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ALAPSZAKOS SZAKDOLGOZAT

Zárhangok elemzése /s/ után az angolban
Analyses of stops after /s/ in English

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Abstract

The contrast between the stops /p, t, k/ and /b, d, g/ is neutralized when they follow /s/ word-initially. So in words like *spin*, *steam*, or *skin* the stops after /s/ are not voiced and not aspirated, which raises the question of whether these stops should be analysed as fortis or lenis. Some linguists argue that the sounds after /s/ should be analysed as /p, t, k/, while according to others, /b, d, g/ is the preferable solution. For example, Kahn (1968) and Iverson and Salmons (1995) analyse the stops as /p, t, k/ and they offer different explanations on why these sounds are not aspirated, as opposed to Davidsen-Nielsen (1969) who prefers to analyse the sounds after /s/ as lenis. Kahn explains the lack of aspiration with syllable structure, while Iverson and Salmons give a phonetic explanation for the absence of aspiration which is based on the [spread glottis] feature of fortis stops. Davidsen-Nielsen, on the other hand, suggests that the sounds after /s/ are closer to the lenis ones phonetically, therefore they should be analysed as /b, d, g/. This thesis explores these different approaches to the issue and discusses whether /p, t, k/ or /b, d, g/ might be the favourable analyses of the stops after /s/.

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1. Introduction

The contrast between the stops /p, t, k/ and /b, d, g/ is neutralized when they follow /s/ word-initially. So in words like *spin, steam,* or *skin* the stops after /s/ are not voiced and not aspirated, which raises the question of whether these stops should be analysed as fortis or lenis. Some linguists argue that the sounds after /s/ should be analysed as /p, t, k/, while according to others, /b, d, g/ is the preferable solution. For example, Kahn (1968) and Iverson and Salmons (1995) analyse the stops as /p, t, k/ and they offer different explanations on why these sounds are not aspirated, as opposed to Davidsen-Nielsen (1969) who prefers to analyse the sounds after /s/ as lenis. Kahn explains the lack of aspiration with syllable structure, while Iverson and Salmons give a phonetic explanation for the absence of aspiration which is based on the [spread glottis] feature of fortis stops. Davidsen-Nielsen, on the other hand, suggests that the sounds after /s/ are closer to the lenis ones phonetically, therefore they should be analysed as /b, d, g/. This thesis explores these different approaches to the issue and discusses whether /p, t, k/ or /b, d, g/ might be the favourable analyses of the stops after /s/ in English.

2. Background

2.1. Fortis–lenis contrast in English

English is an aspirating language, which means it "contrasts voiceless aspirated fortis stops with passively voiced lenis stops in word-initial and word-medial contexts" (Jansen, 2004, p. 1). One of the phonetic properties that contrasts the fortis stops /p, t, k/ and lenis stops /b, d, g/ is force of articulation. The fortis stops tend to be pronounced with relatively more muscular energy, than the lenis stops; hence the names strong or fortis and weak or lenis (Cruttenden, 2014). The laryngeal contrast between fortis and lenis stops can be maintained by aspiration or voicing in word-initial and word-medial position. Voice is not a constant feature of lenis stops; they can be passively voiced only in certain positions. Lenis stops can be passively voiced when they occur between vowels and sonorants, however, in other positions they are partially or fully devoiced. For example, /b, d, g/ are voiced in *labour, leader, eager, language or penguin,* but they are partially or completely voiceless in *bill, done* or *game* (Cruttenden, 2014). Therefore, in the case of minimal pairs like *bill–pill, time–dime, clue–glue* voice is not a contrastive feature. Since /b, d, g/ are partially or completely devoiced word-initially, here the aspiration of the fortis stops /p, t, k/ maintains the contrast. The next section discusses aspiration.

2.2. Aspiration of fortis stops

Aspiration is defined as "a voiceless interval consisting of strongly expelled breath between the release of the [fortis] plosive and the onset of a following vowel" (Gimson, 1980, p. 153). Aspiration can occur when a vowel follows /p, t, k/, but it can also be manifested in the devoicing of an adjacent approximant, /l, r, j, w/. When a fortis stop is articulated with aspiration, first closure is made, which causes pressure to build up behind the obstruction. After the closure is released the formulation of the next vowel or approximant starts, but its voicing starts only later. The time interval between the release and the voicing of the next sound is referred to as Voice Onset Time (VOT) (Kahn, 1968, p. 70). There are three different types of VOT: negative, zero and positive. If voicing was ongoing before the release it is called negative VOT. Zero VOT refers to when voicing and the release happens at the same time. Positive VOT means that voicing starts later than the release. Thus, aspiration is associated with positive long-lag VOT. When the voicing of the next sound starts later than 35 msec it is referred to as long-lag. If the time interval is shorter than that, it has a short-lag VOT and the articulated sound is considered to be voiceless unaspirated (Keating, 1984, p. 295).

