A Cognitive Model of Sound Representations in Children with Speech Sound Disorders

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Abstract

The goal of the current work is to develop a theoretical model that can possibly account for certain speech disarticulations that occur among children with Speech Sound Disorders (SSDs). In trying to do so, we propose an interface module, a specialized transducing system within the speech sound system, the nature and functioning of which in the cognitive system may provide us with some useful insights into SSDs. The postulation of an interface module here is necessitated by the fact that there are facets of errors in SSDs and in typical populations that cannot be simply explained in terms of either articulatory/phonetic factors or matters pertaining to abstract sound representations. This paper will, therefore, present a detailed view of the interface, its nature, its relation to levels in the cognitive system, and the functions it performs. The results of applying the proposed model to certain types of sound alterations in SSDs are described with implications for the cognitive representation of speech sounds.

Keywords: Speech Sound Disorders; Phonological Representations; Interface.

Introduction

The realization that language is fundamentally a complex system has helped understand the significance of the human mind as a cognitive system. In this context, the analysis of speech production has played a crucial role in first formulating cognitive theories and then subsequently applying them in the real-world context. However, there are certain gaps of understanding in speech production, specifically in speech sound disorders, that elude satisfactory explanations. Speech language pathology has, of course, made several advancements in terms of speech diagnosis and treatment. Nonetheless, there is more to the issue than meets the eye. More often than not, speech language pathology has catered to speech disorders that relate either to articulatory disorders or to matters pertaining to phonological representations (PRs). There are, however, certain facets of SSDs that cannot be simply explained by either. How do we treat or possibly explain the speech dysfunctionalities of a child, for instance, who displays no motor or structural abnormalities, and also at the same time demonstrates a capacity to discriminate two different sounds? While physiological defects are entirely ruled out in such cases, one cannot account for such speech errors by merely appealing to phonological representations.

If PRs, as popularly propounded by many (Dodd, 2005; McNeill & Hesketh, 2010; Anthony et al. 2011, Sutherland & Gillon, 2007), are to be held responsible for the disarticulation of the sounds, then it simply does not explain why and how a child can possess the capacity to distinguish a minimal pair set. Likewise, if we are to advance the inaccessibility of the mentally instantiated phonological symbol as the reason for speech dysfunctionalities, it does not always seem reasonable to attribute all the speech problems to a loss of a certain cognitive capacity that cannot, for reasons that are not very clear, access the right symbol from the phonological system. Moreover, given the understanding that speech disorders mostly exhibit a pattern in terms of the errors they commit, the symbol extraction problem does not seem to spell out the exact reasons as to why only certain specific sounds (under predictable environments) are misarticulated. It is cases like these that we believe require closer inspection and probably more explanation in terms of what kind of cognitive processes drive a child to produce a certain sound in a way that is deviant from the typical speech.

Thus, this paper outlines a theoretical model that focuses on contributing to an understanding of the internal cognitive mechanisms/procedures that ultimately lead to variants in speech production in typical and atypical populations. For the same, we will discuss in detail, with the help of relevant data, how a model such as ours can account for variations in speech differences.

Cognition and Speech Disorders

Speech sound disorders are speech and language disorders identified by the inappropriate use of speech utterances, which may involve errors in the production, perception or organization of speech sounds. These are particularly relevant to the present study because the current work intends to look at the cognitive processes of the speech sound system not in terms of how effectively the speech system functions in producing the correct speech utterances, but in terms of how inadequately the system can possibly work in the production of unintended utterances. Numerous different categories of models such as the connectionist model of Dell, Change & Griffin (1999), Fromkin's five-stage model (Fromkin, 1971) and Garrett's model (Garrett, 1975) have been developed in an attempt to account for speech sounds in general. Our study, however, differs in its effort to consider the disordered data as its preliminary basis to explicate the cognitive procedures in the speech sound system, and thus emphasizes the need for an 'interface' module inside the human cognitive system in view of the specific patterns of errors found in speech sound disorders.

