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Cognitive Phonetics: The Mental Processes Involved in Manipulating The Vocal Tract Mechanism

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Abstract

The concept of cognitive phonetics (Tatham, 1983, 1986) has been put forth to address the theoretical issue surrounding the interface between phonology and phonetics. Phonological grammar directly feeds the sensorimotor system involved in speech production through Cognitive Phonetics. Phonetics has been concerned with the neuromuscular events connected to the physical realization of these phonological processes. In contrast, phonology has been concerned with hypothesizing mental processes that produce the sound pattern. Thus, this paper is designed to answer the following questions: 1. What is the nature of the cognitive system? 2. How does the Cognitive Phonetics work? 3. How does the transduction process work in Cognitive Phonetics? In order to answer the following questions, the following aims are designed: 1. Identifying the phonetics and cognitive phonetics to show the mental process that adds to phonetics. 2. Defining the inner workings of CP. 3. Showing the processes and the levels of the transduction from the phonological representations to the phonetic representation.

Keywords: Cognitive Phonetics, Phonology-phonetic overlap, Transduction, Coarticulation

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الصوتيات المعرفية: العمليات العقلية المشاركة في معالجة آلية الجهاز الصوتي

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المستخلص

طرح عالم الصوتيات تاثام مفهوم الصوتيات المعرفية وذلك في اصدارين له عامي 1983و 1986).وكان ذلك من اجل معالجة القضية النظرية ذات العلاقة بالتداخل بين علم الأصوات والصوتيات. وترتكز نظرية هذا العالم على ان النحو الصوتي يقوم بتغذية مباشرة للنظام الحسي الحركي والذي بدوره يشارك في إنتاج الكلام من خلال الإدراك. يهتم علم الصوتيات بالعمليات العصبية والعضلية المرتبطة بالإدراك المادي لهذه العمليات الصوتية. وعلى النقيض من ذلك، يهتم علم الأصوات بفرضيات تتعلق بالعمليات العقلية التي تنتج نمط الصوتالكلامي. وقد تم تصميم هذه الورقة للإجابة عن الأسئلة التالية: 1. ما هي طبيعة النظام المعرفي الصوتي ؟ 2. كيف يعمل علم الصوتيات المعرفي؟ 3. كيف تكون عملية النقل في الصوتيات المعرفية؟ من أجل الإجابة على هذه الأسئلة تم تبني الأهداف التالية: 1. التعرف على الصوتيات والصوتيات المعرفة لإظهار العملية العقلية التي تضيف إلى علم الصوتيات. 2. تحديد التركيب الداخلي للصوتيات المعرفية 3. عرض عمليات ومستويات التحول من علم الأصوات إلى الصوتيات.

الكلمات المفتاحية: الصوتيات المعرفية، التداخل الصوتي، علم الأصوات، النقل، المجانسة الصوتية

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Introduction

Phonetics studies spoken sounds, including how they are produced physiologically and acoustically. It focuses on the vocal tract configurations that produce speech sounds (articulatory phonetics), the acoustic characteristics of spoken sounds (acoustic phonetics), and the method of combining sounds to create syllables, words, and sentences (linguistic phonetics)(web source 1).

While language is a brain-based system of knowledge that is internal, individual, implicit, and intentional(Chomsky 1980: 101–102), most linguists have studied language as a cognitive phenomenon since the 1950s. Thus, it is simple to understand why linguists and phoneticians consider phonetics a non-cognitive science relating to acoustics, aerodynamics, and motor control. A phonetic model may, at most, receive input from a phonology that is cognitively focused(Chomsky 2012: 48).

1. Cognitive Phonetics

Cognitive phonetics is defined by(Volenec and Reiss, 2017)as "A neurobiologically grounded theory of phonetic implementation" that connects phonology's (surface representation's) substance-free output to a motor program (phonetic representation) ."Cognitive phonetics has been proposed to address the theoretical issue surrounding the relationship between phonology and phonetics" (Tatham, 1983, 1986). The issue stems from the fact that two branches of linguistics have evolved as distinct model types. Phonetics has been concerned with the neuromuscular events connected to the physical realization of these phonological processes, while phonology has been concerned with hypothesizing brain processes in producing sound patterns.