The traditional rule to account for aspiration was that "/p, t, k/ are aspirated if and only if they stand before a stressed vowel, and do not follow /s/" (Kahn, 1968, p. 69). Another rule states that /p, t, k/ are aspirated when they are initial in an accented syllable (Gimson, 1980, p. 153). So for example /p, t, k/ are aspirated in *pin* [pʰɪn], *tin* [tʰɪn] and *kin* [kʰɪn], and aspiration is manifested in the devoicing of the following approximant in *please* [pl̥ɪjz], *try* [tr̥ɑj], *twice* [tw̥ɑjs], and *queue* [kj̥ʉw]. Kahn (1968) says that the length or strength of aspiration correlates with the amount of stress the following vowel has (p. 70). Considering sentences, /p, t, k/ in words with primary stress have stronger aspiration than secondary-stressed ones (p. 70). If we look at isolated words, aspiration may occur in stressless syllables as well, although shorter than before stressed syllables. Gimson (1980) also differentiates weak and strong aspiration, he says that /p, t, k/ can be weakly aspirated when they are in an unaccented syllable, such as in *apricot* or *polite* (p. 154). Table 1 summarises the view of four linguists on aspiration. Linguists mostly agree that there is no aspiration in words like *spin*, *stop* and *skin*, although /p, t, k/ are followed by a stressed vowel. The syllable-based rule seemed to eliminate the exception of /s/ + /p, t, k/ clusters, as if these clusters are analysed as tautosyllabic, /p, t, k/ are not in syllable initial position, thus they cannot be aspirated even if they are in a stressed syllable. The issue is that /s/ is preferably syllabified as a degenerate syllable, so /s/ + /p, t, k/ clusters are still exceptions to the rule and a different explanation is necessary to account for this issue, which will be discussed later on.

Aspiration of /p, t, k/ in English			
Position of /p, t, k/ / Author	Initial in a stressed syllable	Initial in an unstressed syllable	After /s/
Jones (1989)	aspirated	weakly aspirated	less strong aspiration
Wells (1998)	aspirated	–	no aspiration
Gimson (1980)	aspirated	weak aspiration can occur	no aspiration
Cruttenden (2014)	aspirated	weak aspiration can occur	no aspiration

Table 1 Aspiration

2.3. Neutralization

According to Cruttenden (2014) the contrast between /p, t, k/ and /b, d, g/ is neutralized when they follow /s/ word-initially. The contrast is neutralised in most cases word-medially as well, but there are some exceptions, for example, in the case of *disperse* and *disburse* or *discussed* and *disgust* (Cruttenden, 2014, p. 47). The main contrastive feature between the fortis and lenis sets could be aspiration or voice. The opposition is well established in word-initial position, for example, consider *pin* [p^{h} ɪn] vs *bin* [b̥ɪn], where aspiration serves as a contrastive feature. However, when stops follow /s/ word-initially, in words like *spin, stop* or *school,* this contrast fails to apply and the articulated stops are neither aspirated nor voiced. The literature mostly agrees that /p, t, k/ and /b, d, g/ are neutralised, but some sources consider these sounds as weakly aspirated. For example, Jones (1989) says "aspiration is less strong when the p is preceded by s" (p. 183). However, there is experimental evidence supporting the view that the stops after /s/ are neutralised, which will be discussed later on. Unlike Jones, Gimson (1980) and Wells (1998) both argue that the stops after /s/ are not aspirated and the contrast is therefore neutralised.

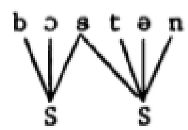
Since the stops are neutralised, there are different views on how the stop sounds in #s_ environment should be analysed, whether /p, t, k/ or /b, d, g/ would be the preferable solution. Gimson (1980) argues that /p, t, k/ are never opposed to /b, d, g/ following a word-initial /s/, therefore the words *spin, steam and skin* can be transcribed phonetically as either /spɪn, stiːm, skɪn/ or as /sbɪn, sdiːm, sgɪn/ without ambiguity (p. 53). Wells (1998) says there may be phonetic grounds for preferring one solution over the other, but the solutions may be arbitrary (p.53). He mentions that the native speaker intuition is in favour of /p, t, k/, but this may also vary in different accents, as in Welsh English, /b, d, g/ seem to be the preferred one (p. 53). Cruttenden (2014) says that even though the writing system suggests /p, t, k/, the sounds occurring after /s/ are closer to /b, d, g/ in some respect, as there is no aspiration which generally accompanies /p, t, k/. The former sources do not to mention that /s/ is not the only fricative that is related to lack of aspiration. As Kahn (1968) pointed out, /t/ in *after* is not aspirated. Thus /f/ has the same effect as /s/, the difference is that /f/+ fortis stop clusters cannot occur word-initially and these clusters are way less common than /s/ + fortis stop ones in general.

