Exceptionality of /s/: Evidence from Aphasia

SHANNA PHILLIPS

1. Introduction

This paper will look to aphasic speech production for insight on phonological properties of spoken language in general. Aphasia is a type of language deficit resulting from stroke, lesions, or other kinds of injury to speech processing areas of the brain. Its effects can devastate a person's ability to interact with others through verbal communication. Although aphasic speech can seem nearly incoherent in severe cases, the errors produced carry a wealth of meaning about how language is produced.

The particular point of interest in this paper, the /s/ consonant, has been highly scrutinized within the context of child language and second language acquisition, but less often as a focal point in aphasic error analysis. Borrowing from several studies investigating syllable structure and cluster treatment in aphasic speech, this study will attempt to determine a few generalizations in support of theories on the exceptionality of /s/.

First, this paper will provide background information about various types of aphasias that differ according to symptoms and location of injury in the brain. It will then review some of the unique phonological properties of the /s/ phoneme. A sample of studies examining the /s/ consonant in developing child speech and second language acquisition will then be covered. This paper will then go on to review aphasic research that discusses syllable structure and the treatment of consonant clusters in aphasic speech, including what has been suggested of /s/ clusters. Finally, data inclusive of /s/ cluster tokens gathered from various aphasia analyses will be presented, accompanied by an examination of the findings in terms of the phonological properties /s/.

2. Background

Aphasia

The study of aphasia recognizes several varieties of aphasia that are classified by symptoms and by areas of the brain where injury occurred. The Boston School of Aphasia provides a localization model and diagnostic test widely referenced in aphasic studies and rehabilitation programs (Damasio 1981). Some of the types of aphasia identified in this framework are discussed here.

Broca's aphasia, named after nineteenth-century anthropologist and founder of aphasic studies, Pierre Paul Broca, is a type of aphasia resulting from damage to the region of the brain called the anterior third frontal convolution. Broca's aphasia is characterized by slow, halted, agrammatic speech, often lacking function words, morphemes, and in some cases, verbs in general. However, the ability to comprehend speech remains intact in Broca's aphasia (Kearns 1997).

Wernicke's aphasia, named after its discoverer, Carl Wernicke, results from damage to another language processing area of the brain located in the posterior region of the superior temporal gyrus. Unlike Broca's aphasics, Wernicke's aphasics produce fluent, but somewhat incoherent speech comprised of paraphasias and neologisms. Paraphasias are aphasic utterances containing phonological modifications to a known target word, whereas neologisms are produced independently of a target word. In addition to a decreased ability to comprehend speech, Wernicke's aphasics show a lack of self-awareness in their language deficit (Roth and Heilman, 2000). Impaired ability in writing, reading comprehension, and in repetition of words is also characteristic of Wernicke's aphasia (Graham-Keegan, Caspari 1997).

Conduction aphasia, a type of aphasia marked by fluent speech, results from a lesion that disrupts the connections between Broca's and Wernicke's areas of the brain. Unlike Wernicke's aphasia, grammar and comprehension remain intact, although repetition is impaired. Conduction aphasics are able to recognize their own speech errors, but correction and word retrieval is often labored (Simmons-Mackie 1997).

Transcortical aphasias form another class, including transcortical motor, sensory, and mixed transcortical aphasias. Transcortical motor aphasia occurs from damage to the right hemisphere of the brain, resulting in an inability to produce spontaneous speech, but a preserved ability to repeat words – an incongruity indicating that these two levels of speech are processed in different areas of the brain. Transcortical sensory aphasia exhibits similar characteristics, but with impaired comprehension. Mixed transcortical aphasia is a non-fluent aphasia with spared repetition, but hindered comprehension (Cimino-Knight, Hollingsworth, Gonzales-Rothi, 2005).

There are numerous other rare aphasias, some of which include: global and anomic aphasias, alexia with and without agraphia, and pure word deafness. Atypical aphasias include those which do not fit into any one category (Damasio 1981).

This paper will not be limited to any particular type of aphasia, but will rather focus on the behavior of /s/ and /s/ clusters in aphasic utterances where the target words are known (i.e. paraphasias). These paraphasias will be examined for their adherence to the phonological properties reviewed in the next section.

