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Phonetics and phonology of sound perception in a changing system

Abstract. Since the establishment of phonology as a separate branch of linguistics, scholars such as N. Trubetzkoy, C. B. Chang, E. de Leeuw, D. LaCharité, and others have demonstrated that phonological principles serve as the fundamental framework for sound perception. In particular, the key concepts of phonological sieve, approximation, language attrition and language drift show steady patterns of phonology driven sound perception. However, not all instances of sound perception adhere strictly to such phonological principles. This article examines a case of sound perception in Ukrainian revealing that, under the circumstances of phonological instability, the basic principle of sound perception may tend to shift from phonologically to phonetically driven sound perception.

Keywords: phonetics, phonology, sound perception, Ukrainian, language attrition, language drift

1. Introduction

The field of linguistics is a tapestry of interconnected facets, each contributing to our understanding of how human beings communicate through language. Among these facets, phonetics and phonology play pivotal roles, acting as gateways to unraveling the mechanisms of sound perception. In linguistics, phonetics and phonology serve as cornerstones for exploring the auditory dimension of language. Phonetics delves into the physical properties of speech sounds, examining the articulatory and acoustic features that give rise to distinct phonemes. On the other hand, phonology focuses on the more abstract, cognitive aspects of sound patterns, seeking to understand how humans categorize and process these sounds within the boundaries of their linguistic systems. This duality between phonetics and phonology contributes to the complexity of studying sound perception.

This paper explores the intersection of phonetics and phonology, tracing the history of dominant approaches to the study of sound perception and examining a case that provides valuable data to expand the current understanding of the mechanisms behind sound perception.

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The following sections will be dedicated to the history of sound perception as a subdiscipline within phonetics, the formation of the current approach, and possible ways to further develop the dominant framework, as illustrated through an experimental study.

2. History

Since its establishment as a significant part of linguistics, phonology has made substantial progress thanks to the efforts of many prominent linguists. In *Grundzüge der Phonologie*, N. Trubetzkoy defined and formalized what phonology is, and how it differs from phonetics and other related fields. One of the key concepts introduced at the beginning of *Grundzüge* is the notion of the "phonological sieve", described by Trubetzkoy as:

> The phonological system of a language is like a sieve through which everything that is said passes … Each person acquires the system of his mother tongue. But when he hears another language spoken, he intuitively uses the familiar 'phonological sieve' of his mother tongue to analyze what has been said. However, since this sieve is not suited for the foreign language, numerous mistakes and misinterpretations are the result. The sounds of the foreign language receive an incorrect phonological interpretation since they are strained through the 'phonological sieve' of one's own mother tongue. (Trubetzkoy, 1939, p. 51).

In this paragraph, Trubetzkoy essentially describes the foundational principle of sound perception. According to him, perception follows the rules of phonology, meaning that phonetic similarity plays a lesser role in how sounds are perceived.

Later, in the United States during the 1950s and 1960s, the topic of sound perception, along with sound production, gained renewed interest among linguists. With several new waves of migration from Europe and other countries after World War II, and thousands of first-generation immigrants learning English, linguists became interested in *system-in-change*. This was the period when the field of second language acquisition, along with other related phonetic and phonological aspects of non-native speech, gained prominence. Concepts such as *phonological interference*, *phonological variability*, and the *phonetic and phonological manifestations of L1 phonology*, among others, entered the linguistic discourse of the time.

One of the first works to address a related topic appears to be William Nemser's *Approximative Systems of Foreign Language Learners* (1971). Although Nemser did not specifically focus on sound perception in this work, one of the issues he studied was sound perception within a system experiencing rapid change. The outcome was a concept that extended beyond the traditional understanding of sound perception, namely, the idea of an approximative system — *the deviant linguistic system actually employed by the learner attempting to utilize the target language* (Nemser, 1971, p. 2). According to Nemser, the reason learners develop an approximative system is essentially the same as Trubetzkoy's notion of a phonological sieve – the speaker's inability to properly

hear and produce a new set of phonemes. Nemser's concept also expanded upon Trubetzkoy's originally phonological idea by incorporating semantics, syntax, and other linguistic areas.

This approximative system, according to Nemser, is an ever-evolving system that undergoes abnormally rapid changes as the learner progresses. The system is also coherent and forms a patterned product distinct from both the learner's L_1 and L_2 systems (in the original work marked as LS, LT, and La, standing for the *source language*, *target language*, and *approximative system*, respectively).