The relation between cognition and disordered speech has been a subject of investigation for many years, and the results have only cemented the already existing belief that they exert a rather strong influence over each other. Shriberg & Widder's (1990) findings from nearly four decades of speech research in cognitive impairment indicated that persons with cognitive impairments or any sort of deficits at a cognitive level are likely to have speech problems. That is, the articulatory skills of a subgroup with cognitive deficits differed significantly from the normally developing children. Similarly, in several of the case studies conducted by Sutherland (2006) on children with severe speech impairments, it was observed that 3 out of 4 children demonstrated poor phonological skills. The results indicate that children with consistent speech impairments experienced deficits at the cognitive-linguistic level (i.e., phonological representations) of speech production (Dodd, 2005). Cognition and disordered speech are inexplicably intertwined in a manner that is overt in terms of the influence the former exerts over the latter, and yet imprecise in terms of the exact cognitive processes or the mechanisms that actually result in specific speech dysfunctionalities.

The purpose of this study, therefore, is to address these crucial gaps and explore in some detail the phonological processes in the mind that can be held accountable for some of the dysfunctional speech. We will discuss in detail the phonological processing of speech sounds in both typical and atypical populations in the later sections. Before delving deep into the confinements of the modelling theory, we shall first have a look at the PRs.

Phonological Representations

The concept of a phonological representation has undergone a significant number of changes over the period, and there is no single classification that can possibly take into consideration the difference of opinions that had gone into defining PR in specific frameworks. However, there is a common consensus among scholars that PRs represent the underlying structures of the sound system. Locke & Studdert-Kennedy (1983) formally define phonological representations as the underlying sound structure of specific words stored in long-term memory. Berent (2013) considers PRs to be discrete and combinatorial. These representations reportedly distinguish different kinds of symbols that are instances of some form in the real or imaginative world. Berent also emphasizes a categorical distinction of different classes of sounds as a means to form a specific category of members that are alike. Such a perception of PRs seemingly supports generalizations that apply across the board to all members of a class. A large amount of relevant literature on the study of PRs, however, also differ significantly on account of numerous parameters contributing to PRs. While Browman & Goldstein (1986) describe PRs based on articulatory gestures, Halle (1985) associates them with certain mental scripts. Foley (1977), on the other hand, believes that PRs denote abstract, phonological objects-a proposition, which of all other assumptions somewhat resonates with the view adopted in our current study. Coleman's (1998) view on phonological representations (bearing acoustic signatures of sounds) as something capable of supporting computations of some kind also holds importance in our present-day analysis of sounds.

As far as the presentation of PR in our present analysis is concerned, our study adopts the concept of an element in accordance with the Element theory (Kaye & Harris, 1990; Harris, 1994; Backley, 2011), which was developed as part of Government Theory. The need for a PR deviant from a traditionalistic view is necessitated by the latter's inability to explain certain facets of SSDs that simply cannot be explained by considering PR as a system that has within itself all the phonetic details of the sounds. As mentioned in the introduction, there are cases that cannot be simply explained by appealing to the PR. A case in point is a study conducted by Leahy & Dodd (1987) where it was revealed that a child with bizarre phonological processes such as the deletion of final consonants or marking them by a glottal stop, and no apparent articulatory defects produced defective sentences. Despite her ability to discriminate minimal pairs, or to recognize her own errors as errors, the subject in question exhibited abnormally deviant patterns of speech. The data demonstrated that there was no deficit in perceptual processing, indicating that there was no apparent problem with the PR as well. In cases such as this, it becomes necessary that we revise the notion of PR that can maximally account for most of the speech sounds, if not all.