3. Syllable-based approaches

3.1. Overview of Kahn's approach

Syllables can be helpful to provide an explanation for phonological phenomena which include less exception, for example in the case of /l/-darkening or R-dropping in English. Considering aspiration and s+ /p, t, k/ clusters, however, one can find contradicting views. Kahn (1968) sets up a rule for aspiration as follows: "/p, t, k/ are aspirated if and only if they are both syllable-initial and non-syllable-final" (p. 74). This rule works well if we accept his two theories: on the one hand, that /sp, st, sk/ clusters are in the same syllable, in other words, they are tautosyllabic, and on the other hand, that in words like *after* or *aspin*, where /ft/ or /sp/ are in word medial position, /f/ and /s/ are ambisyllabic. This would mean that the stops after /f/ and /s/ are not syllable-initial, thus they are not aspirated. Although Kahn's theory solves the issue of the exception of s, f + /p, t, k/ clusters from aspiration, at the same time he goes against other rules of syllabification which raises the question of whether his analysis is acceptable. If his theory is not sufficient, it means there has to be a different explanation for the lack of aspiration after fortis fricatives, which will be discussed later on.

Kahn's first rule for syllable-structure assignment is that "with each [+syllabic] segment of the input string associate one syllable" (p. 39). The second rule consists of two parts and he based these rules on the assumption that word-initial and word-final clusters are parallel with syllable-initial and syllable-final clusters (pp. 42–43). The first part of the rule adds the segments on the left to the syllabic segment, which has to be a permissible initial cluster. The second part of the rule adds the segments on the right to the syllabic segment, which have to be a permissible final cluster. This means that a word like *atlas* has to be syllabified as *at.las*, as *tl* is not a word-initial cluster in English. He also argues that word initial/final consonant has to be syllabified with the first/last syllable of the word and the same is true for consonant clusters. After establishing this rule, he found that there are many cases in which more than one syllabification is allowed, so he introduced the idea of ambisyllabicity. Ambisyllabicity means that there is no clear boundary between the two syllables and "intervocalic consonants in English may belong simultaneously to a preceding and a following vowel's syllable" (p. 34). Thus the word *Boston* is syllabified as follows:



(Kahn, 1968, p. 37)

Kahn (1968) also found that "each [+syllabic] segment is associated with exactly one syllable and each [–syllabic] segment is associated with at least one syllable" (p. 38).

3.2. Counterarguments on Kahn's proposal

3.2.1. Sonority hierarchy

According to Kahn's analysis, in words beginning with /sp, st, sk/, /s/ and the fortis stops are in the same syllable, therefore /p, t, k/ cannot be aspirated. This hypothesis contradicts the Sonority Sequencing Principle which says "between any member of a syllable and the syllable peak, only sounds of higher sonority rank are permitted" (Clements, 1990, p. 285). This principle is based on the observation that some sounds are more sonorous, meaning vocalic or loud than others. Based on this characteristic of sounds a hierarchy can be set up which is called the sonority hierarchy. According to Parker (2002), there is a universal sonority hierarchy: “vowels > liquids > nasals > obstruents”, which seem to be valid for all languages (p. 63). This hierarchy does not differentiate subgroups among obstruents, which would mean that /s/+ stop clusters are not violating the Sonority Sequencing Principle and they can be in the same syllable. Parker (2002) argues that stops and fricatives should be divided into the following subgroups: voiceless stops, voiced stops, voiceless fricatives, and voiced fricatives. According to some linguists, voiceless stops and voiceless fricatives are equal in sonority, therefore /s/+ stop clusters are not problematic for them when applying the Sonority Sequencing Principle (Parker, 2002, p. 69). Parker (2002), on the other hand, argues that the order of these subgroups in English seems to be voiced fricatives > voiceless fricatives > voiced stops > voiceless stops (p. 262). Most linguists are also in favour of this scale, only the ranking of voiceless fricatives and voiced stops is disputable. (Parker, 2002, p. 68–69). The relevant part of Parker’s sonority hierarchy, which is valid for English is shown in Table 2.

Sonority of fricatives and stops in English		
voiced fricatives	/v, ð, z/	4
voiceless fricatives	/f, θ, s/	3
voiced stops	/b, d, g/	2
voiceless stops	/p, t, k/	1

Table 2 Parker’s (2002) sonority hierarchy (p. 262)

According to Parker’s hierarchy, /s/ is more sonorous than /p, t, k/, therefore a syllable like *spot* violates the sonority sequencing principle, as it has two peaks. Kahn has a different approach to syllabification, he applies [+/– syllabic] feature to determine nuclei, which is one of the major features that can be used for syllabification. The other two major features are [+/– consonantal] and [+/– sonorant]. Selkirk (1984) argues that these features should be eliminated from phonological theory and that they should be replaced with the hierarchical feature sonority, because it allows a better account of syllable structure (p. 107). She also argues that assigning sonority index to sounds leads to an easier way to form natural classes needed for syllabification (p.113). Formulating rules is much more complicated with major features, as several filters have to be added to them (Selkirk, 1984, pp.112–13). She also says that it is well known that syllables conform in general to Sonority Sequencing Principle, therefore it gives basis for a sonority hierarchy-based approach (p. 116). The Sonority Sequencing Principle is a generalization, which has exceptions and has to be specified for certain languages (Clements, 1990, p. 284). However, it "expresses a strong cross-linguistic tendency, and represents one of the highest-order explanatory principles of modern phonological theory" (Clements, 1990, p. 284), so it should not be neglected.