This period also saw the emergence of similar new concepts. For instance, in his 1980 work Phonetic Approximation in Second Language Acquisition, James E. Flege first introduced the concept of phonetic approximation. In this study, Flege researched how the L_1 phonology of Saudi Arabic speakers manifests in their L2 English output. He concluded that the more experienced Saudi English speakers produced word-final stops closer to those found in native American English while still maintaining phonological features typical of Saudi Arabic. This resulted in a sort of intermediate (or approximative) system.

As the new millennium approached, linguists continued to explore principles of sound perception. Starting in 1995, linguists from Quebec's Laval University, such as Darlene LaCharité, Carole Paradis, and their colleagues, conducted research on loanword phonetic approximation – that is, how English loanwords were adapted into the system of Quebecois French. Their research topics include LaCharité & Paradis (2002), LaCharité & Prévost (1999), and Paradis & LaCharité (2008). In Poznań, Poland, Ewa Waniek-Klimczak and her colleagues have worked on areas related to second-language pronunciation (Waniek-Klimczak, 2009, 2014, 2016, 2019; Waniek-Klimczak et al., 2015; Waniek-Klimczak & Shockey, 2013), focusing primarily on the speech of Polish immigrants and the Polish accent in English as a second language, as well as its perception. The Linguistics Department at Boston University has produced numerous works in the field of phonetics and phonology, contributing valuable research to the discussion on the role of phonetics and phonology in non-native, second/third/heritage speech, language attrition, and drift (Chang, 2008, 2013, 2019a, 2019b; Chang & Ahn, 2023; Chang & Dionne, 2022; Chang & Kwon, 2020; Hutchinson, 2022).

The conclusion of the studies mentioned before is that the main principle of sound perception follows the principles of phonology. The phonetic aspect, however, seems to manifest mainly in sound production. Thus, for instance, Flege described *phonetic approximation* as a phenomenon when a speaker is unable to accurately produce the correct target L2 sound and produces a (range of) rough approximation(s) instead:

> In much previous research, especially that done within a phonemic theory framework the L2 sounds produced by a language learner have often been viewed as discrete entities which are produced either correctly or incorrectly instead of as a continuum of approximations to phonetically accurate L2 sounds. (Flege, 1980, p. 119) [emphasis added]

or as in:

> Importantly, it seemed to be the case that the least correct mispronunciations tended to disappear first from the learner's speech, while the closer (but still phonetically inaccurate) approximations to L2 phonemes remained longer. (Flege, 1980, p. 119) [emphasis added].

To put it differently, phonology is concerned with sound perception, while phonetic approximation accounts for a range of unstable acoustic realizations. Nevertheless, some authors suggest that such influence may also extend to the phonetic level. For instance, Al-Kinany et al. (2022), Hasan et al. (2011), Kodirova (2021), Rohali (2018), and Soares (2012) mention *phonetic interference* as the influence of L1 on the L2 production by non-native speakers. Despite varying terminology, their ideas reflect a common theme: *phonology*-driven *phonetic* realization. This is closely related to articulatory variability, a phenomenon where speakers struggle to accurately produce the target L2 sound, instead generating a range of rough approximations, as described by Yun and Sung (2022). Thus far, instability has been discussed as a cause of phonetic variation in speech. This raises the question of whether such instability can also lead to variation in sound perception.

3. Phonetics or phonology?

Proponents of the phonetic approach argue that sound perception occurs at the phonetic level, meaning sounds are perceived based on their phonetic proximity. This is often the case with bilinguals, who naturally attempt to approximate the closest possible pronunciation. This perspective was described in Paradis and LaCharité's (2008) paper on apparent phonetic approximation in Quebecois French during the 19th and 20th centuries. However, they concluded that sound perception in loanword adaptation is phonologically rather than phonetically driven. In contrast, proponents of the phonological approach argue that sounds are adapted not only based on their phonetic proximity but also in accordance with the rules of the respective phonological systems, (false) analogies, and other factors. Although a final consensus has not yet been reached, it appears that more linguists – such as Larry Hyman, Mathias Jenny, Michael Kenstowicz, Darlene LaCharité, Lynn Nichols, Donca Steriade, Bert Vaux, and Jie Zhang – lean towards the phonological approach.

