not to occur. Investigating Japanese learners, Aoyama et al. (2004) examined the difference in the acquisition of English /r/ and /l/. Compared to Japanese /r/, English /r/ is more distant than /l/ (which is close to Japanese /r/), which leads to the prediction that Japanese learners of English should be able to create a new category for English /r/ more easily than /l/. Aoyama et al. did indeed find this to be the case, with evidence of greater perception improvements over time, and importantly, improvements in production, offering evidence of the perception-production link.

Baker and Trofimovich (2006) reported similar findings in their investigation of L1 Korean learners of English, where they claimed perception was clearly linked to and a necessary condition for production. Flege, MacKay, and Meador (1999) extended these findings for the perception and production of English vowels by L1 Italian speakers, and further offered that the degree of perceptual accuracy is linked to the degree of production accuracy. These findings related to English vowels were corroborated by Jia, Strange, Wu, Collado, and Guan (2006) in a study of L1 Mandarin speakers of English in the US. Jia et al. found that higher degrees of accuracy in perception were reflected in production, offering confirmatory evidence for Flege et al. (1999). Additionally, by considering length of residence in the design of the study, Jia and colleagues were able to observe temporal lags in production accuracy following increases in perception accuracy. While a considerable portion of research in this area focuses on segmental perception and production, evidence has also been found for the perception-production link for syllable structure (Cardoso, 2007, 2011). Cardoso found that by intermediate levels of English proficiency, Brazilian learners were better able to discriminate differences in coda structure than

Table 1
Summary of Selected Studies Addressing the Perception-Production Link

Study	Participant L1(s)	Target		Results
		Language (Status)	Target Feature(s)*	
Aoyama et al. (2004)	Japanese	English (FL)	/r, l/	Perception improvement followed by production improvement.
Baker & Trofimovich (2006)	Korean	English (SL)	/i, ɪ, u, ʏ, ø, ε/	Perception exceeded production, moderated by proficiency and age.
Bradlow et al. (1999)	Japanese	English (FL)	/r, l/	Perception improved after perception training; production also improved.
Cardoso (2007, 2011)	Portuguese (Brazilian)	English (FL)	word-final coda	Production lagged behind perception.
Chan (2014)	Chinese (Cantonese)	English (SL)	/θ, ð, v, ʃ z, ŋ, l (final), r/, /i:, ɪ/, /u:, ʊ/, /ɔ:, ɒ/, /æ, e/	Successful perception, major production difficulty for some consonants (e.g., /ð/). Lack of association between perception and production of other sounds.
Darcy & Kruger (2012)	Turkish	German (B)	/i:, ɪ, e, ε, a:, a/	Production indistinguishable from monolingual peers, perception categories different.
Flege et al. (1999)	Italian	English (SL, B)	/i, ɪ, e ^l , ε, æ u, U, o, ʌ, ɒ/	Perception accuracy linked to production accuracy, age effect found.
Jia et al. (2006)	Chinese (Mandarin)	English (FL, SL)	/i, ɪ, e ^l , ε, æ, ʌ, ʊ/	Perception accuracy linked to production accuracy, age effect found. Production lags evident.
Kim & Park (1995)	English	Korean (FL)	/l/, /ɾ/	Successful perception, major production difficulties.
Motohashi-Saigo & Hardison (2009)	English	Japanese (FL)	geminate (/t, k, s/)	Perception improved after perception training; production also improved.
Oh et al. (2003)	English	Korean (HL/FL)	/t, t ^h , t ^ʰ / (lax, aspirated, tense)	HL > FL in perception, near NS. HL w/ childhood speaking had better production than HL w/o childhood speaking, but not near NS for all features.
Sheldon & Strange (1982)	Japanese	English	/r, l/	Production more accurate than perception.
Tsukada et al. (2005)	Korean	English (SL)	/i, ɪ, e, ε, æ, ʌ, ʊ/	Production exceeded reception for children, but not adults. Language use a factor.

Note: SL = Second Language, FL = Foreign Language, HL = Heritage Language, B = Bilingual.
*IPA symbols used in primary studies retained.

produce them. At a more advanced level, coda production ability was similar to perception ability.