3.2.2. The issue with the Maximal Cluster Approach; justifying sonority sequencing

Kahn's theory of syllabification uses word edges to identify syllables. He argues that only those clusters are allowed syllable-initially that can occur word-initially and the same is true for syllable-final and word-final clusters as well. Lowenstamm (1981) calls this the Maximal Cluster Approach, which is widely accepted by traditional or nongenerative phonologists, but he argues it should not be the case among generative phonologists (pp. 580–581). In generative grammar the organization of phonology is not linear, it is built up from several levels of description that are related in a specific way, from underlying representation to surface representation (Lowenstamm, 1981, p. 581). Lowenstamm (1981) argues that words cannot provide the desired criterion for determining syllable structure and the rules Kahn set up can be dispensed with in generative phonology. Specifically, the first and second rule, that states first we have to identify the nuclei, or "syllabic segments in a string, and then stack nonsyllabic segments to it, first to its left, then to its right" (Szigetvári, 2010, p. 7). Lowenstamm (1981) shows why Kahn's theory is "faulty, since it cannot syllabify strings that are not encountered on the surface" (Szigetvári, 2010, p. 8).

Lowenstamm (1981) proposed an alternative to the Maximal Cluster Approach, which he calls the Universal Syllable. The idea of the Universal Syllable is based on the observation that syllables in any language typically conform to a certain type, and its characteristics can be summarized as follows:

"In a string of segments, a syllable is a maximal substring such that:

a.

  i. no segment is lower on the hierarchy than both its immediate neighbors

  ii. no two segments of equal ranking on the hierarchy are adjacent

b. the onset is maximal within the limits of (a)" (Lowenstamm, 1981, p. 593).

The first point refers to the Sonority Sequencing Principle, and the second to Onset Maximization. Lowenstamm (1981) argues that if this approach is applied instead of the Maximal Cluster Approach the problematic cases discussed below can be solved. He provides phonological evidence on how Maximal Cluster Approach fails "to provide a satisfactory characterization of syllable structure" and he argues that syllables are "as deep and abstract as the rest of phonology" (p. 602).

Lowenstamm (1981) presents different phonological phenomena which cannot be explained with Kahn's theory, for example, syllabic sonorants in Modern English and Yiddish. In Yiddish, the /l/ in *axlt*, and /n/ in *vornt* is syllabic, while, in *axlin* and *vornin* they are not. It can be observed that a sonorant becomes syllabic word-finally or before a consonant, and based on this observation the following rule was drawn up by Lowenstamm: [+sonorant] → syllabic/ C__(C). This means if a sonorant is in a coda they will be syllabic on the surface. If this rule is correct it means that this phonological phenomenon is syllable-sensitive. This suggests that the syllable structure must be determined before the syllable nuclei become available. Thus, Kahn's theory fails to account for this phenomenon, as he starts the syllabification process by identifying the [+syllabic] elements first. The case of syllabic /l/ in English is quite similar. If the word *simpleton* is analysed according to Kahn's rules, /l/ remains unassociated, which violates Kahn's own rule that all elements have to be assigned to a syllable. However, if we apply the Universal Syllable, it solves the issue. Considering the Yiddish word /hɔrndl/, /r/ and /d/ are lower on the hierarchy then their neighbours so they have to be in a separate syllable, and if we apply onset maximization /r/ has to be in the second syllable. Thus the rules of Universal Syllable predict that the word is syllabified as /hɔ.rn.dl/. If we apply the rule for syllabic sonorants to /hɔ.rn.dl/ it derives the surface form [hɔ.rn̩.dl̩], therefore Universal Syllable predicted the correct syllable structure, while Kahn's rules could not.

Lowenstamm (1981) also presented phonological evidence on why word-medial /sp, st, sk/ clusters in French cannot be tautosyllabic. These clusters can occur word-initially, so Kahn's rule predicts that, for example, [astüs] will be syllabified as *a.stüs,* as his second rule makes the onset maximal. However, this form cannot account for a syllable-sensitive rule, Closed Syllable Adjustment. The rule says that [ə, e] realized as [ɛ] when they are followed by a syllable-final consonant. If we consider the pairs like [zere] (to manage) – [zɛstyɔ] (management), or [fete] (to celebrate) – [fɛstɛ] (feast), one can see that the rule applies to them. Therefore, the syllabified form for them has to be *zɛs.tyɔ* and *fɛs.tɛ*, where /s/ is in syllable-final position. This means that even though /sp st, sk/ clusters are allowed word-initially, they have to be split up by the rules of syllable structure assignment. Further evidence is that /e/ never stands before sibilant-obstruent clusters, which also indicates that the sibilant closes the syllable (p. 599). Here again, Kahn's theory fails to predict the favourable form, Universal Syllables, on the other hand, leads to the correct one. This part of the discussion is especially relevant to the topic of this thesis, as if the same holds in English as well, it means syllabification cannot account for the lack of aspiration in word-medial /sp, st, sk/ clusters.

