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LANGUAGE LEARNING | REVIEW ARTICLE

The functions of English fricative sounds to speech intelligibility in the education of English majors and the students of Aeronautical English

Mehmet Demirezen

Abstract: Fricative sounds in English hold phonemic values in the English consonant inventory. By nature, they resemble the sibilant sounds in terms of acoustics. In speech, fricatives transmit most meaning as they are heard in minimal pairs by creating selective hearing. Sounds can be specified by their loudness and frequency or pitch degrees. Therefore, many non-native English majors, aircraft pilots, copilots, air traffic controllers, and other learners of English, such as English majors, may not be able to perceive with healthy hearing. In this study, some specific minimal pairs, homophonous words, inferences, and L1 interferences on affricative sounds of the English language will be proposed to be used in the education of English majors, pilots, and air traffic controllers in Aeronautical English.

Keywords: hissing, hushing, sibilants, fricatives, homophony

Pronunciation is a common area of bad success in the education of English majors, aircraft pilots, and traffic controllers at airports. "English has a larger inventory of fricatives than most languages" (Koffi, 2021, p. 130). The inventory of fricatives in English includes the following segments: /θ, ð, f, v, s, z, ʃ, ʒ, h/. Being divided evenly between sibilants and non-sibilants, while the sibilant class is made up of /s, z, ʃ, ʒ/, the non-sibilant group consists of /θ, ð, f, v, h/. The pronunciation and perception of these fricatives give those hard times in doing their jobs. This is also because "The acoustic structure of fricatives seems to vary widely from individual to individual" (Ladefoged & Maddieson, 1996, p. 139).

In addition, fricatives sometimes become the cause of plane crashes. For example, the mispronunciation of some of the fricatives joined with the L1 impacts of Brazilian pilots are said to have caused deadly results for Brazilian pilots (Cristófar-Silva, 2012). "In 2006, the deadliest airplane crash in Brazil took place, with a death toll of 154 people: miscommunication (and pronunciation) was one of the causes of the accident" (Babboni & Quast, 2020, p. 3). Apparently, due to faulty use of speech sounds, in communication vehicles, certain errors can happen between aircraft pilots and copilots, pilots and cabin crew, pilot and ATC (Air Traffic controller), pilot and the ground crew, pilot and passenger, and other air-to-ground communication officials.

2. The features of Aeronautical English

English has been used as an international aviation language since 1951. Aeronautical English, also known as aviation English, is the international language used by members of aviation firms and institutions around the world. Aeronautical English is a very special type of communication language that pilots use while flying an aircraft and communicating with the air traffic controllers on the ground. In civil aviation, it is the actual international language. This is an exceptional use of English which is crucial for the safe and efficient operation of the aircraft both in the airspace and at the airports. To communicate effectively, clear, concise pronunciation and intonation are highly required to

coordinate with pilots, copilots, and other controllers. Therefore, Aeronautical English has been particularly organized to assist pilots and air traffic controllers to accomplish and sustain operational level 4 as planned by the International Civil Aviation Organization, which is shortly known as ICAO, which requires a minimum of level 4, or operational English proficiency.

In order to accomplish the English Language Proficiency Level 4 as a minimum operational level which is equally recognized and valid in all Member States, ICAO stresses implementation, clear comprehension, and standardization of all the communication elements. Aeronautical English differs from General English; thus, not only native speakers of English but also non-native speakers must learn it. The purpose of ICAO is to ensure minimum acceptable levels of English pronunciation and comprehension universally yet does not attend to difficulties.

Evidence suggests that voice transmissions between pilots, co-pilots, air traffic controllers, and ground people. Some consonant sounds constitute a particular problem in international airspace and pilots may not understand messages due to the impacts coming from their acoustic nature. The acoustic nature of voice transmission gets to be even worse when pilots have regional dialect features. That is why regional dialects are not accepted in the field of Aeronautical English because regional dialects are against the principle that aviation English must be free from any ambiguities and vagueness.

Fricative sounds of English are problem-causers in radio communication. Fricatives have hissing and hushing overtones in their sound structure, and therefore they are noisy, hence their perception is distorted. Furthermore, it is the voiceless fricatives that have the effect of shortening the preceding vowel, in the same way as voiceless plosives. "The impact of noise on phoneme perception has led to some modifications in the pronunciation of highly confusable words. The best-known examples are those of five pronounced as fife due to confusion between voiced and voiceless fricatives because of the narrower frequency range, and nine pronounced as niner in order to avoid confusion with five and with German Nein" (Estival et al., 2016, p. 16)

Furthermore, fricative sounds possess turbulence in their articulation. "The typical properties of /f/ include high frequency turbulence concentrated between 3,000-4,000Hz." (Ladefoged & Johnson, 2015, p 56). According to Stevens (1971), fricatives require a pressure drop across the constriction to generate turbulence noise. Their turbulence creates noise, vagueness, and incomprehensibility on the microphones. It must be noted that even though there are modern high-quality headsets, the sound level in a cockpit atmosphere is the same with a normal office on the ground.

3. Theoretical background

3.1 Fricative consonants of the English language

Fricative sounds in the group of consonants are [f, v, s, z, θ, ð, ʃ, ʒ, h] in the English sound inventory system. Fricatives are very noisy sounds; therefore, they pose a serious problem both in pronunciation difficulty and speech intelligibility (Demirezen, 2022). A great part of pronunciation difficulty stems from their hissing and hushing features, which may attack the listeners' hearing capabilities. For example, fricatives such as [s, h, f] possess acoustically higher frequencies, which make them harder to hear. So, a great majority of English majors, pilots, and traffickers may have a hard time with such specific speech sounds. Naturally, higher-pitched sounds may not be heard at all by non-native learners of English. Therefore, pronunciation in tandem with intonation is a fundamental part of language learning, allowing them speaker to express themselves coherently and accurately in their profession.