/s/ and Universal Violations

As a fricative, /s/ is the only obstruent that occurs before nasals /m/ and /n/ and in three consonant-clusters where the second segment is a stop and the third an approximant. As a coronal, /s/ violates the Obligatory Contour Principal (McCarthy, 1986), which requires distinction in adjacent segments, because it occurs next to other coronals in English onsets such as /st/, /sn/ and /sl/ and in codas, /ts/, /ds/, /ns/, and /ls/.

Most notably, /s/ violates the Sonority Sequencing Principle (SSP), which groups segments by class according to the level of noise they produce. The sonority hierarchy consists of vowels, glides /j, w/, liquids /l, ɹ/, nasals, and obstruents (including stops and fricatives). The SSP places constraints on the structure of a syllable so that sonority rises from the edges of the syllable and reaches a peak at its middle, or nucleus, usually consisting of a vowel. (Clements 1992, Roca & Johnson 1999). The Sonority Dispersion Principle asserts that the rise in sonority is sharper in the onset and first half of the syllable, or demisyllable, than in the second demisyllable (Clements 1992). These constraints place restrictions on the segment combinations that are permitted in onsets and codas in human languages. Therefore, while it is unlikely that an onset cluster would occur in the order /lp/ or /kt/, such clusters do occur in coda position since they fall in sonority. If these segment combinations were to occur at the beginning of a syllable, the consonants /l/ and /k/ would most likely constitute the nuclei of their own separate syllables – a feature that appears in languages like Berber and Bella Coola (Dell and Elmedlaoui 1985, Bagemihl, 1991).

Different means of ordering the segment classes in the sonority hierarchy have been proposed. Clements (1992) and others (including Roca and Johnson 1999) have suggested a hierarchy that includes the following classes, ranked in ascending sonority:

Obstruents < Nasals < Liquids < Vowels.

Many (among others, Barlow 2001, Broselow 1987, Geirut 1999, Morelli 2003, Weinberger 2002) specify fricatives in a category separate from stops within the obstruent category, accounting for the following sequence:

Stops < Fricatives < Nasals < Liquids < Vowels.

This ordering recognizes the higher sonority of fricatives and justifies /s/+stop coda clusters in English, but lends no better explanation than the first ordering for the exceptionality of /s/+stop onset clusters in violation of the SSP.

Having presented background information about the many varieties of aphasia and the peculiarities of /s/, this paper will proceed with brief reviews of literature on the uniqueness of /s/ clusters in the areas of child and interlanguage phonology.

3. Review of Literature

/s/ in Child Phonology

Several viewpoints are argued for the treatment of /s/ clusters in child language acquisition. These theories generally argue over appropriate underlying representations of /s/ clusters through analyzing deletion errors in child speech production. Four studies, which supply a sample of the range of viewpoints on this topic, are reviewed here.

By analyzing errors resulting from reductions in word initial consonant clusters in the Iowa-Nebraska Articulation Norms Project, Smit (1993) found that two-segment /s/-clusters typically reduced to the nasal, approximant, or stop. In very young age groups, /s/+nasal clusters were produced as nasalized /s/s or were substituted by other nasal-like sounds. In three element clusters /skw, spl, spr, str/, reduction to one element occurred sometimes to the approximants and stops, but rarely to /s/. Patterns of reduction to two segments were highly variant, but interestingly, the children rarely reversed the ordering of the /s/+stop clusters (e.g. in which /st(r)/ became /ts(r)/). In general, reduction to a single element occurred more often in two-segment /s/ clusters than in three-segment /s/ clusters. Smit concluded that due to markedness, /s/ had the highest deletion rates in onset clusters overall.