In the present analysis, PR is merely viewed as a system that contains certain elements, the combination of which gives rise to more complex segments. It consists of a set of finite elements like |A|, |I|, |U| that correspond to different acoustic properties of speech sounds. To elaborate, let us take two elements |X| and |Y| that combine to give rise to a segment say z. The resultant segment z, formed by the combined acoustic properties of two or more elements, is fed into a system where it takes another form. For instance, the element |A| corresponds to central spectral energy mass where high F1 converges with F2, and the element |I| corresponds to high spectral peak where high F2 converges with F3. The physical correlates of the element |A| roughly represent the gutturals (e.g. pharyngeals, uvulars) and some types of coronals, while |I| represents palatals and other types of coronals (Backley, 2011). Likewise, the segment /æ/, which imbibes the acoustic properties of both |A| and |I|, can be viewed as the combination of both the elements.

Although the elements in PR tell the speakers which patterns they must produce, it does not tell the speaker how to produce them. The description of the sounds in terms of the vocal tract and the ways in which it constrains the production of speech sounds physically are all realized at a level beyond the PR. For now, the function of the PR is to simply provide the underspecified inputs to the system where the segments can be further processed.

What contributes to a deficiency in speaking and reading is often attributed to primarily having deficits at the level of PR. Most of the research claims that the children with speech impairments produce erroneous segments or sounds because their PR, by default, is disturbed (Bernthal, Bankson & Flipsen, 2009; Anthony et al., 2011; Johnson, Pennington, Lowenstein, and Nittrouer, 2011; Sutherland and Gillon, 2005, 2007). That is to say that the PR of a person with a speech disability and that of a person without a disability are different. In other words, it seems to suggest that the disabled have a defective PR and the abled a perfect PR. Nevertheless, more often than not, we see that linguistic phenomena like metathesis and spoonerisms are not uncommon in persons without speech disorders. While one can argue that they are mere 'slips-of-the- tongue' and therefore correspond to the articulatory factors than to any representational factors, it is also worth noting that these 'slips- of- the-tongue' also often provide useful insights into the phonological structure of the language (Fromkin, 1971; Harrikari, 1999). It is therefore suggested that it is not viable to directly dismiss or establish PR as being either imperfect in the case of SSDs, or totally perfect as in the case of persons without speech impairments. Rather, what seems to be more plausible is to view PR as a representational system that is just 'good enough' in both cases. The correct or the incorrect utterances produced at the articulatory system are not because of 'mental misrepresentations' at the PR level but somewhere else. We propose that there is an intermediate system in the cognitive system, somewhere between the PR and the articulatory system, where a variety of operations take place. We presume any malfunction at this stage can possibly lead to speech errors. We call this intermediate system an interface whose nature and functioning is discussed in the next section.

The Interface System

The concept of an interface is operationally defined in this paper as a transducing system that receives, alters, processes, and shares the phonological information from one level to the other. The notion of the interface is primarily proposed to account for the sensitivity to points of intersections between a system of PR and the articulatory system where the idea of autonomy is quite constrained. Though Ohala (1990) argues against using the term 'interface' between a system of phonology and phonetics, we choose to preserve the term for reasons which we will discuss in brief. Firstly, Ohala's objection is that an interface translates itself into a mechanism that passes the information from the system of phonology to phonetics when the two are assumed to be mostly independent of each other. Explicitly discussing the concept of an interface in the context of phonology and phonetics, Ohala contends that phonetics and phonology, for several reasons, are two domains of the same speech universe that are highly intertwined with each other. Therefore, the use of the term interface is inappropriate as it leads people to believe that the two domains are mostly autonomous, bearing very little or no interaction on each other. This work, however, chooses to use the term to designate a system in itself in line with Jackendoff's (2002) concept of interface systems, even though it does not advocate the outdated view that the system of phonology and phonetics are autonomous, as Ohala also thinks. In fact, the interface in the present context is viewed as a system that mediates the link between the two domains. We draw upon the concept of an interface as a system that does not mediate between two different domains of language but functions within the narrow spectrum of phonology. Therefore, we suggest that there are different levels within the mentally instantiated phonological system, one of which is the interface.

