SEGMENTAL FACTORS IN LANGUAGE PROFICIENCY:
Degree of velarization, coarticulatory resistance and vowel formant frequency distribution as a signature of talent

Von der Philosophisch-Historischen Fakultät der Universität Stuttgart

zur Erlangung der Würde eines Doktors der

Philosophie (Dr. phil.) genehmigte Abhandlung

Vorgelegt von

Henrike Baumotte

aus Bielefeld

Hauptberichter: Prof. Dr. Grzegorz Dogil, Universität Stuttgart

Mitberichter: Prof. Dr. Daniel Recasens, Universitat Autònoma de Barcelona

Tag der mündlichen Prüfung:

18.11.2011

Institut für Maschinelle Sprachverarbeitung der Universität Stuttgart

2011

Danksagung

Die vorliegende Dissertation wurde in Stuttgart am Graduiertenkolleg *Sprachliche Repräsentationen und ihre Interpretation* (gefördert von der Deutschen Forschungsgemeinschaft) erstellt. An dieser Stelle sei allen herzlich gedankt, die auf die eine oder andere Weise an der Entstehung dieser Arbeit beteiligt waren.

Mein besonderer Dank gilt Herrn Prof. Dr. Dogil, der mir die spannende Arbeit am Institut für Maschinelle Sprachverarbeitung ermöglicht hat. Für vielfältige Kommentare und den Beginn einer Kooperation danke ich Herrn Prof. Dr. Recasens, der auch zur Vollendung meines vorhergehenden Buchkapitels wertvolle Beiträge geleistet hat.

Weiterhin richte ich ein herzliches Dankeschön an Dr. Susanne Reiterer und Dr. Matthias Jilka, in deren DFG-Projekt diese Dissertationsschrift eingebettet ist und die somit die Basisidee für das herausragend interessante Forschungsthema geliefert haben. Die Mitarbeit im Projekt während der Aufnahme von Sprachdaten in der schalltoten Kammer in Stuttgart sowie der Durchführung von fMRI-Experimenten in Tübingen diente mir als wertvolle experimentelle Erfahrung.

Auch danke ich Herrn PD Dr. Möbius für seine fortwährende Gesprächsbereitschaft und wichtige Hinweise auf manch eine wissenschaftliche Frage. Gleichermaßen sei Herrn PD Dr. Wokurek gedankt, der mir als Ansprechpartner in technischen und auch fachlichen Fragen stets mit Rat und Tat zur Seite stand. Das Graduiertenkolleg mit seiner jährlichen Klausurtagung sowie wiederum der alljährlichen Vortragsreihe war ein bedeutendes Forum, um in konstruktiven Diskussionen den Aufbau der Experimente, die Resultate und aufkommende neue Ideen zur Fragestellung zu thematisieren.

Über stets anteilnehmende und gewinnbringende Gespräche bedanke ich mich bei Prof. Dr. Dr. Müller von der Universität Bielefeld. Mein sechswöchiger Forschungsaufenthalt an der University of Newcastle/England bei Herrn Senior Lecturer Alter hat mich sehr geprägt und war ohne Zweifel richtungsweisend.

Die Kollegiaten, Assoziierten des Graduiertenkollegs und auch meine Mädchen im Erfolgsteam gegründet mit Hilfe des Mentoring Programms zur Frauenförderung an der Universität Stuttgart sowie insbesondere auch meine Mentorin Frau Prof. Dr. Henn-Memmesheimer bildeten meine zweite Familie an der Universität und spendeten Kraft und Mut zur Weiterverfolgung der notwendigen Dissertationsschritte bzw. ebneten den Weg für die klare Sicht zur Umsetzung neuer Ziele.

Für das kontinuierliche inhaltliche Interesse an meiner Arbeit, ihre Analysetätigkeit und vor allem auch ihre fortwährende mentale Unterstützung möchte ich Frau Sibylle Kötzer danken. Für moralische und fachliche Unterstützung in vielen Bereichen danke ich zudem meinen

Zimmerkolleginnen – Olga Anufryk und Natalie Lewandowski sowie André Blessing. Ferner danke ich vor allem Manuel Kountz für ermunternde Worte über weite Strecken meiner Dissertation sowie zusätzlich Hilfe und Unterstützung bei der Erstellung automatischer Extrahiermethoden zur Datenanalyse, ohne welche ich wahrscheinlich noch heute mit Daten und Werten zu kämpfen hätte.

Für Töne und gemeinsames Schimpfen bedanke ich mich bei meiner sehr guten Freundin Dr. Friederike Barth, ohne die die harten und mühsamen Phasen sicherlich nicht so leicht zu überwinden gewesen wären.

Mein ganz besonderer Dank gilt meiner Mutter, Angelika Baumotte, Tante, Adelgund Schwalbe, wie auch meiner fast 90jährigen Oma, Wilma Horstkotte, die mir stets mit Aufmunterung, Verständnis und auch – wenn nötig – finanzieller Unterstützung zur Seite standen.

Insbesondere aber danke ich schließlich meinem Vater, der durch sein Schaffen, seine eigenen Werke und seiner Freude am Publizieren mein wissenschaftliches Interesse zu Lebzeiten und von meiner Kindheit an maßgeblich inspiriert und gefördert hat.

Table of contents

Abbreviations

AMMA	Advanced Measures of Music Audiation
ANE	Australian English
BAS	behavioural activation system
BE	British English
BIS	behavioural inhibition system
C	consonant
CAT	Communication Accommodation Theory
CD	coarticulatory distance
CE	Caribbean English
CPH	Critical Period Hypothesis
CR	coarticulatory resistance
CSM	context-based production model or context sequence model
CV	consonant-vowel
CVC	consonant-vowel-consonant
df	degrees of freedom
df_{bg}	degrees of freedom between groups
df_{wg}	degrees of freedom within groups
DFG	Deutsche Forschungsgemeinschaft
DLAB	Defense Language Aptitude Battery
DSD	Differentielle Sprach-Diagnosticum
DTI	white matter fiber tracking
EE	excitation strength
EEG	electroencephalography
E-IQ	IQ of Empathy
EMG	electromyography
EPG	electropalatography

ERP	effective radiation power
E-Scale	Empathy Scale
ESOL	English for Speakers of Other Languages
ESPS	Entropic Signal Processing System
f.	female
F()	any statistical test in which the test statistic has an F-distribution under the null hypothesis
F_0	fundamental frequency
F_1	first formant
F_2	second formant
F_2‘	mean value out of F_2 and F_3 ($[F_2 + F_3]/2$)
F_3	third formant
F_v	difference value out of F_2 minus F_1 (F_2-F_1)
fMRI	functional Magnetic Resonance Imaging
GA	*General American* English
H*	high accent
Hz	Hertz
IPA	International Phonetic Association
ISC	*Incremental Specification in Context* model
IQ	intelligence quotient
kHz	Kilohertz
L0	non-acquired language
L0	amplitude level of F_0
L1	acquired mother tongue
L1	amplitude level of F_1
L2	second language, i.e. first acquired foreign language
L3	third language, i.e. second acquired foreign language

L*H	rising pitch accent
L*	low accent
m.	male
MA	Mid-Atlantic
MBTI	Myers-Briggs Type Indicator
MCD	mean coarticulatory distance
MEG	magnetic encephalography
MLAT	Modern Language Aptitude Test
MR	*magnetic resonance* imaging
ms	millisecond(s)
ms(ec)	millisecond(s)
MWT-B	Mehrfachwahl-Wortschatz-Intelligenztest
N	number
NE	Northern English
NOE-FFI	neuroticism, extroversion, openness to experience, agreableness and conscientiousness-Five Factor Model
p	level of probability
PANAS	The Positive and Negative Affect Schedule
r	correlation coefficient
RA	residual air flow (or dynamical leakage)
RK	symmetry of rising and falling branches of the glottal flow pulse)
RP	Received Pronunciation (British English)
rtfMRI	real time functional magnetic resonance imaging
s	second(s)
SAT	speech accommodation theory
SLA	second language acquisition
SPSS	Statistical Package for the Social Sciences
SSBE	Southern Standard British English

SSE	Standard Scottish English
STAI	State-Trait Anxiety Inventory
Std.	Standard
t	Student *t* value
ToBI	tones and break indices
TOEFL	Test of English as a Foreign Language
VBM	white and grey matter density measurements
VCV	vowel-consonant-vowel
VOT	voice onset time
WM	working memory
y	year(s)

0. Introduction and overview

Differences in people's aptitude, capacity, success and speed of foreign language acquisition are commonly observed and documented (e.g. Saville-Troike 2005). The phonetic-articulatory aspect is in particular seen as a specific sub-skill for which separate neural substrates have been assumed. The research project supported by the DFG, *Language Talent and Brain Activity* at the Universität Stuttgart and University of Tübingen/Germany, attempted to find out the differences between talented and untalented second language learners regarding phonetic abilities (pronunciation) with the help of neuro-imaging techniques. All of them were submitted to a large battery of tests, including phonetic and psychological experiments together with neuro-imaging techniques. The subjects taken have been categorized as proficient, average and less proficient speakers of L2 English in previous studies (Jilka 2009b). There are talented learners who exhibit less of a foreign accent while untalented learners show more. Until now, no study has examined pronunciation talent in combination with neuro-imaging research. Researchers at the University of Tübingen hoped to detect brain areas which are responsible for these differences in foreign language articulation abilities. There could be brain correlates of the different phonetic strategies used by the two groups. fMRI and MEG studies intended to find neuro-linguistic evidence for clarification.

The present research project is part of the above-described DFG project and intends to evaluate the *Segmental factors in language proficiency: Degree of velarization, coarticulatory resistance and vowel formant frequency distribution [being] a signature of talent*. The aim of this PhD thesis is to uncover individual differences in phonetic/phonological processing (encoding/decoding) strategies between phonetically proficient and less proficient second language learners. Acoustical data is presented involving the degree of velarization and coarticulatory resistance measurements, as well as formant frequency distributions of various vowels after /l/ for L2 English and German speech of 41 German speakers. Proficient and less proficient L2 English /l/ sounds are assumed to be distinguishable, confirming the conventional separation of the consonant into the two distributionally conditioned extrinsic allophones, the to some extent velarized ("dark", here symbolized as [ɫ]) or non-velarized types ("clear" [l], with some degree of palatalization). The author expects proficient speakers to realize the more velarized variety compared to less proficient learners who are expected to produce the non-velarized variety. In a second step, the author will then contribute these strategies to certain phonetic/phonological models – most importantly in *The Exemplar Theory*. Many studies have taken into consideration the degree of coarticulation in vowel-consonant-vowel articulation and have simultaneously observed cross-language differences, as well as accent production in an L2, but none have also included dialectal variations plus proficiency level in non-word and additionally natural language stimuli.

The present thesis is organized as follows: *Chapter 1* introduces second language acquisition research for then leading over to the *Language Talent and Brain Activity* project. The project is described in detail while presenting its tests and their respective results. It is claimed that investigation of performance by means of perceivable events is not sufficient, so that there is the need for instrumental analysis to get a complete and rounded picture (Jilka 2009b:34). Therefore, explicit phonetic phenomena such as prosody, phonetic convergence and within this work *coarticulation and/or coarticulatory resistance* have been the subjects of research. As there are so far no fully successful methods for learning a foreign language accent free, the following paragraphs outline the reason for the accent production to further point to strategies for accent-free language learning.

It is suggested that the full range of experimental findings cannot be explained when individual, cross-language (also in vowel articulation) and dialectal differences are not taken into account. This is the reason for *Chapter 2* which builds the basis for later interpretations of the outcomes while taking into consideration diverse dissimilar German vs. English and inter-dialectal sound patterns.

Before turning to the experimental part of this thesis, a background on articulatory-acoustic theory is given in *Chapters 3* and 4 which should further help to make the transfer between experimental results and coarticulatory/coarticulatory resistance, psycholinguistic and speech production theory.

Chapter 5 further accounts for the interrelation between the theories considered while pointing to their relevance with regard to coarticulation/coarticulatory resistance and at the same time for second language acquisition research.

Chapter 6 (Experiment 1), the first experimental chapter in this work, principally examines non-word sequences /əlV/ to find out differences in degree of velarization in /ə/ and /l/ (as measured at the quasi-steady-state period in symmetrical VCV-environments) and in coarticulatory resistance measured in /ə/ and in vowel formant frequency distributions measured 100 ms after onset of /[aɪ, eɪ, y, u:]/ following /l/ across levels of proficiency. Differences in these features could lead to the acoustical perception of a higher or lower accent production in L2 English speech of less proficient and average learners. In one paragraph the author correlates the auditive assessment of German L2 speakers of English with their degree of velarization and level of proficiency. The purpose is to discover whether the perception of a given dialect matches the degree of velarization and whether the degree of velarization, the categorization in dialectal varieties and levels of proficiency interact with each other. In addition, the in-depth comparison of only female speakers and individual subjects serves to verify the preceding group results. It is shown that proficient and less proficient speakers' degree of velarization measured in /ə/ and /l/ varied significantly. In all of the respective comparisons proficient speakers showed the tendency to velarize more than less proficient speakers. The group of only female subjects also validated the hypothesis.

The initial hypothesis of proficient speakers being more coarticulatory resistant, i.e. velarizing more, than average and less proficient speakers, was basically confirmed. It is concluded that these outcomes might be plausibly attributed to the same mechanism of articulatory coordination, i.e. tongue fronting and raising vs. tongue backness, influencing degree of velarization. For the /əleɪ/ vs. /əlu:/ comparisons velarization outcomes were not re-identified, presumably for the reason of various vowel characteristics which conflicted with each other. The interdependence of auditive assessment, level of proficiency and degree of velarization showed that the degree of velarization did not serve as the only indicator for the evaluation of auditive assessment. Finally, vowel formant frequency distributions after /l/ do not seem to importantly influence the realization of the consonant.

Chapter 7, on the basis of the findings of Díaz et al. (2008) who have discovered individual differences between more or less "talented" or "able" phonetic perceivers not exclusively in the foreign, but also originally in their native language sound system, this chapter comprises measurements of velarization in /ə/ and /l/, as well as of coarticulatory resistance in favour of this interrelationship between native and non-native phonetic abilities. In line with Díaz et al. (2008), results taken from /ə/ turned out according to the initial hypothesis regarding high and low general impression informants, whereas the outcomes taken from /l/ behaved contrary to the expectation. In both cases average general impression speakers did not support the prediction. These observed results are explained on the basis of *The Exemplar Theory* claiming that average general impression speakers have stored as many exemplars as high general impression speakers, but are not in the same way able to adequately have access to and produce them.

CD values out of coarticulatory resistance measurements for high general talent impression speakers underlined the inference of very different varieties of /l/, but computations out of /əly/ vs. /əla:/ did not behave accordingly.

In order to obtain supportive evidence for German and L2 English also differing significantly in their degree of velarization, English is compared with German outcomes in *Chapter 8*. The observed results fully confirmed previous predictions, German stimuli being velarized to a lesser extent than English stimuli.

Chapter 9 (Experiment 2), in a series of analyses taking natural language stimuli it accounted for /l/ being articulated differently in syllable-/phrase-final and -medial or syllable-/phrase-initial position and in German vs. English of speakers possessing a certain proficiency level and realizing various English dialects. The chapter followed the research line of whether the perception of a given dialectal variety can be associated with the appropriate degree of velarization in a certain syllable-/phrase position. The juxtapositions of formant frequencies in /l/ in contrasting syllable or phrase positions mostly underlined the findings of the previous *Experiment 1*, while obtaining the expected tendencies.

Finally, the analyses of the present thesis are summarized and evaluated in *Chapter 10*, by considering the results gotten from the whole *Language Talent and Brain Activity* project and the theories outlined. In addition, open research questions and issues for future studies are discussed in the final chapter.

1. Theoretical overview

1.1. Second language acquisition research

Individuals differ significantly from each other in their aptitude, ability and speed of foreign or "second" language (L2) acquisition. The existence of a critical or "optimal" period for attaining native-like proficiency in all linguistic levels is a "classic" issue in L2 acquisition research. While Lenneberg (1967) postulates that the

> *"language readiness [...] begins with (age) two and declines with cerebral maturation in the early teens" (Lenneberg 1967:176, 377),*

Birdsong (1992), Montrul and Slabakova (2001) take the view that certain grammatical skills such as semantics or syntax do not undergo these restrictions of the second language learners' age. Flege (1987) and Flege et al. (1995) point out that there is no sudden distinction in the pronunciation of individuals differing in the Age of Learning Onset (AOL). It has generally been accepted to differentiate between two substructures of linguistic skills: talent for grammar vs. talent for accent (Schneiderman & Desmarais 1988; cf also Birdsong 1992). Actually, a specific problem for the acquisition of pronunciation is claimed in opposition to other linguistic features, which is almost proverbial, as manifested in the popular and often applied term "Joseph Conrad Phenomenon" (e.g. Bongaerts et al. 1995; Bongaerts 1999; Guiora 1990; Abu-Rabia & Kehat 2004). This term brings up the Polish-born novelist's native-like abilities in English grammar (syntax, morphology), vocabulary and style expressed through his intensely accented pronunciation. The "Henry Kissinger Phenomenon" serves as its synonym for similar reasons. These two individuals, namely Joseph Conrad and Henry Kissinger, and a large number of experimental studies substantiated the gap between pronunciation and other L2 abilities. Even some years earlier, Neufeld (1987), for example, pointed out that ratings of pronunciation skills could not be related to the effects attained in general language aptitude tests.

