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## The Effects of Foreign Accent and Language on Reaction Time and Accuracy in an Air Traffic Control Task

Rosabelle Suarez

*Embry-Riddle Aeronautical University - Daytona Beach*

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The Effects of Foreign Accent and Language on Reaction Time and Accuracy  
in an Air Traffic Control Task

By

ROSABELLE SUAREZ

B.S. Embry-Riddle Aeronautical University

A Thesis Submitted to the  
Department of Human Factors and Systems  
In Partial Fulfillment of the Requirement for the Degree of  
Master of Science in Human Factors and Systems

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The Effects of Foreign Accent and Language on Reaction Time and Accuracy  
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by

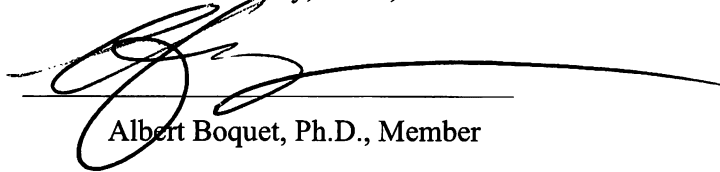
Rosabelle Suarez

This thesis was prepared under the direction of the candidate's thesis committee chair, Shawn Doherty, Ph.D., Department of Human Factors and Systems, and has been approved by the members of the thesis committee. This thesis was submitted to the Department of Human Factors and Systems and has been accepted in partial fulfillment of the requirements for the degree of Master of Science in Human Factors and Systems.

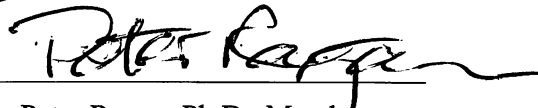
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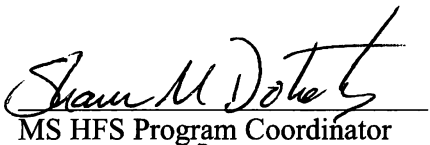
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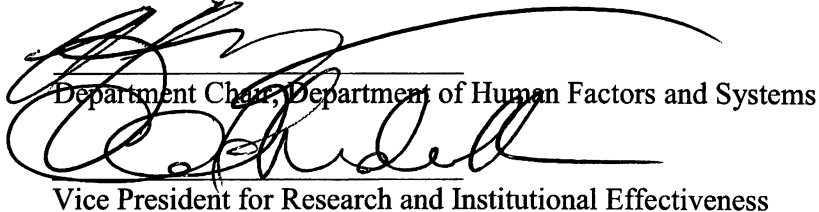
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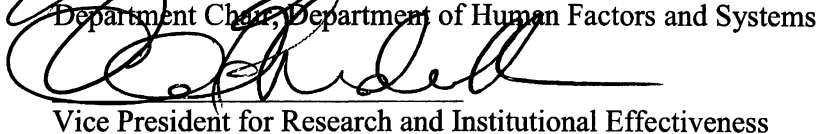
Peter Ragan, Ph.D., Member



MS HFS Program Coordinator



Department Chair, Department of Human Factors and Systems



Vice President for Research and Institutional Effectiveness

## Abstract

The present study examines the effect of foreign accent interference with the ability to execute commands presented in speech format. The objective of this study was to demonstrate that a foreign accent influences performance. Participants were between 18 and 40 years of age. Half of the participants were native speakers of Spanish who began learning English as a second language via the classroom setting. The other half were native English-speaking with little or no exposure to the Spanish language. The experimental design was similar to an aviation scenario where participants listened to simulated ATC procedural commands and execute them on a simulated control panel. Response time (in milliseconds) and accuracy were recorded. Accuracy was measure by incorrect responses and false starts. Incorrect responses were measured when participants pressed an arrow key different from the commanded direction. False starts occurred when the participant pressed a key before the command was presented. The results of this study did not reveal an effect of language for reaction time. However, the false start data indicated a significant effect on accent for native English speakers, but not an effect on accent for non-native English speakers. On the contrary, the data from incorrect responses does not show a significant effect of accent for native English speakers but a significant difference in effect of accent on non-native English speakers. Therefore, the accuracy hypotheses were not supported.

## **Acknowledgment**

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## Table of Contents

Abstract .....	iii
Acknowledgment .....	iv
List of Tables.....	vii
List of Figures .....	viii
Introduction .....	1
<i>Problem Statement</i> .....	2
Literature Review .....	2
<i>Second Language Processing</i> .....	3
<i>Speech Comprehension</i> .....	10
<i>Pronunciation</i> .....	12
<i>Accent</i> .....	15
<i>Reaction Time</i> .....	18
<i>Communication Problems in Aviation</i> .....	19
<i>Hypotheses</i> .....	25
Methods.....	26
<i>Participants</i> .....	26
<i>Apparatus</i> .....	26
<i>Design</i> .....	27
<i>Procedure</i> .....	27
<i>Results</i> .....	28
Discussion .....	33
Limitations .....	38
Conclusion.....	39
References .....	41
Appendices .....	57
APPENDIX A	
Examples of Communication Problems in Aviation.....	57

APPENDIX B  
HR Story..... 61

APPENDIX C  
Scripts..... 63

## List of Tables

Table 1. Categorization of Pilot-ATC Oral Communication Problems. ....	6
Table 2. Result of Some Experimental Studies Done to Find Out How Human Brain Organizes Two Languages. ....	22
Table 3. Categories of ATC Communication Errors. ....	24
Table 4. Overall means and standard deviation for native and non-native English speakers .....	32

**List of Figures**

Figure 1. The basic speech and language circuit of the cerebral cortex .....	5
Figure 2. De Bot's Model of Second Language Processing .....	9
Figure 3. Reaction Time in Milliseconds .....	32
Figure 4. False Start Results for Native English Speakers.....	34
Figure 5. False Start Results for Non-Native English Speakers .....	35
Figure 6. Incorrect Responses for Non-Native English Speakers .....	36
Figure 7. Incorrect Responses for Native English Speakers .....	37

## Introduction

Today, thanks to the Wright Brothers and those who risked their lives in the name of aviation, we can enjoy the beauty and mystery that each country harbors. We can travel from one part of the planet to another in a matter of hours.

Every country has its own set of customs and language; for this reason, human beings needed to find a universal language for aviation, which would enable us to communicate among citizens of different countries. As a result of this dilemma, and because the aviation industry was dominated by the English-speaking nations, the International Civil Aviation Organization (ICAO) recognized that many countries would wish to use their native languages. For this reason ICAO made two recommendations. First, ICAO recommended communication in the country's native language be used by the air traffic control's stations on the ground. Second, ICAO suggested that English be available at all control facilities serving international traffic. ICAO recommendations were a provisional measure until a more universal aviation language was developed; in the meantime English was used and now it has become the official aviation language (Uplinger, 1997).

Unfortunately, the English language has many linguistic inconsistencies, and these irregularities have brought serious problems to the aviation industry. For instance, on March 27, 1977 a K.L.M. Boeing 747 and a Pan Am Boeing 747 collided in Tenerife, Canary Islands, killing 583. After an intense investigation, the National Transportation Safety Board (NTSB) and the Spanish Aviation Safety Board concluded that the cause of this accident was due to a failure of the flight crew to communicate effectively with Air Traffic Control (ATC) due to the crew's limited ability to use the English language.

## Problem Statement

There is no doubt that the collision between the Pan Am and KLM Boeing 747s at Tenerife was a tragic lesson for the aviation community. This accident demonstrated that the “information transmitted by radio communication can be understood in a different way from that intended, as a result of ambiguous terminology and/or the obliteration of key words or phrases” and that “the oral transmission of essential information, via single and vulnerable radio contacts, carries with it great potential dangers.” (Job, 1994)

Unfortunately, miscommunication still causes aircraft accidents. In September 1997, confusion between the pilot and air traffic controller was considered the most likely cause of the Garuda A300 Airbus crash at Medan, Sumatra, which claimed 234 lives (Thomas, 1998). (See appendix A for more examples of communication problems in aviation.)

In addition, to preventing accidents, such as the one that occurred at Tenerife and Medan, aviation agencies such as the Federal Aviation Administration (FAA) and the ICAO have created departments that focus on developing better language training programs for non-native English speaking pilots. This study is intended to assist in this endeavor by investigating if accents influence flight performance based on whether English is the pilots’ primary (L1) or secondary (L2) language.

## Literature Review

It is through language that people share their thoughts, their experiences and their culture. There is no doubt that a large number of our social interactions are made through our speech. We acquire most of our education through conversation, lecture and discussion. Our behavior can be affected through language, and for this reason many researchers are extremely interested in how human beings acquire and process language and comprehend speech.

Before continuing with the literature review, it is necessary to clarify some terms. According to Skutnabb-Kangas and Phillipson (1989) and for the purpose of this study, the terms mother tongue, and first language (L1) will mean: (1) The language learned from the mother; (2) First language learned; (3) The stronger language at any time of life; (4) The language most frequently used by a person; and/or (5) The mother tongue of a specific area or country. On the other hand, the terms such as foreign language (FL), bilingual and second language (L2) will indicate: (1) Some exposure to an additional language beyond the first language; (2) A variety of native languages spoken by individuals that come from different countries; and/or (3) The English language learned formally by individuals 12 years old or older.

### *Second Language Processing*

It is well known that that a dual language ability can influence performance (e.g. Albert & Obler, 1978; Flege, Munro & Mackay, 1995; Lennerberg, 1964; Preston & Lambert, 1969). However, there are controversies among researchers about how a single individual can process two languages. Some believe that the two languages are divided into two different systems (Cook, 1992; Grosjean, 1989). Others contemplate the idea that the two languages are part of one unified system (Redlinger & Park, 1980). The vast majority of language researchers believe that the truth lies in the middle of these two views.

While studying patients with brain damage to their linguistic areas (aphasics), Pitres (1895) discovered that many bilinguals who suffer from aphasia have lost one language (usually the first language) but not the other. This finding suggests that each language can function independently from the other and this separation must be at the root level of words because one language is not impaired when the other is lost (Smith, 1997). Furthermore, Pitres believed that all languages were localized in a common language area. Recent studies performed by Electrical Stimulation of the

Brain (EBS), electrophysiological techniques such as Event-Related Potentials (ERPs), Magnetic Source Imaging (MSI), Functional Magnetic Resonance Imaging (fMRI), Magnetic Resonance Imaging (MRI), and Positron-Emission Topography (PET) have demonstrated that Pitres was correct when he postulated that the process of language is independent from other processes such as vision, attention and memory (Perani, Paulesu, Galles, et al., 1998; Fabbro, 2001).

In addition, in 1978, Ojemann and Whitaker used electrocorticostimulation during brain surgery to study the linguistic function of the brain. They discovered that there are specific cortical areas that both languages share. For instance, stimulation of the temporal lobe disrupted both languages that bilinguals possess. The temporal lobe (see figure 1) language area is important for language comprehension (understanding). After this breakthrough, several scientists such as Kim et al. (1997), Illes et al. (1999) and Pouratian et. al. (2000) conducted numerous studies on how human brain organizes two languages. Table 1 gives an idea about Kim et al., Ills et al., Pouratian et al., and other researchers' findings on how the human brain organizes two languages.