Thus, in line with Fodor’s (1983) conceptualization of 'domain specificity', the interface system is domain-specific in being restricted to only classes of phonological objects, and the information processed in the system (interface) is circumscribed in a comparatively narrow way. Though the proposed interface is *autonomous* in terms of its functionality and nature, it also at the same time allows for the flow of information into its mechanisms from the system of PR conceived of as an inventory of elements and their combinations. The interface is autonomous with respect to syntax and semantics, for example, only in the sense that its intrinsic functioning is not affected by the contents and operations in syntax and semantics. While the interface maintains domain-specificity, the interface system is *informationally encapsulated* relative to syntax and semantics, for example, because only phonological objects and the internal grammar for operations on such objects are relied on. However, the interface system is not *informationally encapsulated* relative to the subsystems of the entire speech sound system because it interacts with the system of PR. As for the neural architecture, the interface may be instantiated by Poeppel's (2014) *sensory-motor interface* and *phono- logical network* involving the left Sylvian parietal-temporal fissure and the bilateral superior temporal sulcus. Poeppel's *articulatory network* may not be involved because that is responsible for sound articulation, while the interface is not directly responsible for articulation

The interface system in its functioning significantly differs from Dell's connectionist model of spreading activation (Dell, 1986) because, in Dell's model, there is no scope for the mapping of the symbolic units of phonology to articulatory instructions. Besides, phonological units are not decomposed into their components-acoustic or otherwise-although the significance of phonemes is acknowledged (Dell, 2014). The idea of an interface of a similar kind has been discussed in detail by Reiss and Volenec (2017), where the interface is seen as establishing an intermediate level between phonology and phonetics. The paper's goal jells with the central idea of our line of work in terms of positing an interface that operates on its own set of rules.

Additionally, Reiss and Volenec’s work renders the transduced features $PR_{[ROUND]}$ or $PR_{[+BACK]}$ in terms of the muscular contractions that each of them relates to. It is, however, still unclear as to what exactly triggers the articulatory movements for the specific sounds. The authors also, of course, discuss how these temporally coordinated muscles are related to features, but it is not clear by what means the feature information in the sensory-motor gets translated into the actual rounding of the lips (in the case of $PR_{[ROUND]}$) or the real-time function of raising the back of the tongue (in the case of $PR_{[+BACK]}$). In other words, it is not clearly established what articulatory aspects get encoded in each specific feature and how these features interact with specific muscles. However, for the purpose of speech externalization, there has to be a mechanism that explicitly states or provides at least some kind of a signal for the articulatory movements to get started. In trying to address this key issue, the current work has adopted a model of an interface system that not only bridges the gap between the abstract mental representations of the sounds and the actualizations of the sounds, but also specifies in a series of steps what exact instructions have to be followed in order to produce a particular sound.

In spite of an indication in our theoretical model that the interface is linked to other domains of language like syntax and morphology since no sound can be produced in isolation, the study of the interaction between the interface and the other domains is outside the purview of the present study. Henceforth, the nature and the functioning of the interface will be presented as it occurs in a relatively narrower spectrum of the phonological system.

How does the interface system work?

The input received from the PR is fed to the interface module where certain operations take place. The interface module can be considered as a workspace that hosts a set of slots comprising of articulatory features pertaining to both consonants and vowels. Depending on the phonology of each person, these slots are filled up with relevant articulatory features (See figure 1). We suggest that it is usually the mapping or rather the mis-mapping of the input segment from the PR to the relevant slots that produce a defective speech.