Pronunciation instruction (PI) research has also borne evidence in favor of the perception-production link. Inclusion of perception activities in PI has demonstrated favorable

results in terms of production (Kissling, 2014; Okuno & Hardison, in press). One helpful feature of PI studies in relation to the perception-production link is that they document changes over time, allowing for a causal interpretation of results, shedding more light on L2 phonologic acquisition than one-shot studies comparing perception and production accuracy. Perhaps the most powerful evidence of the perception-production link comes from Bradlow et al. (1997) and Motohashi-Saigo and Hardison (2009). Bradlow et al. provided only perceptual training to Japanese learners in English /r/ and /l/ distinction, and saw improvements in the production of those phonemes. Motohashi-Saigo and Hardison (2009) took a similar approach with L1 English learners of Japanese. The learners were only provided with perception training related to geminates (/t,k,s/), which involved listening to audio stimuli and choosing among minimal-triplets. After training, the learners were found to have improved not only their perception of singleton-geminate contrasts, but also their production of geminates according to native-speaker judges. These findings support the primacy and necessity of perception in the perception-production link, and even further suggest that perception alone may unlock ‘potential’ L2 phonologic features. That is, if a particular feature is not being produced in the L2, but exists (or components of it exist) elsewhere in a learner’s inventory, perception of the feature may be sufficient for production. In the case of Motohashi-Saigo and Hardison’s (2009) L1 English learners of Japanese, English consonant gemination (e.g., *midday*), though rarely a contrast, could rapidly be accessed for production in L2 Japanese once the perceptual category was established.

Challenges to the Perception-Production Link

Although the perception-production link is supported in mainstream theories of phonologic acquisition and possesses potentially powerful effects when applied in PI, it is not without challenges: evidence of perception without production, and evidence of production without (or exceeding) perception. The first challenge, perception without production, greatly limits the strength of the link. Derwing and Munro (2015) point out that is very easy for L1 English speakers to perceive the difference between Spanish’s trill /r/ and tap /r/, but they often struggle, in some cases perpetually, to produce the distinction. Keep in mind that the trill /r/ is unlike anything in the English phonetic inventory, which suggests ease in new category formation under the SLM. Indeed, the persistent difficulty of this feature has been attested to recently by Lord and Harrington (2013), who found little improvement in producing the phonemes after production-focused learning activities for Spanish learners. Kim and Park (1995) found that L1 English learners of Korean had major difficulties producing /l-r/ contrasts accurately despite successful perception. Similarly, in a study of L1 Cantonese learners of English, Chan (2014) found that learners had accurate perception of the English /ð/ but generally failed to produce it, and characterized this finding as a significant challenge to the perception-production link.

Some research involving heritage learners and bilinguals (childhood age-of-onset L2 speakers) questions Flege et al.’s (1999) stronger assertion related to the degree of perceptual accuracy and production. In the case of Korean heritage learners enrolled in 1st-year university Korean courses, Oh, Jun, Knightly, and Au (2003) found that heritage learners had advantages over non-heritage learners in terms of consonant phoneme perception. Interestingly, whether the heritage learners spoke the language as children or only heard it had little effect on perception; both types of heritage learners approached native speaker accuracy rates for perceptual accuracy (lagging behind only about 10%). However, it was only the heritage learners who had experience

speaking the language as children who approached native speaker norms for two types of consonant phoneme productions (lax and aspirated), while all groups (including non-heritage learners) struggled with production of tense consonants- a feature absent in English. This may suggest that accurate production requires something more than accurate perception.

The second challenge, production without perception, is less attested to. Sheldon and Strange (1982) found that for a group of Japanese learners of English, production of /r/ and /l/ was more accurate than perception. It is important to note, though, that the group of “good” Japanese English learners in the study only had a production error rate of 1% and a perception error rate of 10%, which could suggest something of a ceiling effect: their L2 phonological perception will only *approach* native-like accuracy, but perhaps production can exceed that perception limit (by certain measures; accuracy was judged by native listeners but the acoustic qualities or accentedness of speech were not considered). Additionally, because the study was not developmental, the results do not answer the question of which came first for the learners. Outside of Sheldon and Strange’s (1982) widely-cited study, relatively little evidence exists supporting production without perception as a frequent phenomenon.

Bilinguals who learn an L2 early (typically before 7 years of age) and sustain use of the L2 are often found to be indistinguishable from L1 speakers in production. As such, one might expect that they would also mirror L1 speakers in perception. However, Darcy and Kruger (2012) found that L1 Turkish/L2 German child bilinguals, despite being indistinguishable from L1 German peers in production, categorized contrasts of some German features differently than their monolingual peers. They suggest that it may be possible for bilinguals to form new L2 categories that are distinct from the L1 but at the same time differ from monolingual norms. Tsukada, Birdsong, Bialystok, Mack, Sung, and Flege (2005) also reported similar findings for L1 Korean/L2 English child bilinguals. In their discussion, the authors speculated that L2 production might also require L2 production experience, in addition to perception, which would explain the superior production of some child bilinguals who reported high levels of L2 use compared to adult-aged arrivals with similar lengths of residence.