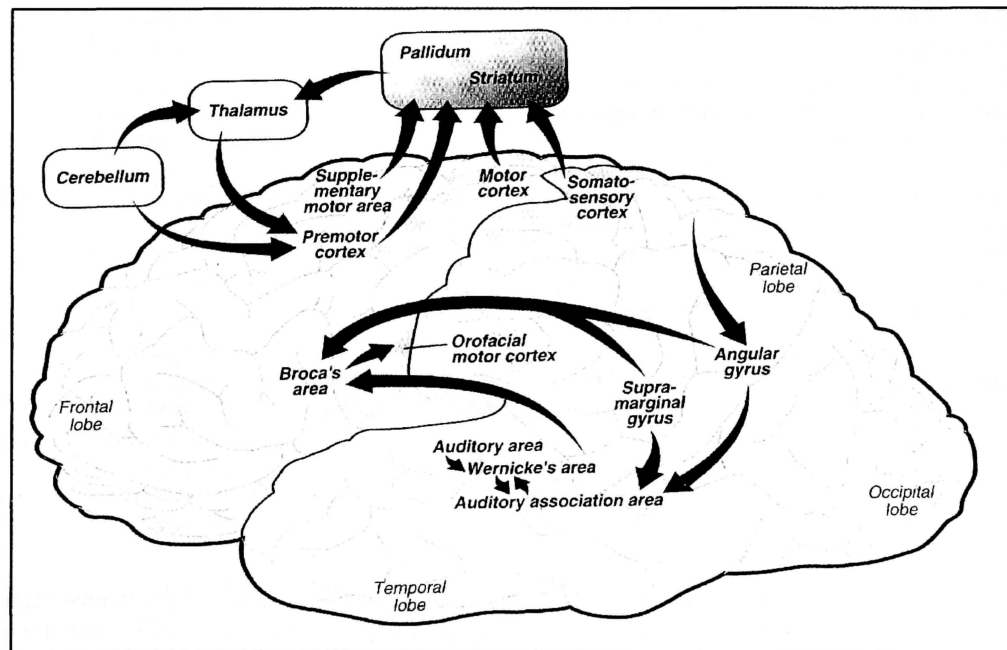


Figure 1. The basic speech and language circuit of the cerebral cortex



Table 1. Results of some experimental studies done to find out how human brain organizes two languages. (See Figure 1 for a better understanding of human language circuit of the cerebral cortex.)

Authors	Technique	Subjects	Task	Results	Conclusions
Kim et al. (1997)	fMRI	eb-Acquired L1 and L2 in early childhood LB- acquired L2 as young adult Language varied	Response to questions	LB- significantly showed activation area for L1 and L2 in BA. EB – No activation between two languages	Age of acquisition is important for functional organization of Broca's area
Illes et al. (1999)	fMRI	Fluent LB in Spanish and English (average age 12)	1. Decide if the word shown is abstract or concrete. 2. Decide if the word shown is upper or lower case.	LB and EB showed no difference	Age does not determine organization in the brain. Proficiency localizes the functional region for each language at least in semantic processing
Pouratian et al. (2000)	Optical Imaging, ESM, fMRI	43-year old female Spanish L1, English L2 (L2 was learned at age of 6) with damage in middle temporal lobe	Naming visual objects in L1 and L2	STG including WA and MTG had similar activation area for both L1 and L2. PTG had separate region of activation	The function of areas in the brain determines the cortical representation of bilingual brain
Perani et al. (1996)	PET	Italian (L1) and English (L2) with moderate command of L2	Listening to a story	L1 – most activated area were IFG, the STG and MTG, the TL, and AG	Result clearly supported the hypothesis of different representation of the two languages
Dehaene et al. (1997)	fMRI	8 subject, French (L1) and English (L2) with moderate command of the L2	Listening to a short story	L1- all subject showed activation on the LTG L2 – Activation varied from subject to subject. 6 showed disperse activation of LTL; 2 showed activation RTL	Supports the hypothesis that first language acquisition relies on a dedicated left-hemispheric cerebral network, while late second language acquisition is not associated with a reproducible biological substrate.
Simos et al. (2000)	MSI	11 Spanish and English bilinguals. Spanish as L1= 7 subjects. English L1= 4 subjects	Reading or listening to words either in Spanish or English	No significant difference in activation when reading words. Listening task activated STG and MTG	The location of activity varied across individuals

Temporal lobe, RTL=right temporal lobe, STG= superior temporal gyrus, MTG= middle temporal gyrus, SupTG= superior temporal gyrus, PTG=posterior of temporal gyrus, IFG= inferior frontal gyrus, TP= temporal lobe, angular gyrus=AG

These studies suggest that even though languages can function independently from each other, second language processing might be processed in the same way as the primary language, since they both use the same areas.

Paradis (1981a) agrees with Pitres. Paradis believes that L1 and L2 might be stored in similar systems, but the elements of each language probably come from separate networks, subsystems within the larger system. He writes: "According to this hypothesis (the subset hypothesis), bilinguals have two subsets of neural connections, one for each language, while at the same time they possess one larger set from which they are able to draw elements of either language at any time." Paradis' also believes that these subsystems can be independently activated. In other words, a person can activate his/her L2 without activating his/her L1. In addition, bilinguals may stay within a subsystem when speaking or bringing in elements from the other subsystem. Paradis' subsystems hypothesis is a neurolinguistic model of how two (or more) languages are organized in one brain.

A similar model to Paradis' subsystem hypothesis has been proposed by Green (1993) to account for word production and translation. Green concurs that L2 is organized in separated subsystems of the language area of the brain. However, he differentiates three levels of activation. According to Green, a language is more activated when it is selected, meaning, when it is currently spoken. It is less activated, but still active, when it is not being spoken, yet still working in the trough process. Lastly, there are dormant when they are not active at all. Dormant languages are not in regular use and do not affect the ongoing processing of the other language. For instance, when an individual desires to speak in his or her second language, he or she will activate the L2, and the L1 will keep on working, but it will be inactive until it is needed. However, if the person uses his/her L2 continuously, his/her L1 will be dormant.

In contrast to Green's theory, de Bot (1992) postulated a psycholinguistic processing model. In this model, de Bot tries to account for language processing from the conception of a message to its acoustic realization. He employed Paradis, and Green's hypothesis to create his own model for speech production. For instance, de Bot uses Paradis subset hypothesis to connect between elements from one language to the other language. Then, he applied Green's proposal of three levels of activation in language spoken by bilinguals. The language can be selected or articulated, active or language that is processed but not articulated, and dormant or language stored in the memory but not processed. Subsequently, in 1992, de Bot contends that it is in the conceptualized (see Figure 2) area where the decision to speak a language must be made. In other words, it is in the conceptualized realm where the speaker's knowledge of a language is located. By this he meant that due to the difference of languages' grammar and structures, languages could not be encoded by the same rules of syntax.

For instance, Korean and English languages have a different syntax; therefore, a person cannot encode these languages in the same fashion. For this reason, de Bot adopted Paradis' subset hypothesis and, based on this theory, he believes that the L1 and L2 languages are grouped in different subsets (e.g. one subset for L1 and another for L2) and can be activated depending on which language is going to be used.

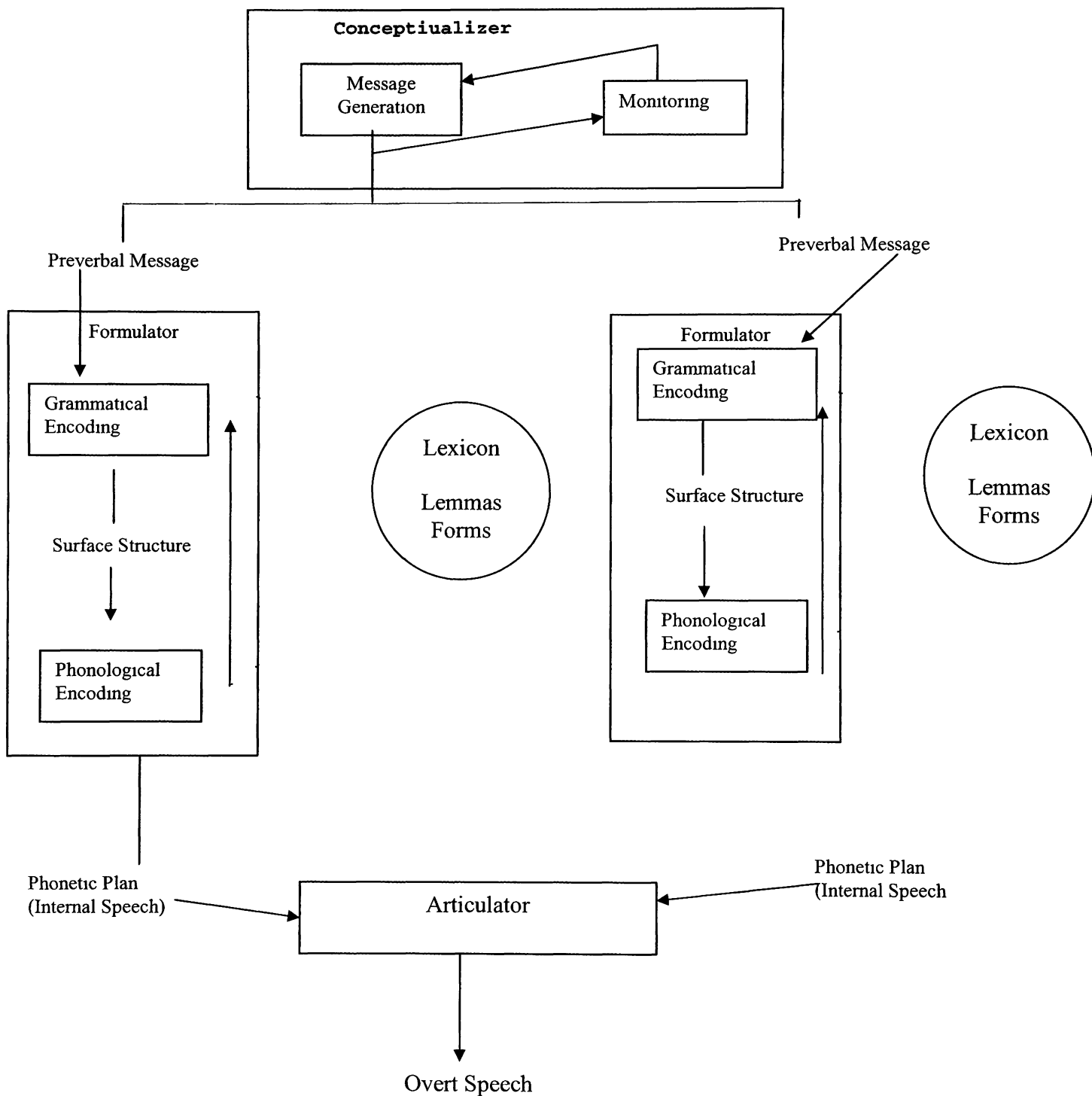


Figure 2. de Bot's Model of Second Language Processing

The second component of de Bot's model is the formulator. According to him, the formulator is language-specific. In other words, the formulator encodes the grammar and the phonology separately. He believes that bilinguals generate two speech plans at the same time, one for the active language (the one that the individual is speaking at the moment of speech) and for the inactive one (the one that the individual is not using at the moment of speech). He also thinks that speech plans for the two languages are always available. Therefore, it will be easy for the speaker to end the encoding of one language and continue with the other one.