While the gestural movements of the articulators in different combinations primarily indicate the formation of a particular sound, they also explain the human tendency to prefer specific sound patterns over others. For instance, John Ohala (1983) argues for the absence of the /g/ sound over the other voiced sounds in terms of the aerodynamic factors. He maintains that the sound /g/ is more susceptible to deletion than any other voiced plosive by the degree of its closeness between the larynx and its point of closure. Because the location of the closure is much closer to the larynx, the air pressure in the supraglottal region exceeds that of the air below the larynx, thereby leaving insufficient air to drive the vibration in the vocal cords. Similarly, we suspect that a predisposition to using certain sounds over others can be traced back to the mapping of the input segments from the PR, which can be aerodynamically motivated. While most of the errors analyzed in the model are errors due to the mapping problem as part of the interface, but these errors are not random and hence they can arise as epiphenomena or 'side effects' of the ongoings within the articulatory system. Because PR is solely a representative module devoid of articulatory slots, we presume that the articulatory or phonetic factors are *partly* instantiated in the interface (in slots) and *wholly* manifested in the articulatory system. Consequently, a mis-mapping of the underspecified input from the PR onto the wrong slot evinces the instantiation of an unintended property of a specific sound, thereby resulting in the production of a disordered utterance. This kind of analysis is particularly helpful in analyzing the sound patterns in persons with SSDs since most of the errors produced in SSDs, if not all, dovetail with patterns indicating a preference for one sound or one class of sounds over others.

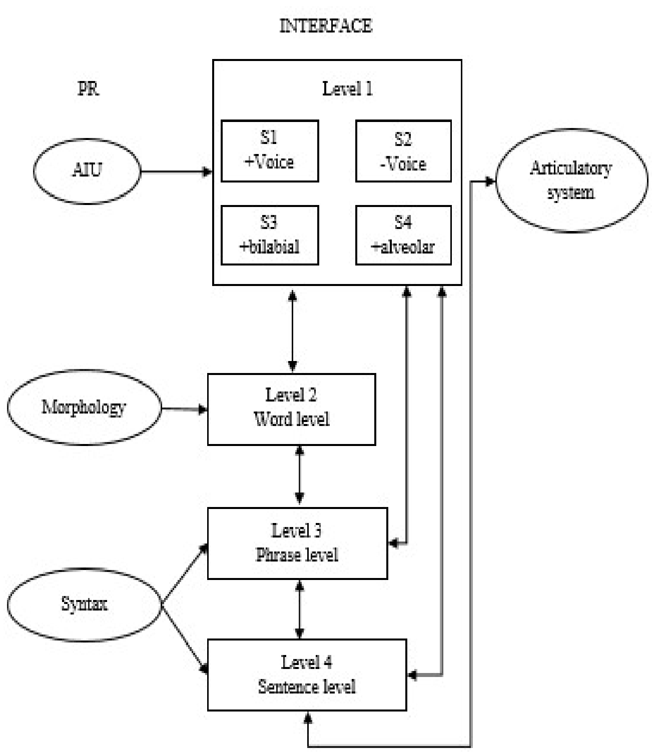

Figure 1: The model comprising of the PR, the interface and the articulatory system.

Samples of Data

Case 1

Presented in table 1 is the clinical case conducted by Barlow and & Gierut (2002) on a 4-year old child Joseph who was diagnosed with functional phonological delay. The child displayed a variety of speech errors, a few of which are currently drawn from the large-scale study to illustrate how our proposed theoretical model can accommodate the actual data. The child in question displayed normal hearing, intelligence, oral-motor functioning, and regular receptive and expressive language skills as per the formal testing procedures. Joseph’s speech data display several gaps in terms of the normalized phonetic inventory of the English language and some deviant patterns that are otherwise not to be found. The kind of errors ranged from simple substitutions and deletions to cluster simplifications or a combination of all of these. Figure 2 demonstrates level 1 of the interface in terms of how the substituted /t/ (/ tʌnɪ /) for /s/ (sunny) can be articulated, followed by their set of operations.