The manipulation of the vocal tract mechanism is the subject of cognitive phonetics. It regulates the speech mechanism following phonology's establishment of the language's sound pattern. Phonology chooses from a list of sounds provided by phonetics, in contrast to cognitive phonology, which decides how to implement the demands of phonology (Tatham,1984:37-47). Cognitive phonetics studies the final steps of converting thoughts to sound, including the mental processes of encoding and decoding. It entails what must be activated when entering an idealized phonological requirement to produce a sound wave that must be decoded to some a copy of the original thinking that is only minimally declined. It involves modifying these processes' control under the control of the mind. Such processing must call for data or a knowledge base to be accessed. It must have been possible to gather, store, retrieve, and process the knowledge. Information on the range of performance requirements that might be required is included, along with information regarding physical mechanisms and how they are controlled.

Additionally, data collection for ongoing performance monitoring may require handling separately from long-term data storage(Tatham,1986:271-276). Additionally, cognitive phonetics serves a purpose separate from ongoing motor control. It is the source of knowledge regarding the available mechanisms, their results, and the limitations and constraints of cognitive phonology. In its relationship to phonology, cognitive phonetics takes the position previously occupied by non-abstract phonetics. The grammar part comes after phonology and is in charge of the phonetically dominant parts of phonology (ibid).

There is a set of rules known as "production instructions" in cognitive phonetics. These structures are the detailed method of controlling the physical system that action theorists have defined as being otherwise neutral or free-running. They start the tuning process so that the system can be continuously adjusted. Due to our understanding of the system's motor, aerodynamic, and acoustic potential, specific instructions are called(Morton and Tatham, 1980b:107-116). The knowledge essential for such a system to operate successfully is stored in the mind and addressed cognitively; according to the dualist perspective, it cannot be physical. Cognitive phonetics only describes the facts of the motor system because doing so is necessary to modify them (Tatham,1990:193-218).

2. Cases of Cognitive Phonetics

These two cases, in point, are mentioned by (Katherine, M., 1987: 191-194) to show that cognitive phonetics is the mental process involved in manipulating the vocal tract mechanism.

2.1 Case 1

Several phonologists have employed phonetics as an explanatory foundation for specific phonological processes. A phonologist might explain the obstruent devoicing rule by stating that sub-glottal air pressure tends to fall in the final position, violating the delicate balance between air pressure and vocal cord tension required to ensure vibration. One cannot, however, have it both ways: either the rule is cognitive (in which case the tendency to lose vocal cord vibration is irrelevant because you choose to stop the vibration), or it is not (in which case the aerodynamic constraint takes dominance).In that scenario, the rule is both phonetic and physical. The phonetician only works with physical phenomena, while the phonologist groups together anything in speech production that can appear to have a cognitive origin. Phoneticians have yet to do much to modify their models to fit the new cognitive linguistics (Katherine, M., 1987: 191-194).

2.2 Case 2

Vowels that follow stop consonants experience a delay in starting the vocal cord vibration process due to the phonetic realization of the phonological aspect [voice] in these consonants. Numerous studies have demonstrated that the average delay differs from language to language, even in languages where only two segments are realized and differ between [+voice] and [-voice]. There may be systematic differences in the delay, known as VOT (voice onset time), which is phonologically dominated by the same [voice] characteristic in two languages. This distinction, which can be changed voluntarily but is nonetheless systematic, is managed cognitively (Katherine, M., 1987: 191-194).

These Two cases involve the speaker's selections out of various choices. A selection process starts when a specific realization of a phonological requirement is available. The vocal mechanism cannot independently realize phonological requirements that are abstract. It is proposed that, for phonological reasons, a Cognitive Phonetic ability governs this choice. The function of Cognitive Phonetics has another aspect.