Grosjean's (1998) theory is very similar to Paradis', Green's, and de Bot's theories. He argues that language modes, defined as the state of activation of the bilingual language(s) processing mechanism at any given time, are activated by bilingual persons according to variables such as listening, or conversing to another monolingual or bilingual, topic of the conversation, situation or the purpose of the interaction. At one end, the bilingual can be in a total monolingual mode. In this mode, one language is activated and the other is deactivated. This happens when a bilingual individual is interacting with a monolingual individual. It is here where the interference of the other languages is visible.

The second mode is when two bilinguals choose to communicate in an L2 language, or one of the speakers lacks knowledge of a language. These two individuals do not necessarily share the same first language (e.g. a Spanish speaker talking to a Korean speaker in English). Here, both languages are activated, but one language will be to some extent less active than the other language. In this "mode" the speaker will produce less interference than in the monolingual mode.

The last mode is when two bilinguals share the same first language. One language is activated and the other is dormant. They are most likely to interact on a base language and the other language(s) is (are) available in case they need to borrow from their L2. This borrowing can be

defined as second language interference. In other words, the temporary departure of the common language is due to influence of the other language that is slightly dormant and this can influence the performance in a person's L1 or L2.

From these arguments it is clear that cognitive researchers on bilingualism have been arguing regarding the functional integration of the bilingual brain. On one end of the spectrum, human mental representations of the two languages were viewed as being shared. At the other side, each language has its own separate representation. However, what is clear is that at any give point in time and based on these linguistic theories, a bilingual individual has to decide, sometimes unconsciously, which language to use.

Understanding a spoken message is dependent upon the ability to hear and differentiate the sounds that comprise the words of the message. Although speech decoding occurs rapidly, it is a complex task that relies upon a number of distinct processes and is complicated by the fact that phonemes have varying acoustic characteristics depending on: 1) where they are found within a word, 2) which phonemes they accompany, and 3) the individual speaker.

### *Speech Comprehension*

Many times, human beings take for granted their ability to understand spoken language. However, this is a complex process, and is a major subject of psychological investigation. Cognitive psychologists aim to explain the sequence of mental events that enable us to perform a complex cognitive task. In the case of speech comprehension, cognitive psychologists must explain the sequence of events that take place from the moment the spoken language enters the ear to the moment the listener understands the intended meaning of what was said. These processes must translate thoughts into sounds, using the patterns and elements of a code that constitutes the grammar of a language. For theories of language comprehension, the goal is to explain how the

mind uses this code when converting messages into spontaneous speech in ongoing time. This requires an explanation of the action system that puts language knowledge to use.

For most of us, listening to another person speak is an effortless task. It is a well-known fact that the perception of human speech goes through a series of steps in which the acoustic signals are extracted and stored in our sensory memories and then mapped into linguistic information (Collins & Quillian, 1969). Words are stored in a network in their memory. When a word refers to an object, the word connects to a concept in the mental dictionary or lexicon and the process of calling up words from one's memory is called lexical access. The rate at which words are retrieved is influenced by how frequently the word appears in an individual's speech (e.g. Rubenstein, Garfield, & Milliken, 1970). Therefore, understanding a language is a complex process.

One of the first steps of language comprehension is the analysis of the structure of the language perceived. This is called parsing. During parsing the brain determines how words are grouped. This group is attached to a series of rules, specific for each language, which appear to be internalized when a child learns his/her mother tongue (Inglis, 2002). Then, the sentence is interpreted. However, the brain must utilize its memory system. Working memory or short-term memory is considered an active system that temporarily stores and manipulates information while it is being needed in the execution of complex cognitive tasks.

In 1970, Warren and Warren conducted a study where they selected a simple sentence, such as "It was found that the wheel was on the axle." and removed the /w/ sound (phoneme) from "wheel." They found that listeners could not detect the sound (phoneme) that was missing. The same happened in the following sentences:

**It was found that the \*eel was on the shoe.**

**It was found that the \*eel was on the orange.**

**It was found that the \*eel was on the table.**

Listeners perceived heel, peel, and meal, respectively. They concluded that perception of a word with a missing phoneme depends on the last word of a sentence. Therefore, this indicates that perception is highly interactive since an earlier aspect of a phrase can be affected by one appearing later in the phrase. When a person tries to decode what the other person is trying to say, this action can lead to miscommunication, which could result in an error of performance. As Austin (1962) stated, miscommunication can be viewed as instances of action failure (when the speaker fails to produce the intended effect), misperception (when the hearer cannot recognize what the speaker intended to communicate), or both. Therefore, these missing phonemes could result in a catastrophic accident especially in the aviation domain.

As mentioned before, the human communication system is complex. The sender delivers a message to the receiver. The receiver processes the message, comprehends it, and utters an idea. The action of uttering an idea is called pronunciation. In other words, pronunciation is the manner in which a person utters a word.

### *Pronunciation*

There is no doubt that most individuals have trouble with sounds (phonemes) that do not exist in their first language. In infancy children begin to learn the sounds of their first language (L1). By the time a child is a year old, he/she has learned the distinctions among sounds that are relevant to his/her language. It has been demonstrated that the older a person gets, the harder it becomes to learn the sounds of a different language. Researchers such as Flege, Munro and Mackay (1995) have focused their investigation on the effect of age of the L2 acquisition on L2



phonology. The findings suggest that the earlier in life a person learns the L2, the closer to native-like pronunciation it would be. However, if a person learns his/her second language later in life, the less accurate is the L2 pronunciation of vowels and consonants, which may also suggest what comprehension of those phonemes may be. Further studies performed by Flege et al. (1997) and Piske and Mackay (1999) concluded that L1 use could have an influence in the production of L2 pronunciation, whether a person learned the L2 as a child or as an adult. To explain this, Fledge et al. (1997), proposed the single system hypothesis, which infers that bilinguals have a single phonological system in which the L1 and L2 phonetic system reside. Consistent with this theory, bilinguals are unable to isolate their L1 and L2 phonetic system, similar to the second language processing theories of Pitres.

According to Anderson-Hsieh, Johnson, and Koehler (1992), the major areas of pronunciations are segmentals (the individual phonemes of the language) and the prosody (the rhythmic and intonation of a language such as loudness, pitch, and tempo) aspect of a syllable structure, and voice quality. Deviance in segments involves errors in consonants and vowels, such as the substitution of one sound from another or the modification of a sound (Dickerson, 1975; Hecht & Mulford, 1982; Altenberg & Vago, 1983; Beebe, 1984). Errors in prosody involve deviations in patterns of stress and intonation as well as in timing, phrasing and rhythm (Grover, Jamieson, & Dobrovolsky, 1987; Flege & Bohn, 1989; Juffs, 1990; Shen, 1990). Syllable structure errors involve the addition of a segment or syllable, the deletion of a segment or syllable, or reordering of segments in syllables. The most common are the deletion of a consonant or vowel (Tarone, 1980; Anderson, 1983; Broselow, 1983, 1984; Sato, 1985; Karimi, 1987). As demonstrated by Warren and Warren (1970), these errors could lead to performance errors.

Many researchers found that the hardest sounds to learn may be those that are similar to, but just a bit different from, sounds in the persons' native language (Flege, Frieda, Walley and Randazza, 1998). It seems to be very difficult to overcome the tendency to keep using the familiar sounds from your native language. In this sense, native language causes 'interference' in the person's efforts to pick up the new language. For example, to say "I call myself" in Spanish, one must say "me llamo" which is pronounced may-yah-moe phonetically. However, the non native speaker will incorrectly say may-lah-moe assuming that the "ll" is pronounced as an "l" sound. He/she ends up saying: "I lick myself" rather than "I call myself".

Another factor that has to be taken into consideration in the study of second language pronunciation is the relationship between languages an individual speaks. For instance, French, Italian, Spanish, and Portuguese are all descended from Latin, so they are closely related, and a speaker of one can speak any of the others fairly easily. However, learning the pronunciation of a language that's closely related to your native language can also bring problems because their similarity can result in interference from your native language that would cause you to make mistakes. Albert and Opler (1978) claim that people show more lexical interference on similar items than dissimilar items. Therefore, languages with more similar structures (e.g. Spanish and English) are more susceptible to mutual phonological difficulties, and therefore performance interference (Selinker, 1979; Dulay et al., 1982; Blum-Kulka & Levenston, 1983; Faerch & Kasper, 1983; Bialystok, 1990; Dordick, 1996) than languages with fewer similar features (e.g. English and Korean).

The human perception system is extraordinary flexible. Nygard and Pisoni (1998) believe that "the human ability to recognize spoken language is due to a period of perceptual adaptation in which listeners learn to differentiate the unique properties of each talker's speech pattern from the

original indented linguistic message.” This process is involuntary, automatic and effortless. Only when an individual’s speech deviates from the listener’s dialect, it becomes difficult to understand and leads to errors in speech perceptions. These interferences in word recognitions lead to miscommunication and slowed processing. Accents are a classic example of speech that deviates greatly from the listener’s norm so that it cannot be understood by the average speaker of a language.

### *Accent*

There are two different kinds of accents. One kind of accent is the way a group of people speaks in their native language. This is determined by where they live and what social groups they belong to. People who live in close contact grow to share a way of speaking, or accent, which will differ from the way other groups in other places speak. Crystal (2002) defined this type of accent as “...the cumulative auditory effect of those features of pronunciation which identify where a person is from, regionally or socially.”

The other type of accent, and the one that is of interest in this study, is the “foreign” accent, which occurs when a person speaks one language using some of the rules or sounds of another one. For example, if a person has trouble pronouncing some of the sounds of a second language, he/she may substitute similar sounds that occur in his/her first language. This will sound wrong, or “foreign”, to native speakers of the language. Munro (1998) defined foreign accent as “a non-pathological speech that differs in partially systematic ways from the speech characteristics of native speaker of a given dialect.” The term foreign accent is often used in a general, non-scientific context and as a term describing a linguistic occurrence. It refers consistently to the inability of non-native language users to produce the second language with the phonetic accuracy required by native listeners for acceptance as a native speech. (McAllister, 2000)

The perception of a foreign language accent originates from the difference in pronunciation of a language by native and non-native speakers. One characteristic of foreign accent is miscommunication, which leads to the perception of segmental sound substitutions (substitution on the acoustics aspects of a speech.) For instance, a French or a Spanish native speaker, speaking in English might say, “I sink so” instead of “I think so.” An Arabic native speaker speaking in English might say “I put my car in the barking lot” as a substitute for “I put my car in the parking lot” (Flege, 1988). These speech events may happen because each language has its own intonation pattern depending on the syntax, semantics and phoneme structure. When the L2 does not have the same phoneme, the L2 speaker tries to pronounce this phoneme with the closest sound in his L1 phoneme system. For example, the Spanish language does not have the phoneme for “th”, but the closest phoneme is “s”. Therefore, the L2 speaker substitute the “th” sound for the “s” sound as in the “I sink so” example. (Van Wijhe, 1999)

A speaker with a foreign accent may also frequently misplace lexical stress, which emphasizing the incorrect portion of the word, which sounds alien to a native listener. One of the effects of misplacing lexical stress is the difficulty of processing the speech of the non-native talker. This could increase the cognitive loads of the listener resulting in a lack of comprehension, difficulty in decoding the message and perhaps even replaying it in the short-term memory several times (Southwood & Flege, 1999).