Authors generally agree that the phonetic subsystem is the most difficult system to acquire because it is based on hard-wired biological processes. These processes cannot be affected easily by consciously induced behavioural learning efforts. "Grammar" and "accent" presumably provoke disparate challenges in the acquisition of an L2. Both of them obliged to be flexible by means of neurocognition for circumventing the system settled for L1; whereas in the acquisition of pronunciation, it is also necessary to circumvent set-up motor pathways in order to control articulatory movements (Jilka 2009a:4). Taking into account the literature on second language acquisition research, age limits are suggested from young infancy (Kuhl et al. 1992) through childhood (Krashen 1973) to puberty or adolescence (Johnson & Newport 1989). But apparently within the same group of L2 learners at approximately the same age some perform better than others (i.e. they show different competence levels), so age cannot be considered as the sole determining factor. Some studies even report late (adult) learners who are able to learn a second language with native-like pronunciation abilities (e.g. Amunts et al. 2004; Bongaerts et al. 1995). This is why the Critical Period Hypothesis (CPH) should rather be viewed with caution (Flege 1987; Flege et al. 1995 [less strictly defined "Sensitive Period"]). Flege et al. (1995) devised the theory that children preferably acquire language(s) in an auditory rather than in a phonetic manner, because he was able to discover that they have less rigidly organized L1 categories[1]. As a consequence, they could actually be able to arrange perceptual targets more precisely.

Until now research on second language acquisition has been based on purely behavioural psycholinguistic, psychological or applied linguistics research. Bongaerts et al. (1995) ascertained that, in addition to innate talent, specific pronunciation training, high motivation, substantial L2 input and typological proximity of L1 probably lead to native-like performance. Maybury (1993) pointed out that especially talented speakers of a second language are often quick learners of their first language as well and could be specifically biologically assigned and neuronally prewired. Despite this speculation, no neuro-imaging studies have been performed so far to study high ability, but only low ability and pathological language impairment that concern so many studies in the field of neuro-linguistics, neuro-imaging and neuropsychology.

1.1.1. Neurolinguistics and neuropsychology in SLA research

Much is known about the brain mechanisms during the production of the first language and during impaired speech production. Less has been observed with regard to brain activation during the production of a second language. Reiterer et al. (2005) conducted a study to find correlations between second language proficiency level and neural brain activation. They intended to regard especially individual differences in second language proficiency and motivation both for native language and foreign language text processing tasks. As a rule, Reiterer et al. noticed more neural brain activation (high intensity and/or extent) in connection with a lower proficiency level and, in contrast to these findings, lower activation, (i.e. a prefrontal decrease of neuronal activation) correlating with a higher proficiency level/high motivation for L2 speakers. Other studies (Golestani et al. 2002; Golestani & Zatorre 2004) dealing with age of acquisition versus proficiency level support these findings.

Also including linguistic (phonetic/phonological) data and with respect to the findings described, the author places special emphasis on phonetic models which could help to explain individual differences in language talent and the distinction in neural activation differing in second language

1 This means that there is no need for children to severely trace back acoustical events to specific phonetic categories, but they flexibly build new ones.

high versus low proficiency levels.

A new generation of naturalistic psycholinguistic models is becoming increasingly important, which, in contrast to Levelt (1999), also considers speech planning processes from the segmental, phonematic level to the level of muscle commands. Schneider et al. (2006) have presented a newly conceptualized *Exemplar Theory* based on the *Incremental Specification in Context* (ISC) model developed by Dogil and Möbius (2001), Möbius and Dogil (2002), as well as on the framework of *The Exemplar Theory* of Goldinger (1997) and Pierrehumbert (2001). This theoretical concept is consistent with the speech representations (phonetic and phonological) that appear as regions in the perceptual space of speakers/hearers of a language. The authors cited and others have suggested that speech exemplars do not illustrate concrete realizations, but representations set up through an internal analysis-by-synthesis process.

> *"Category-specific exemplars emerge from the internal analysis-by-synthesis process and a successful match to patterns derived from the input speech signal." (Dogil 2007)*

The constant presence of the production-perception loop in these exemplar based models accounts for the expected individual differences among speakers.

1.2. *Language Talent and Brain Activity*-project and its overall objective

The research project *Language Talent and Brain Activity,* funded by the DFG at the universities of Stuttgart and Tübingen, started in February 2006 and is attempting to substantiate talent in pronunciation, especially in a second language, of talented, average and untalented second language learners regarding various phonetic/linguistic abilities and, in addition, psychological and behavioural effects on pronunciation performance. Its primary goal was to uncover neural correlates of pronunciation talent, i.e. deviations in brain activity between talented and untalented speakers.

Beforehand, the project leaders (Ackermann, Dogil and Grodd) explored cortical processes, namely *cortical deficiency*, in investigations, observing aphasic, dysarthric and other subjects with cortical disabilities, and then investigated the topic further with non-cortically impaired subjects. The project under discussion principally intended to discover dissimilarities in *cortical efficiency* regarding talented, average and untalented second language (L2) learners of English. During the duration of the project the performance of over 100 speakers was correlated with personality, musicality, intelligence, memory span, sociolinguistic features, their exhaustive phonetic skills using new tests and methods, and, in addition, even brain scans for the examination of language talent. The final insight in this broad survey of language talent (also including brain activity measurements) is that there is an interrelationship between efficiency in language learning (talent) and specific cortical efficiency which has been quantified with neuro-imaging methods (Dogil & Reiterer 2009: Preface).

The project was based on the assumption that differences in people's aptitude, capacity, success and speed of foreign language acquisition are commonly observed (e.g. Saville-Troike 2005). If similar learning circumstances can be assumed, the acquisition of aptitude for and speed of foreign language acquisition obviously yields very divergent results. In particular, there is validity for the achievement of the L2 sound system, which encompasses all segmental and prosodic revelations on a phonetic and also phonological level, presenting remarkable difficulties for some speakers who show wide variation with regard to each other. These discrepancies can be interpreted in various ways beginning with exceptional genetic characteristics to particularly developed brain networks, to deviations in declarative (i.e. learning and use of fact and event knowledge) and procedural (i.e. acquisition and expression of motor and cognitive skill) memory (Ullman 2007) and concluding with intelligence and personality factors such as motivation, extroversion or even empathy. However, the familiar phonetic approaches of second language acquisition (SLA) concentrate less on innate learner attributes, but rather on external factors such as age of learning, age of arrival, length of residence or quantity of L1 and L2 use. Judging these external factors, conditions could be imaginable in which the acquisition of a second language could proceed in an exemplary course of action. However, the supposition of speaker intrinsic factors governs the idea of language learning competence being partly unaffectable by external powers. The presence of immunity against external influences serves as an overall determinant for the definition of what "talent" comprises, or for a broader definition:

> *"a disposition toward a good performance in language-related activities" (Jilka 2009a:2).*

There is overall correspondence between the need to distinguish between proficiency, i.e. the unconcealed remarkable performance of a specific faculty, and talent per se. Degree of proficiency comprises factors such as motivation, practice and experience, however, these aspects are not related to talent. The conclusion to be drawn from this statement agrees with highly accepted concepts that believe talent to be an inborn, a somewhat mysterious property which a person either does or does not possess.

Powerful neuropsychological models of the source and structure of talent were found in a model of well-defined skills where specific abilities appear alongside one another, and linguistic talent resembles musical, logical, spatial talent, etc. (Gardner 1983). However, most tests of general ability exclusively serve to explain the precise nature of the skill. Exceptional occurrences are only present in widespread tests (e.g. Novoa et al. 1988), while judging IQ, vocabulary skills, verbal fluency, verbal memory, apprehension of abstract patterns, and learning of code systems.

The attempt to split innate talent, if it actually exists, from these other factors employing an experimental design for fixing what constitutes the deviation of general proficiency, is not a negligible affair. Therefore, individual test tasks should be developed and elaborated in a manner which ensures that the final objective will be examined last of all. Parallel to this, the clarification of the superordinated effects on performance has to be achieved. These principal effects can be summed up and placed in categories primarily composed of all developmental/neuropsychological issues such as age of learning, psychological factors such as motivation and attitude directed to L2, and finally, the matter of practice and experience, i.e. amount of language use and broader greater familiarity with the huge variety of possible linguistic structures (e.g. unusual types of sounds, syntactic structure, etc.) nonetheless of explicit knowledge of the definite language asked to be used (Jilka 2009a:8). To reveal the essence of "talent", control of these factors or – for greater certainty - their entire exclusion, is indispensable. Regarding the project under consideration, control was aimed at these experiments while taking subjects with great experience in their L1. It is, however, not possible to find subjects of equal L1 experience. This is why it is more desirable for the selection of subjects to conduct such a study to build up a large homogeneous group of similar ages and courses of learning, i.e. identical time and conditions of L2 acquisition (cf Jilka 2009b). The research group considered collected this information with the help of a questionnaire answered by each of the test subjects.

Nowadays, a large range of various performance tests, reading, comprehension, speaking, grammar, etc., is available for foreign learners, but not for native speakers: To list some examples for English, there is the *Test of English as a Foreign Language* (TOEFL) for learners of American English, and the Cambridge test *English for Speakers of Other Languages* (ESOL) for learners of British English, with numerous exercises such as reading, comprehension, speaking, grammar etc.. Other than being mere performance tests for L2 speakers, such as TOEFL or ESOL, and investigations of the significance of clearly determined factors on characteristic parts of language performance, these tests do not intend to evaluate performance in a specific L2. The tests rate general language ability based on L1 and predict possible success achieving any L2 dealing with, for example, vocabulary memory, syntactic structure, the coding of symbols and meanings or sounds. The *Modern Language Aptitude Test*, short MLAT (Carroll & Sapon 1959) serves as one positive example within these tests, which were designed for native speakers of English, for the prediction of success and/or talent respectively during a course of second language acquisition. Besides the MLAT, there are more language aptitude tests for English speakers, namely the *Oxford Language Aptitude Test*, and the *Defense Language Aptitude Battery* (DLAB) conducted by the American Department of Defense. The *Differentielle Sprach-Diagnosticum* (DSD), a comparative test set submitted for German (Acker 2001), was collected from diverse individual tests on verbal intelligence, grammatical judgement, comprehension, etc..

A partial overview of studies with a principally phonetic focus on second language acquisition brings to light the diversity of individual external factors regarding conditions of language acquisition and their practise which have been the subject of research. Once again, these studies are comprised of age of learning (e.g. Johnson & Newport 1989), length of residence/age of arrival (e.g. Flege et al. 1995) or amount of L1/L2 use (e.g. Piske et al. 2001). Cognitive/psychological studies account for, e.g. working memory (e.g. Pagagno & Vallar 1995), motivation (e.g. Moyer 1999) or personality factors such as empathy and extroversion (e.g. Edmondson & House 1993). The majority of studies aimed to prove the significance of the one factor they exclusively investigated, whereas multi-factorial analyses by, e.g. Bongaerts and colleagues (Bongaerts 1999; Bongaerts et al. 1995, 2000), discovered that, if subjects have innate talent and undergo specific pronunciation training, are highly motivated, go through substantial L2 input, and if L1 is typologically close to L2, there is a great chance of reaching native-like performance (Jilka 2009a:11).

The investigation of the psychological factors affecting performance runs in an analogous way. A considerable number of cognitive and sociopsychological tests and questionnaires are made for the reason of appraising multiple components of the subjects' cognitive abilities (working memory, intelligence, etc.) and personality traits (extroversion vs. introversion, etc.) incorporating motivation and interest especially in the acquisition of languages (Hu & Reiterer 2009).

In general the phonetic subsystem is supposed to be much harder to master because of presumably being based on hard-wired biological processes which cannot be controlled by conscious learning effort without difficulty, but merely by means of neurofeedback techniques (cf Chapter 1.3.).

The first major task within the project consisted of the implementation of extensive phonetic experiments in order to detect individual differences, to measure the phonetic aptitude of German subjects and to assess pronunciation talent in its multiple proportions such as production and perception, the segmental and suprasegmental levels of speech and various utterance forms (such as spontaneous speech, reading and imitation). With the help of these tests the pronunciation talent assessment in L2 and the more specific interactions between the talent-related parameters explored have been worked out in order to see more precisely the state of the art of phonetic language aptitude, especially in velarization properties. At the same time these examinations aimed to contribute a reliable categorization of talent and proficiency levels employed for singling out subjects for the following neuro-imaging studies. 102 female and male native speakers of German have been tested (right handed). The majority of subjects (amongst them 50 university students of

English) have an academic background and have learned English mainly in the formal setting of the German school system since they were approximately 10 years old (in German schools regularly since fifth grade), preferably including a stay in an English-speaking environment at some stage of their lives which for the vast majority did not exceed more than a few months (cf Jilka 2009b for more details).

In principal, English served as the language under investigation and also, but to a lesser extent, German and Hindi. The choice of English was essential to expand the vast group of learners and likewise the probability of receiving speakers with native-like pronunciation skills. Besides, because of the inclusion of English and German, comparative linguistic descriptions to extract segmental and prosodic characteristics could be done. The German and Hindi exercises were created for the purpose of weakening the power of learning experience on performance. Native speakers of German are expected to have (almost) the same knowledge of their L1, Hindi, however, serves as a language of which they all have absolutely no experience with (Jilka 2009b:18).

The following overview of tests taken within the *Language Talent and Brain Activity*-project should provide evidence for not merely measuring *proficiency* in a foreign language, but also *talent* per se, what is meant to be the main research objective.

1.2.1. Testing general language aptitude and English proficiency

Nowadays no validated tests for the evaluation of general linguistic aptitude are available. Altogether a huge quantity of tests solely assess general proficiency in a particular second language. These tests of language aptitude were originated to supply standardized methods for the quantification of general language learning abilities and therefore for a prognostication of the ability to acquire a second language.

An abbreviated variant of the MLAT, *Spelling Cues* (ability to associate sounds and symbols), *Words in Sentences* (comprehension of grammatical structure), *Paired Associates* (verbal memory test with 24 Kurdish vocabulary items), had to be executed by the German native participants in the investigation. Within the MLAT a substantial constituent of English proficiency has to be regarded. The results cannot be explained as mirroring an innate aptitude as they would do for veritable native speakers of English. Nevertheless, a distinction between the test subjects' general language abilities, such as operating with syntactic structure, vocabulary and the link between sounds and letters, is possible (Jilka 2009b:21). Within the project's large phonetic test battery, a small part from the *Test of English as a Foreign Language* (TOEFL) was also employed for reasons of obtaining a more transparent image of the German test subjects' global English proficiency.

1.2.1.1. Testing phonetic ability

All the participants were surveyed in an approximately 90 minutes session in the sound-proof recording room of the Institute of Natural Language Processing at the Universität Stuttgart (45 minutes of production/imitation tasks *plus* 45 minutes of perception tasks) with the purpose of running experiments to establish phonetic abilities. Within the production tasks, the speakers produced the native accent of English (General American, Received Pronunciation, Australian English, etc.) they were familiar with. The imitation and perception tasks were equally balanced between GA and RP stimuli (Jilka 2009b:22).

On the basis of studies directed by Oyama (1976), Bongaerts et al. (1995), Markham (1997) or Flege and Hillenbrand (1987), phonetic experiments in production and perception skills in English as a second language for L1 native speakers of German were conducted with the help of various elicitation techniques (Jilka 2009b:22). In principal these are executed to accomplish diverse kinds of intonational configurations, speaking rates and degrees of fluency. The result is based on the degree of foreign accent to correlate with task complexity and in line to alter as a function of the type of elicitation. Evaluations of segmental production can obviously be carried out in all controlled environments, however, occasions for distinction are overtly restricted to (quasi-) spontaneous speech which can only be taken to analyze what has just been formulated by the speakers.

The reading and the imitation tasks embody all phonemes, crucial allophonic variations and phonotactic constellations of the L2, i.e. English. The uncertain areas, the researchers have been aware of for native speakers of German, are inspected in detail, e.g. the employment of clear /l/ in all positions including the syllable-/phrase-final position serving as an indicator of a heavy German accent is essential for the analyses exhibited in this work (cf Jilka 2009b:23 for more details).