3.2.3. Binary theorem violation and governing

Kaye (1996) argues that s+C clusters, such as /sp, st, sk/ are never tautosyllabic, which goes against Kahn's hypothesis, that s+C clusters are onsets word-initially or that they are ambisyllabic word-medially (p. 155). Kaye's theory focuses on binary theorem, which was derived from principles of Government Phonology. Binary theorem claims that "all constituents are maximally binary" (p. 156). Forms like *spray* or *stress* would be problematic to this rule, if it was necessary to "syllabify all initial consonant sequences up to the first vowel into the onset" (p. 156). In that case, there would be three segments instead of two in the onset. Interestingly, the sequences that could violate the binary theorem with respect to onset are all s+CC clusters, where CC is a permissible onset, thus it would be beneficial to analyse s+C clusters as heterosyllabic in general. Furthermore, considering governing, /s/ would be in governor position if s+C are analysed as tautosyllabic. However, "/s/ is normally assumed to be neutral" (p. 157) which is a property of governees, not governors, therefore /s/ is not a potential governor. Also, /s/ does not behave like a typical onset governor, as it can occur before seven sounds, compared to other real governors that only govern one specific sound in an onset. Kaye (1996) suggests that there is no evidence for assuming that /s/ should be analysed as tautosyllabic in s+C clusters, but there is evidence for the contrary.

Kaye's first evidence is from Italian, which requires stressed vowels to "occur in rhymes containing two positions" (p. 158). The two options to satisfy this is either branching rhyme or a branching nucleus (p. 158). The latter is not present in Italian, so the vowel lengthens in open syllables to acquire the second position. Considering /ka:pra/, /sa:kro/ and /re:tro/ one can see that /pr/, /kr/ and /tr/ clusters are branching onsets, as the vowel lengthens before them. However, in the case of /pasta, moska/ or /krespo/, the vowel remains short, which means /s/ is part of the first closed syllable, thus s+C clusters are not tautosyllabic (p. 159). Applying the weak version of Uniformity Principle- which is “in a given language, sequences of contiguous positions that are in a governing relation and contain the same phonological material have the same constituent structure” (p. 159)- means that s+C clusters always have to be analysed as heterosyllabic, word-initially as well. If the strong version of the principle is applied, which is expanded to all languages, then it means the case might be the same in English as well.

Vowel nasalisation in Portuguese also indicates that s+C clusters are not branching onsets. When the negative prefix *in-* is added to words with an empty onset no nasalisation takes place, however, when the onset is filled, it will be realised with a nasal vowel [ĩ] (p. 164). When *in-* is added to words with a word-initial s+C cluster, no nasalisation takes place. Again, this means /s/ is not part of the onset, since *in-* realised the same like in words with an empty onset. Finally, evidence from British English also suggests that s+C clusters should not be analysed as branching onsets. Kaye (1996) points out that if we consider “dialects that display ly, as in lyurid we note that postconsonantal y never occurs after a branching onset” (p. 166). /j/ can occur after s+C clusters, for example in *stupid*, *spew* or *skewer*, which indicates that these clusters should not be analysed as tautosyllabic, not even in word-initial position (p. 167).

In addition to evidence from the languages discussed above, Kaye (1996) also brings psycholinguistic evidence based on experiments to justify that s+C clusters are not branching onsets. The experiments Kaye (1996) mentions were conducted by Treiman, Gross, and Glavin. Although they did not investigate word-initial clusters, their results still suggest that s+C clusters should not be treated as branching onsets. The first part of the experiment was a written syllabification task, which involved s+C clusters with rising and falling sonority, along with true branching onsets like /fl/ (Kaye, 1996, p. 169). People syllabified both rising and falling clusters in separate syllables, which "support the claim that cluster onsets may not begin with /s/" (p. 169). The second part of the experiment was an oral version of the first one and the results were similar as well. In the third part participants had to read out loud nonsense words, for example, *wospeem* and *wosweem*. They usually pronounced these words with a full vowel in the first syllable, not a reduced one, which means they identified s as part of the first syllable rather than as part of the onset of the second one.

All this evidence suggests that /s/ is not part of the onset, and according to Kaye (1996), /s/ "occurs in a rhyme, whose nuclear head is empty" (p. 170). Although Kaye (1996) could not offer a theoretical explanation for the empty nucleus, it can be observed that s+C clusters serve as P-licenser in some languages. P-licenced, or empty elements do not have phonetic interpretation, and an element is P-licensed if it is domain final or properly governed. One criterion of proper government is violated in the case of word initial s+C clusters, therefore Kaye solved this issue by adding an extra requirement which he calls parameterised "Magic Licensing". Although his argument for the structure he proposed is inefficient, other linguists also argue that such syllables without a nuclei exist, which are called degenerate syllables. Szigetvári (2010) also argues that there is no evidence supporting claims that suggests syllables without vowels cannot exist (p. 25). Therefore, even if Kaye's argument is not supported by a well-established theoretical background, he seems to be right about the fact that /s/ is not part of the onset considering s+C clusters, and /s/ is rather a degenerate syllable without a nucleus.