The hypothesis of this article is that sound perception typically follows phonological principles when the phonological system is in a relatively stable state. However, when a phonological system is undergoing change or when a significant number of speakers experience prolonged language *attrition* (as discussed by de Leeuw and Chang, 2023), sound perception may, at least partially, follow phonetic principles. In de Leeuw and Chang's conceptualization, language attrition—contrary to the more commonly known understanding—refers to nearly permanent changes in an individual's language system, usually affecting grammar and phonology, resulting from prolonged language contact.

To gain a better practical understanding, an example should be introduced into the discussion. A case in the English-Ukrainian language pair and phonemes /g/, /ɦ/, /h/ /x/ might illustrate

the hypothesis. English possesses two out of four phonemes: /g/ and /h/ as in *growl* and *house*. The phonological inventory of Ukrainian possesses three of them: /g/, /ɦ/ and /x/, as in <ґанок> [ganɔk], <ґарний> [ɦarneɨ̯] and <ходити> [xɔˈdɪte]. Having such phonemes in its inventory, as well as applying the principles of phonology, one would expect Ukrainian speakers to perceive and adapt English /g/ and /h/ as /g/ and /ɦ/ respectively, as /g/ is present in both phonological systems and /h/-/ɦ/ share the same place of articulation as both phonemes are glottal fricatives. Such principles of phonology, for example, work as expected for phonologically similar Czech (Mołęda, 2008; Duběda, 2020). Czech speakers, therefore, tend to perceive /ɦ/ as the closest equivalent of /h/. The situation with Ukrainian speakers is, however, somewhat different. The phoneme /g/ in Ukrainian is rather marginal. It used to be a core part of the inventory of its ancestor language, Proto-Slavic, while at later stages of its development etymological /g/ first changed into /ɣ/, subsequently changing into /ɦ/ during the 10-13th centuries. This process also involved domesticating loanwords, e.g., the word *etymology* itself is [etemɔˈɬɔɦʲijɛ] in contemporary Ukrainian. The list of frequently used words containing the phoneme /g/ would not be longer than approximately 20 vocabulary units that, in spoken Ukrainian, *may* also be pronounced with [ɦ] instead.

Furthermore, there are two other sociolinguistic factors that should be mentioned. The first factor is that most Ukrainians are either Ukrainian-Russian bilinguals or advanced L2 speakers of Russian. They are also aware of the so-called hekannia, i.e., pronouncing [ɦ] instead of [g] when speaking Russian – a phonological feature characteristic of Russian spoken in Ukraine. Additionally, the two languages share multiple cognates where the Russian word would contain [g] while the Ukrainian word would contain [ɦ] as, for instance, is the case with Russian город [gɐˈra] and Ukrainian город [ɦɔˈra]. Such words are easily recognisable and oftentimes have (nearly) identical spelling. This sociolinguistic feature has created a strong link between the two sounds and, as a result, it influences how Ukrainian speakers tend to render /g/ and [h]-like sounds of foreign languages. Eventually, it creates a phonological collision when perceiving and adapting English /g/ and /h/. A speaker indicates that growl and house have different initial consonants in the original language. To avoid a collision the latter is often rendered as [x] instead, thus giving us [ɦrɔuɬ] and [xaus] respectively.

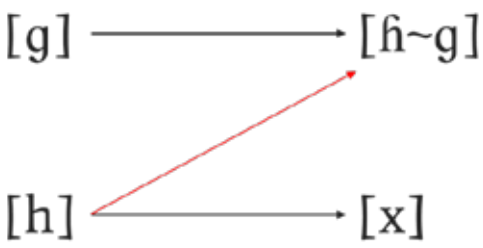

Figure 1. Phonetically driven [x]-based perception (Chybras, 2024). The red line indicates the phonologically expected perception.

The second sociolinguistic factor is orthography. The latest Ukrainian orthography from 2019 (The Cabinet of Ministers of Ukraine, 2019) states that foreign /g/ and /h/ sounds are to be transliterated as <r>, which stands for /ɦ/, while there are certain exceptions where a foreign, often English, /h/ may be transliterated as <x>, which stands for /x/. In most, if not all, cases this tradition of transliteration is Russian influenced as Russian used to be a mediator language, i.e., loanwords would enter Ukrainian through Russian. For instance, the classical orthography of Ukrainian from 1928 mentioned that foreign /h/ should be adapted as <r> while foreign /g/ should be adapted as <ґ>, [g] phonetically, except for the older loanwords, that is, those that had undergone the process of a /g/ to /ɦ/ change (Skrypnyk, 1929). Additionally, the same 2019 orthography update mentions that in personal names <g> and /g/ *may* be transliterated as <ґ>, which stands for /g/. As the majority of contemporary loanwords are of English origin, Ukrainian speakers tend to apply this exception to newly borrowed words usually stating *phonetic similarity* as the reason for choosing <x>. This state of affairs has also led to decades-long discussions about correct transliteration methods (Molotkina, 2017).