Many L2 foreign accent studies of subject’s age of exposure to the second language support the view that the earlier in life a person learns a second language, the better his/her pronunciation will be (Asher & Garcia, 1994; Fathman, 1975; Seiler et al., 1975; Suter, 1976; Oyama, 1982; Piper & Cansin, 1988; Flege, 1988; Flege & Fletcher, 1992; Flege, et al, 1995; Moyer, 1999). According to Walsh & Diller (1981) a complete success in producing a non-accented second language is

almost impossible because pronunciation is a “lower order” linguistic function, which is “genetically specified and consolidated in an early development.” In 1990, Long inferred that second language is usually spoken accent-free if it is learned by the age of 6. In other words, one expects to find a foreign accent in those individuals who learned the L2 after the age of 6. This accent could lead to a miscommunication between the speaker and the listener. In the aviation domain, these types of miscommunication can produce catastrophic accidents.

To study accented speech, researches have used a variety of scaling techniques such as four to nine point scales (Asher & Garcia, 1969; Oyama, 1982) direct magnitude estimation (DME) (Brendan, Ryan & Dawson, 1975; Ryan, Carranza & Moffie, 1977) and continuous scales (Flege, 1988; Munro, 1993). These techniques have allowed researchers to measure the degree to which non-native speakers differ from native speakers. Unfortunately, these scaling techniques are about relative relationships between judgments of stimuli of different intensities. Therefore, they are not an accurate method to study this phenomenon. It has been difficult for researchers to develop an appropriate methodology in which the individual characteristics of the speaker do not affect accent judgments. These characteristics must be kept constant; otherwise, it is not clear whether changes in judgments reflect speaker or accent.

When a person produces language, he/she transforms ideas represented as thoughts into speech. These ideas are understood and a person converts this information into thoughts. These actions should be carried out in a fluent manner. This fluency refers to the speed and accuracy of an individual’s speech. Sometimes these ideas are not clear due to the person’s accent. When a message is either imprecise or was delivered in a speedy manner, it will become susceptible to errors.

### *Reaction Time*

According to Noble (1999), language dominance can be measured with a great degree of accuracy and this accuracy is expressed in reaction time (RT). Reaction time is measured in terms of speed. The longer the RT (speed), the less automatic is the linguistic behavior. In contrast the faster the RT (speed), the more automatic is the linguistic behavior (Lambert, 1955).

In 1994, Catell and Dolley observed that it took longer for English speakers who were familiar with German to associate an English word to its German equivalent. Based on this observation, Lambert (1955) decided to concentrate his studies on bilinguals decoding time (RT). In his study, Lambert randomly selected 52 French and English participants and divided them into three groups of 14 according to their degree of experience in their L1 (French). The first group (A) was made up of native English speakers who were undergraduate French majors. Group (B) consisted of native-English speakers who had graduated with a major in French. The last group (C) were native French speakers with a minimum of seven years in an English speaking country. Lambert concluded that the experience in L2 influences the decoding time among bilinguals. Lambert's experiment shows how the knowledge of a language will affect performance.

Preston and Lambert (1969) conducted several studies employing eight English-Hungarian and English-French bilinguals who claimed to be proficient in the two languages. They used the Stroop (1935) color-word task. They concluded that depending on the subject's language skill, words in one language that sounded like words in the other language, or words in the same language that were in juxtaposition could cause interference and an increase in reaction time (Noble, 1999). For instance, an English-speaking air traffic controller tells a Japanese pilot to "way down." However, the English word "way" has the same pronunciation for the Japanese word "up." The

pilot might initially interpret the command, as “up down” Therefore, there is a potential for translation interference and a time delay in understanding or complying with the command.

### *Communication Problems in Aviation*

An excellent area to investigate for the way in which a person’s second language influences his/her performance is in the air traffic control communication realm. The primary function of air traffic controllers is to ensure the separation of aircraft. During the course of a flight, pilots communicate with several controllers and each controller communicates with pilots on a separate, published frequency. As an aircraft moves from one sector of airspace to another, the flight is handed to the next controller before introducing the pilot to that controller. Each controller is responsible for a different area of airspace and operates on a separate frequency. In other words, the ground control would not expect to hear requests regarding altitude, and an enroute controller would be surprised if a pilot contacted him/her for takeoff clearances. Air traffic controllers deal with several aircraft at the same time. Their goal is to maintain even space flow of all aircraft from airport to airport. Controllers must focus on the pilot’s speech to acquire the message, often against the background of a noisy environment. Many times controllers have to take into consideration that pilots’ communications are less standard than controllers and their level of training, phrasing ability, and fluency of English is different from theirs. As well, pilots have to take into consideration the discrepancies between the pilots’ and controllers’ first language when they fly internationally.

It is well known that the dialogue between pilots and controllers is almost unintelligible for the average speaker. Most exchanges are short, fast, and full of jargon. To compensate for this, the Federal Aviation Administration (FAA) created standard phrasing. These phrases were built with words that exhibit a low degree of linguistic confusion and to remain unique when non-English speakers spoke or heard them. In some cases the FAA gave alternative pronunciation to increase

word intelligibility. For example five became “fife” and nine became “niner.” Aviation vocabulary is small and incorporated into letters and numbers. Conversations between pilots and controllers should be fluent with the use of standard phrasing to avoid any misunderstanding.

Communication problems (see Table 2) in aviation arise because complex ATC messages can overload the pilot’s memory.

Table 2. Categorization of Pilot-ATC Oral Communication Problems.

Category	Number of Reports	Definitions
Absent (no send)	1,991	Failure to originate or transmit a required or appropriate message
Other Inaccuracies in Content	792	Erroneous data (formulation errors) Error of judgments Conflict Interpretation
Untimely transmission	710	Message not useful to the recipient because it arrived too early or too late
Recipient not monitoring	553	Failure to maintain listening watch, proper lookup, or read available correct information
Ambiguous phrasing	529	Message composition, phrasing, or presentation could lead to misinterpretation or misunderstanding by the recipient
Incomplete content	296	Originator failed to provide all the necessary information to recipient to understand the communication
Garbled phrasing	171	Content of the message lost or severely distorted to the point where the recipient could not understand the intended message
Absent (equipment failure)	153	Equipment malfunction resulting in complete loss of a message
Inaccurate (transposition)	85	Misunderstanding caused by the sequence of numerals within a message
Misinterpretable (phonetic similarity)	71	Similar-sounding names or numeric led to confusion in meaning or in the identity of the intended recipient

Source: U.S. National Aeronautical and Space Administration (NASA) Aviation Safety Reporting



In a study of altitude deviation Carlow and MiTech (1992) indicated that almost half (49%) of the pilots' altitude deviation involved multiple instructions given by the same controller. Controllers can talk to a pilot while looking at the radar, but it is hard for him/her to talk while listening to another controller or pilot. In addition, most controllers have a difficult time trying to remember previous conversations while they are listening or speaking. As Morrow and Rodvold (1998) indicated, when the message is too long and a person has to respond to both messages, the chance of forgetting one message increases due to limitation in long term memory.

In 1994 Cushing studied numerous communication-related accident and/or incident reports from NTSB and from the pilots' newsletter and concluded that the main cause of accidents was language related. According to him, several properties of language (such as ambiguity, and the language structure) were the main cause of these accidents. In addition, Grayson and Billings' taxonomy of pilot-ATC oral communication problems included 10 classes of linguistic communication errors (see table 3), of which at least three were specifically linguistic: ambiguous phrasing, inaccurate (transposition) and misinterpretation (phonetic similarity).

Most pilot-controllers' communication is limited to radio. Their communication usually takes place on noisy crowded radio channels and the quality of acoustic signal is generally poor. As the noise increases, the listeners' capacity to distinguish differences decreases, which means that the ability to receive information also decreases. The most persistent noise pilots and controllers struggle with is the sound of another person's voice. It seems that it is relatively easy for a listener to distinguish between two voices, but as the number of voices increases, the desired speech is lost in the general confusion,

Table 3. Categories of ATC Communication Errors.

<b>Communication Error</b>	<b>Type of Error</b>	<b>Contributing Factors</b>
Clearance Composition	Sequencing/ Content	Heavy traffic causing controller overload Similar call signs Coordination difficulties
	Heading Altitudes Misleading instruction Inappropriate instruction Inconsistent instructions Non-standard vector given	
Phrasing and Delivery	Non-standard terminology	Frequency congestion Blocked transmissions Enunciation, speech rate Poor radio techniques
Readback/Hearback	Failure to correct erroneous readbacks	Frequency congestion Blocked transmissions Controller overload

Source: Prinzo and Brittron, 1993

even though the overall intensity of the masking speech is held the same (McMillan, 1998). With several voices, a continuous masking signal is produced and the babble of four or more voices will drown out the desired voice as effectively as any other kind of noise (Miller, 1951).

Another problem that controllers and pilots face every day is the speed with which they have to converse. Spoken speech can produce as many as 400 words per minute (about 6.7 per second). This is faster than the fastest rate at which human beings can recognize individual sounds. Wingfield (1996) argued that rapid speech rate reduces the amount of time available to process the word strings. In addition, Morrison and Wright (1991), in their study of ASRS records from 1986 to September 1988, found out that “too rapid issuance of instructions (‘speed feed’) was the most common delivery technique problem cited.” The problem with speed feed is that many times the

controllers begin to issue the next instruction without waiting for acknowledgement of the previous message, and they assume that the instruction was understood and accepted by the pilot.

All these points demonstrate the communication problems that exist in the aviation industry in the United States. These communication problems may be illustrated more specifically through a number of case studies related to international language errors. For example, on November 13, 1993 two bilingual Chinese pilots, flying a McDonnell Douglas MD-82 with 92 passengers aboard, were communicating in their L1 to native Chinese-speaking air traffic controllers in Urumqi, China on a landing approach. Unpredictably, an automated voice warning system announced in English: "Pull up, pull up!" (Proctor, 1996). The Chinese pilots having trouble understanding the message, asked in their native language, "What does pull up mean?" Twelve people died in the accident. This accident indicates a lack of knowledge or misunderstanding of intended meaning. Indeed, aviation English communication problems exist for both native and non-native English speaking pilots everywhere (FAA, 1995; Noble, 1997; Ragan, 1997). Unfortunately, there is no formal evaluation of language proficiency for the aviation industry.