Table 1: Joseph's data

S.No	Target	Utterance	S.No	Target	Utterance
1	bite	bɑɪ	9	kids	kɪp
2	bus	bʌ	10	mud	mʌ
3	cheese	tɪ	11	tooth	tʊʔ
4	cut	kʌʔ	12	drive	gɑɪ
5	five	pɑɪ	13	sharp	tɑʊp
6	gift	gɪp	14	soap	to
7	toes	to	15	sunny	tʌnɪ
8	juice	dʊ	16	soup	tʊʔ

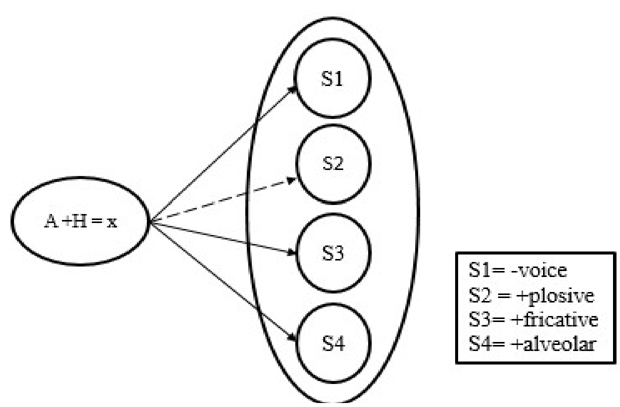

Figure 2: Straight line = correct mapping, dotted line= incorrect mapping.

Operations

For the intended utterance /s/,

Step 1: A+H = x, where x is the underspecified segment from PR

Step 2: x+S1+S3+S4 = initiation of /s/ sound

For the disordered utterance /t/,

Step 1: A+H = x, where x is the underspecified segment from PR
Step 2: x+S1+S2+S4 = initiation of /t/ sound

While the sounds /s/ and /t/ differ minimally on a single slot, they also share the same place of articulation and voice and yet the mis-mapping of one single sound may result in a collapse of contrast between two sounds. As was also seen in Joseph's case, the sound /s/ never occurred in his phonemic inventory of sounds. Hence we can possibly infer that the mapping, or rather the mis-mapping of the S2 slot from the underspecified PR segment, by way of fossilization, has permanently been established. The presence of the articulatory features and the mishaps in the operations performed at the level of the interface also serve as an explanation as to why Joseph's receptive skills are still intact, despite his inability to produce the sounds correctly. Because the present model considers PR to be an efficient system with almost no malfunctions within it, we assume, Joseph still displays the capacity to understand /s/ and /t/ as two distinct sounds.

Case2

In case 1, we have looked at errors of substitutions and their operations at the interface level. We will now look at how deletions can possibly be explained by the model. For that purpose, we will consider another set of sample data from a case study conducted on a subject named Josie between the ages of two and five (Bowen, 2015). Josie was diagnosed with developmental verbal dyspraxia (DVD) and had performed poorly on articulatory tests. Her speech was rendered unintelligible despite maintaining a mid-range receptive, expressive, and total language score. The data used in table 2 are impoverished and a part of the sample prior to the intervention.

Table 2: Josie's data

S.No	Target	Utterance	S.No	Target	Utterance
1	cup	kʰʌ	11	snake	fneɪʔ
2	gone	kʰɒn	12	house	hæʊ
3	Knife	nɑɪ	13	toe	tʰoʊ
4	sharp	wja:	14	mouth	maʊ
5	fish	de	15	nose	noʊ