To conclude, Kahn's analysis that s+ /p, t, k/ clusters are tautosyllabic does not seem to hold, which was presented from two different approaches. Lowenstamm (1981) showed why using word edges as means to determine syllable boundaries cannot work. He argued that the Universal Syllable is a better solution, which is based on the Sonority Sequencing Principle. He showed through examples that Kahn's theory is inadequate to account for certain phenomena, while Universal Syllable can provide a better explanation. The other approach was binary theorem and governing. Although Kaye argues against the relevance of Sonority Sequencing and prefers Government Phonology, he also demonstrated with evidence from languages why Kahn's analysis cannot be acceptable. This suggests syllabification cannot explain the lack of aspiration after /s/, as there seems to be a syllable boundary after /s/, which puts /p, t, k/ in syllable initial position. Therefore, s+ fortis stop clusters are still exceptions to the general rule which said that /p, t, k/ are aspirated when they are initial in a stressed syllable.

4. Phonetic approach

4.1. Spread glottis feature

Aspiration is interpreted as a partial devoicing of the following sounds and it is explained with Voice Onset Time, which is the interval between the release of the stop and the onset of the voicing of the next sound (Kim, 1970, p. 107). Kim (1970) proposed a new approach to aspiration: he says that aspiration is "a function of the glottal opening at the time of release" (p 111). The basis of his hypothesis was the examination of the larynx with cineradiography while the test person uttered a string of words in Korean. They measured the size of the glottal opening, which is "the distance between the two vocal folds at the narrowest point along the axis" (p. 109). They found that the degree of glottal opening at the time of the release correlates with the degree of aspiration: the longer it takes for the glottis to close, that is the wider the opening, the longer the aspiration (p. 109). His founding also suggests that aspiration has nothing to do with the subglottal pressure, only with the length of the voicing lag. So Kim's hypothesis is in accordance with Voice Onset Time, which also suggests that the length of the voicing lag determines the strength or length of aspiration.

According to Kim (1970), English stops are not aspirated after /s/ because the clusters contain a single specification of [spread glottis] which is shared between the fricative and the stop (in Iverson, 1995, p. 371). Kim (1970) argues that the glottal movement starts during /s/ and the glottis starts to close by the time the closure for /p/ is made, hence there is no aspiration (p. 114). In other words, “the period of aspiration is consumed in the oral closure phase of the stop member of the cluster” (Iverson and Salmons, 1995, p. 371). Kim (1970) also pointed out that this hypothesis is mere speculation, based on the idea that the syllable is the smallest unit that gets a package of instruction for articulation, not a phoneme (p.113). Iverson and Salmons (1995) say there is phonetical and phonological evidence which confirm Kim’s hypothesis that the glottal movement is shared in s+ stop clusters (p. 372). For example, the results of experimental work using photoelectric glottography suggest that “in single fricatives the peak of glottal opening is coordinated with the beginning of oral constriction. In single stops the peak occurs later, at the point of oral release, but in clusters there is only one gesture” (Iverson, 1995, p. 372). Since there is only one gesture which is shared, the time of start of glottal opening is a result of a compromise between the two sounds, thus in the case of clusters the peak glottal opening occurs later than it would with single fricatives and earlier than it would with a single stop (Iverson, 1995, p. 372). Goldstein (1990) also found “that words may begin with at most one glottal gesture” (as cited in Iverson, 1995, p. 372).

According to Iverson and Salmons (1995), if the feature [spread glottis] is shared in obstruent-initial consonant clusters, it also explains why sonorant consonants become devoiced when they occur after fortis stops word-initially (p. 373). Thus in words like *slip*, the spread glottis feature is shared between /s/ and /l/, resulting in voicelessness in /l/ (Iverson, 1995, p. 373). This hypothesis also involves the assumption that the specification of [spread glottis] has a set duration which causes the different VOT values: zero and positive (p. 374).

Based on the correlations between the metrical foot and aspiration, Iverson and Salmons (1995) drew up a new rule for aspiration: "voiceless stops are aspirated in foot-initial position, elsewhere they are not" (p. 375). However, evidence shows that the feature "[spread glottis] is implemented with fully abducted vocal folds only in foot-initial position" (p. 377), but a less strong aspiration can occur elsewhere as well. Thus, "in words like Atlas, the /t/ is not part of the onset of a foot-initial syllable, and [spread glottis] . . . is consequently not implemented in its strongest, aspiration-inducing form" (p. 377). Iverson and Salmons (1995) also argue that "vocal fold abduction in syllable onsets is enhanced in relation to metrical prominence", which means the degree of aspiration correlates with the degree of stress (p. 378).