This phonological anomaly was the primary research interest in Chybras (2024). The study aimed to reveal why some Ukrainian speakers tend to have [x]-based perception of foreign [h] instead of the phonologically expected [ɦ]-based perception, as previously described in the hypothesis. The results obtained from the study showed there is a correlation between exposure to Ukrainian-accented Russian and [x]-based perception of [h]. The most prone to [x]-based perception group proved to be the bilingual group the phonological system of which has experienced prolonged *attrition* (as in de Leeuw & Chang, 2023). Their phonological system of Ukrainian, therefore, seems to exist in a state of instability and change. This phonological instability, thus, creates favourable conditions for phonetic and phonological uncertainty in sound perception. That is when two sounds, [g] and [ɦ], are ultimately perceived as one phoneme with peculiar realisation patterns, meaning that [g] can be realised as [ɦ], while [ɦ] cannot be realised as [g], therefore [h] cannot be perceived as [ɦ], the phonetically and phonologically closest sound.

The study was conducted as a single-blind experiment that studied the participants' phonetic perception. A total of 34 participants were asked to listen to the recordings of words containing [g] and [h] in various positions and combinations. The null hypothesis of the study was that the reason why some Ukrainian speakers perceive [h] as [x] is purely phonetic, and Czech [ɦ]-based perception is caused by orthography. This, however, was disproved, with the ultimate reason identified as language attrition, which affects the phonological system of bilingual speakers of Ukrainian living in a mixed language environment. Furthermore, respondents from the bilingual group exhibited mixed perceptions of [h], that is, in one phonetic environment, they would perceive [h] as [x] while in a different phonetic environment they would perceive [h] as [ɦ]. Interestingly, they tended to perceive [h] as [ɦ] when [x] was also present in the neighbouring position in a word, thus contrasting the two sounds. The results showed that the bilingual group, on average, reached $\bar{x}$ 80.1 % [x]-based perception, while the results for the Ukrainian-dominant and the Russian-dominant groups were $\bar{x}$ 56.2 % and $\bar{x}$ 69.9 % respectively.

Furthermore, the results suggest that there might be positional tendencies in sound perception among Ukrainian speakers. Although the position did not appear to be the original cause of [x]-based perception, it seems plausible to argue that such tendencies arise from phonological instability. For instance, it was revealed that the respondents tended to perceive [h] as [x] in positions such as [VhV] and [hV̥Ç] where the perception of [h] was either contrasted to vowels or influenced by regressive assimilation by a following voiceless consonant. Contrary to that, [h] tended to be perceived as [ɦ] in positions like [Çh], [hVÇ] and [xVhV]. These positions either contain a voiced consonant close to [h] or [h] is contrasted to [x].

4. Implications

These findings establish a foundational premise for the ensuing argument: the impact of phonology on sound perception diminishes when a language system undergoes changes in its phonological structure, or when specific phonemes within that system occupy peripheral and precarious positions. In such scenarios, phonetically driven perception becomes more reliable from the perspective of language speakers. However, the uniformity of this perceptual shift across diverse languages requires further scholarly inquiry.

Currently, several conceptual results can be discerned. While the concepts of *articulatory variability* and *phonetic approximation* primarily characterize phenomena in the domain of speech production, *perceptual variability* – manifested in speech perception – seems to arise from phonological instability. Additionally, the structural foundations of phonology-driven perception appear to transition to a phonetics-driven paradigm, often characterized by an ad hoc and functional perceptual approach influenced by the surrounding phonetic context. This suggests that in an unstable phonological environment, sound perception may revert to a lower (phonetic) structure, which is more easily comprehensible, rather than a higher (phonological) structure that demands stronger connections and oppositions between phonemes. If these observations withstand scrutiny, as supported by similar phenomena in other language combinations, they should enhance our understanding of sound perception.

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