The Department of Transportation requires that all private pilots in America read, speak and understand English. Therefore, it is a prerequisite for nonnative English-speaking aviation students to pass a multiple-choice exam in English before flying solo in the United States (Noble, 1997). However, to pass this test is an easy task because many flight schools in America sell study guides, which contain all the questions and answers for the test (Noble, 1997). Consequently, the students buy these guides and memorize the questions and have the ability to pass the test lacking the knowledge of the language. One extreme example of this is detailed by Noble (1997) who recounts the story of HR, a Japanese flight student who was prevented from getting his license when it was clear to the examiner that the answers had merely been memorized. (see appendix B)

The acquisition of a foreign language is complex and involves learning the language pronunciation, intonation and its usage. Uplinger (1997) once said, "To develop a functional vocabulary in a foreign language is a difficult task." He also argues that mastering specialized technical terminology (vocabulary) is insufficient to avoid ambiguities, and dealing with these ambiguities in ATC communications is even more difficult when pilots, controllers or both are communicating in non-native English, such as might be found in a secondary language. It is interesting to know that the International Civil Aviation Organization (ICAO) does not mandate the use of English as an international language for aviation. Pilots and Air Traffic Controllers are expected to demonstrate knowledge in "the language or languages nationally designated for use in air traffic control and [the] ability to speak in such language or languages without accent or impediment which would adversely affect radio communication. Pending the development and adoption of a more suitable form of speech for universal use in aeronautical radiotelephony communications, the English language should be used as such and should be available, on request from any aircraft at all stations on the ground serving designated airports and routes used by international services" (Verhaegen, 2001). Considering the challenges of controller and pilot communication and the lack of a rule to make English an international language for aviation, the number of accidents involving non-native English speakers in the aviation industry should not be surprising.

Most aviation communication is limited to radio. The training programs for pilots in other countries such as China and Japan require the pilot to pass a challenging domestic radio communication license examination before the training begins. Unfortunately, the FAA does not require pilots to obtain a radio communication license. Perhaps, this is one reason that many people come to study aviation in the United States. However, Steward wrote (1992), "Learning the form of

radio telephony (R/T) term and phrases and adapting to the many speech peculiarities of countries is something like learning another language. Sometimes the difficulty is in understanding the plain English used, especially in such countries as Japan where the pronunciation is a problem.”

Some might argue that the pilots’ or air traffic controllers’ second language does not interfere with his/her performance. In spite of this argument, this paper has outlined evidence that the person’s second language does cause interference in his/her performance and this interference could be fatal, especially in the aviation industry (Bialystok, 1990; Blum-Kulka & Levenston, 1983; Chen & Ho, 1996; Dordick, 1996; Dulay et.al., 1982; Faerch & Kasper, 1983; Fledge et al., 1997; Mägiste, 1984; Noble, 1999; Piske & Mackay, 1999; & Selinker, 1979). Unfortunately, many studies conducted in the aviation domain do not address this important problem. The aim of this study is to discover how different accents in pilots’ second languages affect their performance.

#### Hypotheses

Based on studies done on second language processing conducted by Paradis (1981), Green (1993), de Bot (1992) and Grosjean (1998), it is logical to conclude that there will be a significant difference between native and non-native English speakers. In other words, since all commands will be given in English, it is expected that native English speakers will perform better than non-native English speakers due to language differential. Furthermore, based on past studies done on language pronunciation (accent) (Albert & Obler, 1978; Selinker, 1979; Flege, 1981; Dulay et al., 1982; Blum-Kulka & Levenston, 1983; Faerch & Kasper, 1983, Bialystok, 1990 & Dordick, 1996), it is anticipated that the results of those participants with close pronunciation (e.g. English and Spanish) will be more accurate in their performance than those subjects whose languages are distant (e.g. Spanish and Korean or English and Korean). When language and accent are combined, it is expected that participants will have their best reaction time and accuracy when listening to

commands spoken in the same accent as their native language. Participants are expected to show increased reaction time and decreased accuracy for accents that are not consistent with their native language. It is also predicted that both native and non-native English speakers will be worst in accuracy and reaction time when listening to the Korean accent when compared to the other accents. These hypotheses regarding interactions are based on studies done on language similarity between English and Spanish (Flege, Frieda, Walley & Randazza, 1998), and because English and Spanish are the most common languages at Embry-Riddle Aeronautical University.

### Methods

In this experiment, each participant heard a set of simulated ATC commands (e.g. descend and maintain three thousand five hundred) and were asked to respond as quickly as possible to the commanded direction.

#### *Participants*

Participants were 24 undergraduate students from Embry-Riddle Aeronautical University between 18 and 40 years of age who are non-pilot or ATC majors that have normal hearing. Half of the participants were native speakers of Spanish who began learning English as a second language via the classroom setting (L2). The remaining participants were native English-speaking with little or no exposure to the Spanish language (L1).

#### *Apparatus*

Male speakers with different accents recorded a script using aviation terminology. Their voices were recorded on a regular wave file. The presentation of air traffic control phrases, timing of phrases and participant data collection were collected on a personal computer using a customized computer program using the Borland C++ Builder v. 6 program. Participants listened to the ATC

messages through a standard set of headphones. Responses to commands by participants was made through keyboard presses.

### *Design*

Due to the fact that the focus of this study is in the area of aviation, this experimental design was similar to an aviation scenario (e.g. Air Traffic Control's instructions, aviation terminology, etc.). This experiment was a three by two mixed factorial design. The current study contains two independent variables. The first independent variable was investigated by comparing participants on the basis of whether English or Spanish is their native language (L1). The second independent variable was manipulated by the presentation of three different gender specific (male) accents (English, Spanish and an accent that is neutral to both native languages, Korean). The dependent variables were the participants' performance during the experiment including reaction time to verbal commands and the accuracy of their responses to the command given.

### *Procedure*

Participants were exposed to a standard consent form and then asked to be seated in front of the experiment apparatus. The participants were presented with two introductory screens for the experiment. The first window questioned the participant on basic demographic data such as age, sex, citizenship, pilot licenses, TOEFL examination and flight hours. On the second display the participants had the opportunity to adjust the sound to a comfortable volume. Following the basic calibration screen, participants began the task portion of the study.

This experiment was divided into four sections and simulated a set of aviation scenarios. The first section was a practice trial and the other three sections were experimental trials. Prior to each trial, instructions for the exercise were given. As soon as the participants understood the instruction they pressed the spacebar on the keyboard to begin the trial, which activated a timer.

The participant heard a script where a controller instructed him/her to perform a set of actions. These instructions were aviation related instructions given by a male air traffic controller at normal air traffic control speech via headphones (i.e. no “speed feed”). These messages varied in length from 15 to 20 words. In addition, each message contained a command word with the following structure: turn (right or left), climb (up) and descend (down). As soon as the participant heard the command, he/she was required to press the corresponding arrow key located on the right side of the keyboard. For instance, if the participant heard the statement, “descend and maintain three thousand five hundred” it was expected that he/she pressed the correct key, in this case “↓”, which would stop the timer. Non-correct responses were also be measured. This sequence continued for six practice trials. When the practice trials finished, the participant heard the statement, “This exercise has finished.” Then, the participant pressed the spacebar to go to the next window, which instructed the participant to take a two-minute rest prior to the next trial.

Following the practice trials that allowed the participants to become familiar with the experimental setup, the experimental trials began. The same procedure as for the practice trials were in effect, but a counterbalanced presentation of the three experimental accent conditions of fifteen trials of each accent were provided to the participant.

Once the three experimental trials were complete, the participants were debriefed regarding the purposes of the experiment.

## Results

Response time (in milliseconds) and accuracy were recorded from participants. Response time was measured from the time in which the directional command was presented in the air traffic control statement to the point at which the participant pressed a direction key. Accuracy responses were counted as correct if (a) the participant pressed the corresponding arrow according to the



command, and (b) the participant pressed the response key during or after the command was given.

This study was analyzed by a 2 (languages) x 3 (accents) mixed factor ANOVA for the reaction time of correct responses (RT). The two measures of inaccuracy also analyzed included incorrect responses where participants pressed an arrow key different from the commanded direction and false starts in which the participant pressed a key before the command was presented

The mean and standard deviation (SD) for each group is presented in table 4.

Table 4. Overall means and standard deviation for native and non-native English speakers.

		Reaction Time		False Starts		Incorrect Responses	
		Mean	SD	Mean	SD	Mean	SD
Native English Speakers	English	113,66.92	635.81	.00	.00	2.00	.78
	Spanish	1,239.05	487.08	.64	.49	.64	.84
	Korean	1323.43	274.24	.00	.00	1.14	1.61
Non- Native English Speakers	English	1597.33	1206.81	.01	.27	3.50	1.51
	Spanish	1533.33	843.17	.36	.50	1.43	1.50
	Korean	2129.56	1434.06	.071	.27	4.43	3.18

The results from the reaction time data (as shown in Figure 3) did not reveal any significant difference between the interaction of natural English language ability speaker accent,  $F(2, 52) = 1.95, p=0.21$ . Reaction time data analyzed on language (native versus non-native language participants) and on accent (English, Korean and Spanish) did not show any significant effect,  $F(1, 26) = 2.59, p= .12$  and  $F(1, 26) = 1.10$  respectively. Therefore no effect of language or accent was found for the reaction time data.

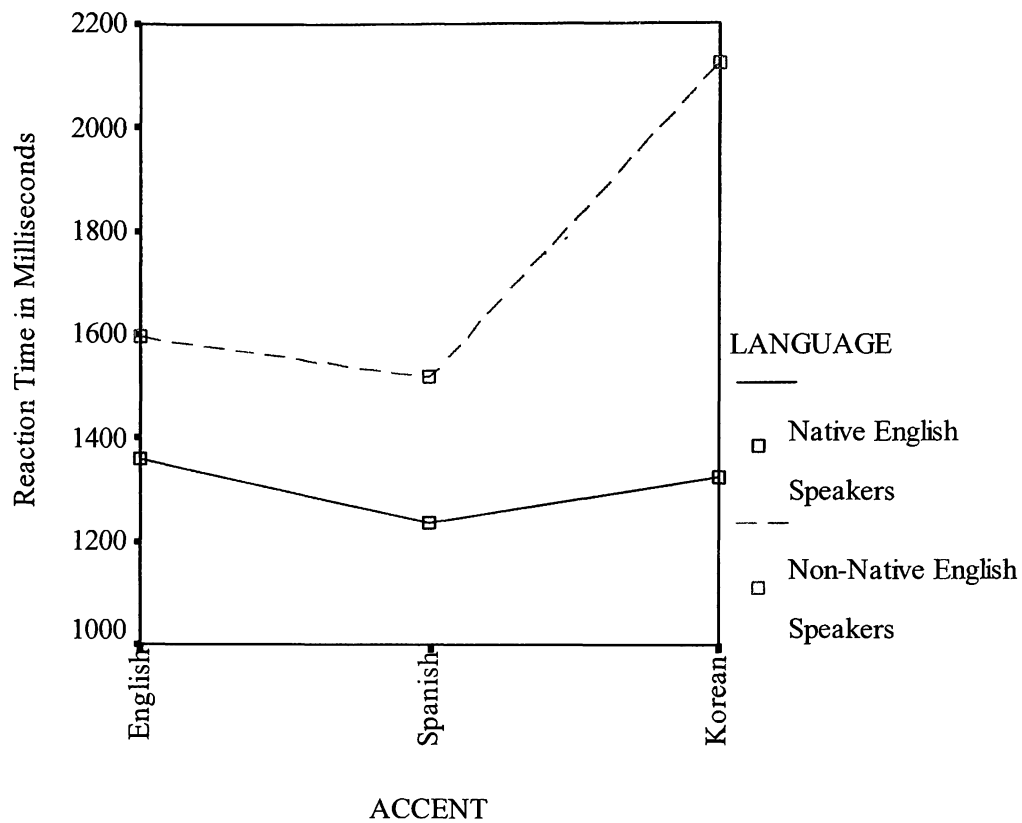


Figure 3 Reaction Time in Milliseconds

The two measures of inaccuracy measured in this study were also analyzed. These measures included false starts in which the participant pressed a key before the command was presented and incorrect responses where participants pressed an arrow key different from the commanded direction. A non-parametric test (the Friedman test statistic) was performed on the two accuracy measures for each of the two language groups because they are ordinal data.