The tasks fulfilled were as follows:

<u>(Quasi-)Spontaneous speech (term of task: “acted speech”)</u>

By determination spontaneous speech represents the most usual type of human communication and by all means pictures the general pronunciation abilities, the optimal enabling particularly representative impressions of fluency, speaking rate, segmental realizations and choice of prosodic patterns. During the opening of each recording session, speakers were invited to present themselves and talk about their experience with the English language/culture. Afterwards, this monologue was broadened into a short conversation with the instructor. The requested prosodic or segmental outputs worthy of noting have been extracted from the data recorded. The use of the short Gary Larson cartoon (Larson 1984) ensured control of then quasi-spontaneous output to a reliable extent evoking vocabulary choices (and thus segmental realizations), and simultaneously arousing specific prosodic constellations such as continuation rises (Jilka 2009b:24).

Read speech

Reading tasks operate with a controlled coverage of the phoneme inventory and specific phonotactic clusters, along with a properly controlled elicitation of pitch accent distribution and tunes related to particular discourse situations which simplifies the analyses. At the same time they make sure that speakers cannot hinder the employment of problematic sounds, words or sentence structures which could serve to diminish the possible effects of syntactic/morphological inaccuracies on the assessment. A specific kind and limited number of prosodic patterns is immanent of the read speech style perhaps additionally causing a more conscientious segmental articulation compared to "regular" speech. The English reading task comprised the standard IPA text *The Northwind and the Sun* for segmental coverage and one page taken from a short story for the observation of less usual vocabulary, that was harder to articulate, such as *"unlocatable"* or *"deliberately"*, and several dialogs calling for question or exclamation intonation, etc.. Supplementary reading tasks were made up of single sentences which asked for the production of special segmental and/or prosodic constellations, e.g. the short sentence *"She's teething"* with the underlying purpose of provoking miscellaneous emotional states and to check for the pronunciation of the voiced dental fricative with which many speakers struggle. After this, prosodic choices were made by ear and not necessarily with the help of an instrumental analysis technique.

Equivalent sentence reading tasks were established for German, as well, with special attention to the appropriate prosodic choices and realizations. Besides, the imitation of English accent production and in that way the speakers' consciousness of supreme phonetic and phonological features of other languages and their realization ability of these was tested by asking the subjects to read the text *"Der Nordwind und die Sonne"* in German, but with an English accent. This procedure was selected from Flege and Hammond (1982) comprising a sort of delayed mimicry (Jilka 2009b:26).

Speech perception

Phonetic ability is not exclusively composed of speech production, but also contains speech perception, both components being looked upon as evenly matched. That is why an examination of performance in the native language or a relatively familiar language provides a profound understanding of the perception of segmental features. At the same time, discrimination or identification tasks have been estimated to be fairly effortless to complete, whereas the identification of foreign or regional accents actually comprises this ability. In the project speech perception tasks incorporated the discrimination and interpretation of prosody involving comparisons of speech melody including low-pass filtered stimuli, i.e. the higher frequency components involving segmental information are plugged up and therefore language-specific differences between German and English are reduced to prosodic content and accent identification, identification of speaker intentions and emotional colouring and additionally listening comprehension tests to uncover semantic, pragmatic and probably also extralinguistic information. First of all, phrase intonation is constituted of pitch, but at the same time duration and loudness build up discourse structure and meaning (Dogil 2003). The intonation description and analysis employed in this project took place based on the *Tone Sequence Model* (Pierrehumbert 1980) introduced by Silverman et al. (1992). Intonational distinctions are thus defined as either categorical (different tone category, e.g. pitch accent or boundary tone wholly changed) or realizational (same category, different phonetic realization) (cf Jilka 2009b:28f. for an example). As categorical differences are more strongly linked to alterations in interpretation/discourse meaning, it is principally assumed for those to be more simply perceivable than the slighter realizational differences which are more difficult to differentiate from veritable twin pairs. A higher degree of talent would prove itself in the form of much greater sensitivity, particularly in view of the smaller realizational distinctions.

Perception and production combined

Imitation tasks are composed of speech production and speech perception tests which are treated in the earlier passages and request the ability to be entirely aware of a model and to recreate an exact representation of it. These kinds of tasks evidently profit to an utmost extent of immediate control over the upcoming verbalizations of an individual speaker. This is how composite tonal constellations and complicated segments, slight phonetic variation on the segmental, as well as suprasegmental levels have been explored. The German and English language have mostly provided for prosody examination. Additionally, Hindi being unkown to all the test participants was applied to acquire imitations of words and short phrases and within these segmental aspects, as well as the perception of these sounds and phonotactic compositions not existing in the native language and furthermore the ability to copy the deducible acoustic patterns. Conclusively, Hindi was used to scrutinize the perception, understanding and mimicry of suitable prosodic exemplars surveyed in the two dimensions, i.e. categorical and realizational. For the purpose of equilibrium, British English (Received pronunciation) and General American were comprehended and well-balanced.

Direct and delayed imitation

Within the direct imitation tasks, subjects were stimulated to merely imitate an utterance they were confronted with in order to especially detect temporal structures and to test constellations which are traditionally difficult to pronounce (allophones).

While in the delayed imitation task, question-answer-sequences were introduced to the subjects, whereupon a repetition of the question followed, then replacing the given answer by means of a speaker-generated imitation. In summary, the advantage of all imitations is the attainment of a higher degree of control and precision. In comparison with direct imitation, delayed imitation requires greater capacity of sensory memory and is, according to, for example, Piske et al. (2001) and Flege (1995) said to be the best imaginable elicitation technique which measures actual linguistic competence level.

The test materials established in Jilka (2000) at the Institute of Natural Language Processing, Universität Stuttgart were reused or recreated examples for new stimuli.

1.2.1.2. Evaluation methods

From these exhaustive phonetic experiments covering many various kinds of exercises a vast corpus of data ensued. Hence multiple forms of results followed which required an elaborate effort with regard to evaluation and analysis. The genuine production tasks such as reading aloud, narration, and acted speech were perceptually and thus subjectively appraised by an ample number of raters. More restrictedly determined designs such as accent imitation and interpretative reading demanded the execution of expert analysis dependent on an expected template. Furthermore, imitation tasks called for instrumental analysis to enable a comparison with the respective originals. Perception tasks were rated using an automatic scoring system, which offered a limited number of answers. Noticeably, talent is one of several factors responsible for a speaker's indeed palpable performance, but how might it be feasible to set apart inherent talent from superficial proficiency? Within the test battery the information on biographical data and personality factors facilitated the assessment of experience and practice. However, it is the most decisive to assess L2 English ability for a general assessment of performance quality. For this reason a basic perceptual evaluation comprising the two English production tasks (*Gary Larson cartoon* and *The North Wind and the Sun*) was run to gain a reliable score of the test subjects' abilities with reference to one another and analogously in absolute terms in relation to native speakers. A web-based evaluation design was constructed to reach a large number of native English-speaking raters mastering assorted accents of English and of native speakers of Hindi for the assessment of the Hindi imitation task. Altogether 117 speakers (102 German test subjects and 15 native speakers of English with various accents) were judged from an overall representative sample of 200 raters (cf Jilka 2009b:36 for further details).

An expert analysis consisted of a perceptual evaluation within which an overall impression formed by the more or less conscious awareness of individual phenomena in the speakers' productions was generated. Apart from the evaluations mentioned, a more precise look at individual linguistic criteria is indispensable while conducting a particular investigation of production performance, also for uncovering the motive for the auditive impression perceived. This is why three expert raters executed an in-depth analysis and evaluation of each expression uttered by every individual subject, even more profound in those task types in which the speakers produced merely one utterance. Afterwards these individual criteria carried out were determined and their impact was fixed. In connexion with performance it is claimed to be sufficient to lean conclusions based on perceivable events, instrumental analysis does not necessarily play a prominent role (Jilka 2009b:38). Instrumental analysis is, however, all-important to check explicit phonetic phenomena, such as prosody (cf Chapter 1.2.6.2.), convergence (cf Chapter 1.2.6.1.) and, within this work, coarticulation and/or coarticulatory resistance, expected to bring to light the occurrence of various talent levels. See Jilka (2009b:Appendix) for, among other things, a scorecard of the expert ratings for a single test subject.

The most exciting question is which of the tasks within the extensive test battery will end up being particularly profitable for the assessment of phonetic talent. It is essential to uncover the relationships between the phonetic tasks, the psychological test and also the personal data obtained within the questionnaires.

Early results pointed to a relationship between better performances in the interpolation tasks and a higher empathy score. Besides this, particularly high correlation could be detected between performance in the German interpretation tasks and accent identification which probably stands for an augmented awareness of the more indirect distinguishing marks of the native language. Predictably, performances in the whole group of pair comparisons (German, English, low-pass filtered) were associated with each other, which might be more a sign for a minor weight of linguistic knowledge/awareness than of merely perceptual abilities. Notably, the correlation between better performance in the low-pass filter-tasks and the personality factors of less inhibition and more conscientiousness serves as an example of the importance of perceptual abilities being an outstanding indicator of more extreme effort and motivation in the course of the examination. These results gave a first conclusive insight into the total of the data gained and an idea of feasible interdependencies between the various types of tasks, as well as their importance for the goals of the tasks. Without any doubt the focus of the entire investigation is on the distinction of the two concepts of talent vs. proficiency, and the knowledge taken from this will at the same time be the most relevant information of the analysis. The effects of both of these task types developed to draw attention to talent and those only evaluating general proficiency in a particular field must also be linked to the knowledge about the speakers' experience and status of motivation as determined in the questionnaires and the psychological tests. Up until now, no experimental method for the immediate estimation of phonetic talent has existed, hence many tests are still needed to approach the nature of speech talent and its subcomponents. In the long run, the entirety of the originated data base should be analysed to get the best ranking/classification to determine the most informative task types and then figure out a more compressed and successful test to be able to identify/assess phonetic talent in native speakers of German in an easier and more rapid, more regular, way (Jilka 2009b:41).

1.2.2. Investigation of cognitive aspects of pronunciation talent

In stage II of the project, subjects participated in psychological experiments which measured the cognitive aspects of pronunciation talent including phonological working memory, empathy, personality (e.g. learning style and motivation), verbal and non-verbal intelligence (Raven Test), musicality (Gordon Test), as well as mental flexibility.

Within the subsequent passages, the author will discuss cognitive factors important for L2 acquisition, such as empathy, mental flexibility, working memory abilities and intelligence, as well as their power in the groups of subjects divided into their levels of proficiency and talent in L2 pronunciation ability. The main purpose of this is to work out the interrelationship between personality factors and language acquisition with native-like capacity.

1.2.2.1. Empathy

Empathy serves as one of the relevant factors to take into account in order to reach the core of the cognitive aspects of pronunciation talent. At the present time the term *empathy* subsumes the faculty to build up the ability to be sensitive to and sympathize with the emotional states of others (Rota & Reiterer 2009:68 f.).

As early as in the 70's, Guiora et al. came up with the idea of interpersonal competence being, among other things, responsible for the acquisition of phonetic skills, therefore forwarding L2 pronunciation. According to Guiora et al. (1972) the state of ego-permeability, i.e. the development stage in which native speech abilities first arise, is meant to be fundamental for increased abilities in pronunciation, as it enables the speaker to discern slightly implied speech nuances and to master the re-creation of them.

Our research group made use of the questionnaire E-Scale for testing empathetic skills, a psychometrically sound instrument designed by Leibetseder and colleagues (2001). Leibetseder et al. (2007) defined empathy as the endeavour of identification with persons in imaginary or real-life situations. Two different proportions of empathy have been scrutinized: *sensitivity* and *concern*. The dimension *sensitivity* stands for the observation of empathetic abilities derived from fictitious visionary situations and the dimension *concern* for empathy experienced in real-life circumstances. The questionnaire accounts for cognitive sensitivity with the help of items that picture fictive, but concrete social situations from which empathetic reactions are to be derived. Further, tasks dealing with emotional sensitivity direct their attention to the emotional situation of the actor and cope with fictitious situations. Moreover, items provoke emotional concern by evoking reactions to situations marked by an elevated amount of reality. Lastly, cognitive concern is investigated by the encouragement of empathetic feelings to concrete situations of real-life making cognitive analysis necessary. The general score on empathy finally attained provides an IQ of empathy (E-IQ) which depicts the overall ability of the individual to face empathetic feelings in both invented and real-life conditions.

To conclude, the integration of the questionnaire portrayed in the test battery intends to find a correlation between phonetic abilities in L2 pronunciation and empathetic openness to others (cf Guiora and his co-workers' study and Jilka [2009a]), while phonetic proficiency is uncovered, taking both L2 pronunciation and perception.

To sum up, correlations revealed significant results for *empathetic readiness*, yet not for *social concern*. Interestingly, proficiency levels, talent, MLAT (Modern Language Aptitude Test) and Hindi imitation task, as well as the E-IQ scores were interrelated to each other. In this way subjects were scored higher on the *talent* score in pronunciation, in the case of also having high grades in the Modern Language Aptitude Test for *phonetic coding ability*. If high scores were given by Hindi native speakers on the Hindi word imitation task, empathy scores on the subscale *Empathetic readiness* were elevated at the same time. Additionally, correlations occurred between empathetic readiness and the ability to play a musical instrument, indicating the frequently presumed intervowenness between phonetic language talent and music. Altogether, the interaction between empathy and the miscellaneous measures of phonetic pronunciation talent manifest that the theory of empathy in speaking and learning a foreign accent might not be illusionary, but a reality calling for further clarification.

1.2.2.2. Mental flexibility

In the context of the topic *mental flexibility* several issues and research questions arose, such as the importance of mental flexibility to learn an L2, its relevance for the pronunciation of phonetic features, which largely vary from the ones we are familiar with in our native language, and whether there is an effect on brain plasticity while speaking a second language or multiple languages. Further, the query arises whether maintenance of a high cognitive functioning could be conserved if the brain were constantly being trained in the future times. Moreover, there is the matter of whether accent retainment in older L2 learners giving a hint of the native language can be setback, which mechanisms create this process and whether they can be singled out and if their effect can be reversed.

Originally, the *Simon Task* by Simon and Rudell (1967) was set up as a tool to check the effects of handedness and gender on selective attention. Later on, Lu and Proctor (1995) widened this evaluation, offering a range from executive functions to cognitive control. Participants are asked to concurrently process stimuli possessing pertinent features (e.g. colour) vs. immensely distracting irrelevant ones (e.g. the position on a screen, such as left or right). Subjects reach higher reaction times on congruent stimuli (e.g. red stimuli come into view on the left side of the screen and they must press a key on the left side for red) than in the case of giving feedback to incongruent stimuli (e.g. blue stimuli emerge on the left side of the screen and they need to press a key on the right side for blue). While performing this kind of task, the primary challenge for the subjects is the inhibition of automatic response processes to properly react to incongruent stimuli, which is very time consuming and as a consequence causes slower reaction times (*Simon effect phenomenon*) and lower accuracy levels. Beside this, the Simon effect has been noted for the attributes *pitch* and *form* (Simon 1969).

According to Fan et al. (2003) training and experience are apparently the most decisive for building up cortical plasticity and are the relevant factors for the specialisation of brain networks as well. Extended experiences that cope with attentional control, as those found in bilingualism, supposedly transform its neuronal bases, and substantiate their functioning.

In their investigation, Rota and Reiterer (2009) checked for an influence of the acquisition of L2 after puberty on selective attention and task switching capacities, making use of the Simon task and German L2 speakers of English as mentioned above (cf Chapter 1.2.). For that purpose they examined the performances, i.e. accuracy and reaction times, of their subjects which have been grouped as proficient, average and less proficient learners (cf Jilka 2009b). Additionally, the researchers chose the classical version of the Simon task on a laptop with E-Prime software (Schneider et al. 2002) to programme and run the experiment (see Rota and Reiterer (2009:76 f.)). They expected significant differences in the performances of proficient vs. less proficient volunteers, and proficient speakers were presumed to exhibit higher accuracy rates and diminished reaction times than less proficient speakers. Analyses of the statistical outcomes suggested that there is no correlation between accuracy in the Simon task and L2 proficiency when L2 is acquired after puberty, i.e. mental flexibility as assessed by the Simon task is not affected by the subject's proficiency. Consequently, learning L2 after puberty might not cause changes on brain plasticity as is the case in younger children, then reducing the effect of linguistic management on cognitive control.

To conclude, mental flexibility has no impact on the ability to master a foreign language and its phonetic features after puberty. The next chapter accounts for working memory capacity which is an important issue with regard to the acquisition of a foreign language, while also attempting to uncover in which way working memory capacity influences L2 pronunciation skills.

1.2.2.3. Working memory

Rota and Reiterer (2009:78) have taken the definition of working memory (WM) as being *a temporary retention of recently acquired information*. Several studies give evidence for the prediction of children's academic achievements by considering WM skills in diverse disciplines such as mathematics and reading (e.g. Swanson 2006). In line with these results Rota and Reiterer (2009) pose the question whether WM capacities are essential for acquiring a new language and whether the height of WM span can adequately forecast the ability to pronounce L2 with a native-like accent. As an extension, it would be interesting to engage in the training of WM span to discover whether the subjects coached require less effort to learn L2 and/or for the enhancement of their pronunciation skills. It might finally turn out that WM span training is an indirect, but nevertheless powerful approach to stimulate and strengthen linguistic abilities.