Josie's disorder was severe and often exhibited patterns that were most likely unintelligible. Though intervention studies altered Josie's speech at a later stage, for the purpose of our study, we shall first try to investigate what, in the first place, had caused such chronic distortions. Josie exhibited a range of patterns starting from single sound substitutions and deletion to the production of sounds that bore no resemblance to the target word. One possible explanation for the case of deleted sounds could be traced back to the inactivity in the slots. That is, there could be instances when the slots do not function actively even in the cases when they are required to do so. The inactivity of a slot can eventually lead to two consequences: firstly, the segment generated from the PR, upon finding the slot inactive, deviates to other slots, thereby producing a different segment. So far, this mis-mapping has served as an explanation for the substituted sounds. Secondly, the segment generated from the PR, upon finding the slot inactive or invalid, does not end up being assigned any feature. However, in this case, the segment does not get itself 'attracted' to the wrong slot. Instead, the segment is left in situ, devoid of any articulatory features to process. Specifically concentrating on the case of /p/ deletion in the word 'cup', we speculate that the slots holding the corresponding features of /p/ fail to assign the articulatory features to the segment generated from the PR. Moreover, because the segment has been assigned a null value, no particular articulatory instruction is taken forward for the next levels. As a result of this, there is no production of the sound /p/ in the articulatory system. The transitory nature of the slots also justifies why certain slots holding features like –voice remain passive in the production of /p/ but stay active in the production of other voiceless sounds like in the production of /f/. It is plausible that certain slots can go inactive for certain element combinations in this way due to the impact of relevant aerodynamic factors, as discussed in the previous section. Hence, it is essentially the nature of the slots that result in the deletion and not the mapping. Illustrated in figures 3a and 3b are the inactive slots in /p/, and the active slots in /f/ respectively.

Significantly, the current model can capture other datasets, two of which are briefly discussed here. The first case comes from the numerous studies conducted on pre-school children with speech impairments (Sutherland & Gillon, 2005). The data involve a wide range of substitution errors in both vowels and consonants. While there are some observable patterns in terms of which syllables (stressed or unstressed) or segments (either consonants or vowels) were generally prone to disarticulation in the children, the quality of the sounds produced is highly impoverished. The second is a case history of a 3-year-old child Kirk (Bernthal, Bankson, & Flipsen, 2017) who exhibits poor intelligibility in speaking despite having normal motor and language development. The child displays unusual processes like initial consonant deletions or final constant deletions, which are atypical for a 3- year-old child. As far as the substitution errors are concerned, the analysis has revealed that stopping was the most dominant and the most preferred process of all. With /d/ substituting the likes of /f/, /v/, /θ/, /d/, /s/, /z/, /ʃ/, /tʃ/, and /dʒ/, the sound emerged as the most prominent sound in Kirk's vocabulary. A similar pattern was also observed in Joseph's case, where the child had also exhibited a similar preference for the use of plosives instead of fricatives and affricates.

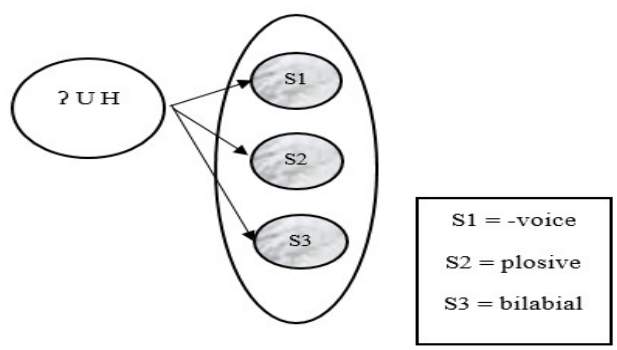

Figure 3a: The inactive slots in /p/ indicated by the marbled slots.

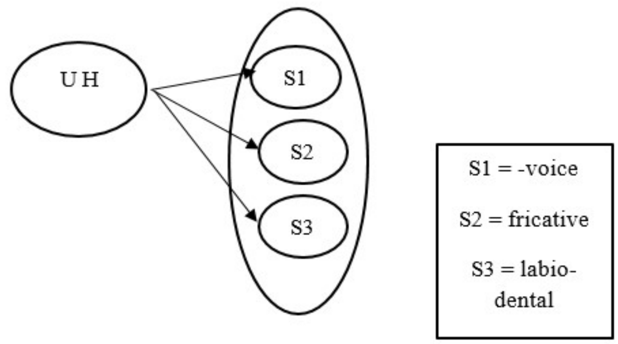

Figure 3b. The active slots in /f/ indicated by the plain slots.