3.2 Basic features of fricative sounds in English

The word fricative as a word is derived from the modern Latin word “fricativus, from Latin fricat-, past participle stem of fricare “to rub” (Online Etymology Dictionary, n.d.), which means a sound that is characterized by friction. As mentioned before, in phonetics, fricative consonants are [f, v, s, z, θ, ð, ʃ, ʒ, h], each of which holds a phonemic status in English consonant inventory. Fricatives are made by squeezing the outgoing air stream in a narrow passage that creates a constriction. It is in this constriction that a noisy sound is created while the outgoing air stream flows turbulently as it leaves the oral cavity. Fricatives are also called spirants.

Fricative consonants are pronounced by a contraction of the oral cavity by two articulators, such as the lips, teeth, tongue, or palate, which come into near contact with each other. The outgoing air stream forces its way through the narrow gap creating turbulence or friction, and the blocked airflow produces audible friction when coming into contact with the articulators in the oral cavity, hence the term fricative. The fricative sounds such as [v, ð, z, ʒ] are voiced because they are pronounced with vibration in the vocal cords. Conversely, fricative sounds [f, θ, s, ʃ, h] are voiceless since they are made without the vibration of vocal cords in the larynx. As a fricative, [ʃ] has the most acoustic energy among the fricatives in terms of pronunciation.

3.3 Fricatives versus sibilants

The word “sibilant” comes from the Latin “sibilare,” (“having a hissing sound,” 1660s, from Latin sibilantem (nominative sibilans), present participle of sibilare (Online Etymology Dictionary, n.d.). Some of the fricatives are, then, also called sibilants. “Sibilants of English, which are [s, z, ʃ, ʒ, tʃ, dʒ], by nature a combination of fricative and affricate consonants, produced with an audible hissing sound ([s, z]) and hushing sounds ([ʃ, ʒ, tʃ, dʒ]) gain their overtones” (Demirezen, 2016, p. 750). By nature, sibilants are also termed fricative consonant sounds. In the production of sibilants, the tip, or blade, of the tongue approaches to nearby the roof of the mouth through a narrow channel in the oral cavity. In this position, the air stream is pushed past the tongue to make an acoustically characteristic high-pitched hissing or hushing sound. For example, the sibilant fricative consonants /s/ and /ʃ/ are produced with high intensity in the vocal tract. It must be noted that [s] is a voiceless alveolar fricative and sibilant and is one of the most common sounds cross-linguistically. Sibilants are louder in pitches, and their acoustic energy occurs at higher frequencies, which creates some perceptual problems. Thus, the pronunciation difficulties of Turkish English majors spring up, along with the aircraft pilots, copilots, ATC, and in air-to-ground communication people.

3.4 Fricatives as hissing and hushing sounds

The fricatives and sibilants have inherent hissing and hushing qualities. The hushing quality effects of fricative sounds carry articulatory and high-pitch acoustic values. Fricative consonants possess high-frequency noise energy in the narrow-band spectrogram. Additionally, they have higher amplitude and pitch. This is made by directing an outgoing stream of air with the tip or blade of the tongue towards the teeth in the oral cavity. Therefore, sibilant sounds are produced by forcing the air toward the tongue tip or blade, either with hissing [sssss], a buzzing or pesky sound [zzzzz], or by [shhhhh], by which it is made to silence someone. That is why fricatives are very necessary for speech intelligibility and to keep voices clear throughout the speech. In the vocal tract, the flow of the air stream becomes turbulent as it passes through a narrow constriction. It is the noise of this turbulence that gives many fricatives a characteristic of hissing overtones or sibilant quality. A small opening, made by articulators in the oral cavity, lets the air escape with certain friction and resonance of hissing and hushing which becomes the cause of faulty pronunciation. The escape of the air captures a turbulent nature and produces a noisy friction-like sound, called friction. Since the flow of breath is heard in the production of fricatives, fricatives are also termed as spirants.

3.5 Frequency of fricative consonants

Fricatives join together to establish the syllables, and syllables grow into words via a phonotactic strategy of the languages. The ranking of the relative frequency of fricative consonants in English language can be stated as follows:

Table 1. Relative frequency of fricative consonants in English language

Phoneme	Relative Frequency	Examples
/f/	1.71%	fine, five, free, from, fight, cuff, tough, laugh, life, fault, fifth
/v/	2.01%	valid, van, valve, vary, velvet, vet, veto, vivid, vital, vivacious
/θ/	0.41%	thin, thank, theme, bath, gather, bother, thirteenth, thousandth
/ð/	2.95%	mother, father, Netherlands, either, neither, whether weather
/s/	4.75%	sick, sin, seen, sauce, scar, scarce, science, secrecy, seduce, series
/z/	2.76%	zap, zebra, zero, zenith, zest, zombie, zone, zipper,
/ʃ/	0.97%	mission, sheep, shell, shake, short, sush, sugar, sure, shellfish
/ʒ/	0.07%	fusion, inversion, rouge, mirage, pleasure, seizure, treasure
/h/	1.40%	habit, height, hill, help, heat, high, yeah, cheetah, Sarah, Hannah

(Cmløegcmluin, 2012).