Variations can be seen in the repeated realizations of intended phonological components. The output of the vocal mechanism does not correspond precisely to the underlying phonological information of the speech. Segments in phonology are either the same or different, which means they can operate differently for encoding needs. However, controlling variability is a crucial factor in choosing the inventory for this functioning. The distinction between units cannot be made when realizations are too similar or overlap. The degree of separation required for the hearer to make a necessary phonological distinction and the allowable level of variability is controlled by cognitive phonetics (Katherine, M., 1987: 191-194).

3. The phonology-phonetic Interface in Cognitive Phonetics

Phonetics is characterized by gradient, temporally ordered articulatory movements and continually changing sound waves, whereas phonology consists of abstract, symbolic, discrete, timeless components and formal procedures. Phonological competence must effectively transmit information to the sensorimotor (SM) system, which controls speech production since humans speak. The phonology-phonetics interaction allows these two systems to communicate with one another (PPI) Volenec & Reiss (2017,251–294). Cognitive Phonetics, a representational format containing substantive information, is given to the SM system through two transduction mechanisms in cognitive phonetics, which transform the substance-free output of phonology. The SM system may or may not then externalize language through speech. The outputs of phonology, or surface phonological representations(SRs), are the inputs to Cognitive Phonetics. Strings of segments make up SRs, each with a set of features. Each feature of SR is transmitted by the SM system, which then interprets it(Lenneberg, 1967: 3).

4. The Process of Transduction in Cognitive Phonetics

The idea that phonetics has a cognitive component in no way blurs the line between competence and performance. Phonetics, including its cognitive component, is performance by definition because only mental grammar is regarded as competence in phonology. The transduction process depicted by cognitive phonetics does not require "knowledge" in any meaningful sense of the word, such as "knowing how" to generate speech (Chomsky 1980: 101–102). Transduction of SRs into PRs involves a set of neuromuscular processes. Its ontogenetic development, most expected, follows the development of performance systems in general (Lenneberg 1967:24).

Two algorithms carry out this transduction. The paradigmatic transduction algorithm (PTA) connects a component (a symbol in the brain) to a motor program, which outlines the muscles that must be contracted to produce the intended acoustic effects. The syntagmatic transduction algorithm (STA) limits the PTA-specified neuromuscular activity's temporal organization. Put, PTA associates muscular activity with each feature, and STA spreads that activity over time. The output representation of Cognitive Phonetics produced by these transduction algorithms subsequently feeds the SM system. The phonetic representation (PR) results from CP and can be characterized as a complicated array of temporally coordinated neuromuscular orders that activate speech-producing muscles(Marr, 1982,2010: 23–24). Thus, the transduction carried out by Cognitive Phonetics can be accommodated by expanding the typical schema of phonological competence as it is shown in the figure (1) below.