The next chapter gives an insight into *The phonological loop*, a model developed by Baddeley and Hitch (1974), comprising the working memory system as the basic linguistic sub-component. The researchers have integrated working memory capacity constituted of a phonological storage in language learning skills to stress the relevance of this structure.

The phonological loop (Baddeley & Hitch 1974)

Baddeley and Hitch have put forward a model in which the working memory (WM) system depends on a linguistic sub-component, called *phonological loop*, composed of a phonological store, which operates by way of an articulatory rehearsal process (Baddeley 2003). Atkins and Baddeley (1998) follow the opinion that this system makes up the structure providing for language learning. According to the authors the phonological loop constitutes the basis for the ability to promptly reiterate newly perceived phonological strings or non-words, and what is still more relevant, the ability to commit these stimuli to memory. The phonological loop is considered to be the storage of memory traces comprising linguistic data for a short period of time. Synchronously, the quantity of data it is capable to accumulate mirrors its encoding capability. Articulatory rehearsal processes permit an extended preservation of the data. This active rehearsal of verbal material mainly encompasses its reproduction, an action within which the focus is recurrently laid on the items to commemorate, and subvocal articulation comes up (Baddeley 1986). Phonological characteristics of the material are most relevant to impede the loss of memory traces: when encoding unrelated letters, listeners commit sequences of dissimilar sounding letters easier (e.g. X, K, R, Y, Q) to memory compared to sequences of similar ones (e.g. P, B, T, etc.). There is a necessity to exclusively count on phonological features when learning meaningless material (Baddeley 2003). Papagno and Vallar (1992) examined the power of the phonological loop on foreign language learning while pointing out its impairment with regard to two variables. These two variables, namely phonological similarity and word length, have been uncovered to be of great importance concerning the functioning of the loop. Notwithstanding the two variables mentioned interposed with the acquisition of foreign vocabulary, none of them influenced the assessment of pairs of native language words, while following the assumption that a dependence between the acquisition of recent phonological forms and the loop exists.

In their examination of working memory capabilities, Rota and Reiterer (2009) computed the digit and word span of all subjects who took part in the extensive test battery. The researchers made use of the Wechsler Digit Span test, a subtest of the up-dated version of the Wechsler Adult Intelligence Scale (Wechsler 1939), to calculate digit span. Subjects were requested to fulfill forward and backward repetition of strings of figures which comprised a growing quantity of items (from 3 to 9 figures for forward repetition, and from 2 to 8 figures for backward repetition).

For the determination of word span Rota and Reiterer (2009) designed another test including strings with an augmenting number (from 2 to 8) of monosyllabic non-words and with a German-like phonetic quality. The goal of the task was to attain a reiteration of as many items as possible from each string. The correctness of iteration was calculated for both test types.

As a result subjects with outstanding skills in L2 pronunciation benefited from heightened rehearsal abilities, and/or advanced their phonological store's capacity as a consequence of the linguistic training. As Rota and Reiterer (2009) expected proficiency and forward repetition strongly correlated, whereas no correlation could be discovered between proficiency and backward/non-word repetition in the data set previously analyzed. Interestingly, L2 pronunciation skills and WM capacity influence each other. On the one hand excellent L2 pronunciation skills, even after adolescence, are encouraged by WM capacities, on the other hand (very) promising L2 pronunciation skills expand WM capacities, this emphasizing the strong link between phonological

WM and the readiness to acquire foreign languages. Therefore it would be advantageous to train WM span from childhood upwards. In turn speaking multiple languages has an effect on WM. Connected with this interaction is the observation that even adult individuals with elevated WM capacities are likely to learn an L2 more easily. In the future it would be of immense profit to conduct longitudinal studies (also on a larger corpus of data) to examine the expansion of WM capacities during a certain temporal interval and its impact on linguistic expertise, such as second language acquisition.

1.2.2.4. Intelligence and L2 phonetic abilities

Within his theory on intelligence based on his prior examination results Spearman claims intelligence to be a general cognitive ability which one can quantify within an experimental setting and which can further be characterized by the ability to think, interpret all kinds of circumstances and find solutions for difficult situations (Spearman 1904). In contradiction Thurstone (1938) and colleagues started to put forward the idea that intelligence cannot be regarded as a general ability. In continuation of Thurstone (1938), Gardner (1983) developed the theory of *multiple intelligences* extracting core abilities that are crucial to manage ordinary life situations, and defined *seven types of intelligence*: *verbal-linguistic*, *logical-mathematical*, *visual-spatial*, *interpersonal, body-related* or *kinaesthetic*, *intrapersonal*, *musical*, and later on added *naturalistic intelligence*. These disparate core abilities exist independently of each other and ensue from a complementary independent evolutionary course.

To approach the factors of intelligence, Rota and Reiterer (2009:87f.) explored general and verbal intelligences. Raven's Progressive Matrices (Raven 1938) were made use of to quantify nonverbal intelligence, bearing in mind that cultural factors such as social environment, status, schooling and occupation greatly affect the development of intellectual skills beyond all doubt. However, the other way round to be joined up in scholastic education supports intellectual skills, such as e.g. reasoning, problem solving or attention, these skills progressing differently in each individual. Raven's Progressive Matrices (Raven 1938) provide a norm to evaluate reasoning and abstract thinking and are for this reason set up as a culture-free test for the assessment of general intelligence regardless of nationality, education, age and sex. Thus, their matrices incorporate geometric patterns gradually rising in complexity, while for each of these perceptually complex matrices, a missing geometric part of the row has to be completed carefully - considering the alternatives - and aptly. On the grounds of this decision procedure researchers are able to value performance within a multiple-choice process.

Apart from Raven's Progressive Matrices to assess general intelligence, Rota and Reiterer (2009:88) carried out the *Mehrfachwahl-Wortschatz-Intelligenztest* (MWT-B) to measure verbal intelligence. Altogether, the researchers engaged 60 subjects in both of these tests, searching for correlations between these IQ measurements and the subjects' scores on the linguistic measurements, including performance (genuine pronunciation proficiency, Jilka 2009b) and the "talent" scores. The result of these analyses: no correlation of the pronunciation talent estimation by Jilka, the MLAT (*Modern Language Aptitude Test*) with subtests (phonetic coding, grammatical sensitivity and vocabulary learning), and a direct imitation task of Hindi unknown words graded by 5 native speakers of either the verbal or the non-verbal IQ with the measures taken into account could be found. But significant outcomes with some of the MLAT sub-/scores were detected. These results were in agreement with the initial hypothesis stating that no significant effects between aptitude or ability for foreign language pronunciation and IQ measurements should occur. Nonetheless, a significance arose between both intelligence measurements and the scores on the *Modern Language Aptitude Test* (MLAT). This significance occurred due to the MLAT additionally covering some kind of intelligence assessment equivalent to numerous other language aptitude test batteries.

1.2.3. Personality and pronunciation talent in second language acquisition

Personality has been a popular research objective of many psycholinguists due to the awareness of it being a constant, persistent, eminent and important aspect immanent in each individual (dispositional point of view), which definitely has a vast impact on how the SLA is accomplished. From the point of view of cognitive sciences personality has been handled as an information processing system.

Guiora's concept of permeability of the *language ego boundary* (Guiora 1979) merges both the pronunciation aspect of the SLA behaviour and the personality's empathetic capacity. Remarkably, the permeability of language ego boundary does not correspond with a "weak ego", but is an indication of the capability to switch between languages and the "personalities" that are apparently associated with them. It can often be noticed that people behave as if they have been transformed into a different person when changing to another language, and then they also behave very deviantly.

According to the "Myers-Briggs Type Indicator" (MBTI; Myers and Briggs (1976)) four contrastive pairs of disparate subclasses of personality prevail: *Extroversion – Introversion* (E-I), *Sensing – Intuition* (S-N), *Thinking – Feeling* (T-F), and *Judgment – Perception* (J-P). Personality type has been connected with learning and cognitive style by some researchers, which is the reason for Bailey et al. (2000) to assume that personality types can make a forecast of SLA attainment. In particular, the personality traits *Extroversion – Introversion* have often been investigated, showing that extroverts produce higher fluency rates (not accuracy) than introverts.

Dewaele and Furnham (1999) explored the interdependence between extroversion and second language in oral formal, as well as informal situations and found out that it significantly augments with situation complexity. Connected with this observation is Gardner's statement (1985) that anxiety has been referred to as best predicting success in learning a second language. In line with this is Dörnyei's (2005) résumé of most theoretical conclusions matching language teachers' and learners' experience that language anxiety negatively affects language habits. In the totality of SLA research the definition of anxiety turns is finally inconstant. Carrying on, MacIntyre and Gardner (1991) had a closer look at this inconsistency and summed up that the volumes of research on anxiety and SLA behaviour can be split up into three kinds: *trait anxiety*, *state anxiety* and *situation specific language anxiety*; whereas trait anxiety is defined as a person's universal personality trait that is important across a few varying situations, state anxiety is determined as the "here-and-now" experience of anxiety as an emotional state, and situation specific language anxiety encompasses test anxiety and communication anxiety.

Eysenck (1979) previously redetermined anxiety as being a cognitive interference and claimed anxious persons separate their attention into task- and self-related cognition. This separation results in less productive cognitive performance. It might be that anxious people are conscious of this interference and therefore go to great lengths to compensate, which results in fairly minor consequences of language anxiety on cognitive processing in a second language (MacIntyre & Gardner 1994). However, the compensation effort even diverges considerably in individuals with the same amount of (language) anxiety, which can be traced back to the behavioural withdrawal-approach system BIS/BAS, a biological personality concept suggested by Gray (1981, 1987). The question arose as to what the source for the effort of compensation is and if it can be linked to motivation in language learning and to some other personality traits which can be answered with the help of Gray's BIS/BAS Model (Gray 1981, 1982). According to Gray (1981, 1982) two general motivational systems form the basis for behaviour and affect, the so-called behaviour inhibition system (BIS) and behaviour activation system (BAS). Gray claimed that this physiological mechanism rules the experience of anxiety in reaction to anxiety-relevant signals (Gray 1982, 1987). The central idea of BIS is anxiety which prevents behaviour that may terminate in unpleasant or sore consequences, whereas BAS provoke the persons to start (or to intensify) movement in the intended direction. BIS and BAS react to contrasting signals. While BIS replies to punishment, nonreward, and novelty, in opposition BAS answers when reward, non-punishment, and escape from punishment are required to be coped with. Thus, BIS/BAS traits display individual dissimilarities in two systems of action supervision, which are perhaps coupled with cognitive aspects of control (Gray & Braver 2002). Seeing that BAS and BIS symbolize well-defined structures in the nervous system (being disjoinable both pharmacologically and by brain lesion), their sensitivities are supposedly orthogonal (Gray 1987; Quay 1993).

Coming back to SLA behaviour the orthogonal relationship of BIS/BAS personality is suggested to prevail in the same way. Assuming an equivalent extent of (language) anxiety, the individual distinct amount of endeavour (compensation) during SLA pronunciation tasks is probably mirrored by BAS. This in fact stresses the importance of personality factors for SLA, in spite of the lack of clarity within this relationship.

Previous research perspectives uncover that more in detail differentiations in the form of language materials (oral and written), between overall proficiency and specific aptitude and also in subcomponents of linguistic variables (phonetic, semantic, grammatic or pragmatic) are indispensable to gain more transparent insight into the relation between personality factors and SLA pronunciation aptitude. In parallel, it would be profitable to find out which personality is dealt with. Studies have continuously proven that extroversion and situation specific language anxiety (mainly founded on Eysenck's personality theory) serve as relevant variables in SLA behaviour (particularly in speaking situations). Taking the psychoanalytic perspective, ego boundary and empathetic capacity play a dominant role in SLA aptitude, in particular pronunciation aptitude, whereas from the learning perspective self-efficacy is the prevalent factor. Examinations considering other perspectives are somewhat restricted.

Based on the above portrayed level of knowledge, Hu and Reiterer (2009:115) presume for their inquiry: 1. an interdependence between some personality traits (e.g. extroversion) and pronunciation aptitude (cf Jilka 2009b), 2. an interrelation between personality traits (e.g. correlation between anxiety and BAS) or between traits and other cognitive features, and 3. connections displayed either on the behavioural or on the brain activity level (cf Reiterer 2009, brain imaging study).

For the collection of all-embracing personality data a body of 62 native German-speaking undergraduates (31 m., 31 f.; all right handed; aged = 26.0±4.5; verbal IQ = 126.2±11.2; non-verbal IQ = 130.1±12.4) filled out each of the three formulas of the assignments (second language: L2 English, age of onset = 10.5±1.2). This personality evaluation of subjects took place applying Internet-supported instruments and by classical "on the spot" analysis prior to and succeeding an fMRI study.

The tools for personality appraisal as follows:

NEO-FFI

The NEO-FFI constructed by Costa and McCrea (1992) serves as a wide-spread self-declaration of personality on the basis of the Five-Factor Model comprising neuroticism, extroversion, openness to experience, agreeableness and conscientiousness. NEO pertains to the three first personality traits.

BIS/BAS

BIS/BAS (Carver & White 1994) was built up to document two opposing action control systems, namely approach and withdrawal, via the BIS and BAS scale evolved by Gray within his biological theory. The BIS scale encompasses items pointing to reactions to the anticipation of punishment, while the BAS scale establishes three kinds of characteristics: *Drive*, the items question the incessant engagement in arriving at the objectives strived for, the *Fun seeking* scale is composed of the two items indicating a request for new remunerations and a readiness to move totally spontaneously towards a possibly worthwhile incident; and the *Reward Responsiveness* scale comprises items that put their attention on explicit hints to the appearance or expectancy of reward.

E-Scale

The E-Scale generated by Leibetseder and Laireiter (1994), as well as Leibetseder et al. (2001) contains a German questionnaire to measure empathy. The scale is constituted of two main columns: the inclination for empathy, i.e. conceiving the behaviour and experience of someone else in invented situations; and social concern, i.e. imagining empathetic behaviour in real-life situations.

PANAS

The Positive and Negative Affect Schedule (PANAS; Watson et al. 1988), an assessment of the disposition to go through positive and negative affects linked to BIS, however not to BAS, was inserted in the test battery for a natural control of the reliability of the Internet check of BIS/BAS and an evaluation of the global affect taking a subgroup of subjects.

STAI

The State-Trait Anxiety Inventory (Spielberger 1983), an evaluation of the trait and state aspects of anxiety, was included to confirm that there is no correlation between these two and SLA behaviour. The majority of researchers postulates the probability of predicting SLA behaviour, while judging situation specific language anxiety, but not trait and state aspects. Simultaneously, the reliability of the on-line experiment was controlled for a second time.

1.2.3.1. Behavioural results

Test reliability

The conduction of the above described tests led to personality scores which were calculated including the interaction (two tailed in each of the cases) with pronunciation talent as measured by Jilka (cf chapter 1.2.1.1.). Therewith an intercorrelation between BIS/BAS and PANAS or STAI which was taken as the reliability measure for BIS/BAS could be figured out. Further, there appeared to be a significant correlation between BIS and STAI trait (r = .65) as well as between BIS and STAI state (r = .52), and moreover a significant correlation between BIS and the negative affectivity scale of the PANAS (r = .34) could be unmasked, but after comparison of the negative scale (r = -.07) and the BIS score no correlation was detected, both being highly reliable. Whereas BAS significantly correlated with both the PANAS positive subscale (r = .33) and the negative subscale (r = .27), no interaction within the three BAS scales could be found, these being reliable. The results concerning the relationship to the positive subscale were in accordance to the prediction, whereas for the negative subscale, post hoc analysis looking at the interdependence between the negative subscale and the three subscales of BAS (drive, fun seeking, and reward responsiveness) did not reveal any significant interrelationships among them, ending up with the judgment that the BAS scale can be considered reliable as well. Despite the fact of having been performed via internet testing, the reliability of the BIS/BAS questionnaire has been approved. Two questionnaires had an identical testing condition, which could at the same time be in relation to the test reliability of NEO-FFI (Hu & Reiterer 2009:119).

Correlation between personality traits and pronunciation talent

The following paragraph outlines the correlation results between personality traits and pronunciation talent:

Verbal (Raven's Progressive Matrices) and nonverbal intelligence (MWT-B)

In reference of verbal IQ (r = -.115) or nonverbal IQ (r = -.01) there was no interrelationship discovered, i.e. intelligence cannot be fixed as a prominent factor for pronunciation aptitude in view of the set of subjects incorporated.

NEO-FFI

Taking into consideration the NEO-FFI scale no significant relation could be discovered between pronunciation talent and extroversion, openness to experience and neuroticism, but modest correlations with regard to conscientiousness and agreeableness. Probably extroversion could not be found to be ascertained to pronunciation talent due to pronunciation aptitude being exclusively one really particular (phonetic-articulatory) aspect of spoken language. The interdependence between SLA and agreeableness or conscientiousness made clear that the more talented subjects behaved in a way that was more agreeable and less conscientious.