4. Basic features of sibilant sounds

Although it is extensively accepted that sibilant affricates are also sibilants, Crystal (2008) identifies sibilant as a fricative. Even though the benchmark of a sibilant is to gain an s-like sounding, sibilance can also include more than just [s] sounds. Sibilants in English are created by forcing the air stream through a narrow opening between the tongue and dental/ alveolar/palatal zones in the oral cavity. The oral cavity acts like a resonating cavity with hissing and hushing overtones. Due to high-frequency turbulence, the air stream strikes the teeth in dental/alveolar/palatal zone. A great majority of phoneticians state that sibilance includes any letter groups that create a hissing sound, including [ʃ, θ, f, z, v] sounds. In English, each sibilant sound holds a phonemic position in the English consonant inventory. Sibilant consonants have an inherent whispering quality.

Acoustically speaking, sibilance comes into being within 5 to 10 kHz frequency range. Sibilants are acoustically louder, and most of their acoustic energy occurs at higher. Additionally, sibilants are reported to have lesser high-frequency noise energy than the fricatives. It is different from the other sounds because of narrowness of this constrictive opening in the oral cavity and the high-frequency turbulence that results from the air subsequently striking the teeth at high speed and resonating in the cavity between teeth and tongue (Ladefoged & Maddieson, 1996; Trask, 2004).

Table 2. Phonemes and relative frequency

Phoneme	Relative Frequency	Examples
/s/	4.75%	bus, face, brace, trace, boss, fuss, stress, kiss, sausage
/z/	2.76%	zap, zeal, zinc, zip, buzz, zone, zoo, zoom, zigzag, zilch,
/tʃ/	0.56%	beach, catch, church, hatch, hit match, teach, watch
/dʒ/	0.59%	gin, gem, jeep, jeans, judge, hijack, George, jazz, Jack,

The wrong articulations of the fricatives and sibilants, mentioned above, with high pitch spitty voices will impede the speaking volume of pilots whose speech will never be at a constant level, which will lead to confusion in aircraft pilot/air controller communications.

5. Homophony and fricative sounds

Homophony shows words that sound the same but are spelled differently. Homophony includes words of different origins that become identical in pronunciation. This is a confusing characteristic of English because it creates ambiguity in aviation parlance. According to some calculations, the rate of homophony in English ranges from 7.4% (Rodd et al., 2002) to over 15% (Baayen et al., 1995).

Aircraft pilots, copilots, and air traffic controllers must know the homophonous words both in spoken and written language of aviation parlance. Therefore, homophony is also a linguistic phenomenon that can lead to confusion in pilot/controller communications. There may be different pronunciations of the homophonous words in different accents; therefore, pilots and air traffic controllers must be on the alert. Expanded training by minimal pairs must be obligatory for the education of pilots, copilots, ATC, and air-to-ground communication officials.

In Appendix A, there are some examples in corpora of homophonous words in North American English (NAE), which can be used to provide the students with exercises.

Homophones are pairs of words that are pronounced the same with two distinctly different meanings along with their dissimilar spellings. Understanding homophonous words is an essential and crucial part of learning the English language in relation to vocabulary building and spelling. Along with homophony, sometimes, bad speech-transmitting tools in planes and at air traffic centers harm the highest possible intelligibility of pilots and traffic controllers. Likewise, Turkish and English hold the same type and number of sibilants, which are /s, z, ʒ, ʒ, tʃ, dʒ/. But “L1 Turkish speaking students and teachers of English on-the-job are prone to encounter pronunciation problems in the plural, third person singular and possessive forms posed by sibilants of English” (Demirezen, 2016, p. 753).

In the book called *Fatal Words*, Cushing (1994) explains how miscommunication has led to dozens of aircraft disasters. He has clearly explained that in many flights ambiguities of words created communication misunderstandings. He has demonstrated some of the most notorious aircraft tragedies of our time. Every air traffic controller should read it because the book recommends an intelligent voice interface to filter conversations for deadly confusion. Cushing (1994) also provides real-time feedback and innovative solutions to help clear up unclear language in the aviation profession to prevent them.

Once again, the book called *Fatal Words* (1994) demands that pilots and air flight controllers should abide by strict aviation terminology. Also, it highlights pronunciation, intonation, and accent errors as fatal language barriers between aircraft pilots, copilots, air traffic controllers, and ground officials. All in all, it appeals to scholars in communications, applied and educational linguists, pilots, air traffic controllers, aviation experts, and English majors. Here are some of the words that contain hissing and hushing overtones:

Of the aforementioned vocabulary items, the following words are trickier to the pilots, and air traffickers because they contain fricative sounds whose pronunciations are full of hissing and hushing sounds. In fact, these words are dangerous, and therefore they resemble, as Cushing in the book *Communication Clashes and Aircraft Crashes* said (1994), to fatal words. In fact, all aviation personnel are required to know the aviation phonetic alphabet to communicate the information fast. Apart from the aviation phonetic alphabet, here is some information in IPA phonetic transcription describing homophony, which is a real problem causing issues in pronunciation for the personnel of aviation:

pigeon → ['pɪdʒən] ← pidgin	serial → ['sɪri:əl] ← cereal
weather → ['weðər] ← whether	through → ['θru:] ← threw

martial → ['mɑ:rfəl] ← marshal ceiling ['si:lɪŋ] ← sealing

In Appendix B, there is a list that represents further examples of minimal pairs with fricatives which can be utilized in the training of pilots, English majors and aviation-related counter-intuitively pronounced words.