For the purpose of this study, a false start was defined as the time the participant pressed a key without a given command. Looking at the false start data, a significant effect of accent was found for native English speakers,  $X^2(2) = 0.01$   $p = 0.00$ . Figure 4 shows that participants made the most false starts when listening to commands presented in the Spanish accent.

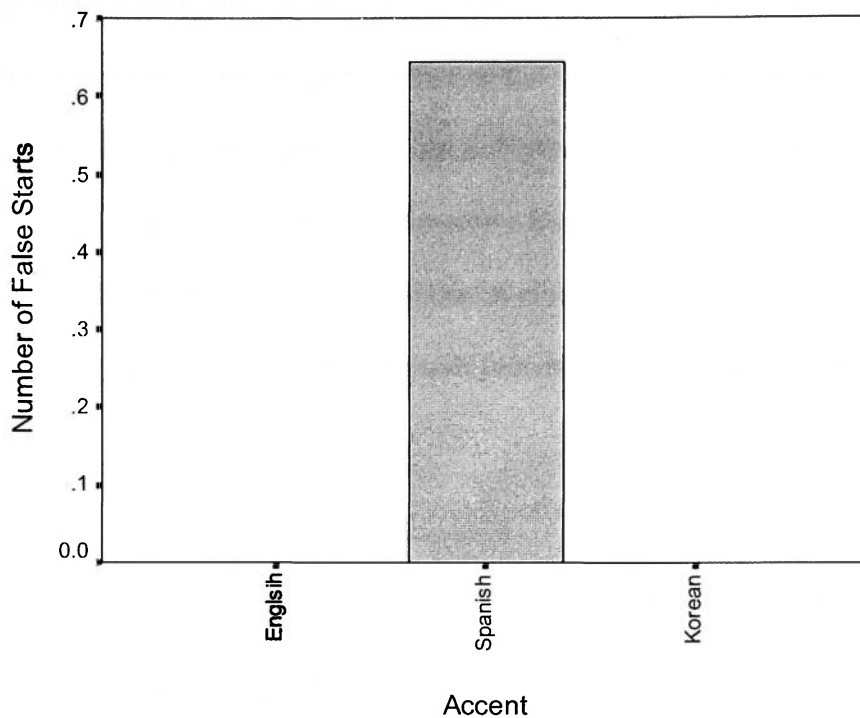


Figure 4. False Starts result for Native English Speakers

In contrast, as shown on Figure 5, no significant effect of accent was found for non-native English speakers,  $\chi^2(2) = 0.01$   $p = 0.10$ .

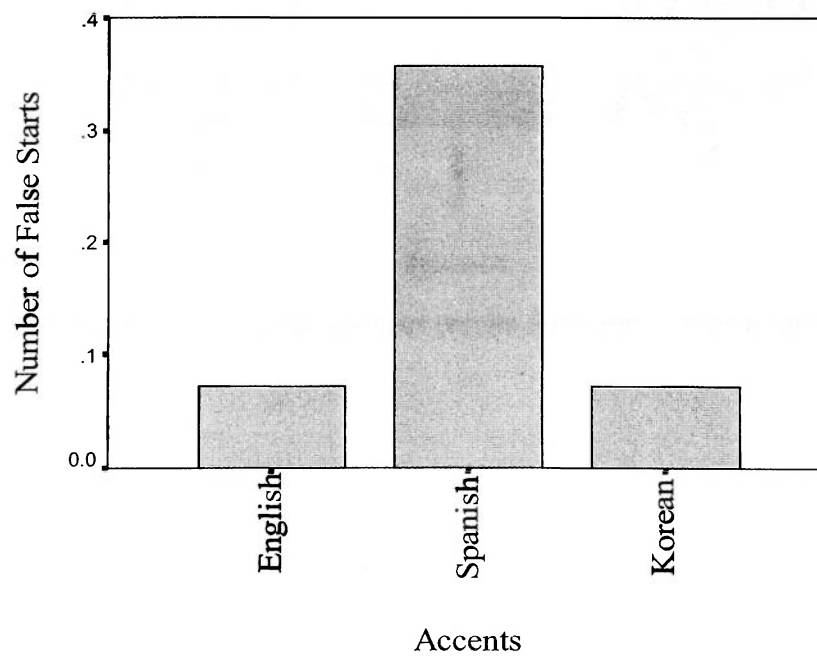


Figure 5. False Starts result for Non-Native English Speakers

Data were also analyzed for how often the participant pressed an incorrect key compared to the commanded response (incorrect responses). Looking at the data, it can be concluded that there was not a difference for native English speakers as seen in Figure 6,  $X^2(2) = 0.01$   $p = 0.10$ , but there was a significant difference in effect of accent for non-native English speakers as seen in Figure 7,  $X^2(2) = 0.01$   $p = 0.000$ , English and Korean accents produced more incorrect responses in the non-native speaking group than when listening to the Spanish accent as seen in Figures 6 and 7 respectively.

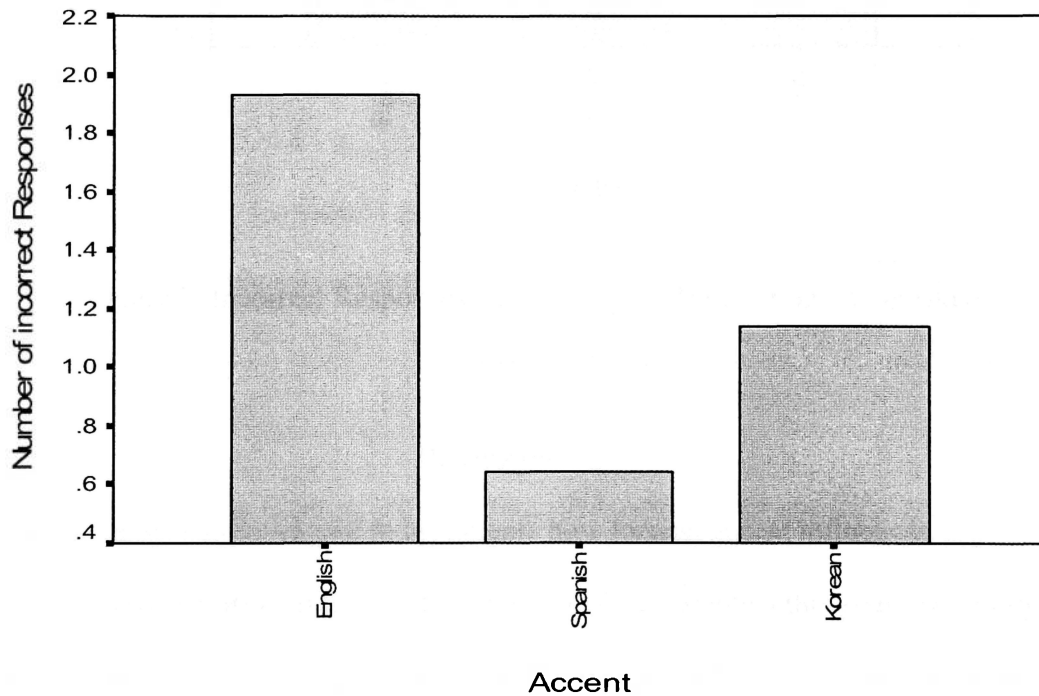


Figure 6. Incorrect Responses results for Native English Speakers

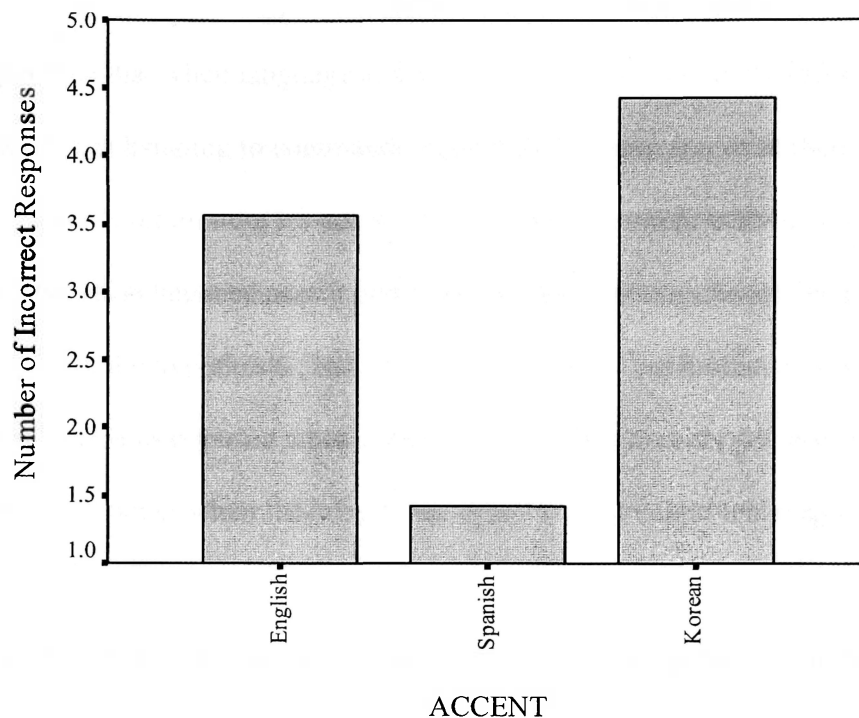


Figure 7. Incorrect Responses results for Non-Native English Speakers

### Discussion

The current study was developed to investigate how foreign accent influences comprehension of communication in the aviation domain. To accomplish this goal, two groups of participants (native and non-native English speakers) were exposed to 15 aviation commands produced by an English speaker, a Korean speaker and a Spanish speaker. These commands were given in English and were of different lengths.

Since all commands were presented in English (but in different accents), it was expected that native English speakers would perform better than non-native English speakers on reaction time. However, the results of this study found no statistically significant difference between native

English speakers and non-native English speakers for reaction time. Nevertheless, the relationship between native and non-native was in the predicted direction as shown in Figure 3.

It was also expected that when language and accent were combined, participants would have their best reaction time when listening to commands spoken in the same accent as their native language, as well as slower reaction time for accents that are not consistent with their native language. While the interaction between accent and language was non-significant, the patterns of results were consistent with the hypothesis. Native English speakers' performance was lower when listening to the English accent as opposed when listening to the other accents and non-native English speakers performed better when listening to the Spanish accent than listening to the other accents.