BIS/BAS

The BAS results have not been exhibited in the prevailing outcomes on the behavioural level, but the BAS dimension might play a role on the neural level because of being a more biologically driven personality trait.

E-Scale

The readiness for empathy calculated within the E-Scale revealed a significant interdependence to pronunciation talent (r = -.28). More talented subjects showed the tendency to more readiness for empathy and are in connection with that capable of imaginarily visualizing the behaviour and experience of another person. Conclusively, these outcomes are in accordance with previous research on the pronunciation aptitude and ego boundary or empathetic capacity (cf Chapter 1.2.3., psychoanalytic perspective).

PANAS

PANAS positive subscale combined with its various sub-aspects resulted in a significant interdependence. This outcome points to subjects with a greater degree of pronunciation talent going through more positive affects like excitation and proudness having been identified in the course of the phonetic-articulation tasks.

The behavioural results demonstrate a significant interrelationship between some personality traits and pronunciation aptitude. Notwithstanding, no interdependencies could be displayed in view of extroversion. However other personality factors such as agreeableness, conscientiousness, and readiness to empathy led to significant correlations. It can be stated that personality is highly relevant within the second language acquisition (SLA) behaviour. At the same time personality factors affect the phonetic-articulatory aspect of the second language and thereunder pronunciation talent in an exceedingly characteristic manner. These research results ensuing from behavioural testings do not give an entire picture of what might happen and is of importance during second language acquisition and especially in subjects performing differently in pronunciation. This was the reason for Dogil, Reiterer and their project group (Dogil & Reiterer 2009) to complete these testings while also themselves approaching language talent from cognitive and biological perspectives. Researchers followed the intention to add a supplement to existing insights and to present an innovative and new point of view on SLA in connection with personality research (Reiterer 2009:121).

1.2.4. Investigation of cognitive & biological aspects of pronunciation talent

According to Roach (1992:22) one of the aims of experimental phonetics is to uncover how brain mechanisms control speech production. The *Language Talent and Brain Activity*-project has explored subjects in speech production and perception experiments with the help of experimental phonetic methods, in psychological and also brain imaging studies to broaden the initial insight on language pronunciation abilities in relation to personality factors and speech as well as language processing capabilities. That is why these subjects identified as being particularly skilled or unskilled have been invited to take part in in-depth neuroanatomical and neurofunctional examinations. These examinations included i.e. brain anatomy based on magnetic resonance (MR) imaging, white and grey matter density measurements (VBM) and white matter fiber tracking (DTI), fMRI, MEG and EEG. In parallel subjects underwent phonetic tests similar to those performed earlier. The preliminary data corpus developed for this brain imaging research pointed out the fact that differences in brain acquisition between more or less talented subjects appeared for the L2 pronunciation abilities also on the functional level. Three German native speakers (*mean age* = 28 years) being equal with regard to age, level of education, and onset of L2 acquisition, except with diverging "talent"-degree linking to L2 pronunciation ability (cf Jilka 2009b) served as the first subjects being exemplarily under investigation. In prior examinations the languages having been taken for the "online" fMRI experiment were German L1, English as L2 and Hindi as "L0", wherein Hindi had not been a target language under exploration beforehand. 12 pairs of German, English and Hindi words being identical with reference to their number of syllables (N = 3), length (2s) and semantic content read aloud with neutral intonation by a male native speaker were played for the subjects. The subjects were requested to precisely pay attention to every single word and then reiterate the target stimulus into the innscanner microphone. Brain activity while pronouncing L1, L2 English, and L0 Hindi stimuli caused activation patterns of a bilateral network mostly restrained to the superior temporal gyri, motor areas, insulae, basal ganglia and left frontal areas. Primary statistical results suggest talented speakers require significantly more effort than untalented speakers and additionally a larger extent of activation to accomplish the experiment. Principally outcomes in talented vs. untalented speakers regarding brain activation and pronunciation aptitude (cf Jilka 2009b) were related to each other, but not to the distinct languages (L1, L2, L0). This is an indication for the core of language aptitude (such as proficiency and expertise) being in interdependence with weakened endeavour in speech production and increased cortical efficiency. As a consequence the results of Reiterer (2009) highlighted the importance of the concept of cortical efficiency, a concept set up by the area of psychology for the acquisition of new faculties (Reiterer 2009:177); this same concept has not yet been widely considered in the field of second language acquisition research. Despite this fact the maxim of efficient neural processing (from effortful to effortless) serving as a main stream hypothesis also in the cognitive neuroscience of individual differences of L2 processing (Reiterer 2009:176 f.), language learning and its progressive perfection in expertise and high level ability (talent) can be considered as a faculty to be acquired and ameliorated (by the complex interaction of nature and early nurture as well as practice) (Reiterer 2009:177).

1.2.5. Musicality and pronunciation talent

Previous studies (e.g. Harrison 1979, Karimer 1984, Milovanov et al. 2007 [cf Nardo & Reiterer 2009:230 for delineations of these and additional studies]) have brought to light the connection between musical training and language proficiency. Recently, Pastuszek-Lipinska (2008) gave evidence for music education having a quantifiable effect on speech perception and production and concluded in the end that music education should be regarded as being a facilitating component in the favourable acquisition of L2. The term *musicality* was first employed by Révész (1953) in the field of psychology of music as a description for receiving the pleasure of music in an aesthetical way, whereas *musicality* now determines the sensitivity to, a knowledge of, or a talent for music (Nardo & Reiterer, 2009:213).

Up until now a few different definitions of *musicality* have come up (cf for a more detailed look at them Nardo & Reiterer 2009:213 f.). On the basis of these different determinations for *talent* and *aptitude* in music (cf Nardo & Reiterer 2009:214 for a thorough statement) Nardo and Reiterer (2009:214) have built up a temporary definition of musical talent

> *„as [being] a (predominantly) innate tendency to understand/appreciate, perform or create music outstandingly".*

Many researchers could discover an interconnection between music aptitude and linguistic skills and in a narrower focus between music aptitude and second language acquisition. Milovanov et al. (2008) could prove that acceptable linguistic skills in children coincided with more satisfactory musical skills which did not occur in children with less correct linguistic skills. Furthermore, ERP results from children with satisfactory linguistic skills manifested a more marked sound-change elicited activation with the music stimuli, but to a lesser extent in children with precise linguistic skills. Following from this the authors infered that musical and linguistic skills probably have somewhat in common the same neural mechanisms. With reference to L2 pronunciation aptitude

Slevc and Myiake (2006) discovered that musical aptitude can be a clue to draw conclusions to both receptive and productive L2 phonetical ability, however not to syntax and lexical knowledge which point out to musical skills making the acquisition of L2 sounds easier.

One string of research within the *Language Talent and Brain Activity*-project is to follow up with musicality tests and miscellaneous other musicality measures to discover whether a correlation between the results reached in musicality testings and linguistic abilities and among them specifically in L2 pronunciation talent can be brought to light (Nardo & Reiterer 2009:235 f.). Therefore many different measures of musicality were made use of (Nardo & Reiterer 2009:235 f.):

a) Gordon's AMMA is constituted of two subscales: 1.) a scale for rhythm discrimination ability; and 2.) a scale for pitch discrimination ability which provides a total score of musicality.

b) Another supplementary introspective set of enquiries intends to gather self reported abilities concerning music: 1.) *singing capacity* (performance) and the *liking for singing*; 2.) *dancing ability* (performance) and the *liking for dancing*; and 3.) *instrument playing* (how many of them, the capability with regard to each instrument and the fun factor being attached to the playing of an instrument). The scale for the self scoring started from 1 point at least and went until maximally 5 points. The resulting scores were interrelated to several test sets which are exhaustively listed in Nardo and Reiterer (2009:236).

Results after statistical measurements are outlined for a cohort of 66 individuals (33 males, age range 20-40 years, males: *mean age:* 26.49 years +/- 5.36; females: *mean age:* 25.31 years +/- 4.47) who participated in the experiment. Correlation coefficient (r) was calculated after Pearson, 2-tailed, with a level of probability of $p < .05$ (*) and $p < .01$ (**). Nardo and Reiterer (2009) intended to figure out in which way linguistic scores for the different L2 abilities (aptitude and performance) correlated with the outcomes from musicality testings. The result showed the highest interrelationship for musicality as computed from nearly the whole group of subjects taken (apart from *dancing ability*) could be derived from productive *phonetic talent* (as assessed in the pronunciation talent score) and the aptitude for *grammatical ability*. Subsequently, Nardo and Reiterer (2009:238) ensued from the still continuing research that musicality, most likely characterized through a nicely elaborated rhythm perception ability, a well developed pitch perception ability, a raised ability and pleasure while singing were the most favourable combinatory factors to achieve talent and expertise in the pronunciation of a foreign language. In line with these statements language and music do not behave like two unconnected phenomena,

> *„ [...] but perhaps two sides of one coin with a lot of similarities, yet not being exactly the same." (Nardo & Reiterer 2009:238).*

This chapter has explained the fact of music practice putting forward language processing, and some aspects of music and language processing being interrelated, in particular rhythmic processing and phonetic aspects. According to Nardo and Reiterer (2009:246) pitch perception and singing capacity are highly related, as well as pronunciation talent, pronunciation performance/proficiency, phonetic encoding ability and even grammatical sensitivity and proficiency. Taking the knowledge from this study the most important upcoming field of interest now is what the link between musical skills, language skills and cognitive processes might be. To find this interdependence further investigations are unavoidable for the reason of figuring out which cognitive operations build up the basis for the diverse musical and language abilities, to advance the commonalities between both. The ultimate goal is to get to know how these components can be widened and modified to enable them to positively influence each other.

1.2.6. Investigation of phonetic aspects of pronunciation talent

Previous chapters have shown that various factors play a role in view of pronunciation talent in L2 such as personality, cognitive and biological aspects as well as musicality. Jilka (2009b) and his team have conducted an extensive test battery of phonetic experiments (cf Chapter 1.2.1.) to get a broad picture of the production and perception skills of their subjects and have then categorized these in groups of proficient vs. average vs. less proficient speakers of L2 English. Lewandowski (2009), Anufryk (2009) and the research presented in this thesis have taken these language assessment tests and also the results, after categorization of subjects, as a basis for more in-depth investigations of phonetic skills of a smaller number of subjects having been selected from the whole group of the *Language Talent and Brain Activity*-project. Besides the factors having been considered so far, Lewandowski (2009) had a close look at phonetic convergence for the reason of uncovering whether more proficient speakers are better able to adapt to the speaking style of a native English speaker than average and less proficient speakers (cf the following chapter). Moreover Anufryk (2009) inquired into intonational variation following the assumption that more proficient speakers produce more variability than less proficient speakers. Both of these explorations are portrayed in the next chapters to complete the phonetic issues raised by the project concerned. The third phonetic approach to pronunciation talent this project addresses is raised by this PhD thesis work itself.

1.2.6.1. Phonetic convergence as a signature of pronunciation talent

In the 1970s groundwork on adaptation processes, initially called "speech accommodation theory", (SAT) was set up by Giles (1973) and developed within the framework of Communication Accommodation Theory (CAT). From the very beginning one main objective was to concentrate more and more on specific dimensions of context, such as language itself and the function of the receiver in the interaction (Giles, Coupland & Coupland 1991). Convergence is determined as one of the approximation strategies within the CAT framework and accounts for the adaptation of communicative behaviours in the direction of a conversational companion. This adaptation takes place in verbal and nonverbal characteristics, e.g. gestures, smile, facial affect, head nodding, information density, voice quality, speech rate, utterance length, pausing frequencies and response latency (Giles et al. 1991). The notion of divergence covers a set of behaviours comprising the verbal or non-verbal allowance to approach to or respectively remove one from a conversational partner. According to Giles et al. (1991) possible realizations are usually indicated by an explicit accentuation of differences in speech style and/or facial expressions and gestures. Shepard et al. (2001) have termed the probable disagreements between the performance and the actual perception of a conversational partner "perceptual/subjective divergence". If there is no remarkable convergence or divergence, the speaker makes an effort to defend her/his own speaking and behavioural style. A speaker willing to persist in his/her own way of speaking, the so-called *maintenance,* might however be explained as diverging from the interlocutor in many cases (Shepard et al. 2001). Up until now phonetic convergence has been investigated in several different ways, but mostly in a severly native language setting and focusing on individual parameters such as utterance duration, F_0 contours or speaking rate (for more details cf Lewandowski 2009:259, 268). With the help of amplitude envelope signals consisting of a smoothed representation of the energy introduced in splitted frequency bands, Lewandowski (2009:268) worked out a global measurement for convergent behavior in dialog. Lewandowski (2009:258) assumed the convergent behaviour taking place controlled on the one hand and also unconsciously on the other hand, was altered by several internal factors which could not be restricted, increasing or decreasing the amount of accommodation (presumably talent, personality traits) and external factors having an effect on the subjects by way of the situational environment.

Subjects and procedure

The 8 German native speakers (3 female (2 proficient, 1 non-proficient), 5 male (2 proficient, 3 non-proficient); *mean age:* 25.9 years) were taken from the earlier experiments by Jilka (2009b; cf Chapter 1.2. for further details on the whole subject group). For the reason of exploring the convergent behaviour within two different dialog sessions, one after another, two native English speakers have additionally been invited for the experiments (one female Southern Standard British English (SSBE) speaker (age 56), one male speaker of General American (GA) English (age 32)).

Data were obtained within a Diapix-task designed by Bradlow et al. (2007), a picture matching game within which the subjects had to detect ten differences between their pictures without looking at the partner‘s pictures at the same time (Lewandowski 2009:267). The control task consisted of three parts taking place before and after the dialogs, each including reading out a list of words from the two picture-sets and additionally with unrelated filler words, resulting in the following order of tasks:

1. reading of the word-list **(a)**,
2. Diapix-dialog A with the GA speaker (or with the SSBE speaker),
3. reading of the word-list **(b)**,
4. Diapix-dialog B with the SSBE speaker (or the GA speaker),
5. reading of the word-list **(c)**.

Lewandowski (2009:268) provides more information of the corpus attained and the motivation to choose the tasks mentioned above.

After having been recorded in the same way as specified in the procedure of Chapter 6.1.1.3., the raw data was automatically annotated with the help of the Aligner tool (Rapp 1995) for English and manually corrected. Amplitude envelopes, which consist of a smoothed picture of the energy appearing in separate frequency bands, were taken out as in the method presented in Wade et al. (2010).

Results and discussion

Amplitude envelope results of words taken from the first 40% and last 40% of the diapix-task have been compared and have in total given rise to a significant variation in the match values early and late in the dialog; this gives evidence for computable differences in pronunciation of the participants within a task-oriented dialog in a controlled environment. Correlation analysis has thus proven a significant effect for proficient, but however not for less proficient speakers. These results point out to the fact that proficient German native speakers have converged with regard to their pronunciation with their English native diapix-dialog partners in this study. There was a significant increase found in match values for the GA conversation. On the contrary no significance occurred for the SSBE conversation and their performance in the two conditions which was traced back to the experimental setting in which the GA dialog was put in the beginning every time. Nevertheless most of the subjects judged themselves to generally (attempt to) make use of BE English when uttering English speech (cf Lewandowski 2009:270, 272). Results from the control task (read word list comprising target words from the dialogs and filler words) carried out before and after the respective dialog ended up with no significant correlation between match values for none of the two proficiency groups. Besides no significant results were uncovered regarding gender differences in performance in the two tasks (dialog and control task). Lewandowski (2009:274) infered that apparently no generalization can be made from alignment to all speaking styles and that convergence is a conversational phenomenon which cannot be detected in other speaking modes. Lewandowski (2009:274) added that some biases might be for the reason of amplitude envelopes curves needing cross-correlations in both items amplitude and time. Therefore length normalization of the target words might be helpful to more successfully align spectral features. If this is brought to light in upcoming studies, L2 speakers of English might be better able to accommodate with the spectral features of the/a native speaker rather than with timing properties.

1.2.6.2. Intonational variation as a signature of pronunciation talent

Most of the speakers of a foreign language reach to transmit the communicative content of what they want to get through to the interlocutor. These L2 speakers can thus be said to be different in terms of giftedness as respects their degree of suitability and expressiveness, as well as variation (Anufryk 2009:305). Intonational variation lays one main foundation for general pronunciation talent presuming that more variability interrelates with higher grades in proficiency. In cross-linguistic research two principal statements have come up. Whereas Klein and Perdue (1997) argue for L2 being a reduced system comprising a merely elementary variety of language features, which were uttered by a speaker after the perception of the specific language in question, Selinker (1972) supposes that an L2 speaker selects features of both L1 and L2 and also inserts some specific supplementary attributes unifying characteristics of both L1 and L2, i.e. this setting up the creation of an interlanguage (cf Anufryk 2009:309 f. for studies underlining both views). The existence of these diverging positions with regard to phonetic variation sheds light on the high dependency of the verbalizations on the languages and more entailed phenomena. The composition of the English and German languages resemble phonological systems, as a consequence variation patterns play together in an even more convoluted manner in these languages.