The NAE and BrE are not using the same sounds in homophones. For example, while a minimal pair is homophonous in BrE, it may not be in NAE. While the words given below are minimal pairs in BrE, they are not in NAE, due to the fact that /r/ phoneme is a silent word-finally and after vowels in BrE:

horse → [hɔ:s] ← hoarse soar → [sɔ:] ← sore seller → ['selə] ← cellar
 career → [kə'ri:] ← Korea pear → [peə] ← pare mayor → ['meɪə] ← mare
 morning ['mɔ:nɪŋ] ← mourning coarse [kɔ:s] ← course fourth → [fɔ:θ] ← forth

The minimal pairs given above demonstrate the acoustic characteristics of clearly spoken English fricatives. It must be noted that such acoustic features like friction, hissing, and hushing tones of them make their perception by the people difficult. If these minimal pairs are adequately and appropriately carried out, they will ensure unambiguous pilot-controller-communication. As the main purpose of Aviation English training solely relies on voice communication, minimal pair training will essentially pave the way for a communicative approach to aviation parlance. Minimal pair training will, of course, promote language learning, particularly by focusing on speaking, listening, and interactive skills.

6. Fricatives and pronunciation intelligibility relations

Fricative sounds sound very spitty and pesky in speech, especially when occurring along with sibilants. Such acoustic features of words containing fricative sounds harm the audibility of words in conversations. When you have the feeling of perceiving the meaning of some words but if you cannot pronounce them properly, you are left with feelings of insecurity and inadequacy. If you can pronounce these words how they should be pronounced, you will gain the confidence to keep on improving your language skills.

6.1 Pronunciation and Aeronautical English relations

It must be indicated that "Aviation English" is not only confined to pilots and air traffic controllers (ATC), but it also refers to English on general terms in aeronautical and/or aviation universities" (Aiguo, 2008, p. 151). Aviation English is the internationally established language of pilots, ATC, and ground officials, so on. It consists of about three hundred terms that are a combination of professional plain English and aviation jargon, but this is not enough. If you don't have the Aviation English Language Assessment standard, it means you need to be assessed at a minimum of Level 4, 5 or 6. If you are assessed as a Level 6 then no further testing is required. So, one of the toughest topics for pilot students is to learn English efficiently.

Fricatives, like sibilants, are noisy sounds, which may create hearing difficulty for them in the cockpit. Therefore, fricatives and sibilants become a danger for crew safety in flights and can be a severe, disastrous jeopardy to aircraft and crew during take-off, approach and landing in aviation English. Pilots and ATCOs are the two integral partners in the radiotelephonic conversation. Communications between pilots and air traffic controllers (ATCO) are carried out via radiotelephony, without visual contact: this situation creates a serious hardship in communication between the aircraft pilots, ATCO, and the interlocutors. Aircraft pilots and ATCO in the airspace business need specific technical pronunciation knowledge as well as efficient communication skills. Even though communication between pilots and ATCOs is generally successful, miscommunication frequently occurs which can lead to irreparable accidents.

Miscommunication because of faulty hearing of fricatives and sibilants may occasionally be fatal for the future of the profession of aircraft pilots, copilots, and ATCOs.

For aircraft pilots, good pronunciation means that the airport controllers and passengers can understand what they say easily and that the pilots do not create confusion. "In 2006, the deadliest airplane crash in Brazil took place, with a death toll of 154 people: miscommunication (and pronunciation) was one of the causes of the accident" (Babboni & Quast, 2020, p. 1-14; Cristófar-Silva, 2012; ICAO, 2010). After this plane crash awareness towards communication issues gained more attention. "This will involve the making of adjustments by NSs as well as NNSs of English, towards an agreed international (rather than NS) norm" (Jenkins, 2002, p. 85).

Thus, in aeronautical English, another implication of Jenkins' work is that non-native speakers (NSs) should also be aware of those aspects of their own native speaker (NS) accents. This is an aspect that is especially relevant in pilot-ATCO communications. Pilots must know most of the frequent words, phrases, clauses, and sentences pertaining to pilot-ATCO communications.

The intelligibility of pilot-ATCO communication is also mentioned in the official documents of ATCO (2010). "Intelligibility has as much to do with the listener as with the speaker" (Kenworthy, 1987, p.14). According to Jenkins (2000, p. 79), "intelligibility is dynamically negotiable between speaker and listener, rather than statically inherent in a speaker's linguistic forms." "There is a need for linguistically trained communication specialists who can assist in the training of national experts, language trainers, and assessors, etc., as they will be aware of the particular language pitfalls faced by speakers of that speech community" (Seiler, 2017, p. 202).

Teaching pronunciation would professionally contribute to a general improvement of flights if the 'Lingua Franca Core' (Jenkins, 2000, 2002, 2005) is taken into consideration in relation to safety. Additionally, "Accent affects clear and concise communication between pilots and controllers, resulting in excessive time on radio frequency, loss of situational awareness, and added stress." (Clark, 2017, p. 45).

6.2 The lack of proficient pronunciation and accent in Aeronautical English

The global aviation community widely uses English as a tool of communication. The lack of efficient pronunciation and a standard dialect in English can be exemplified as follows:

1. Velarization of the glottal fricative /h/ (i.e. pronouncing English /h/ as a Brazilian velar [x])
2. The labiodentalization of the <th> interdental fricative was pronounced as /t/, /d/, /f/, /s/, /z/ or /v/) as pronunciation inefficiency to Brazilian pilots
3. Palatalization of alveolar stops /t/ and /d/ before /i/ (i.e. pronouncing /t/ as [tʃ] and /d/ as [dʒ])" (Babboni & Quast, 2020, p. 14).

As it is seen in the examples given above, all the causes of plane crashes stem from the inadequate hearing of fricative sounds all of which have different acoustic properties. Therefore, good pronunciation in pilot/traffic controller communications is vital to safety. Pronunciation of pilots and air traffic controllers needs to be sufficiently clear without any interference from their L1. The dialect and/or accent they use must be intelligible to the aeronautical community. Using thick local accents is highly hazardous. Their pronunciation, stress, rhythm, and sentence intonation must not be influenced by the first language or regional variation and consistent with the Lingua Franca of the highest possible intelligibility.