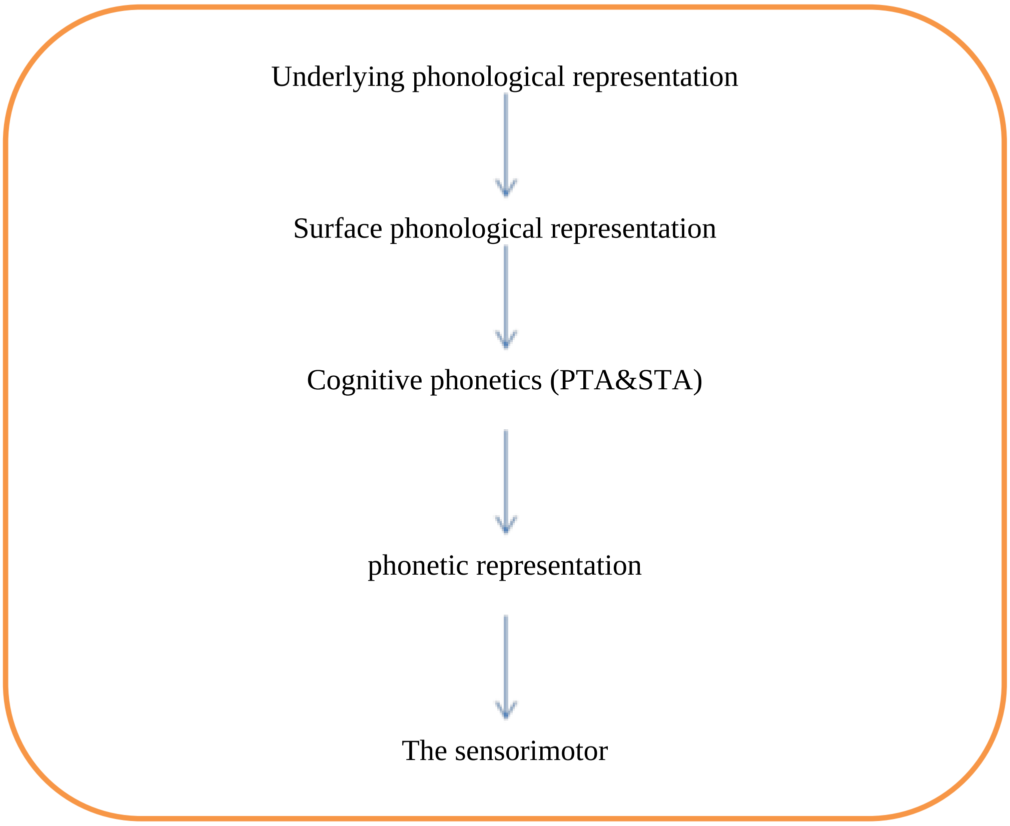

Figure (1): Cognitive Phonetics Transduction

The black elements of the schema correspond to the early phonetic processes in speech production, whereas the gray parts represent phonological competence. In other words, the contrast between shading types reflects the competence/performance contradiction. Cognitive phonetics is (one element of) performance. Phonology is competence. (ibid)

5. Characteristics of Cognitive Phonetics Transductions:

As seen by (Lenneberg 1967: 92)

1. Because Cognitive Phonetics' transduction is deterministic, each feature receives an identical neuromuscular schema each time it is transduced. All feature combinations that result in intra- and intersegmental coarticulation are also included in this.
2. Cognitive Phonetics thus proposes the following empirically testable hypothesis: In principle, employing just the two algorithms suggested by Cognitive Phonetics should be sufficient to fully explain all relevant intra- and intersegmental co-articulatory effects given a complete and accurate set of features.
3. It is important to emphasize that the phonetic representations produced by Cognitive Phonetics should not be compared to physical articulatory movement or the acoustic output of the human body. Numerous factors in the externalization process further complicate what is pronounced.
4. After transduction, other performance factors have nothing to do with phonology or transduction, such as muscle fatigue, the degree of enunciation, interruptions from sneezing, and many other situational effects. These factors will all impact the body's final output and make (co)articulatory variation

appear more variable. Because of this, it is not true that any feature or feature combination will always have the same articulatory and associated acoustic content.

5. It is not a transduction issue when a cognitively invariant category appears to lack invariance. Lack of invariance is only a concern for language and speech scholars who adopt an incorrect physicalist perspective (as opposed to a mentalist one) towards their respective objects of study.