This research also takes into consideration the use of more speaking styles: L1 categories corresponding to those in L2 are required to be transferred (Flege 1995, Wode 1981). In contrast, unfamiliar or indistinguishable L2 units cannot be reproduced by the speakers of a foreign language (Cruz-Ferreira 1987). Furthermore, it depends on the individual characteristics of each speaker as to how great the impact of all the above factors finally is. Anufryk‘s (2009) study especially attempted to inquire into the variability of intonation categories on the phonetic and phonological level in speakers with different scores in pronunciation ability. A comparison of the respective variation patterns was conducted for the reason of investigating regularities between them and to, moreover, search for a relationship between the general linguistic and second language acquisition paradigms previously mentioned. Anufryk (2009) pursued the aim of fixing the phenomenon of intonational variation within the manifold linguistic paradigms and theories of second language acquisition. Within a complex experimental design she enquired into the validity of the above mentioned supposition about an interdependency between prosodic variability and pronunciation talent.

Subjects and procedure

The subject group was composed of 38 (16 m., 22 f.) native German speakers mainly between 20-29 years old, and six speakers aged between 30 and 40. The characteristics of the subjects were identical to those described in Jilka (2009b). The result from the phonetic assessment tests conducted by Jilka (2009b) showed these subjects have been rated as being below average (6 f., 3 m.), average (7 f., 7 m.) and above average (9 f., 6 m.). To enable a juxtaposition of the outcomes with native English speakers 12 of them (4 f., 8 m.) constituted a control group.

The recording procedure was once more the same as the one exhibited in the procedure of Chapter 6.1.1.3.

The subjects had to recite the classical fable *The North Wind and the Sun*, while the German native speakers were asked to accomplish the text reading in German and in English, the English native speakers merely had to fulfill it in their mother tongue.

Afterwards the recordings were downsampled to 16 *kHz*/16 Bit for the next steps of the process. As specified in previous procedure descriptions the Aligner (Rapp 1995) was then used and phone, syllable and word boundaries were manually corrected to avoid labelling errors (cf also Chapter 6.1.1.3.).

Afterwards, manual labeling of the intonation events was carried out according to the overall rules of autosegmental metrical phonology and the ToBI convention and incorporating some adjustments considered as essential with regard to the aims of this research study (Anufryk 2009:312).

Then, the syllables with ToBI accents and boundary tones were examined in a parametric intonation model (Möhler 2001).

Anufryk (2009:312 ff.) further expounded on the intonation labelling procedure and the parametric model.

Results and discussion

Results confirm the initial hypothesis of a correlation between prosodic variation and language ability. Significant differences between the groups were found both in the distribution of the ToBI categories and in the realization of the individual F_0 curve parameters.

<u>Phonological findings</u>

In a first step of the analysis the distributional and frequency parameters of separate ToBI pitch accents and boundary tones were the subject of study.

The rising F_0 contour, i.e. high boundary, German productions of the English text exhibited a much wider distribution than the ones of the native speakers. In opposition to this finding the low boundary prevailed in the native speakers‘ group.

Interestingly, within their L2 English production all German native speakers diminished their typical mother-tongue variation pattern, whereas in the above-average group the accommodation of the target L2 variation model exposed the greatest power which served as an indicator for tendency to native language features in the German realizations, i.e. in particular a wider distribution of the L*H accents and high boundary, as well as a smaller percentage of falling contours in opposition to the native speakers within the text taken. The simple low L* and the high H* targets occurred most frequently in the native speaker group, which is in common with these accents‘ emergence in English. Speakers of above-average level were most equivalent to native speakers in the H* and L* accent distributions. In the English language samples there was a tendency for negative prosodic transfer of the German speakers, while reaching nearly equal percentages.

The distribution of individual ToBI pitch accents was observed. This was remarkably homogeneous regarding separate percentage values.

In the second step of the phonological analysis the distribution of ToBI events on the text level was accomplished for reasons of investigating the uniformity or variability of the prosodic interpretation of the text by the native and the German speakers. A striking observation was the homogeneity within the speaker groups underlining their subdivision within the pronunciation aptitude categories. Within the English version of the text, greatest uniformity in the text interpretation was reached within the native and the average group – neutral reading manner.

A greater degree of variation in the prosodic text interpretation by the above- and below-average speakers could possibly be a consequence

– of these speakers intending to interpret the text in an original manner, which might appear to be more representative for above-average speakers, or

– of L2 speakers‘ being unsure of which intonation to be chosen in each specific context, which occured in below-average speakers. The text interpretation of *The North Wind and the Sun* yielded significant outcomes across aptitude groups.

Nevertheless, no significant correlations could be detected in the below mentioned group comparisons:

1) on the pitch accent level

   - in English – below-average vs. above-average and average vs. native
   - in German – average vs. below-average

2) on the boundary tone level

   - in English – above-average vs. below-average
   - in German – above-average vs. average and average vs. below-average

   In this regard statistical significance can be interpreted as a greater/lesser variability in the text interpretation between the groups, in contrast to the reverse condition which indicates a degree of variation practically being alike.

Phonetic findings

To obtain phonetic analysis results, intonation model parameters were thus uncovered in two different ways:
discretely – each split up parameter being scrutinized across the aptitude group;
globally – with the help of the measurement of the cosine similarity which integrates all the six parameters as a whole

discretely:

some indications for prototypical contours: in each intonation category there were recurring parameters of all six values,

globally:

singled out the four most frequent intonation events, pre-boundary events H* and L*H; as well as the nuclei – the final fall and the final rise, but no regular variation pattern.

Investigation of individual temporal and pitch parameters

The missing parameters did not lead to any palpable tendencies. This is why future research should account for both individual and interrelational temporal and pitch aspects.

Investigation of similarity and variation in F_0 curves

Overall, the results imply that, as far as the F_0 curve similarity/dissimilarity is concerned, the four aptitude groups realize various intonation categories in a similar way, with the exception of the average group leading to a significant effect and female values laying well above, male tokens below the other density functions concerning cosine similarity scores.

L*H accent in male German language samples: below-average realizations were significantly different from the corresponding average and above-average values.

Spontaneous speech needs to be included to draw more accurate conclusions about the uniformity/variation of separate F_0 curves. In summary, the results are not in line with the initial hypothesis that the degree of variation increases with talent/proficiency. It is thus relevant to discriminate between patterns being changed to L2 or those being typical for L1 standing for a better proficiency.

2. Individual and cross-language differences in articulation

2.1. Articulatory differences between speakers and/or speaker groups

The previous chapters thus far have discussed a wide range of studies conducted within the *Language Talent and Brain Activity*-project while taking into account German L2 speakers of English, but there has not yet been a more general overview of English vs. German articulatory-acoustic patterns as such. The present chapter will provide an introduction into studies directing their attention to these inter-language differences regarding diverse sound patterns. Thereafter the main objective of this research will be established, while leading into it via examinations in pathological speech which have given evidence for the importance of the subject of coarticulation also in clinical (i.e. neuro-linguistic) environments.

2.1.1. In English vs. German

Based on the biological, gender indexical and social class explanations and searching for direct morphological or articulatory data, Fuchs and Toda (2007) conducted an electropalatographic (EPG) approach searching for evidence of inter-language differences in the production of [s] in German vs. English. The authors took the corpus compiled by Brunner et al. (acc.) to investigate the influence of the palate shape on token-to-token variability. Experiment materials consisted of /'sasa/-sequences for the German subjects and /'zasa/-sequences for the English subjects, in which the target sibilants were situated medially in an ambisyllabic post-stressed position. Fuchs and

Toda (2007) found significant differences between palatal parameters of English vs. German speakers. The results of Stevens (1998) and Strand (1999) could not be replicated by Fuchs and Toda (2007). According to them, German speakers realize a wider constriction than English speakers. For many researchers the examination of acoustic differences in the production of [s] has been a field of interest. It has been claimed that there is a certain variability in the [s]-sound depending on sex (e.g. Stevens 1998:398; biological explanation), gender (e.g. Strand 1999; gender indexical explanation) and social class (e.g. Stuart-Smith in press).

Looking at clusters of voiceless consonants has been one of the most common ways to investigate processes of coarticulation or coproduction at the laryngeal level (Hoole 1999:115). Gobl and Ní Chasaide (1999:125) reported differences in the realization of stops between German and English, while for other phonemes these differences are less clear-cut. The VOT of English phonologically voiced stops is slightly longer in stop-sonorant sequences, such as [bl], than in the singleton case (Hoole 1999:111). Docherty (1992) further investigated voicing coarticulation. He considered devoicing of [l] in English words (e.g. "plead") caused by the adjacent voiceless [p]. According to Docherty (1992) place of articulation has a significant effect on VOT; [p] has a shorter VOT than [t] or [k]. This is a consequence of peak glottal opening, which is timed earlier with respect to release for [p] than for the other plosives. In general, [p] has longer occlusion duration than the other stops. Docherty (1992) concluded from this data that the realization of stops is not the same. Apparently, a difference in the mode of phonation in these segments influences the following voiced segment (Gobl & Ní Chasaide 1999:300, Docherty 1992). Gobl and Ní Chasaide (1999:141) observed that the initiation and the ending of voice during unocclusion of the vowel tract are not identical (cf typical pattern of laryngeal-oral coordination in Hoole 1999:110). The authors present a technique for analyzing the voice source (Gobl & Ní Chasaide 1999:300 ff) making use of different parameters which allow detailed voice source measurements. Within this technique the source signal is quantified while using parametrization of the glottal waveform based on a model of differentiated glottal flow. The most relevant acoustical and perceptual voice source parameters are taken to qualify the observations. Some of these are thus described in more detail because they enable the authors to illustrate the differences between German vs. English stop segments. According to Gobl and Ní Chasaide (1999:317) EE, the excitation strength, describes the negative amplitude when maximum discontinuity of the derived flow is reached. In consideration of speech production this characteristic parameter displaces the speed of closure with which the vocal folds vibrate and the velocity of the amount of air going through them. Acoustically, EE gives a description of the overall intensity of the resulting signal. RA measures the residual air flow (or dynamic leakage) coming from the excitation and ending up in complete closure. Taking into account the production level, it depends on the way in which the vocal folds work together, e.g. in a more instantaneous or in a gradual way with respect to their length and depth.

Also RK indicates the symmetry of rising and falling branches of the glottal flow pulse. In the case of a large RK value the skew of glottal air flow pulses is higher. Acoustically, RK is most important regarding the lower part of the source spectrum, because a high RK increases the lower harmonics (cf Gobl & Ní Chasaide 1999:318, Fig. 15.9). At the same time the amplitude level of F_0, the amplitude of the first harmonic and L1 (the amplitude level of F_1) are computed (Gobl & Ní Chasaide 1999:124, 317).

In German, at the onset of the vowel followed by [p^h] the excitation, EE, is very weak, while dynamic leakage, RA, is very high and the shape of the glottal pulse is very symmetrical, RK (Gobl & Ní Chasaide 1999:136). For German stimuli a gradually rising L0 has been detected which attains constant values only after 30 ms or so. Following [p^h] L1 is initially weak. In contrast, an abrupt initiation of voice following [p^h] with strong excitation, EE, has been found and not always an involvement of the weak, very gradual onset in English, which is typical in the German data (Gobl & Ní Chasaide 1999:137 f.). In English, glottal adduction is incomplete, and therefore RA is supposed to be low. In correspondence to the German data, the symmetry of the vocal folds (RK) is also high as for the English stimuli. For this reason no difference in RK with regard to German vs. English can be concluded. In English L0 stays rather constant before the beginning of the last glottal pulse. Finally, L1 amplitudes are lower in English as compared to German data.

Speech sound variations have not only been shown in the comparison of two different languages, but also while taking into consideration pathological speech.

2.1.2. In pathological speech

Ziegler and von Cramon (1985, 1986) and Ziegler (1989), as well as Vollmer (1993, 1997) reported differences in temporal anticipation of articulatory configurations between normal speakers and speakers suffering from apraxia and dysarthria. In apraxic speech there is a problem of phasing speech gestures appropriately which is characterized through a delay in tongue body adjustment, specifically in roundedness within the first two segments (Ziegler & von Cramon 1986).

> *"[...] [t]he problem of phasing speech gestures appropriately is an essential constituent of apraxic speech."* (Ziegler & von Cramon 1986:45)

The significance of interarticulatory phasing in coarticulation is a central concept in speech production theory. Both apraxic and dysarthric subjects prolonged the sequences considerably longer in all test words in comparison to normal speakers (Ziegler & von Cramon 1985:122) shown by increased durations of S_1 (a frame of 25.6 msec in the center of the preconsonantal schwa) and

S_2 (a 12.8-msec frame positioned to the burst onset of the alveolar plosive). Motor speech impairments in apraxic patients can be explained by the various biomechanical properties of speech gestures which lead to articulatory, acoustic and categorical changes in the perception of speech segments. Dysarthric patients reduced the acoustic distances of the vowels dramatically, which ended up in a large centralization tendency.

This thesis will show that these differences in articulatory, acoustic and categorical changes of speech segments do not exclusively appear in pathological speech, but are also the reason for the emergence of an accent in a foreign language produced by healthy informants; this being a remarkable parallel. Differences in coarticulation and coarticulatory resistance will be examined across the groups of proficient vs. average vs. less proficient L2 German speakers of English having been built up in previous investigations and will be traced back to usage-based accounts to language with high explanatory power.

2.2. Differences in the vowel systems of English and German

If the vocal tract forms another phoneme than the central phoneme *schwa* [ə], it moves from the more neutral position, which causes changes in the lower formant frequencies (particularly in the first and second formant) to lower or alternatively higher frequency positions. Ladefoged (2003:Glossary) describes the centralisation to the phoneme "*schwa*" as being

> *"[m]ade with an articulation in the midline of the* ***vocal tract****, allowing air to escape over the sides of the tongue [...]".*

For further explanation concerning central vowels see Catford (2001:148 ff.). These characteristic frequency positions allow a general classification of the German and English vowels as it is illustrated in Figures 20 to 22 (Hess 1983:56).

For instance, a low first vowel formant frequency is in accordance with a high tongue position like in [i] and [u]. A high value for F_2 indicates a frontal tongue position, like this it is again the case for [i]. The degree of lip rounding manifests itself in lower frequencies of F_2 and F_3. These effects can be comprehended in the vowel trapezes of all German and English vowels (cf Figures 20 to 22).

Cardinal vowels are meant to be those that possess a fixed and unchangeable reference point within the vowel system. All other vowel qualities of a language's sound system are put in relation to these reference points (Crystal 2003:240 f., Pétursson & Neppert 2002:100 f.). [i] [u] have a low position of the first vowel formant frequency in common, from which a high tongue position can be derived. In contrast [a] holds the highest position for F_1, which is an indicator for a very low tongue position. [a] is the most open vowel. The arithmetic mean value for the second formant of German [a] marks a relatively neutral position of the tongue. Other languages possess a larger number of phonemes, which can be characterized through a stronger frontal or back tongue position. The rules for vowel articulation are further explained in Pétursson and Neppert (2002:137 ff).

Scherer and Wollmann (1977:155) compared German and English vowels and figured out a few differences concerning especially both of these vowel systems which are listed as follows:

1. The number of front (to middle) vowels is higher in German than in English. The umlauts /y:/ (Hüte), /y/ (Hütte), /ø:/ (Höhle) and /œ/ (Hölle) do not exist in English, just as /e:/ (Ehre) and /ɛ:/ (Ähre). Opposite to this, no counterpart is present for /æ/ in German. For the back (to middle) vowel phonemes the number is identical, but the positions of the phonemes given the same phonetic symbol lie – apart from /u:/ - wide apart, the widest apart for /ɔ/.
2. Generally comparable positions are situated lower in English than in German. According to Delattre (1965:53)

   > *“[t]he vocalic system of English is more open (*low*) [...]. Its close vowels are less close. Its center of gravity is lower. And its low vowels are more extreme (close to cardinal vowels) than its high vowels, which is not the case [...]“*

   for German.

   All four vowels being placed in the upper third of the trapeze cause difficulties for German speakers (for examples cf Scherer & Wollmann 1977:155). The place of articulation of /ʌ/ is often missed (Scherer & Wollmann 1977:155), its articulation with the back part of the tongue is more the style with which conservative speakers realize it (Gimson 1980:111). The young generation produces it as an open middle tongue vowel, for with these speakers an articulation more with the back part of the frontal tongue is commonly observed, accordingly /ʌ/ approximately corresponds to German short /a/, such as in *kann*.