Finally, it was predicted that both native and non-native English speakers would be worst in reaction time when listening to the Korean accent when compared to the other accents. The lack of a significant interaction did not support this hypothesis

This investigation appears to be inconsistent with the results obtained on studies done on second language processing conducted by Paradis (1981), Green (1993), de Bot (1992) Catell and Dolley (1994), Lambert (1955), Preston and Lambert (1969), and Grosjean (1998) who found that native speakers reacted faster than non-native speakers. The researcher would be compelled to point to the possibility that both native and non-native English speakers responded in the same manner because both groups were listening to technical jargon that neither group was familiar with.

It is clear that the results of this study do not substantiate the reaction time hypothesis. However, it is speculated that the cause for these results is due to the length of residence (LOR) of the participant in the United States. Studies conducted by Flege (1988), Moyer (1999), Piske and MacKay (1999), and Malt and Sloman (2003) have indicated that length of residence (LOR)

influences performance. In other words, there is a possibility that the LOR in the United States has helped the non-native participants to become more familiar with the English accent and language and therefore have reaction time performance similar to native English speakers. Unfortunately, LOR was not a variable of interest in this study. Therefore, future research will be needed to decide whether or not the length of residence (LOR) influences performance in the aviation domain.

Acculturation could be another explanation for these results. According to Schumann (1986), acculturation refers to the social and psychological contact between members of a particular group and members of the target culture and psychological contact between members of a particular group and members of the target culture. In other words, the more interaction (i.e., social/psychological closeness) a group has with the target group, in this case English, the more opportunities will result for the group to acquire and use English. Conversely, less interaction (i.e., social/psychological distance) results in less acquisition and use of English. The group's amount of contact with the target culture has an effect on the amount of English acquired and used. Based on this theory, it is believed that most of the participants in this study have become acculturated their new environment and therefore accounts for the failure to find differences between the native and non-native speakers.

To make certain participants weren't responding quickly but inaccurately, accuracy data was also collected. For better understanding of the data, accuracy was divided into two main sections. False starts were defined as the time the participant pressed a key without a given command, and incorrect responses were defined as how often the participant pressed an incorrect key.

From looking at the results from the false start data, it can be concluded that there was a significant difference between accents for native English speakers. However, the data showed no

effect of accent for non-native English speakers. The graph shows that most participants made more false starts when listening to the Spanish accent than when listening to the other accents.

After a careful examination of the results, it was discovered that several participants had troubles with air traffic control command phrases. The first statement, “N407RS the Vandenberg Airport is closed due to poor weather. These will be vectors to your alternate airport turn right heading 270” caused three out of fourteen native English speaker participants and two out of fourteen non-native English speaker participants to start before the direction was given. The second statement, “Deland airport is at your twelve o’clock N14AZ turn right heading 180” caused six out of fourteen native English speaker participants and three out of fourteen non-native English speaker participants to start before the command was given. All other commands had no more than one or two false starts. It is unclear why these sentences in particular caused the false starts.

On the other hand, the data for incorrect responses revealed a significant difference between accents for native English speakers. Then again, the data showed no effect of accent for non-native English speakers. Both native and non-native English participants made fewer incorrect responses when they listened to the Spanish accent than when they listen to the English or Korean accents. Furthermore, English native speakers made more incorrect responses listening to the English accent than listening to the Spanish and Korean accent. In contrast, non-native English speakers made fewer incorrect responses when listening to the Spanish accent than listening to the other accents. In addition, non-native English speakers made more incorrect responses when listening to the Korean accent than listening to the other accents.

After analyzing the results, it was revealed that when listening to the English accent, nine out of fourteen non-native English speakers participants had difficulty listening to commands two, “Climb and maintain two thousand one hundred, N815PY for spacing.”; and statement four (see



appendix C ),” N417ER Miami Departure Radar Contact climb and maintain five thousand. Contact Daytona Approach on 125.35.” Seven out of fourteen non-native English participants and six out of fourteen native English participants had trouble with statement thirteen ,” Descend and maintain flight level 180. Orlando altimeter 29.92...Delta 1454.” Based on this information, it can be concluded that non-native English speakers had more incorrect responses than native English speakers.

In addition, when listening to the Korean accent, eight out of fourteen non-native English speakers had difficulty listening to command eight (N216MV traffic is at your 12 o'clock four miles opposite direction. For spacing turn left heading 030.) Six out of fourteen had troubles with command ten (N108EH descend and maintain two thousand. Cleared visual approach into runway niner left.), and command eleven (N543JT turn left heading 270. Circle to land to runway 16). In contrast, both native and non-native English speakers made less mistakes listening to the Spanish accent .

The results of this study did not substantiate the hypothesis that participants with close pronunciation (e.g. English and Spanish) would be more accurate in their performance than those subjects whose languages are distant (e.g. Spanish and Korean or English and Korean). Yet, there are some speculations about the reason for these results. For instance, studies conducted by Gass and Varonis (1994) and Nygaard and Piosini (1998) reported that recognition accuracy in foreign accented sentences improved after exposure to different speakers with different accents, indicating a possible transfer of adaptation across speakers. One good example is of this situation is illustrated at Embry-Riddle Aeronautical University (ERAU). Embry-Riddle Language Institute (ERLI) offers intensive English preparation courses. The classes are small; therefore, most students have the opportunity to interact with each other while learning English. After finishing this program, the

majority of these students continue their education at Embry-Riddle Aeronautical University (ERAU). Consequently, there is considerable probability that the participants of this study had recognized the different accents and, therefore this recognition has affected the outcome of the study.

Another possible explanation is that the amount of accent impacted the results of the study. Studies conducted by Munro and Derwing (1995), Schmid and Yeni-Komshian (1999), and Weil (2002) demonstrate that accented speech has consistently lower intelligibility than non-accented. While the literature suggests that the type of accent may influence response time and accuracy for these types of commands, it may be that the degree of accent is more important than the type of accent. Evidence of this is that no effect was found in the reaction time data. Even though significant differences were found for accent in both forms of accuracy data, the practical differences were small, reflecting the fact that accents were attempted to be controlled for.

### Limitations

One limitation to this study is the length of residence (LOR). As mentioned before, there is a possibility that the LOR in the United States has helped the non-native participants to become more familiar with the English accent and language and therefore has affected the result of this study. However, Flege and Liu (2001) suggest that the lack of an effect of LOR found in some previous studies may have been due to sampling errors and that it appears that adults' performance in an L2 will improve over time provided that a substantial amount of L2 input is provided.

Perhaps, instead of looking at the types of accents, future research should focus on the degree of accent. In this study the amount of accent was held constant across the three speakers but that control may have led to a lack of finding for the accent variable while an effect may actually

exist. For instance, a study conducted by Levi, Winters and Pisoni (2005) indicate that characteristics of the listener can affect the perceived degree of foreign accent. Also, Thompson (1991) found that inexperienced listeners tended to perceive a greater degree of foreign accent than experienced listeners. In addition, Levi, Winters and Pisoni (2005) argue that many of the factors known to affect the perception of foreign-accented speech are speaker-specific factors that are inherent to a particular individual. Consequently, the gender of the recorders could influence the outcome of this study. For instance, male and female voices differ mainly in pitch; and while the difference is not as complex as with accents, it can still cause difficulties for speech recognition. These previous findings suggest that accent may still have an impact on pilot performance and should be further investigated.

### Conclusion

In a busy international airport, such as Kennedy in New York and O'Hara in Chicago, pilots will represent many nationalities and language backgrounds. However, in the US and often abroad, all communication is conducted in English. Therefore, it is inevitable to conclude that most pilots will have foreign accents. Controllers do their work in high demand environments. In addition to communicating with several aircraft simultaneously, they are also performing other tasks. How does the foreign accent of the pilot impact the performance of the controller or does the foreign accent of the controller impact the performance of the pilot? These questions are impossible to address without examining the context in which the communication occurs in its entirety.

Although the results of an experiment that presents accented and non-accented versions of aviation terms to controllers in isolation may provide some insight into the types of problems to look for, these results may be tempered when all factors that influence communication are combined

An alternate approach is to examine performance in the field in a variety of settings that differ in the amount and types of accents that are encountered, and compare differences among them. The focus of this study attempted to investigate the ability of native and non-native English speakers to listen to air traffic control commands spoken in different accents. Results of this study indicated that accent did not affect performance. However, further studies need to be done to investigate the full range of effects accent has on performance in the aviation industry.

Even though this study failed to prove that accents affect performance, it is well documented that accented speech in everyday life affects the understanding between individuals. Sometimes pronunciation of a simple phoneme or intonation of a word is the main cause of miscommunication among people from different countries. Perhaps, looking at other variables such as length of residence or speed of pronunciation will provide the key to this problem.

If the full extent of the impact of foreign accented speech onto perception is to be understood, two different approaches such as controlled laboratory studies and situational studies would be the best. When these two approaches are combined, the result will be a richer understanding of the effects of foreign accented speech on performance in the aviation domain.

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## Appendixes

## APPENDIX A

## Examples of Communication Problems in Aviation

1. **December 1, 1981-** A DC-9 from Ljubljana-Brnik Airport in Slovenia to Ajaccio-Campo Dell'Oro Airport in France and entered a holding pattern. The aircraft descended through the minimum holding altitude of 6800ft and collided near the top of the Mt. San Pietro in France. The main factor in the accident was the imprecise language used by the DC-9 crew and the air traffic controller. Every one onboard died. Aviation Safety Network. Accident description Retrieved from <http://aviation-safety.net/database/1996/960829-0.htm>
2. **February 9, 1983** Willington, DE - A C-130 cargo aircraft misunderstood the verbal instruction from the controller. As the Cessna 150 was making a 135-degree turn, the C-130 gave reverse to its engines and blew the Cessna 150 that was landing. (NTSB File No. 309, page 3, Wilmington, Delaware. Aircraft registration number N5898G, 2:30 PM EST). In Noble, C.E. (1997). The aviation English problem in America: Can a real-time based flight simulator help?
3. **May 26, 1983-** Oklahoma City, OK – A student in a single engine Cessna 150 misunderstood the instructor's instruction to fly 70 MPH on final approach to the runway. The student flew at 60 MPH and stalled the aircraft in a high flair and crashed (NTSB File No. 2689, page 7, Oklahoma City, OK; aircraft registration number N66245, 5:00 PM CDT). In Noble, C.E. (1997). The aviation English problem in America: Can a real-time based flight simulator help?