4.2. Counterarguments on Iverson and Salmon's hypothesis

Iverson and Salmons (1995) argue that "the assumption of a fundamentally constant duration for the specification of [spread glottis] results in the variable VOT distributions commonly observed in English and other languages" (p. 374). They say that the domain of [spread glottis] feature is exactly two segments, which is illustrated in Table 3. They argue that /s/ is specified for [spread glottis] and they explain the lack of aspiration in /s/+ stop clusters with the fact that [spread glottis] is shared between the /s/ and the following stop. They also say that sonorants are devoiced after /s/, which might be questionable. If we assume that sonorants are not devoiced after /s/, it can be argued that it is favourable to analyse the stops after /s/ as lenis. Since lenis stops are not specified for [spread glottis] feature, just like sonorants, we do not have to account for the lack of aspiration anymore and say that [spread glottis] feature is shared. Also, Iverson and Salmons argued that the [spread glottis] feature is shared to explain why the glottis is not spread when the stops after /s/ are articulated, thus their analysis implicitly suggests that the articulated stops are actually lenis. There is also experimental work suggesting that fricatives are not specified for [spread glottis], the glottal opening is just an aerodynamic requirement for fricatives (Tsuchida, Cohn & Kumada, 2000,

p. 179). If we accept this assumption, then it is clear that the feature cannot be shared between /s/ and the following stop, which means a different explanation is needed to account for the lack of aspiration. This is also in favour of analysing the stops after /s/ as lenis, since lenis sounds cannot be aspirated and they are devoiced when they stand after an obstruent.

Domain of [spread glottis] feature		
[spread glottis]		
/p, t, k/	h	vowel
/p, t, k/	h	approximant
/s/	h ?	sonorant
/s/	sonorant	
/s/	/p, t, k/	vowel/ liquid

Table 3 Domain of spread glottis feature

4.3. Perceptual experiments

Although some linguists prefer the interpretation /sp, st, sk/, Davidsen-Nielsen's investigation of the issue suggests a different solution. They carried out a perceptual experiment that involved the identification of words beginning with *sp, st, sc/sk* after the initial /s/ sound was removed. They found that the test subjects perceived words with initial /b, d, g/ in 92% of the cases. The second part of the perceptual experiment was to identify the sentence *Thanks, Stan, that'll be all*. In 58% of the cases, the participants identified the sentence correctly, however, in the remaining 42%, they heard *Dan* instead of *Stan*. Lotz, Abramson, Gerstman, Ingemann, and Nemser (1960) investigated the same issue with a similar method: they recorded words with initial /s/ plus stop clusters then removed the /s/. They found that American English speakers interpreted the sounds as lenis rather than fortis. Reeds and Wang (1961) carried out an experiment using the same method: they presented the truncated words after the /s/ was removed to the participants who had to identify the words they heard. Their results suggest the same as the previous ones, that the sounds after /s/ are phonetically closer to /b, d, g/ than to /p, t, k/ in terms of perceptual judgements.

These perceptual experiments were carried out to show, that the sounds after /s/ in word-initial clusters are closer to /b, d, g/ than /p, t, k/. The method they used was presenting words to the participants in which that sound in question was word-initial. For native speakers, aspiration is a cue to distinguish between minimal pairs like *pier–beer*, or *pat–bat*, as in that position the contrastive feature between the sounds /p/ and /b/ is aspiration, as the lenis sound /b/ is devoiced in word-initially. Therefore, if native speakers hear a sound at the beginning of a word which is a stop and not aspirated, they will recognize it as lenis. As Lotz et al. (1960) also points out, “the results indicate that there is a hierarchy among the cues in the acoustic stimulus for the perception of these sounds, . . . for American English, the lack of aspiration is a dominant cue for forcing the evaluation of the stops in the direction of /b, d, g/” (p. 77). The other part of Davidsen-Nielsen’s perceptual experiment showed that in little more than half of the cases they heard *Stan* and in the rest of the cases the participants heard *Dan*, which is again proof that the sounds are neutralized and can be interpreted either /t/ or /d/. However, this does not necessarily mean that sounds after /s/ are closer to /b, d, g/, it only proves that the sounds after /s/ are not aspirated, which leads to the conclusion that the contrast between fortis and lenis stops is neutralized in that position.

4.4. Acoustic and articulatory experiments

Davidsen-Nielsen (1969) also investigated the phenomenon from an acoustic and articulatory point of view. They measured the duration of release stage and the results suggested that there is no aspiration after /s/, which means the stops after /s/ are closer to /b, d, g/ than to /p, t, k/. They also examined the duration of hold stage of the sounds but the results were so close that no conclusion could be drawn from them. The next feature to investigate was voicing and they found that voicing is not a constant feature of /b, d, g/, which means in some environments it can be voiced in others they are voiceless. Therefore, the sounds after /s/ can be analysed as lenis even though they are not voiced. They also measured the intraoral air pressure to decide whether the articulated sound is fortis or lenis, and they found that the English tests persons had almost no difference between /p, t, k/, /b, d, g/ and /sp, st, sk/, which is a result of all stops being voiceless. Thus the acoustic and physiological investigation also confirmed that stops after /s/ are unaspirated and unvoiced and they have almost the same intraoral air pressure. So these results again suggest that sounds after /s/ are neutralized. Davidsen-Nielsen (1969) concluded that the experiment demonstrated that the stops after initial /s/ are more similar to the realization of initial /b, d, g/ than /p, t, k/ therefore /sb, sd, sg/ analysis is more legitimate than /sp, st, sk/ (p. 338).