Aircraft pilots, copilots and air traffic personnel must adhere to certain pronunciations of communication while speaking on the radio, which may be different from Received Pronunciation (a standard form of British English pronunciation). In this respect, the related regulations were given by ATCO in 2020. It is especially imperative for pilots to understand different accents because the level of their pronunciation can decide their fate. So, they must maintain their language skills both in aviation English and general English.

7. The use of minimal pairs as a proposal in Aeronautical English

It is surprising that clear pronunciation of consonants with reference to fricatives has not been examined thoroughly in aeronautical English. It is specifically unsettling that clearly produced fricative consonants had not been observed meticulously in terms of pronunciation pertaining to the pilots and ATC officials. Even though English fricative sounds are very loud with high amplitude, they contribute to a large source of errors for normal-hearing listeners in a noisy atmosphere because the air stream passes through a narrow constriction that causes air to flow turbulently by creating a noisy sound along with audible friction all of which generate an airy effect in the oral cavity.

In the production of fricatives, the dominant source is turbulent noise which occurs when air flows rapidly with an audible friction through a constriction established by a narrow passage in the oral cavity. When the noise of the engines and faulty articulation of the aircraft pilots on the plane are added to this airy effect, the vocal efforts of the pilots do not contribute to clear production with any better intelligibility for the passengers and for the ATC officials on the ground.

7.1 The phonemes in minimal pairs

A phoneme is a unit of meaning-distinguishing sounds. It will be much better if the education of teachers of pilots, air traffic controllers and in air-to-ground communications. To begin with, phonemes are indicated as phonetic symbols in the IPA system (International Phonetic Alphabet), which must be extensively utilized in the education of these people. The matter of the fact is that in the education of Aviation English training and testing exams, minimal pairs are not adequately used in relation to content-based language training. For example, there is only a bit of minimal pair training in the listening practice of Aviation English Benchmark Level Test (Lenguax English language experts, n.d.).

Minimal pairs are two words with two distinct meanings that differ only in one sound. They are used to improve the pronunciation of distinct sounds (phonemes) in foreign language teaching. Through practice, Minimal Pairs assist with the correct pronunciation, enabling the learners to perceptively distinguish the different sounds in two similar-sounding words. They are utilized to show the sound differences so that the learners can concentrate on the meaning of distinguishing sound without getting distracted by the neighboring noises, turbulence, and friction. Since fricative sounds have noise, turbulence, and friction in their nature, minimal pair technique is the right choice to be used to study pronunciation in foreign language teaching.

Minimal pairs help us spot the existence of phonemes. For example, when we compare the words ship and sip, their phonetic structure is unearthed as follows:

ship /ʃɪp/ (a large boat used for carrying people and things on the ocean)
sip /sɪp/ (to drink something slowly, swallowing only small amounts)

The comparison of ship /'ʃɪp/ versus sip /'sɪp/ testifies the phonemic fact that it is the [ʃ] and [s] sounds that change the meaning of the two words at hand, and this means that they are able to change the meaning, and therefore each of them is more than sounds but phonemes, yielding /ʃ/ and /s/, each of which is a different phoneme in English language.

It must be noted that the articulation of fricatives and sibilants share very similar muscle activity along with acoustic overtones. The following examples are further cases of phonemic analysis via the application of minimal pair technique on English language fricative phonemes which are /f, v, s, z, θ, ð, ʃ, ʒ, h/ in comparison with the sibilants (/s, z, ʃ, ʒ, tʃ, dʒ/). In the minimal pairs which can be found in Appendix C, the sign /:/ denotes that the preceding vowel is lengthened:

8. Using minimal pairs in teaching Aeronautical English: A proposal

The minimal pairs are proposed in North American English (NAE) here because they rarely take place in the teaching books on Aeronautical English to teach pronunciation to the students (Speech Language Therapy, 2016). They can be used in preparing exercises, dialogues, prose texts, and so on.

8.1 Minimal pairs in relation to fricatives

Minimal pairs give clear distinctions between the pronunciation words. Minimal pairs are pairs of words that contrast in only one sound, such as price and prize, rice and rise, which yield /s/ versus /z/ phonemes which demonstrate the fact that /s/ versus /z/ represent two separate phonemes in the language, namely /s/ versus /z/, and that they are able to change the meaning of words in English. Therefore, minimal pairs are used for the hearing of two similar-sounding words so as to distinguish between the different meanings. In the course books aeronautical English minimal pairs must be used.

Aviation English teachers ought to teach the students aeronautical English who will be able to identify the minimal pairs along with various exercise types that are most relevant to their profession. Moreover, in the minimal pairs of words, the stressed syllable gives the hub of the meaning of utterances in aviation parlance because it is the stressed syllable that carries the tonic stress. Tonic stress refers to the place where the intended meaning is located by the speaker in words, phrases, clauses, or in a sentence. It is the syllable with tonic stress by means of which you mean what you mean to your interlocutors.

Additionally, it is the tonic stress that defines the types of falling in informative expression, rising intonation in declarations and questions, and flat intonation types. For example, an expression like "flight number 1188" will come out of the mouth of the announcer as "flight number 1 1 8 8" in rising intonation. Studying the Tonic stress requires another separate reach.

The issue of intonation teaching is another matter in aeronautical English. Here is an example:

"In reality, there are many factors that hinder radio communications between pilots and air traffic controllers: from radio interference noise and unintelligibly fast speech to linguistic factors like local accents, pronunciation mistakes (wrong sounds, stresses, intonations), incorrect phrasing, syntax, the use of slang, etc." (HSE University, n.d.).