3. German has a tendency to more closed vowels than vice versa. The southern German [i:], [i] and [u] have higher tongue positions than their corresponding equivalents in Standard German, this exactly being in contrast to modern English which again leads to difficulties of German speakers with the English vowel system.
4. English exclusively comprises four rounded vowels /ɔ, ɔ:, u, u:/ which are less rounded than their German counterparts. By contrast, the number of diphthongs is higher in English than in German, because of English having a tendency to diphthongs (for more information about diphthongs cf Scherer & Wollmann 1977:156).
5. The diphthongs /ai, au/ start in a lower position than the respective German ones. The central diphthongs end lower than in German colloquial speech.
6. /i/ and /u/ are produced more central and also lower.
7. Altogether English is characterised through more tongue lowering and backness and a lesser activity of the lips. During the articulation of monophthongs the stable phase is shorter which is in accord with a less tight tongue position.

In Appendix C the vowel trapeze including the relative positions of German and English monophthongs can be found for clarification and comparison purposes (Scherer & Wollmann 1977:157).

2.3. Differences in vowel characteristics of RP vs. GA English

Cruttenden (2008:83 ff) presents different English dialects such as General American (GA), Standard Scottish English (SSE), London English, Northern English (NE), Australian English (ANE) and Caribbean English (CE) while pointing to differences in these dialects compared to RP (Received Pronunciation) English. With reference to Cruttenden (2008), the author of this work restricts the chapter to a description of RP vs. GA English which is most crucial regarding the subject of this thesis.

RP is the implicitly tolerated social standard of pronunciation, being thus more a consequence of a social judgement than of an official decision. Traditionally, RP has served as the type of pronunciation taught to pupils of English as an L2. It is the most commonly discussed variety of English in books of the phonetics of British English. Although, the number of GA speakers is higher than the one of RP speakers, i.e. GA is more frequently produced and is also taken as a standard model for learners of English as a second language in wide regions of Asia and Latin America, RP carries on to be a model in many parts of the world for historical reasons.

In this chapter the author merely looks at RP English vs. GA English because these are the types of pronunciation mainly having been used by the subjects of the experiment (Jilka 2009b). Cruttenden makes up the following different categories for the comparison of dialectal differences in pronunciation (2008:82f.):

systemic differences (or dissimilarities in the inventory of phonemes, i.e. the system is varied, the number of phonemic differentiations is minor or larger), ***distributional differences*** (or contrasting phonotactic options, i.e. the system may be alike, but the phonetic context in which a phoneme can emerge may be limited), ***lexical differences*** (different occurrences or 'incidence' in words, i.e. the system may be identical, but phonemes in words arise differently and this difference does not solely occur for the reason of syllable-position), ***realizational differences*** (i.e. the system of contrasts turns out the same in two dialects, but the phonetic realization of some phonemes is divergent).

Taking into consideration the above mentioned categories the juxtaposition of RP vs. GA has led to the subsequent pronunciation differences:

There are two supreme fields of ***systemic differences*** between RP and GA:

1. In GA the RP diphthongs /ɪə, eə, ʊə/ are missing which is in correspondence to GA sequences of short vowel plus /r/.
2. GA has no /ɒ/, instead RP /ɒ/ is replaced by /ɑ:/ and /ɔ:/ in GA. An increasing number of GA speakers (and most Canadians) does not produce an /ɔ:/, this is finally substituted by /ɑ:/, as well.

distributional differences:

RP /r/ (non-rhotic) exclusively appears in front of vowels, whereas GA /r/ (rhotic) can also come up before a consonant.

lexical differences:

Words contain /ɑ/ in RP, but /æ/ in GA considering the context preceding a voiceless fricative or, alternatively, before a nasal followed by another consonant.

There is considerable re-alignment of vowels before /r/, so that *merry* and *marry* may be realized in the same way while *short* and *sport* may end up in other vowel types.

realizational differences:

Differences in realization are constantly plentiful between any two systems of English pronunciation. In this section only those phonemes are surveyed which have been included in the target stimuli of the experiment within the thesis work (for a more detailed list cf Cruttenden 208:85).

Among the vowels this comprises the realization of the diphthong /eɪ/ and /əʊ/ as monophthongs such as [e:] [o:].

As a rule, /l/ is dark [ɫ] in all positions in GA, by contrast it appears clear [l] before vowels and as dark [ɫ] in other positions in RP.

Comparing L1 with L2 results

Taking into consideration the above differences between German and English vowels, as well as the distinctions within English dialectal varieties, it is of great importance to refer to neuropsychological accounts of L2 performance (e.g. Schneiderman & Desmarais 1988) which presume that a stronger division between L1 and L2 resulting in an avoidance of cognitive pathways built up for the L1 improves the performance of a second language. This way the brain's innate language-processing skills would directly interact with the L2 properties. This procedure promises to successfully put forward the acquisition of the L2 while simplifying it and making it come closer to L1 acquisition. Most interestingly, the predominant models of second language acquisition such as the Speech Learning Model (Flege 1995), the Perceptual Assimilation Model (Best 1995) or the Native Language Magnet Theory of speech perception and production (Kuhl 1991; Kuhl & Iverson 1995) agree in this main hypothesis and postulate the representations established for the L1 to be finally responsible for the development of a foreign accent in the L2. Accordingly, a heavy foreign accent is principally expected when similar phoneme categories are present, as it is the case in German vs. English (cf Chapter 2.2. and 2.3.). By contrast, totally unknown categories are supposed to be learnt with higher precision. The same effects as for phoneme acquisition are asserted to take place in the achievement of prosody (e.g. Ladd & Morton 1997; Jilka 2000).

Table 1. Overview of vowel formant frequency distributions in German (Simpson 1998) vs. RP English (Gimson 1980:101) vs. American English (Wells 1962). The diphthong /eɪ/ is realized as the monophthong [e:] in General American (Cruttenden 2008:85).

Pattern	***Vowels***	**German**	***V***	***RP***	***V***	***American English***
F_1	/a:/	711.75	/aɪ/: /ʌ/ /ɪ/	 760 360		 640 390
F_2		1338	/ʌ/ /ɪ/	1320 2220		1190 1990
F_3		2527.25	/ʌ/ /ɪ/	2500 2960		2390 2550
F_2'		1932.63	/ʌ/ /ɪ/	1910 2590		1790 2270
F_1	/i:/	310.75	/eɪ/: /e/ /ɪ/	 600 360	[e:]	does not exist in Wells (1962)
F_2		2185.5	/e/ /ɪ/	2060 2220		
F_3		2691	/e/ /ɪ/	2840 2960		
F_2'		2438.25	/e/ /ɪ/	2450 2590		
F_1	/y/	342.75				
F_2		1623.5				
F_3		2425				
F_2'		2024.25				
F_1	/u:/	358.5	/u:/	320		300
F_2		974.25		920		870
F_3		2539.25		2200		2240
F_2'		1756.75		1560		1555

3. Coarticulatory effects and coarticulatory resistance

The phenomena of coarticulation and coarticulatory resistance are the basic assumptions of this investigation. Coarticulation is defined as the interaction of successive phonetic segments within connected speech (Ashby & Maidment 2005:132). As a consequence of the continuously changing vocal tract configuration, there is an overlap of articulatory gestures at any point in time on more than one segment, leading to reduced articulatory transitions between phonemes or to temporal displacement, which is the reason for the characteristics of one segment being integrated into its neighbouring phoneme (Bladon & Al-Bamerni 1976:138) with no clear boundaries between phonemes (Keating 1990:452). In turn, phonological processes vary in different languages. Farnetani (1997:376) assumes that coarticulation is a universal phenomenon because it has been found in all languages analyzed, e.g. in French (Benguerel, Hirose, Sawashima & Ushijima 1977a, 1977b), in English (Lehiste 1964; Bladon & Al-Bamerni 1976; Bladon & Nolan 1977; Majewski, Rothman & Hollien 1977), in Catalan (Recasens 1984a, 1984b; Recasens, Fontdevila & Pallarès 1995; Recasens & Pallarès 2001), in German (Recasens, Fontdevila & Pallarès 1995) and in Polish (Majewski, Rothman & Hollien 1977). Coarticulation is one of the sources of variation in phonological processes and differs both according to language (Öhman 1966; Manuel 1990; Recasens, Fontdevila & Pallarès 1995) and to speaker, resulting in allophonic variation and individual speech variants (Baumotte et al. 2007). *Figure 1* represents the occurrences of coarticulation accounting for the appearance of foreign accent.

Coarticulation can be examined with the help of various experimental techniques: acoustic analysis such as spectrograms, electropalatography (EPG), imaging techniques such as x-ray studies (Ashby & Maidment 2005:129), electromagnetic articulography (German: Hoole, Gfroerer & Tillmann 1990), electromyography (EMG) and transducers for investigating velopharyngeal function, as well as techniques for investigating laryngeal articulation, investigations of devoicing gesture and techniques for analyzing the voice source (for further information cf Hardcastle & Hewlett 1999:229 ff). Acoustic analysis has been shown to be especially reliable in the investigation of changes in acoustic characteristics (Recasens 1999). In this thesis the author uses spectrograms to determine vowel formant frequencies for the comparison of coarticulation/coarticulatory resistance patterns in proficient vs. average vs. less proficient learners of L2 English.

This work is situated within the theoretical framework of Coarticulatory Resistance (CR) which was first employed by Bladon and Al-Bamerni (1976). Within the literature, slightly different notions of coarticulatory resistance have been presented: contrasting vowels and consonants differ in the extent as to which they allow context-dependent effects to occur. This is why they can be categorized in terms of stability (Stevens & House 1963) or resistance (Bladon & Al-Bamerni

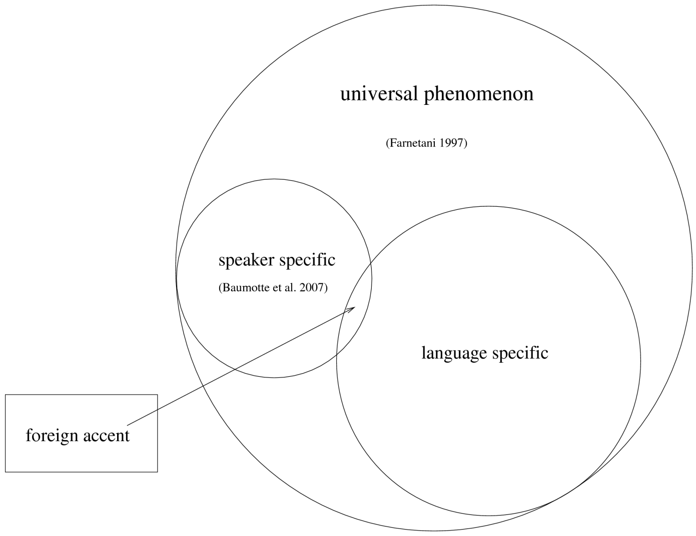


Figure 1. The different aspects of coarticulation/coarticulatory resistance.

1976). Bladon and Al-Bamerni (1976:135) describe CR as being the degree of variation or similarity of the same speech sound across contexts. It is the property associated with phonetic specifications for speech segments that varies according to their magnitude. The term indicates the degree to which a particular segment is susceptible or resistant to potential interference from the neighbouring segments (Farnetani & Recasens 1999:32). Labials and dentoalveolars, for example, leave huge spaces of the vocal tract open for coarticulation with successive vowels, thus permitting coarticulatory effects to a certain degree (Recasens 1985:98). In contrast to these consonants, others like the velarized apicoalveolar [ɫ] (Bladon & Al-Bamerni 1976) and the bilabiodorsovelar [w] (Lehiste 1964) constrain large regions of the vocal tract, which impose a high resistance to vowel coarticulation. Bladon and Al-Bamerni (1976) and Bladon and Nolan (1977) introduced an index value for *coarticulatory resistance* for each extrinsic allophone in combination with each boundary condition, which is a separate segmental "feature" to numerically declare whether some segments let through the characteristics of their neighbours to a minor or larger extent, i.e. the variation depending on contextual properties. These CR indices, i.e. numerical coefficients attributed to a phonetic segment of the form, e.g. 3 CR, underly neither language-particular nor quasi-universal rules. Different speaking styles cause specific articulatory behaviours. Following from this fact, the consonant /l/ can be differentiated into the three main allophonic variants of /l/ (i.e. [l], [ɫ], [ḷ]), for which different assignments of CR have been drawn. Articulatory configurations distinguishable in places of constriction cause the to some extent velarized ("dark", here symbolized as [ɫ]) or non-velarized ("clear" [l], with some degree of palatalization) types of the consonant (Stevens & House 1963). If velarization takes place, the tongue body and root move from their neutral position in the direction of the vowels [u] and [ɒ], towards the soft palate (Clark, Yallop & Fletcher 2007:64, 96). In RP, the clear variant appears before a vowel (e.g. *lend*, *alight*, *believe*) in syllable-initial and/or phrase-initial position, and the dark variant before a consonant or syllable- or word-finally (e.g. *wild*, *halt*, *will*, *hall*) (Clark, Yallop & Fletcher 2007:96). In some varieties of English, the degree of velarization is more extreme than in others; for example, Londoners and South Australians velarize very strongly. Recasens (1985) found for Catalan that syllable-final or word-final [ɫ] is produced with more velarization than its non-velarized, syllable-initial or word-initial counterpart [l], as is the case in some American English dialects (Kenyon 1950). In contrast to RP, General American (GA) /l/ is always a velarized variant [ɫ] of the consonant, independent of position (Cruttenden 2008:85). However, this kind of variation in the pronunciation of /l/ cannot automatically be transferred to every other language. Acoustically F_2 values serve as an indicator for the velarization distinction. Recasens (1985) compared German [l] with Catalan [ɫ] production by collecting acoustic and linguopalatal data (by means of electropalatography [EPG]) and observed greater dorsal contact in the palatal zone for German [l] than for Catalan [ɫ]. Both allophonic variants can be differentiated according to their tongue body configuration having either the characteristic of apicoalveolar or apicodental. The non-velarized variety of the consonant consists of a fairly high front position within the vocal tract (no active tongue dorsum control), in contrast to the velarized variety, which integrates tongue predorsum lowering and tongue predorsum retraction of a similar extent (tongue dorsum activity) (Recasens, Fontdevila & Pallarès 1995:38). The consonants which require tongue fronting, such as palatals, manifest a high second formant frequency. In contrast, those which have a pharyngeal constriction show a low F_2.

On the basis of this theoretical overview, it seems that a better understanding of coarticulatory processes, especially velarization processes, and coarticulatory resistance measurements in L2 German speakers of English of different dialectal varieties ought to gain from an analysis of the interaction between the articulatory structures given. The author assumes that the auditive assessment of a strong foreign accent, and in line with this the categorization of subjects in the groups of less proficient learners, also appears due to the pattern of velarization not being used as is usual in the foreign language. In accordance with this view, it will be shown that proficient speakers of English realize a more velarized type of the variety, while less proficient speakers produce a non-velarized exemplar. Proficient speakers are better able to break and lose their mother tongue-specific coarticulatory constraints. Velarization results are supposed to be inversely related to the degree of coarticulatory resistance induced in the consonant.

4. Usage-based account to languages

In order to study both coarticulation and coarticulatory resistance the author takes into account usage-based approaches, namely *The Exemplar Theory* (Pierrehumbert 2001, 2006), *The window model of coarticulation* (Keating 1990), which aim to provide insights into the storage, access and processing of fine phonetic detail. *The window model* also gives evidence of a high variability, as well as (sufficient) precision in L2 speech production or in opposition to limited production abilities of allophonic variants not used in the native language. These models finally serve to embed the results of study in a broaden and modern theoretical perspective.

4.1. *The Exemplar Theory* (Pierrehumbert 2001, 2006)

For the investigation of coarticulation and coarticulatory resistance, the research is funded on a usage-based account of language seeking to understand the storage and processing of fine phonetic detail, i.e. exemplar theoretical account (e.g. Johnson 1997; Goldinger 1996, 1998; Bybee 2002, 2006; Pierrehumbert 2001, 2006). Primarily, *The Exemplar Theory* was built up as a model in psychology to be further adapted to speech processing and was later re-modelled by Goldinger (1996, 1998), Johnson (1997, 2006) and Pierrehumbert (2001, 2006). Nowadays, exemplar-based accounts exist in or are transmitted to phonetics and phonology, as well as semantics, lexicology, typology (Bybee 2002, 2006), syntax (Bod 2006) and language acquisition (Abbot-Smith & Tomasello 2006). *The Exemplar Theory* developed by Pierrehumbert (2001) serves as a theoretical overview of the following analyses. Pierrehumbert (2001) presented a psychological model of similarity and classification, perception and categorization (especially vowel categorization), i.e. a model of phonological experiences. When identified, a new token is stored within a category of a cognitive map, within which similar exemplars are built up close to each other, whereas dissimilar ones are far apart. Generally and characteristically, exemplar models also integrate word/syllable frequency, more frequent categories automatically having a larger representation of tokens and less frequent categories a less numerous representation. Pierrehumbert‘s stimuli are also rated according to their informative content and compared with the model stored in the human brain. A considerable body of evidence has been accumulated, which claims that speakers have detailed phonetic knowledge of a type, which is not readily modelled using the categories and categorical rules of phonological theory. There are systematic differences between languages in the fine details of pronunciation (exact phonetic targets and patterns of variation) which have to be learned in the course of language acquisition. According to Bybee (2005) learned phonetic detail may be associated with languages and dialects, but at the same time with specific words in the lexicon of a given dialect, for example schwa- or t/d-deletion. Each category is represented in memory by a large cloud of remembered tokens whereby memories of highly similar instances are close to each other and memories of dissimilar instances far apart. The volume of speech which a person processes in a lifetime is great, but not every word is finally stored. According to Pierrehumbert (2001:141) each exemplar is assigned a resting activation level, the so-called associated *strength*. The exemplars encoding frequent recent experiences have higher resting activation levels than exemplars of infrequent and temporally remote experiences. When a new token is encountered, it is classified in *Exemplar Theory* according to its similarity, i.e. its distance in the parameter space to the exemplars already stored. During this last process, i.e. the calculation of summed similarities, a label which has more numerous or more activated exemplars in the neighbourhood of the newly encountered token has an advantage in the competition. *The Exemplar Theory* provides us with a way to formalize the detailed phonetic knowledge that native speakers have about the categories of their language, while also giving a picture of the *"implicit phonetic knowledge of the speakers"*. The acquisition of this knowledge can be understood simply in terms of the acquisition of a large number of memory traces of experiences. The assumption that people learn phonological categories by remembering many labelled tokens of these categories explains the ability to learn fine phonetic patterns of a language.