The assumed markedness of /s/ due to its violation of the SSP was challenged in Gierut's study (1999), which concluded that the /s/ in /s/+stop clusters /sp, st, sk/ is an unmarked adjunct. Smit's study noted that /s/ clusters are acquired relatively early in child speech at the age of 4, but did not distinguish between the acquisition of /s/+stop clusters and what Gierut calls "true /s/ clusters" - /sl, sw, sm, sn/. Gierut's study consisted of 2 experiments, the first one determining the markedness of adjunctive sequences in general through manipulation of sonority sequencing, and the second one which found differential patterning in acquisition between true /s/ clusters and /s/+stop clusters. With these findings, she concluded that in /s/+stop clusters, /s/ is an adjunct attachment to the main syllable in its structural arrangement, thus supporting the theory that /s/+stop sequences, like other adjunctive sequences, are unmarked.

In their analysis of cluster development in disordered child speech, Barlow and Dinnsen (1998) addressed the /s/-cluster issue using an Optimality approach. Optimality Theory (Prince & Smolensky, 1993) provides a non-derivational account for grammatical preferences in surface output forms. In such a system, output forms are governed by the ranking of constraints that determine faithfulness to input forms and markedness of phonological features. As a child's grammar develops, constraints are re-ranked according to which features emerge and disappear. Given that several child language acquisition studies show conflicting evidence for underlying representations of /s/ clusters, an Optimality approach accounts for individual outliers of developmental norms. Such an approach also allows for different representations of a particular /s/ cluster to be referenced in the same system at different points in time in a continuously developing manner.

Barlow and Dinnsen's study (1998) followed the development of a child with a speech disorder at three different stages between the ages of 4 and 9. At stage one, no target /s/ clusters (/sw, sl, sm, sp/) were produced, and were determined to be represented as single complex segments in their underlying structures. At stages 2 and 3 /sw/ and /sl/ were produced as /w/ and /l/ while /sm/ and /sp/ remained unrealized in production. These findings suggest that /s/+nasal and /s/+stop clusters may be represented as affricates, in which the "onset node dominates a single root node that branches into a sequence of contrasting features…[or] in which a skeletal point branches into two separate root nodes, each dominating its own specification of the relevant feature" (p. 5)

Barlow (2001) took a similar, but revised approach in another study focusing primarily on the acquisition of /s/ clusters in the speech of a child with a phonological disorder between the ages of 3 and 4. Three stages of development were analyzed in which the child initially reduced all consonant clusters to singletons. During the second stage, the child produced only /s/ sequences correctly, but by the final stage, was able to produce all clusters correctly. Constraint rankings ultimately showed that by the third stage all /s/ sequences surfaced as adjuncts as opposed to affricates, as determined in the previous study. Again, this approach claims to account for asymmetries in cluster development in a continuous manner and allows for varying structural representations of /s/ clusters through the re-ranking of markedness constraints that disallow complex onsets.

/s/ in Interlanguage Phonology

Second language acquisition of English is marked by a tendency to insert elements, usually vowels, before or within consonant clusters in a process called epenthesis. This process is more likely to occur in speech where the first language is less complex in syllable structure than in the second language. Epenthesis may be attributed to language specific transfer, but may also occur between two similarly complex languages as a universal tendency to prefer unmarked structures in L2 production.

Broselow (1987) found that the process of epenthesis in second language (L2) acquisition of English by Egyptian and Iraqi Arabic speakers occurred differently in sonority violating clusters (i.e. /s/+stop) than in other kinds of clusters. She found that in two element /s/ clusters, epenthesis occurred between the two consonants in /sl/ clusters, but before the cluster in /sn/ and /st/ clusters. In three element /s/ clusters Iraqi and Egyptians showed different patterns. Iraqis split the clusters between the first and second segments in words such as ‘street’, ‘splash’, and ‘square’ whereas the Egyptians epenthesized in two places – before the entire cluster and between the stop and approximant segments. She then revisited two-segment /s/+stop clusters in Egyptian speech and found that epenthesis occurred between segments in /s/+approximant clusters, but before the segments in clusters including an /s/ and a stop. From these data she concluded that differences between Iraqi and Egyptian errors may have occurred due to influence of L1 transfer, and that the Egyptian propensity to not split /s/+stop clusters lent support to the theory that such clusters may function as a single consonant.