Actually, pronunciation is a vital issue for the education of aircraft pilots, air traffickers and air-to-ground communications in terms of phraseology in radiotelephony in face-to-face communication. The audition, perception, and production of fricative sounds of English are crucial problem causer for aircraft pilots, copilots, and ground controller; therefore, they must be specially taught to them. The minimal pair-based pronunciation teaching activities must be incorporated to the programs of aeronautical English. Apparently, "Pronunciation is a frequent area of failure in [ICAO English Language Proficiency tests](#) and one that is often neglected because it is difficult for a learner to identify that they have a specific problem" (Aviation English, n.d).

9. Conclusion

What is the unique acoustic property of all fricative and sibilant sounds is the turbulence, hissing, and hushing overtones; all fricatives involve these acoustic features as a source of excitation in the vocal tract. The pronunciation of hard fricative sounds in vocabulary items coming up at high frequencies gives spottiness, edginess, or graininess of speech to the listeners, and it must be ridden off in aeronautical English. Thus, faulty pronunciation of fricatives along with mispronunciation of sibilants impedes aircraft pilots, copilots, and traffic controllers to maintain a constant speaking volume.

Aviation English training has very specific characteristics, and it is different from general English teaching and even English for specific purposes in other fields. Since pronunciation is a fundamental part of language learning, it must be given priority in aviation education and administration. Teaching pronunciation will adjust aircraft pilots and controllers' pronunciation so that their interlocutors can understand them in order to bring it closer to the pronunciation of native-speaking passengers on the plane in terms of accent (i.e., NAE, BrE, Canadian English, Australian English, New Zealand, etc.) pace, and pauses. So, pronunciation by itself gives information to us, such as the speaker's geographical origin, social class, profession, and education.

Exercises with minimal pairs make the people of aviation able to perceive with healthy hearing. Fricatives are very necessary for the speech intelligibility of the pilots who keep making announcements on the plane. If fricatives and sibilants are mispronounced, they become very disturbing to the passengers on the plane. This fact reminds us of the fact that in aviation English courses more time should be given to the study of Aviation linguistics (especially in phonetics and semantics), to listening and to note-taking. As mentioned before, faulty pronunciation and its perception make pilots more susceptible to accidents. It must be noted that communication failures do happen between the aircraft pilots, ATCO, and the official on the ground inevitably, and a great majority of these failures stem from incorrect hearing caused by faulty pronunciation and intonation interaction. Plus, crowded radio frequencies and bad radio connection, and statics while the pilot is trying to land plane worsen the clear hearing of fricatives mingled with noisy frequencies along with sibilants.

Correct pronunciation of fricatives along with sibilants with no lisping, normal hissing, and hushing are very necessary for speech intelligibility for aircraft pilots flying in the same airspace, and they can monitor air traffic transmissions much skillfully crashes by a mastery of efficient pronunciation of English language with clear audibility, an increase of situational awareness, and stop the possibility of the occurrence of the plane. Of course, pronunciation errors are cumulative, and the errors may occur due to a combination of faulty pronunciation of fricatives and tonic stress. Therefore, aviation English training designed for aircraft pilots and air traffic controllers must be based on a Content-Based Aviation English curriculum, which must include plenty of practice with minimal pairs for pronunciation in practice materials. Thus, integration of the pronunciation practice into the Aviation English curriculum on acoustic attributes of minimal pairs in relation to fricatives will definitely result in positive impacts, especially while pilots talking on the radio.

Having a pronunciation of standard aviation language or a dialect between aircraft pilots and ATC to communicate on the flight is a must because such skills inject confidence in the passengers for the pilots and the crew via acoustic characteristics of clearly spoken English fricatives with no noisy pronunciation features. The mastery of pronunciation over fricatives along with sibilants is necessary to achieving clear speech intelligibility, without a disturbing degree of hissing and hushing overtones in the aviation parlance. It must be noted that flawless English pronunciation with no noisy, hissing and hushing acoustics is especially needed by aircraft pilots who frequently give briefings and announcements to the passengers on the plane. Air safety, then, strongly relies on effective communication between aircraft pilots, copilots, and ATCs. Therefore, clear communication and correct understanding are very important in the

aviation profession and its parlance whose route passes through correct pronunciation and intonation learning and teaching.

For non-English pilots and copilots, there is always a possible probability of giving information with unclear pronunciation to the passengers and ATC people if they are not properly trained in aeronautical English. A tower controller, or an aircraft pilot, or a copilot with pronunciation and accent difficulties on English cannot be accepted. Such people must not give information with unclear and faulty pronunciation. In aviation and ATC profession, bad pronunciation along with a lack of skills in English inevitably leads to miscommunication and misunderstanding which can create fatally dangerous situations. Again, in aviation English, standard phraseology, and clear and unambiguous messages are all vital to effective pilot-controller communication, all of which depend on correct pronunciation and intonation in English. Flight communication failures, misunderstandings or erroneous interpretations and pronunciation of the other speaker's speech can cause irreparable mistakes and errors that can lead to a disaster in aviation parlance.

The cockpit noise in the airplane along with the hissing and hushing vibrations of the fricative sounds on the microphones and loudspeakers can have both temporary and permanent effects on the hearing ability of aircraft pilot. The combined noise can also contribute to pilot fatigue and the pronunciation abilities of the airplane pilot. The same procedure is true ATC people. Finally, it must be noted that poor communication due to faulty pronunciation and phraseology has contributed to several deadly plane crashes in modern air travel. Here is a real example:

“In one instance the flight crew reported to ATC that they were “running out of fuel” instead of signaling an emergency with the words "Mayday", which is a specifically prescribed phraseology for the declaration of an emergency. While "we're running out of fuel" may sound like a declaration of an emergency, in the context of controller-pilot communications, this statement was interpreted as a mere concern and not an emergency situation. That flight crashed after running out of fuel.” (Calibration Aero, n.d).