Methodological Issues

Restrictive tasks, incomparability between perception and production measures, and/or small sample sizes are issues presenting threats to validity in many studies involving the perception-production link.

In most studies mentioned so far, tasks used to measure perception and production are highly restrictive. Perception tasks largely mostly involve minimal pair/triplet discrimination (e.g., AXB tasks), using either words or pictures as choices. These tasks allow researchers to focus on particular phonemes and control for potential moderating variables, but may be susceptible to priming or Hawthorne effects. Production tasks are also often limited to single words, though short sentence templates are also used (e.g., Oh et al., 2003, who used a Korean equivalent of “This is a ____.”). PI research, perhaps more than other areas of L2 pronunciation research, tends to use tasks with longer or more spontaneous output and a recent meta-analysis of PI studies revealed that effect sizes yielded from output measures tend to be lower for these sorts of tasks (Lee, Jang, & Plonsky, 2014). This finding may be partially attributable to the demands of real-time speech production preventing careful monitoring of phonological production, and casts some doubt on how much productions elicited in discrete tasks reflect acquisition rather than careful monitoring aided by explicit knowledge.

Another issue with perception and production measures is their comparability. A perception accuracy rate based on single-word discrimination is difficult to compare with production accuracy rates based on human transcriptions or judgments of learner production. For example, instruments for investigating perception accuracy typically involve forced-choice (i.e., choosing what was heard among only 2-3 options), which introduces chance and/or guessing as potential confounds (Cardoso, 2011). Accuracy in production, on the other hand, may be determined by transcriptions or classifications from a trained expert; these are less susceptible to random chance and at the same time success may have more stringent criteria. Acoustic measures of production (which are compared to NS norms) also have issues of comparability, as they do not account for a binary expression of correct/incorrect in a way comparable to perception tasks. Incongruity between perception and production tasks in terms of difficulty, cognitive demands, and rigor also create challenge in relating outcomes, with production tasks generally thought to impose a greater burden on subjects (Flege, 1999; Jia et al., 2006; Tsukada et al., 2005).

Last is the issue of sample size. In Sheldon and Strange (1982), which presented one of the strongest and most well-known challenges to the perception-production link, the findings were based on a sample of six Japanese L2 English learners compared to four NSs. While it appears that Sheldon and Strange analyzed their data appropriately (i.e., relying mainly on descriptive statistics and limited parametric tests), the small sample size should make for highly-cautious interpretation and extrapolation of the findings. However, the article has been cited over 300 times according to *Google Scholar* (scholar.google.com, accessed 12/9/2015), a non-trivial number even in respect to the article's age. Fortunately, the sample size issue has been ameliorated over time, with contemporary studies related to the perception-production link including respectable sample sizes (e.g., N=72 in Flege, MacKay, & Meador, 1999, N=77 in Jia et al., 2006; N=72 in Tsukada et al., 2004). However, more modest samples are sometimes divided into subgroups for comparisons, and these subgroups are often not much larger than those found in studies from earlier decades. For example, Oh et al. (2002) compared 15 childhood speakers and 6 childhood hearers to 12 native speakers of Korean, sample sizes that make findings from the otherwise well-crafted research somewhat difficult to extend beyond the study.

Summary

The perception-production link appears to have strong foundations in empirical research. Some longitudinal studies and a number of PI studies have shown more than just a link between perception and production. Longitudinal studies have demonstrated orders of perception preceding production. In some cases of PI, sufficient development of perception appears to rapidly unlock appropriate production without any particular production training required. Furthermore, a link between the degree of accuracy in perception and production has also been proposed based on empirical findings. In sum, this positive evidence has led to what could be characterized as a strong link between perception and production: phonological perception must precede production, development of perception may facilitate rapid emergence of production for some features, and the degree of perceptual accuracy has a strong influence on accuracy in production.