5. English loanwords in Welsh

Welsh, just like English, is an aspirating language, it contrasts the fortis and lenis pairs /p, b/, /t, d/, /k, g/ with aspiration when voice fails to maintain the contrast word-initially or word-medially. The lenis series /b, d, g/ are usually voiceless in word-initial or word-final position, for example, *bys* [bɪs] (finger), *dydd* [dɪð] (day) and they fully voiced only occasionally word-medially in voiced environments (Jones, 1984, p. 41). Since voice is not a constant feature of lenis sounds, aspiration can be the cue for laryngeal contrast for example word-initially. This is supported by Ball's (1984) investigation, as he found that the VOT of initial /p, t, k/ are significantly longer than initial /b, d, g/. Ball also investigated whether the stops after word-initial /s/ are aspirated and his results are parallel with the ones of Davidsen-Nielsen. Ball found that the VOT-s of stops after /s/ is even a little shorter than the word-initial lenis sounds. Therefore, the stops after word-initial /s/ are closer to lenis sounds in terms of VOT. Ball concluded that these clusters should be analysed as /sb/, /sd/, /sg/ (Ball, 1984, p. 16).

The words used for the investigation of word-initial /s/ and stop clusters were *sbon, sbâr, stad, stori, sgôr, sgîl*. It can be seen that there is an important difference between Welsh and English orthography, as in English word-initial *s* + stop clusters are spelled as *sp, st, sk*. I carried out online research using two Welsh online dictionaries and found that in Welsh, as opposed to English, all word-initial /sg/ clusters are represented as *sg* in spelling, I did not found any words spelled with *sk*. Almost all of the /sb/ clusters are also represented with the lenis stop *b* in spelling; I found only a few exceptions including *spectrosgopeg, spectrwm* and *spraint* out of more than fifty words beginning with an *s* + bilabial stop cluster. This is important when it comes to the question of whether the stops after word-initial /s/ should be analysed as lenis or fortis. The English loanwords spelled with lenis stops show that the native intuition is to analyse the stops after word-initial /s/ as lenis, which in Welsh, as opposed to English, is also represented in spelling. Some examples for English loanwords spelled with lenis stops are collected in Table 4. This also indicates that the stops after /s/ are closer to lenis than fortis, so the English spelling of word-initial *s*+ stop clusters might be misleading and they should be analysed as /sb, sd, sg/. It is important to note, however, that all /s/ + alveolar stop clusters are spelled with the fortis variant *t*, and no *sd* clusters can be found word-initially in Welsh spelling. Although the experiments confirmed that these stops are not aspirated, just like in the case of /sb/ and /sg/ clusters, the /sd/ clusters are spelled as *st* for some reason.

English loanwords in Welsh			
/sb/ clusters		/sg/ clusters	
English	Welsh	English	Welsh
sport	sbort	sketch	sgets
spanner	sbaner	skill	sgil
spasm	sbasm	skip	sgip
spectacle	sbectol	skirt	sgert, sgyrt
spite	sbeit	skeleton	sgeleton
spell	sbel	scarf	sgarff
to spy	sbio	score	sgôr
splint	sblint	screen	sgrîn
spare	sbâr	script	sgript
spree	sbri	scrum	sgrym

Table 4 English loanwords in Welsh

6. Conclusion

We have seen that the approaches which analysed the stops after /s/ as fortis and tried to find an explanation for the lack of aspiration seem to fail. Therefore, the alternative analysis which says the stops after s are /b, d, g/ might be the preferable solution. First of all, if we say that the stops after /s/ are lenis, we do not have to account for the lack of aspiration anymore, as aspiration is not a feature of lenis sounds. Furthermore, in #s_ position lenis stops are expected to be voiceless, since lenis stops are only voiced when they stand between sonorants or vowels. This analysis is supported by the perceptual experiments which showed that the stops after /s/ were identified as lenis by native speakers. Also, the analysis by Iverson and Salmons suggest that the glottis is not spread when these stops are articulated, so it could be interpreted as a sign that the stops are not specified for this feature and the articulated stops are actually lenis. On the other hand, the reason these stops were analysed as fortis in the first place is orthography. In English /s/ + stop clusters are spelled as *sp, st, sk, sc* which suggests the articulated stops are fortis. However, orthography is only convention and it seems to be misleading in the case of these clusters which was also confirmed by several perceptual experiments. The spelling of English loanwords in Welsh also shows that orthography should not be considered as a decisive argument for analysing stops after /s/ as fortis, since in Welsh the spelling of these stops is not consistent. Also, the spelling of /sb/ and /sg/ clusters of English loanwords in Welsh suggests that the articulated stops are closer to lenis than fortis. Therefore, the analysis /sb, sg, sd/ seem to be the preferable solution for s+ stop clusters in English.

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