To sum it all up, it must be noted that the hissing and hushing resonating overtones of the fricative sounds mask and thus curtail in microphones and loudspeakers the speech intelligibility and healthy hearing of aircraft pilots, copilots, and ATC. The passengers on the plane and the announcements at the airports in terms of aviation parlance must be clearly made heard by the related people. It is important to note that [f, s, h, θ] fricatives are said to be the hardest fricative sounds to hear because they have higher frequencies. Therefore, aviation pilots, copilots, and groundwork officials who have high-frequency hearing loss will additionally have trouble in following conversations in which [f, s, h] sounds take place.

It is imperative that these people of aviation are able to speak clearly, listen, read, and comprehend English with ease. In order to complete their training and become aircraft pilots, they should be trained in aeronautical English the language being globally used in aviation. In the training materials of aeronautical English, the application and practice by minimal pairs are scarce. The minimal pairs proposed in this study can be utilized via preparations of related texts to help avoid misunderstanding in communication and confusion over the radio and on the plane between aircraft pilots, copilots, ATC, flight dispatchers, and international crews. It must be stressed that correct pronunciation is a fatal problem in the job of aviation parlance, which can cause plane crashes. Therefore, pronunciation as well as intonation must be given high priority in the education of aeronautical English teaching programs.

10. Disclosure of Conflict

The authors declare that they have no conflicts of interest.

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References

- Aiguó, W. (2008). Reassessing the position of aviation English: from a special language to English for Specific Purposes. *Ibérica*, 15, 151-164.
- Aviation English. (n.d.). *Elements of English pronunciation*. <https://aviationenglish.com/pronunciation/elements-of-english-pronunciation>
- Baayen, R. H., Piepenbrock, R., & Gulikers, L. (1995). *The CELEX lexical database [CD-ROM]*. Philadelphia: University of Pennsylvania, Linguistic Data Consortium.
- Babboni, C. A., & Quast, K. (2020). Pronunciation and Aeronautical English: Brazilians' difficulties and possible routes to intelligibility. *The Specialist*, 41 (4), 1-28.
- Calibration Aero. (n.d). <https://calibration.aero/importance-of-communication-in-aviation/>
- Clark, B. (2017). *Aviation English Research Project: Data analysis findings and best practice recommendations* (CAP 1375). Civil Aviation Authority, West Sussex, UK.
- Cmloegcmluin. (2012). *Relative frequencies of English phonemes*. <https://cmloegcmluin.wordpress.com/2012/11/10/relative-frequencies-of-english-phonemes/>
- Cristófar-Silva, T. (2012). *Pronúncia do Inglês Para Falantes do Português Brasileiro*. São Paulo: Editora Contexto.
- Crystal, D. (2008). *A dictionary of linguistics and phonetics. The language Library* (6 ed.) Oxford. Wiley-Blackwell.
- Cushing, S. (1994). *Fatal words: Communication clashes and aircraft crashes*. Chicago: University of Chicago.
- Demirezen, M. (2016). Perceptual identification and perception of sibilants of English language by Turkish English majors. *Procedia - Social and Behavioral Sciences* 232(2016), 750 – 758.
- Demirezen, M. (2022). How to teach the /ð/ phoneme to Indonesian and Turkish English majors: First Application. *Futuristic Implementations of Research in Education* 3(1), 2-16.
- Estival, D., Farris, C., & Molesworth, B. (2016). *Aviation English: A lingua franca for pilots and air traffic controllers*. London: Routledge.
- Jenkins, J. (2000). *The phonology of English as an international language*. Oxford: OUP.
- Jenkins, J. (2002). A sociolinguistically based, empirically researched pronunciation syllabus for English as an international language. *Applied Linguistics*, 23(1), 83-103.
- Jenkins, J. (2005). Teaching pronunciation for English as a Lingua Franca: A sociopolitical perspective. In: Gnutzmann, C. F. Intemann (Eds.) *The globalization of English and the English language classroom*. Oxford: OUP
- Koffi, E. N. (2021). *Relevant acoustic phonetics of L2 English: Focus on intelligibility*. CRC Press.
- HSE University. (n.d). *Air lines: Aviation safety and clear communication*. <https://iq.hse.ru/en/news/533834612.html>
- International Civil Aviation Organization. (ICAO). (2004). *Manual on the implementation of ICAO language proficiency requirements. Doc 9835*. (1st Ed.). ICAO.
- Kenworthy, J. (1987). *Teaching English pronunciation*. London: Longman.
- Ladefoged, P. & Maddieson, I. (1996). *The sounds of the world's languages*. Oxford. Blackwell.
- Ladefoged, P. & Johnson, K. (2015). *A course in phonetics* (7th ed.). Boston, MA: Wadsworth.
- Lenguax English language experts. (n.d). *Aviation English benchmark level test*. <https://www.lenguax.com/product/aviation-english-benchmark-level-test/>
- Rodd, J. M., Gaskell, G., & Marslen-Wilson, W. D. (2002). Making sense of semantic ambiguity: Semantic competition

- Online Etymology Dictionary (n.d). *Fricative*.
[https://www.etymonline.com/word/fricative#:~:text=fricative%20\(adj.\),fricative%20consonant%2C%22%20from%201863](https://www.etymonline.com/word/fricative#:~:text=fricative%20(adj.),fricative%20consonant%2C%22%20from%201863)
- Rodd, J. M., Gaskell, G., & Marslen-Wilson, W. D. (2002). Making sense of semantic ambiguity: Semantic competition in lexical access. *Journal of Memory and Language* 46(2), 245-266.
<https://doi.org/10.1006/jmla.2001.2810>
- Seiler, W. (2017). Linguistics in Aviation. In D. Perrin, & U. Kleinberger (Eds.). *Doing Applied Linguistics: Enabling transdisciplinary communication*. Berlin: Walter de Gruyter GmbH, 200-206.
- Speech Language Therapy. (2016). *Word lists: Minimal pairs*. https://www.speech-language-therapy.com/index.php?option=com_content&view=article&id=134:mp2&catid=9:resources&Itemid=108
- Stevens, K. N. (1971). Airflow and turbulence noise for fricative and stop consonants: static considerations. *Journal of Acoustic. Society of America*, 50(4)2, 1180-1192.
- Trask, R. L. (2004). *A dictionary of phonetics and phonology*. London: Routledge.