However, commonly attested accounts of pronunciation difficulties and research on heritage learners and child bilinguals present challenges to the perception-production link,

especially its stronger characterizations. Persistent difficulties in certain phoneme productions despite easy perception delimits the influence of perception in the link. In the case of some complex and/or linguistically rare features, there may simply be an age constraint on the ability to learn articulations (Flege, 1999). The variation of production in different types of heritage learners, all of whom approach NSs in measures of perception, also suggest that something more than just perception (perhaps sufficient L2 use) may be necessary for target-like production. Flege (1991) noted that learners need time to develop accurate production of features that have been established in perception, which might be a satisfactory explanation for early heritage learners but less satisfactory for heritage learners with more experience. Additionally, child bilinguals have been shown to be indistinguishable from NSs in their L2 production, yet appear to form phonetic categories differently than monolinguals. Together, these findings arguably present some challenges, or at least areas requiring further research, for the perception-production link.

Finally, research issues related to the type of experimental tasks, comparability between perception and production measures, and sample sizes pose some challenges for research related to the perception-production link. The first two issues pervade most research on the topic, while the latter issue has diminished over time, though still surfaces in subgroup comparisons of more contemporary research.

Current Status

The current status of the perception-production link is one of general acceptance and strong empirical support. While it is no longer the overt focus of many studies, it is likely to appear in the theoretical background and interpretations of studies involving the acquisition of phonology or examining the influence of other factors (e.g., age of onset) on perception and/or production. This is perhaps due to it being broadly accepted as a general principal of phonological acquisition compatible with the popular SLM. Accordingly, the perception-production link is featured with some importance in a recent volume by two major figures in L2 pronunciation: Derwing and Munro's (2015) *Pronunciation Fundamentals: Evidence-based Perspectives for L2 Teaching and Research*. A chapter by Hardison (2012) in *The Routledge Handbook of Second Language Acquisition* on L2 speech perception also allots space to discussion of the link. Furthermore, PI studies frequently incorporate perception activities in the instructional treatment and sometimes include perception measures, and popular guides to teaching pronunciation feature perception as an important step prior to learner production (e.g., Celce-Murcia, Brown, Goodwin, and Griner, 2010).

Though the link is featured in the important works described previously, it is also not uniquely indexed in other major comprehensive accounts of second language acquisition (SLA) or applied linguistics such as Gass, Behney, and Plonsky's (2013) volume on *Second Language Acquisition* or *The Encyclopedia of Applied Linguistics* (Chapelle (Ed.), 2013). Similarly, Kormos' (2006) volume on speech production in SLA, though primarily a psycholinguistic account of production, does not mention the perception-production link and instead emphasizes L1 influences and compensatory strategies (e.g., reduction, substitution) to explain L2 phonetic realizations. In addition to L1 influences, factors such as age of acquisition and input (quantity and quality) tend to be more prominent in accounts of L2 phonology. It is perhaps appropriate to characterize the current status of the perception-production link as well-established in L2 pronunciation literature and research but taken for granted in SLA more generally.

Future Research

Previously described elements of the perception-production link and general challenges to the link all present empirical questions. Building a more focused body of evidence around the link in L2 phonology would serve to more robustly delineate its effects and may yield useful implications for pedagogy. Within such perception-production focused studies, research designs including more frequent observations over time would yield a more thorough understanding of the relationship between perception and production, especially when considering that for many features learners require time to develop articulation after perception (Flege, 1991). Similarly, perception accuracy exceeding production accuracy at one point in time can only provide indirect support for the link; more time points are necessary to investigate the inherently dynamic predictions of the link.

Additionally, attempts to confirm existing findings in more naturalistic context would be informative. For example, perception could be measured in the context of listening to short narratives or conversations, and production could be measured in extended productions such as picture descriptions or interviews. While this sort of design would require very careful considerations to limit interference from outside of a learner's underlying phonological inventory in relation to the variables of interest (non-words or proper nouns may be one way of achieving this), it could at the same time potentially mitigate the incomparability of conventional perception and production measures. More specifically, accurate perception of individual features while listening for comprehension may be more comparable to the burden of articulating speech sounds in real-time during meaningful communication than commonly used single-word perception/production tasks.

Finally, interesting findings that present challenges to the perception-production link have come from samples outside of the typical college-aged instructed L2 learners (e.g., Darcy & Kruger, 2012; Oh et al., 2003, Tsukuda et al., 2005). Continued research involving child bilinguals or heritage learners could provide unique contributions to the development of the perception-production link in addition to building more evidence around the existing challenges to it. For example, *receptive bilinguals* have high listening comprehension abilities, indicating a well-developed underlying language system, but possess limited ability to produce the language after a long period of disuse. A detailed understanding of their pooled phonological inventories and documenting the (re-)emergence of categories in production could illuminate how the perception-production link may affect types of features and their early patterns of production as well as make progress in uncovering the role of production itself in the link.

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