Karimi’s review (1987) of Farsi treatment of English clusters showed results contradictory to Broselow’s. She found that Farsi speakers treated all /s/ clusters in the same way – that is they epenthesized before all /s/ clusters, as she noted Spanish speakers of English also tend to do during English L2 acquisition. This kind of epenthesis, however, only occurred before /s/ clusters, as the speakers tended to split other kinds of clusters that do not include /s/. She also noticed that epenthesis in L2 Farsi did not occur in the same way as in L2 English. In Farsi, speakers epenthesized between clusters. Using this observation she argued that epenthesis was not an attribute of transfer as Broselow (1987) had determined. Karimi’s results suggested that /s/ clusters may be interpreted as single units or affricates in English, but as adjuncts in Farsi.

In a study conducted by Fleischhacker (2001) asymmetries in epenthesis before sibilant + stop clusters and between obstruent + sonorant clusters showed evidence for highly ranked faithfulness constraints in L2 speech. In regard to /s/ clusters, this evidence gives rise to the theory that they are ranked on a continuum of sonority as follows: ST < SN < SL < SW.

Finally, Weinberger’s accent archive survey of over 700 L2 English speakers (2009) gives compelling evidence for the following generalizations about /s/ clusters: adult L2 speakers treat all /s/ clusters similarly, although they treat all /s/ clusters differently from other types of clusters. Overall it shows that L2 speakers are attending to the exceptional nature of /s/.

The literature reviewed above covers a small sample of the arguments on /s/. Some child language acquisition research supports the viewpoint that /s/ is marked due to its violation of the SSP, which is indicated by high /s/ deletion rates in onset clusters. Another viewpoint argues that differential patterning in acquisition between /s/+stop clusters and other /s/ clusters suggest that /s/ is an unmarked adjunct in /s/+stop sequences like any other adjunctive cluster. Other studies assert that /s/+nasal and /s/+stop clusters may be represented as affricates, while others assert that all /s/ clusters act as adjuncts. What all these studies have in common, however, is that they find that /s/ clusters are treated differently from other kinds of clusters.

Second language acquisition studies arrive at a similar generalization. Some have found that /s/+stop clusters are treated differently from all other kinds of clusters not in violation of the SSP. Others find that all /s/ clusters are treated the same within their own class, but differently from other kinds of clusters. /s/ clusters have also been argued to follow a sonority hierarchy within their own class. Although discrepancies remain about the details of how /s/ is treated, the consensus in the studies reviewed here is that /s/ is unique in interlanguage phonology.

Syllable Structure in Aphasia

Linguistic studies in aphasia cover a broad range of topics with different goals in mind. Some studies focus on finding better measures for rehabilitation and assessment methods, and some look for possible explanations for anatomical connections to language. Other kinds of research observe aphasic speech production as a means of gaining further insight into the properties of language in general; the following studies explore this avenue while also probing for patterns which reveal information about the nature of aphasic speech in its own right.

It has been argued that aphasic speech shows a general trend of movement towards the preferred syllable type (CV) in both paraphasic reduction and neologistic production. Studies focusing on neologistic productions (target word unknown) found the most common type of syllable structure to be in favor of the CV type, where the consonant is most often an obstruent. Christman (1992a,b) asserts that aphasic speech generally abides by the SSP. Stenneken et al. (2005) determined that German speaking aphasics preferred the CV syllable type and never used sounds from outside the German segment inventory.

Blumstein (1978) identified four major types of errors in aphasic speech: the substitution of one phoneme for another, syllabic and cluster simplification, addition of phonemes, and errors triggered by environmental influence of surrounding phonemes. The most common types of errors noted were phoneme substitutions, followed by syllable simplification and segment addition. Most simplification errors occurred around clusters, slightly over half of which were codas. Addition errors gave evidence for the influence of featural specifications of the segmental context within a target word. The simplification errors observed in this study give strong evidence for movement towards the preferred syllable type.

Stark and Stark, (1990) took a nonlinear metrical approach to analyzing syllable structure in Wernicke's aphasia, yielding several notable conclusions about paraphasic speech. They found that more errors occurred in relation to the complexity and number of syllables in a word, and that errors typically occurred in later syllables. The majority of errors produced within syllables affected syllable codas whereas nuclei remained least impaired. In neologistic speech, they found that subjects produced utterances that generally followed natural syllable organization, i.e., they abided by sonority sequencing (except in the case of /s/ or /ʃ/+stop violations).