APPENDIX A

add and ad	ail and ale	allowed and aloud	all and owl
aural and oral	ate and eight	accept and except	altar and alter
coarse and course	cellar and seller	dear and deer	foreword and forward
brake and break	four and for	arc and ark	Greenwich and green witch
hear and here	line and lion	knot and not	missed and mist
piece and peace	plane and plain	right and write	right and rite
see and sea	tail and tale	there and their	wait and weight,
two vs. too vs. to	hole and whole	bare and bear	bough and bow
sell and cell	new and knew	so and sew	blue and blew
break and brake	fair and fare	sun and sun	whether and weather
cent and sent	die and dye	heal and heel	stationary and stationery
hour and our	idol and idle	soul and sole	steal and steel
night and knight	flour and flower	pour and poor	band and banned
dual and duel	dam and damn	find and fined	holly and wholly
canon and cannon	creak and creek	incite and insight	cite vs. sight vs. site
peak and peek	ceiling and sealing	role and roll	reign vs. rain vs. rein
wear and where	by and buy	bold and bowled	yore vs. you're vs. your.
ball and bowl	bard and barred	bee and be	broach and brooch
bean and been	billed and build	bored and board	bridal and bridle
Capitol and capital	beech and beach	census and senses	dun and done
draft and draught	ewe and you	faze and phase	discrete and discreet
fur and fir	flea and flee	foul and fowl	heal and heel



serial and cereal
council and counsel
passed and past
sail and sale
side and sighted
some and sum
vane and vein
price and prize

berth and birth
flex and flakes
marshal and martial
scene and seen
soar and sore
staid and stayed
whose and who's
since and sins

chili and chilly
genes and jeans
profit and prophet
shoe and shoo
muscle and mussel
stare and stair
cue and queue
pause and paws

flew vs. flue vs. flue
flex vs. flecks vs flakes
flew vs. flue vs. flue
principle and principal
slay and sleigh
throne and thrown
rice and rise
stake and steak

APPENDIX B

coarse and course
and peace
sun and sun
holly and wholly
beech and beach
draft and draught
flea and flee
serial and cereal
genes and jeans
sail and sale
shoe and shoo
muscle and mussel
vane and vein
ferry and fairy
advice and advise
waist and waste

cellar and seller
see and sea
cent and sent
creak and creek
census and senses
ewe and you
foul and fowl
berth and birth
passed and past
profit and prophet
side and sighted
staid and stayed
whose and who's
since and sins
tow and toe
phase and faze

missed and mist
sell and cell
steal and steel
incite and insight
ceiling and sealing
faze and phase
heal and heel
flew and flue
marshal and martial
scene and seen
soar and sore
stare and stair
rice and rise
pause and paws
feint and faint
cite and site

Greenwich and green witch piece
so and sew
find and fined
cite vs. sight vs. site
hear and here
discrete and discreet
broach and brooch
council and counsel
principle and principal
flex vs. flecks vs flakes
slay and sleigh
throne and thrown
price and prize
stake and steak
rose and rows
patients and patience

APPENDIX C

shack /'ʃæk/ → /ʃ/

jack /'dʒæk/ → /dʒ/

thin /'θɪn/ → /θ/

gin /'dʒɪn/ → /dʒ/

these /'ði:z/ → /ð/

seize /'si:z/ → /s/

mesher /'mɛʃə/ → /ʃ/

measure /'mɛʒə/ → /ʒ/

these /'ði:z/ → /ð/

cheese /'tʃi:z/ → /tʃ/

chin /'tʃɪn/ → /tʃ/

gin /'dʒɪn/ → /dʒ/

chug /'tʃʌg/ → /tʃ/

jug /'dʒʌg/ → /dʒ/

five /'faɪv/ → /f/

hive /'haɪv/ → /v/

vision /'vɪʒən/ → /ʒ/

villain /'vɪlən/ → /l/

then /'ðɛn/ → /ð/

hen /'hɛn/ → /h/

jazz /'dʒæz/ → /dʒ/

has /'hæz/ → /h/

jeez /'dʒi:z/ → /dʒ/

cheese /'tʃi:z/ → /tʃ/

choke /'tʃoʊk/ → /tʃ/

joke /'dʒoʊk/ → /dʒ/

shade /'ʃeɪd/ → /ʃ/

jade /'dʒeɪd/ → /dʒ/

sink /'sɪŋk/ → /s/

zinc /'zɪŋk/ → /z/d

beige /'beɪʒ/ → /ʒ/

base /'beɪs/ → /s/

lathe /'leɪð/ → /ð/

laze /'leɪz/ → /z/

them /'ðɛm/ → /ð/

gem /'dʒɛm/ → /dʒ/

chain /'tʃeɪn/ → /tʃ/

Jane /'dʒeɪn/ → /dʒ/

shot /'ʃɒt/ → /ʃ/

jot /'dʒɒt/ → /dʒ/

shell /'ʃɛl/ → /ʃ/

jell /'dʒɛl/ → /dʒ/