4. **July 05, 1984** - Hayward, CA Pilot bounced and porpoise on first solo landing collapsing the nose gear. English language problem student and CFI. Cessna 152. Hayward, California. Event #67819. In Noble, C.E. (1997). The aviation English problem in America: Can a real-time based flight simulator help?
5. **August 18, 1984** Madera, CA - A P-63 single engine aircraft misunderstood an air show controller's instructions not to turn right at the end of the runway. The P-63 pilot turned right and his rudder was struck by an aircraft that had just landed on a parallel runway (NTSB File No. 1179, page 33; aircraft registration number N62822, 1:40 PM, PDT). In Noble, C.E. (1997). The aviation English problem in America: Can a real-time based flight simulator help?
6. **August 23, 1984** - Monterey, CA Five people were killed when the pilot of a twin engine Cessna turned right when the air traffic controller told him to turn left. He impacted a hill (NTSB File No. 2230, page 39, Monterey, CA; aircraft registration number N7AE, 8:57 PM PDT). In Noble, C.E. (1997). The aviation English problem in America: Can a real-time based flight simulator help?
7. **July 19, 1985** - Erie, PA - The pilot of a twin engine Smith Aerostar 601 aircraft did not understand verbal instructions because he had apparently fallen to sleep while he was flying. He crashed over Lake Erie killing himself and one passenger (NTSB File No. 1600, page 59; aircraft registration number N71MA, 3:43 AM EDT). In Noble, C.E. (1997). The aviation English problem in America: Can a real-time based flight simulator help?
8. **February 19, 1989** - The Boeing, named "Thomas Haywood", a cargo plane, departed from Singapore to Kuala Lumpur-Subang in Malaysia. While on the landing While on the NDB<sup>1</sup>

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<sup>1</sup> non-directional beacon. A medium-frequency navigational aid which transmits non-directional signals, superimposed with a Morse code identifier and received by an aircraft's It is a ground-based non-precision

approach, the crew were cleared to "...descend two four zero zero..." which was interpreted by the crew as "...to 400...". The aircraft descended below minimum altitude and crashed into a hillside. There were no fatalities. Aviation Safety Network. Accident description Retrieved from <http://aviation-safety.net/database/1996/960829-0.htm>

9. **Sept 13, 1985** A single engine 152 pilot misunderstood the tower to tell him he was number 2 to land, when in fact; they were telling him he had two other aircraft in front of him on final approach to the runway. He then turned right to line himself up with the runway and cut off two airplane's approaches and bumped the top of the plane beneath him (NTSB File No. 2084, page 65, Panama City, Florida; aircraft registration number N757HM) In Noble, C.E. (1997). The aviation English problem in America: Can a real-time based flight simulator help?
10. **July 31, 1992** - Thai Airways Flight 311 was departing from Bangkok International Airport in Thailand's to Kathmandu-Tribhuvan Airport in Nepal. Ineffective radio communication between the area control centre and the TG311 flight crew which allowed the flight to continue in the wrong direction. The main contributing factors for the accident were: radio communication difficulties between the crew and the air traffic controllers which caused 113 fatalities. Aviation Safety Network. Accident description Retrieved from <http://aviation-safety.net/database/1996/960829-0.htm>
11. **August 29, 1996** -Vnukovo Airlines flight VKO 2801 departed Vnukovo Airport in Moncow, Russia towards Svalbard<sup>2</sup> Airport Longyear. The crew tried to request runway 10 for landing twice, but the request was not understood as such by Longyear Information due

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approach and can be located either on the airport or at a remote location. NDBs are very old and their operation is very simple, yet flying them precisely is difficult.

<sup>2</sup> Svalbard is a Norwegian mining community close to the North Pole

to language difficulties. There were 141 fatalities. Aviation Safety Network. Accident description Retrieved from <http://aviation-safety.net/database/1996/960829-0.htm>

12. **November 12, 1996** – Consider the worst air accident in Indian history. A Saudi Arabian Airlines flight 763, carrying 312 passengers from New Delhi to Dhahran, collided with an incoming Air Kazakhstan Flight 1907, flying from Chimkent to New Delhi, at 14,000 feet. There were no survivors. (July 7, 2002) Ignorance Of English language causes crashes, The Statesman, New Delhi <http://proquest.umi.com/pqdweb>
13. **September: 26, 1997** - Garuda Indonesia flight 152, flying from Jakarta, Indonesia, to Medan, Indonesia. The Indonesian air traffic controller was confused of whether GA152 was turning left or right. Just 10 seconds after confirming the right turn, the Airbus crashed in a wooded area, Pancur Batu 18 miles short of Medan Airport. Sadly, 234 died in this accident. Accident description Retrieved from <http://aviation-safety.net/database/1996/960829-0.htm>
14. **March 14, 2001** – After detecting a strange smell on board, the pilot of the Airbus A340, headed from Toulouse to Paris, contacted the air traffic control. The pilot told to the controller fire on board in English; however the controllers understood five men on board. The controller issue a hijack alert and two air force jets were sent to accompany the aircraft to Toulouse airport. (Mar 14, 2002,) Airline industry Information Retrieved from <http://proquest.umi.com/pqdweb>



## APPENDIX B

### HR Story

All his life, HR wanted to fly. Therefore, after completing his high school in Japan, he sought acceptance into Japan's only civil-aviation college in Miyazaki. The college required to take several difficult exams in math, science, and English. Unfortunately, he failed the examinations and he was not admitted into Japan's national flight academy. He looked into several private aviation schools, but because they were private he could not afford them. At that time, he became depressed at the outlook of his dreams not being realized.

One day on a Japanese magazine, he saw an advertisement offering flight training in America at an affordable price. Luckily, this school did not require to pass an English exam. Consequently, he purchased an airplane ticket to Los Angeles, California and in a week he found himself in a motel close to the airport in the middle of the California desert. This airport does not have a control tower and the use of English was minimal.

The morning after he arrived, he received an orientation with an interpreter and within two days, he began his bilingual ground instruction and intense English classes. Later, he bought the written examination study guide and studied it. At this time he did not understand the questions, but memorized them. A few days later he took the exam and passed it. Three days, after passing the written section of this multiple-choice exam, he was ready to fly solo. He flew early in the morning when the air traffic was light. He made basic calls in English and there was no instruction in English. Fortunately, this flight went without incident.

HR continues his training, but his abilities to take off and land on a controlled space were questionable. To ensure that HR meets the regulatory requirements for pre-solo certification, his instructor flew with him. They selected a low air traffic airport with an operating traffic control.

They listened to the uncommonly patient controller who intentionally gave unusually slow English instructions to ensure clarity. During this flight, Hirochi demonstrated the necessary listening and speaking skill to land and take-off as instructed. Consequently his instructor approved his flight and logged it as a safe to solo.

One week later, HR took his oral examination and passed. Then he took a flight check ride. For this flight, he chose to flight in the desert in a non-controlled airspace. Even though the FAA requires to speak English on the ground to explain flight terminology, there is no requirement to speak English through the flight unless the instructor asks a question or give a command. The only commands that the instructor gave to him were to execute basic maneuvers.

A week later, HR decided to fly to Oxnard; Oxnard is a high- density airport with an operating control tower. The closer he got to the airport, the more active the air traffic became. The more active the control became, the more confused HR became. He could not understand the air traffic controllers and of course the controllers could not understand him. In one instance, when the controller tried to contact HR, he failed to identify the call. He became confused and frustrated. He flew into the flight path of another aircraft, nearly causing a mid-air collision. Then, a controller vectored all aircraft away from him and helped HR, in slow English, to land. Then, the controller instructed him to park his aircraft close to the tower and to report to the tower manager. It was then that HR realized how fortunate he was. Noble (2002).

## APPENDIX C

**Scripts****Script 1**

1. American fourteen fifty-five San Juan Approach, expect visual approach to runway 10, report the Moscoso Bridge insight. **Descend** and maintain 2000.
2. **Climb** and maintain two thousand one hundred, N815PY for spacing.
3. N454AC **climb** and maintain four thousand three hundred. These will be vectors to Boca Raton
4. N417ER Miami Departure Radar Contact **climb** and maintain five thousand. Contact Daytona Approach on 125.35.
5. N721HW expect vectors Jacksonville **climb** and maintain flight level 290.
6. N629RS these will be vectors for the ILS Runway 18R **turn right** heading 150.
7. N407RS the Vandenberg Airport is closed due to poor weather. These will be vectors to your alternate airport **turn right** heading 270.
8. Deland airport is at your twelve o'clock N14AZ **turn right** heading 180.
9. N216MV traffic is at your 12 o'clock four miles opposite direction. For spacing **turn left** heading 030.
10. N108EH **descend** and maintain two thousand. Cleared visual approach into runway nine left.
11. N543JT **turn left** heading 270. Circle to land to runway 16.
12. N382PE expect vectors across final for spacing. **Descent** and maintain one thousand six hundred.
13. **Descend** and maintain flight level 180. Orlando altimeter 29.92...Delta 1454.
14. **Turn left** heading 090. Expect one more turn to final, N5405M
15. N819SD Tampa Departure Radar Contact expect vectors on course in 5 miles **turn left** heading 100.

**Script 2**

1. N407RS the Vandenberg Airport is closed due to poor weather. These will be vectors to your alternate airport **turn right** heading 270.
2. N108EH **descend** and maintain two thousand. Cleared visual approach into runway niner left.
3. Deland airport is at your twelve o'clock N14AZ **turn right** heading 180.
4. N382PE expect vectors across final for spacing. **Descent** and maintain one thousand six hundred.
5. N417ER Miami Departure Radar Contact **climb** and maintain five thousand. Contact Daytona Approach on 125.35.
6. N454AC **climb** and maintain four thousand three hundred. These will be vectors to Boca Raton
7. N543JT **turn left** heading 270. Circle to land to runway 16.
8. N629RS these will be vectors for the ILS Runway 18R **turn right** heading 150.
9. N819SD Tampa Departure Radar Contact expect vectors on course in 5 miles **turn left** heading 100.
10. American fourteen fifty-five San Juan Approach, expect visual approach to runway 10, report the Moscoso Bridge insight. **Descend** and maintain 2000.
11. N216MV traffic is at your 12 o'clock four miles opposite direction. For spacing **turn left** heading 030.
12. **Descend** and maintain flight level 180. Orlando altimeter 29.92...Delta 1454.
13. N721HW expect vectors Jacksonville **climb** and maintain flight level 290.
14. **Turn left** heading 090. Expect one more turn to final, N5405M
15. **Climb** and maintain two thousand one hundred, N815PY for spacing.

**Script 3**

1. N629RS these will be vectors for the ILS Runway 18R **turn right** heading 150.
2. **Turn left** heading 090. Expect one more turn to final, N5405M
3. American fourteen fifty-five San Juan Approach, expect visual approach to runway 10, report the Moscoso Bridge insight. **Descend** and maintain 2000.
4. N721HW expect vectors Jacksonville **climb** and maintain flight level 290.
5. Deland airport is at your twelve o'clock N14AZ **turn right** heading 180.
6. **Descend** and maintain flight level 180. Orlando altimeter 29.92...Delta 1454.
7. **Climb** and maintain two thousand one hundred, N815PY for spacing.
8. N454AC **climb** and maintain four thousand three hundred. These will be vectors to Boca Raton
9. N819SD Tampa Departure Radar Contact expect vectors on course in 5 miles **turn left** heading 100.
10. N382PE expect vectors across final for spacing. **Descent** and maintain one thousand six hundred.
11. N417ER Miami Departure Radar Contact **climb** and maintain five thousand. Contact Daytona Approach on 125.35.
12. N407RS the Vandenberg Airport is closed due to poor weather. These will be vectors to your alternate airport **turn right** heading 270.
13. N108EH **descend** and maintain two thousand. Cleared visual approach into runway niner left.
14. N543JT **turn left** heading 270. Circle to land to runway 16.
15. N216MV traffic is at your 12 o'clock four miles opposite direction. For spacing **turn left** heading 030.