In Baum's word game study (2002), control and aphasic speech was tested for sensitivity to sub-syllabic constituents. In other words, through word manipulation, Baum set out to determine if aphasics were sensitive to sonority sequencing and if they would treat onset and coda clusters in a similar manner as non-aphasic speakers. The game consisted of words starting with different clusters, in which participants were asked to insert a syllable (e.g. aez or ib) somewhere. Subjects most frequently preserved the integrity of clusters as opposed to inserting the syllable between clusters. The findings suggested that both right and left hemisphere damaged patients were still responsive to sonority sequencing. In cases where clusters were separated, fluent Wernicke's aphasics showed the highest rate of splitting onsets.

4. Data and Analysis

Data in this section are derived from studies on aphasia including some of those mentioned in the previous section. This analysis pulls data on /s/ from these studies to build an argument on the exceptionality of /s/.

The first set of data is derived from Valdois' 1990 study on the internal structure of clusters in aphasic speech. Samples were elicited from a group of French speakers with Wernicke's, Broca's, Conduction, and Anarthric Aphasia, and illustrate the highly variable nature of aphasic speech. This list pertains to reduction in /s/ cluster onsets in which the preservation of /s/ was sometimes preferred over preservation of the stop. Clusters were also created by the attachment of /s/ to word initial stop onsets.

/S/-CLUSTERS

<u>REDUCTION</u>

ONSETS

reduction to /s/		**reduction to stop**	
target:	**production:**	**target:**	**production:**
/stasjɔ̃/	/sasjɔ̃/	/staty/	/taty:/
/staty/	/səty:/	/spesjal/	/pesjal/
/elastik/	/elasik/		
/estoma/	/esomo/		

<u>CREATION</u>

target:	**production:**
/kulwaR/	/skulwaR/

Valdois asserted that “with respect to /s/ clusters, a trend for more omission errors in the C1 position becomes apparent word-initially when /st/ clusters are excluded from the analysis” (Nespoulous and Villiard 1990 p. 266). The variability in reduction of /st/ clusters seen in the list above is possibly explained by the coronal property of /s/ and /t/ as well as their proximity in sonority. Other stops, /p/ and /k/, do not share the coronal feature with /s/, thus are not as susceptible to deletion in either direction.

The deletion of /t/ instead of /s/ does not lend support to the sonority dispersion principle which would prefer /t/ in syllable initial position over /s/. Nor would the assumed deletion of the /s/ in clusters that do not violate sonority sequencing, /sw, sl, sn, sm/, follow the dispersion principle. The violation of the sonority dispersion principle in these deletion patterns provides another example of the exceptionality of /s/.

In the example of cluster creation above, the attachment of /s/ in C1 position as opposed to C2 position is again significant in that the resulting cluster violates sonority sequencing. Valdois states, “all created /s/ clusters result from the addition of a consonant in the C1 position” (Nespoulous and Villiard 1990, p. 265) and “no /s/ cluster was created by addition of a segment in the C2 position (p. 263). The creation of /s/ clusters that pattern in violation of sonority sequencing gives further evidence for the exceptionality /s/.

In OL cluster creation listed in the data below, variation in the position of the added element is exhibited in addition to segment substitution. However, note that sonority violation does not occur in these paraphasias. In contrast to the sonority violations produced in /s/ cluster creation, the creation of natural OL clusters does not violate sonority sequencing.