Beyond Level 1 of the Interface

Though there are no coarticulation, assimilation, or preservative errors to be found in the present data, our present model can in fact account for those types of errors, if necessary. The levels within the interface system are not sub-modules that are strictly compartmentalized but are presented in a fashion such that they feed information, albeit in constrained ways, into each other. Level 1, which happens to the most important levels of all (because the initiation for the primary articulation takes place here) is connected to all the other levels in a bidirectional way. The word level, phrasal level, and the morpheme level are all again connected to each other in a bidirectional way. To illustrate how this functions, let us take the example of the production of sound /f/. Let the elements U and H combine to form an underspecified segment say x. 'x' is then rightly associated with the slot which provides the feature -voice. The sound thus generated passes on to level 2 (the word level), where it checks for the neighboring sounds. If there is a possibility of the segment getting altered, as in the case of coarticulation, it reverts to level 1 (since we mention that it is a bidirectional system) and picks up the required slot. The newly generated sound is again sent to the word level and further on. If the neighboring sounds do not affect the sound in any way, then they simply get carried on to the next level. The set of operations that occur at this word level can be schematized as follows:

Case 1: If f→f, then move to level 3.
Case 2: Step 1; If f→x, then revert to level 1, where x is the new modified sound
Step 2; Select new slot
Step 3; Generate required sound
Step 4; Pass through level 2

Similarly, the shifts in sounds at the phrasal level and the sentential level can also be explained by connecting them to level 1, both in disordered and typical speech.

Implications

The representative errors in SSD complexities, specifically those concerning the sound structure, stem from either 'misrepresented symbols' or from various processing deficits. Therefore, in order to have differential diagnosis and treatment therapies for the SSDs, the SSD classification must be efficiently established. Based on the earlier developments, and the current advances in neurolinguistics, several systems of SSD classifications have been proposed, some of which have had implications for the differential diagnosis and treatment planning. (Waring and Knight, 2013; Shriberg et al., 2010; Dodd, 2014; Stackhouse and Wells, 1997). However, these classifications, as Terband et al. (2019) claim, do not thoroughly explore the relationships between the different levels of causation, and hence, may deter efficient diagnosis, customize intervention, and optimize outcomes. The present cognitive model explores different levels in the speech sound system and thereby identify the 'cause' of the speech deficit. The implications of such a model extend to an advantage in recognizing SSD subtypes that evince a perfect PR and yet a defective speech output. The ability of SSD patients to identify and discriminate phonemes in relation to their ability to produce sounds, measured on standard clinical diagnostic tests, for instance, serves as a good predictor of the PR efficiency. Thus, an experimental validation of the model, which is beyond the scope of this paper, can be fruitful.

Further study

Owing to the dearth of data that specifically relate to the mental representations of sounds, and to cases where the PR is presumably good enough, this study has been able to look at only few issues. Firstly, this study does not take into account other levels of speech errors occurring at syllabic and discourse levels. It is hoped that a segmental view at first would provide the appropriate information which would, in the future, contribute to accounts for the phrase or discourse level as well. Secondly, this study has looked only at the word substitutions deletions and no other frequently occurring linguistic phenomena such as transposition at a segmental level. The inclusion of other linguistic phenomena such as transposition would require further modifications to the present model.

Conclusion

The present study has attempted to explain why certain clinically notable segmental speech errors, which cannot be explained by significant impairments in the motor, sensory, or even mental representations of sounds, occur in cases of SSDs. The concept of an interface module has been advanced with possible miscalculations at any level of coding resulting in an inaccurate or an unintended utterance. As of now, claims cannot be made if this particular model suffices for all kinds of segmental errors, but further inquiry can help fine-tune the present model further.

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