6. Coarticulation in Cognitive Phonetics

The studies conducted by Volenec and Reiss (2013, 2015, 2017) have indicated numerous impacts associated with PTA and STA, as will be illustrated. Volenec and Reiss (2013: 117–151) argue that phonological qualities serve as the foundational elements of speech production, enabling the comprehensive consideration of the intricate and systematic interdependencies between two distinct types of coarticulation effects. Assuming the existence of a theoretical internal language, it is postulated that this language incorporates two distinct syntactic representations, namely [lok] and [luk]. Each segment consists of a collection of distinctive traits, with the vowels [o] and [u] possessing the feature [+ROUND], which will be the focus of our analysis. It is important to acknowledge that there exists a distinction in terms of height between the vowel sounds [o] and [u]: specifically, [o] is classified as a high vowel with a negative height value, whereas [u] is categorized as a high vowel with a positive height value. A specific segment is selected for analysis in the context of Physical Task Analysis (PTA), whereby its constituent features are examined, and the level of muscular exertion required to execute each component is assessed. In a general sense, the activation of at least four muscles—orbicularis oris, buccinator, mentalis, and levator labii superioris—leads to the rounding of the lips during the +ROUND phonetic feature (Seikel et al., 2009: 719-720). The disparity in the impact of PTA on individuals with a high negative (–HIGH) versus high positive (+HIGH) value is characterized by the algorithm's elevation of the mouth, torso, and jaw in the latter case. However, it does not apply to the former. Given the elevated specifications, the PTA employs a slightly distinct lip rounding configuration for the vowel [o] compared to [u] while transducing the feature +ROUND. The term used to describe a transduced feature, which is considered to be the fundamental element of speech generation, is PR [F]. In this notation, 'PR' represents 'phonetic representation' and 'F' represents a feature that has a unique value. As a result, the feature PR [+ROUND] can be transduced as +ROUND, as described by Volenec and Reiss (2017: 251–294). It can be asserted that the phonetic representation of [o] will exhibit distinct characteristics in terms of PR[+ROUND] due to its interaction with PR[–HIGH], in contrast to [u] which will display distinct characteristics in terms of PR[+ROUND] due to its interaction with PR[+HIGH]. In the meantime, these interactions encompass transduced qualities inside a singular segment, specifically the sounds [o] or [u]. The aforementioned results can be referred to as intrasegmental coarticulation. In cases where attributes within a certain segment are delineated, the PTA (Phonetic Target Approximator) employs a distinct neuromuscular framework to facilitate the phenomenon of intrasegmental coarticulation. The speech timing adjustment (STA) necessitates the temporary extension of PR[+ROUND] from the vowel to the consonant preceding it, specifically in the anticipatory direction. This phenomenon can be considered analogous to intersegmental coarticulation, a widely recognized concept in which attributes sent from multiple segments interact. When considering the phonetic features of SRs [lok] and [luk], it becomes evident that there are distinct differences in the pronunciation of the vowel [o] compared to [u]. This discrepancy can be attributed to the influence of intrasegmental coarticulation with the feature PR[HIGH]. Additionally, the inherent feature PR[–ROUND] of the consonant [l] is observed to overlap temporally with the feature PR[+ROUND] of the neighbouring vowels due to intersegmental coarticulation.

It is imperative to bear in mind that the preceding consonant serves as a distinguishing factor between PR[+ROUND] with [o] and PR[+ROUND] with [u]: the articulation of [l] in [lok] will differ in terms of lip rounding compared to [l] in [luk]. Therefore, the phoneme [l] exhibits the simultaneous influence of both intra- and intersegmental coarticulation.

Cognitive Phonetics allows for a comprehensive analysis of the tiny yet systematic phonetic variations, as it recognizes the different motivations of PTA and STA, which arise from the need for transduction and inevitably lead to one another.

Conclusions

This paper concludes that:

1- The idea of cognitive phonetics has been proposed to solve the theoretical issue surrounding the link between phonology and phonetics (Tatham, 1983, 1986).

2- Cognitive phonetics deals with the manipulation of the vocal tract mechanism.

3- Cognitive phonetics studies the last stages of thought-to-sound transformation, including the mental operations of encoding and decoding.

4- Two transduction mechanisms in cognitive phonetics, which change the substance-free output of phonology, provide a representational format conveying substantive information to the SM system.

5- This transduction is carried out using two algorithms. The motor program specifies the muscles that must be contracted to produce the ideal acoustic effects, and it is connected to a component (a symbol in the brain) using the paradigmatic transduction algorithm (PTA).

6- The PTA-specified neuromuscular activity's temporal arrangement is constrained by the syntagmatic transduction algorithm (STA).

7- Cognitive Phonetics enables us to directly and explain for such subtle yet systematic phonetic distinctions since PTA and STA are independently motivated by the need for transduction and follow naturally from one another.

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