OL CLUSTERS

REDUCTION

ONSETS

reduction to obstruent | **reduction to liquid**

target:	**production:**	**target:**	**production:**
/tRibynal/	/tibynal/	/glas/	/la:s/
/pRɔblɛm/	/pRɔbɛ:m/	/vRɛ/	/Rɛ/
/pyblik/	/pybɪk/	/telegRam/	/teneRamœ/

CREATION

target:	**production:**
/Rɔbinɛ/	/pRobinɛ/
/lãg/	/glãg/
/tabuRɛ/	/kRabuRɛ/
/maRekaʒ/	/makRakaʒœ/
/tRiko/	/tRiklo/
/flakɔ̃/	/flaklɔ̃/

Like /s/ cluster reduction, the OL cluster reduction listed here show varying patterns of C1 and C2 deletion. Some are reduced to the obstruent while others are reduced to the liquid. However, in reference to all data covered in this study, Valdois concluded that “with respect to OL clusters, a consonant is more often omitted…in C2 position” (p. 265) This finding contradicts the pattern found in /s/ clusters as mentioned earlier, with exception to the /st/ clusters featured in the data set.

The reduction and creation patterns in this study indicate that while deletion patterns may not result in maximal onset dispersion, creation patterns follow natural sonority contouring – that is, non-violation of sonority in OL clusters and violation in /s/ clusters. In general, this study demonstrates that /s/ clusters are clearly treated in a different manner than other kinds of clusters in aphasic speech.

Like Valdois’ study, Blumstein’s study (1978) shows a peculiar pattern involving /t/ in the creation of /s/ clusters (e.g. /sawθ/ → /stawθ/) as opposed to their reduction. Blumstein notes, “of the possible addition errors which could occur in the environment of initial /s/ (i.e. /p t k m n w l/) the addition of /t/ occurred 50 percent of the time” (Bell and Hooper 1978, p. 197). The frequency of the addition of /t/ in this environment would have been only 14.3 percent if the probability were distributed evenly among the possible segments in /s/ combinations. It is argued that the high rate of the addition of /t/ may be due to its featural similarity in place of articulation and voicing to /s/. In a sense, /s/’s features are what attract /t/ in the creation of a complex onset. However, this process of cluster creation does not imply the random combination of featurally similar segments, but abides by the sequential constraints of the particular language spoken by the aphasic.

While the creation of /st/ and other /s/+stop clusters violates sonority sequencing, the same trend does not occur in other cluster creations. Hence, in examples like:

target:	**production:**
/tami/	/trami/
/beisbɔl/	/beisbrɔl/

sonority sequencing is still obeyed in the addition of the new segments. Again, this contrast shows that aphasic speech is sensitive to sonority sequencing, and that /s/ is treated differently from other consonants, just as it would be treated in non-aphasic speech.

Finally, a study conducted by Ouden and Bastiaanse (2003) is reviewed here, which gives a comprehensive account of /s/ cluster deletion patterns. The study argues that phonemic paraphasias are a result of articulatory impairment whereas fluent aphasia is affected at the phonological level. Using evidence from cluster deletion Ouden and Bastiaanse make several important claims about this argument and about the treatment of /s/. In /s/+stop onset clusters, they found that /s/ was not as vulnerable to deletion as others have claimed in regards to the Sonority Dispersion Principle. Government Phonology claims that /s/ belongs to the previous syllable and is "licensed" by the following stop. In /s/ clusters, where the second segment is more sonorant than /s/ (e.g. slip), the more sonorant segment is more likely to be deleted, which is considered in this model to be a "dependent" of /s/. In codas, deletions between sonorant and non-sonorant segments are relatively equal in fluent speech, while the sonorant segment is more likely to be deleted in non-fluent speech.

Overall, onset and coda deletion patterns are found to be equivalent between non-fluent and fluent aphasics. This study assumes that /s/ is phonologically unique in terms of sonority. It reviews this factor by observing the different deletion patterns between sC[-son] and sC[+son] clusters. While /s/+stop clusters prove unique at the phonological level, they are assumed here to not involve articulatory difficulty. Given this, Ouden and Bastiaanse posit that the processing of non-fluent aphasic speech not only occurs at a phonetic level, but may also occur earlier at a cognitive or phonological level.

5. Conclusion

This paper has presented sufficient evidence for the special treatment of /s/ in aphasic speech. Having reviewed similar processes in child language and interlanguage phonology, it suggests that aphasic speech, although impaired, still retains the phonological properties found across languages and other exceptional grammars. In turn, it confirms theories about certain phonological propensities – in this case, the curious sonority violations of /s/ - and other fundamental constructs of language.

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