Wade et al. (2010) proposed in their context-based production model or context sequence model (CSM), on the basis of simulations, that not only the exemplar itself (the segment or syllable), but everything which has been encountered is taken into account within its preceding and following contexts and takes part in the decision to choose the correct token for the current production process. According to this view, perception and production take as much of this context into consideration as is necessary to find a proper match. In opposition to static models (for example, the model developed by Pierrehumbert 2001), the CSM is a dynamic model and therefore also considers contextual and temporal information, a temporal match being as relevant as a spectral match.

It is the specific objective of this study to make use of the special explanatory power of the above described usage-based accounts to examine discrete and gradient phenomena (e.g. phonetic neutralization, word frequency- or gender- and speaker-dependent acoustic differences) to find reasons for the individual differences between L2 English aptitude of the subjects. Usage-based accounts are assumed to *"provide the most accurate, parsimonious description of linguistic competence and perfomance"* (Wade et al. 2010:1).

Following *The Exemplar Theory* (Pierrehumbert 2001) subjects categorized as less proficient might not automatically be able to enlarge their exemplar clouds after having heard a sound which is not identical to those existing in their mother tongue. In turn, during L2 production of less proficient learners not as many exemplars may be activated as in proficient speakers. Wade et al. (2010) enlarged Pierrehumbert's theory (2001) to memory sequences taking the form of separate frequency bands. Following Pierrehumbert's line of explanation (Pierrehumbert 2001), Wade et al.'s model leads to the suggestion that it might be more difficult or impossible for less proficient speakers to find a match in both or even one context/s of the unit, taking into account (the left preceding context containing acoustic features and the right following context with linguistic information) compared to the target unit. Less proficient speakers might be unable to store or reactivate recently heard spectral and temporal information, which has no similar contexts to what they perceive regularly within their mother tongue. Even the same types of exemplars are classified differently in different languages because their acoustic and linguistic contexts differ. This is a prediction of the CSM. In her future work the author would like to further uncover whether sounds and/or contextual and temporal information that have not been stored in less proficient learners make up a homogeneous group and if so, whether they can be distinguished in their manner and degree of coarticulation and coarticulatory resistance.

4.2. The window model of coarticulation/of contour construction (Keating 1990)

Keating (1990) proposed a model of the spatial aspect of continuous representations derived from information about the contextual variability, or coarticulation, of each segment. On the basis of the definitions of coarticulation and coarticulatory resistance presented earlier, Keating (1990) attempted to find mechanisms for providing the relatively smooth spatial trajectories between their steady physical values. The model resulted in a description of those coarticulatory effects not causing phonological manipulation of segmental feature values. The subjects of study were the phonological representations of phonetic. Phonological rules are uniquely restricted in their availability for segment-internal matters, whereas, in contrast, phonetic rules can and also quite usually will influence allocations of segments, or modify them only weakly, or lead to a continuous variation in quality. *The window model* offers an appropriate manner of depiction of those coarticulatory effects which do not imply phonological manipulation of segmental feature values, but as an alternative require quantitative interactions in perpetual time and space. For the purpose of simplification, the model only has regard for one sub-type of coarticulation, namely coarticulation covering a single articulator taken for successive segments. Coarticulatory processes which integrate the coordination of two different articulators were not taken into account, moreover principles are called for inter-articulator alignment. In single articulator coarticulation, the given articulator must adapt to the spatial needs of segments following one another. If two such necessities clash, they can be shifted in time (temporal variation), or one of them can be altered (spatial variation). In this instance, then, the matter of interest was to clear up how phonetic rules cope with these circumstances. Target models (e.g. MacNeilage 1970) describe the traditional and still widespread standpoint of what phonetic rules do, though, the modification of segmental features into spatio-temporal targets, which are, moreover, linked together. Rule governed segmental speech synthesis is usually grounded on some sort of targets-and-connections model. Within this model targets were previously characterized as invariant, which serves as the distinctive feature for a given phoneme class. During the course of binding features, target values may not be attained as well because of undershoot or overshoot owing restrictions on movements' swiftness. Subsequently, surface allophonic variations arise from this. Opposed to the assumption of invariance represented in target models, Keating (1990) suggested a slightly different approach of judging the procedure of raising outlines between segmental features. Within her new model, variability, the two systematic and random, is of great importance, while targets, and transitions, i.e. turning points in contours, are of much lower influence.

Keating (1990:466) gave the possible range of probable spatial values for each segment the term *window*. This *window*

> *"is an undifferentiated range representing the contextual variability of a feature value"* (Keating 1990:455).

Each physical articulatory dimension, e.g. jaw position or tongue backness, has its own minimum and maximum, within which the contextual variability of a given feature value is reflected. *Window* size denoted metrically can be either very tight for some segments, i.e. little contextual variation, or extremely broad for others, i.e. high contextual variation. Finally, no other "target" is related to a segment, the target being nothing else than its exhaustive contextual range. In the process of establishing the *window* for a considered segment or for a particular feature value, gathering of quantitative values throughout various contexts is ongoing. To end up with, the overall range of values is applied for, in order to determine maximum and minimum values which are the most crucial ones. Remarkably, though, the phonological feature values being the core finding to pick out *windows* must not obligatorily be equivalent to the earlier discovered values: phonological rules for the alteration or extension of feature values are brought to bear beforehand and the phonetics later. Hence it follows that as far as segments are concerned, *windows* are more likely chosen for extrinsic allophones, but to a smaller amount for phonemes. Analogously, physical parameters are assigned to *windows* more often than phonological features. To further proceed, Keating (1990:456) added that the phonetic implementation comprises the interpretation of features in terms of physical measures with the help of a possibly elaborated method. Therefore, the assignment of one *window* to all plausible states of a phonological feature value doubtlessly oversimplifies the given circumstances. However, on a present range a continuity of feature values of segments can be converted into an arrangement of *windows*. This track is limited by calls for shape interrelationship and uniformity, and of slightest articulatory effort, together with smallest displacements or lowest peak velocities. This is why the interpolation procedure can be judged as an optimization acquiring regular operations which drop down within the *windows*. Most of the feature values are obliged to accommodate the *window*, unless some of its fragments go down within tight “transition” regions between *windows*. If two neighbouring *windows* are small, the complete transition can occur instantly between the *windows* and the interpolation mechanism. *Windows* are ranges within which values building a row are acceptably distributed. Prior to the construction of a current curve the characteristic segment values have never remained. In this way, the occurrence of a turning point connected with a given segment relies on the *window* for the segment and the *windows* of the context. Relying on the specific contextual condition, a track throughout a segmental feature might go past the whole range of values within the given *window*, or uniquely spread a more restricted range of the *window* in question. Because of the dependency of context the *window* cannot be indicated by a mean and in addition a range around the mean (Keating 1990:457). Keating’s model predicts variations in trajectories between speakers and also within reiterations of one single speaker across *window* sequences underdetermining the interpolation. Keating (1990:466) contributed the term *coarticulatory resistance* to her *window model*, discussing the index calculation of this term introduced by Bladon and Al-Bamerni (1976) and Bladon and Nolan (1977) (cf earlier description). According to Keating (1990:466) the fundamental knowledge of coarticulatory resistance is employed in *The window model*: a huge degree of coarticulatory resistance coincides straightaway with a tight *window*, and missing coarticulatory resistance immediately matches a broad *window*. However, in contrast to *The window model*, the variability is not illustrated unattached from discerned, modal, or target values. Besides, Bladon and his colleagues specified values for features, rather more than values for unanalyzed segments, which bear relation to numerical variability.

5. Coarticulation/coarticulatory resistance in the field of second language acquisition

The preceding chapters provided an overview on research about the assessment of L2 abilities and presented phonetic and psychological, as well as neuro-linguistic evidence for German subjects performing differently in their L2 English. The finding of the *Language Talent and Brain Activity*-project about varying abilities in L2 pronunciation proficiency was the reason for reconsidering well-established usage-based accounts to languages such as *The Exemplar Theory* (Pierrehumbert 2001, 2006) and *The* w*indow model of coarticulation* (Keating 1990). The *Window model of coarticulation* (Keating 1990) takes into account the contextual variability of each segment which is meant to be *coarticulation* while investigating those coarticulatory effects not causing phonological manipulation of segmental feature values. Keating (1990) developed her model to merely point to one single articulator with regard to its special spatial and temporal variation. Besides giving insights into a high variability, the model considers precision vs. inaccurate productions of allophonic variants in L2 speech which do not occur in the speaker‘s native language. Therefore Keating‘s model is of great impact for this work because it can be taken to interpret the degree of velarization or the variation in /l/ respectively which is caused by tongue backness or fronting, i.e. by exclusively one single articulatory movement. Simultaneously, it holds for variability in the productions of L2 speakers of English which serves as an indicator for proficiency in the foreign language. The same holds for *The Exemplar Theory* (Pierrehumbert 2001, 2006), which also considers variability, but especially contextual variability. The main purpose of this theory is to clarify the storage and processing of fine phonetic detail, while integrating word/syllable frequency and their representations of tokens in the human brain. Within *The Exemplar Theory* variability is visualized through a larger exemplar cloud which occurs due to more different phonetic features being experienced and in line being representative compared to earlier perceptions. Velarization, coarticulatory resistance and its greater or minor variability in German speakers of L2 English serve as the main columns of this work. It is attempted to account for reasons of more or less variable speech in these speakers while looking at different storage and processing procedures (Pierrehumbert 2001, 2006) or precision and inaccurate productions of allophonic variants (Keating 1990).

The studies in this thesis further explore this issue of variability and benefit from an experimental method that was previously introduced by Bladon and Al-Bamerni (1976) and Bladon and Nolan (1977). The authors presented an index value for *coarticulatory resistance* for each extrinsic allophone combined with each boundary condition serving as a separate segmental “feature” to numerically define if some segments are more or less permeable for the characteristics of their neighbours, i.e. the variation depending on contextual properties (cf *The Exemplar Theory*). Different speaking styles result in specific articulatory behaviours and in line with this various phonetic segments which are mirrored numerically through CR indices in the form of coefficients, e.g. 3 CR, being neither based on language-particular nor on quasi-universal rules.

The basic rationale of methods that have been commonly used for investigating second language acquisition was already introduced in Chapter 1. Whereas general language aptitude can be tested in general language aptitude and proficiency tests, instrumental analysis, i.e. velarization and coarticulatory resistance measurements, offers a more precise look into explicit phonetic phenomena and therewith enable to numerically account for (contextual) variability in speech and might therefore serve as a high indicator for proficiency in the L2.

EXPERIMENTAL PART

The experiments described in this section are intended to provide new evidence for the auditive assessment of a foreign accent in German speakers of L2 English, while performing instrumental analyses and comparing proficient vs. average vs. less proficient speakers which have been categorized accordingly based on earlier phonetic experiments conducted by Jilka (2009b). Previous investigations of cross-language (Öhman 1966; Manuel 1990; Recasens, Fontdevila & Pallarès 1995) and individual (Baumotte et al. 2007) differences in coarticulation and coarticulatory resistance (Bladon & Al-Bamerni 1976) underlined the supposition of differences in the pattern of velarization and coarticulatory resistance in /l/ (Stevens & House 1963) being a consequence of tongue dorsum activity inserted in the consonant. On the one hand continuous allophonic variation of the consonant /l/ in German vs. English (Kenyon 1950; Recasens 1985; Clark, Yallop & Fletcher 2007:96; Cruttenden 2008:85) and on the other hand the impression that missing velarization leads to the auditive impression of a strong foreign accent in German L2 speakers of English led to focus on the variability in this consonant. These studies intend to investigate whether the categorization in a certain level of proficiency correlates with the production of a specific variant of /l/. To measure these different variants coarticulation and coarticulatory resistance calculations are carried out on the basis of previous studies done by Bladon and Al-Bamerni (1976) and Recasens. The consonant /l/ was chosen due to its different productions with or without tongue dorsum activity which is especially important for the occurrence of coarticulatory resistance. The author assumes that in proficient speakers there should be a more velarized variant of [ɫ], while in less proficient speakers the [l] appears to be more non-velarized as it arises in German. Average speakers are presumed to be inbetween proficient and less proficient speakers‘ productions.

Different theoretical predictions are examined to be able to embed experimental findings in various theoretical proposals:

Usage-based accounts with their special explanatory power are accounted for to explore discrete and gradient phenomena (e.g. phonetic neutralization, word frequency- or gender- and speaker-dependent acoustic differences) to uncover the occurrence of individual differences between L2 English aptitude of the subjects.

- *The Exemplar Theory* predicts that less proficient German speakers of L2 English produce a more non-velarized type of the consonant /l/ because of not being automatically able to enlarge their exemplar clouds after the perception of a sound which is not identical to those existing in the foreign language‘s phonetic system (Pierrehumbert 2001). Because the storage of deviating phonetic targets and patterns of variation failed, L2 pronunciation variants are not accessible. Therefore, these speakers are not capable to precisely produce the characteristic L2 sound patterns, which results in the auditive assessment of a (strong) foreign accent. Wade et al.’s CSM (2010) further proclaimed that not merely the exemplar itself (the segment or syllable), but also its preceding and following contexts which are experienced with are processed as memory sequences owing the form of separate frequency bands and are highly relevant for the choice of the appropriate token for the current production process. Following Wade et al. (2010) perception and production consider as much context as is required to obtain an accurate temporal and spectral match. On the basis of Wade et al.’s model the hypothesis was explored of whether it is more complicated or infeasible for less proficient speakers to discover a match in both or even (one) context/s of the unit. Speakers consider the left preceding context comprising acoustic features and the right succeeding context including linguistic information in comparison to the target unit. For less proficient speakers it might be impossible to store or reactivate recently perceived spectral and temporal information without any contexts resembling to what they are usually exposed to within their mother tongue. CSM forecasts that classifications of even the same types of exemplars turn out to be different in dissimilar languages because their acoustic and linguistic contexts vary. In the process of this work the author intends to work out whether sounds and/or contextual and temporal information that less proficient learners are unable to store build up a homogeneous group, and if this is the case, whether they can be differentiated in their manner and degree of coarticulation and coarticulatory resistance.

- Within the *Window model of coarticulation* (Keating 1990) a high degree of coarticulatory resistance is attributed to a narrow *window*, i.e. low contextual variability of the segment, whereas a lack of coarticulatory resistance results in a broad *window*, i.e. high contextual variability of the segment. Tongue backness causing a certain amount of velarization turns into a constriction in the back part of the mouth. Variability within proficient vs. average vs. less proficient L2 German speakers of English will be examined to look if it is possible to derive coarticulatory resistance and coarticulation characteristics from the window size of these subjects under exploration.

The subjects chosen for the experiments within this thesis have been taken from the bigger pool of those who participated in the tests of the *Language Talent and Brain Activity*-project. This project investigated these subjects in speech production and perception experiments while serving itself from experimental phonetic methods. After the conduction of general English pronunciation ability tests, the *Language Talent and Brain Activity*-project categorized its subjects in proficient vs. average vs. less proficient informants. This work has re-taken 41 of these subjects and re-recruited a quite equilibrated number of females and males across these three categories to further uncover differences in degree of coarticulation and coarticulatory resistance which might result in the auditive assessment of a minor or stronger foreign accent in their L2 English. All subjects have a high level of education and an academic background to guarantee a certain level of their L2 English abilities and not to compare too heterogeneous groups which might have led to artifacts in final test outcomes.

In Experimental Part 1 German and English non-words stimuli have been taken including /l/ followed by different vowel types to be able to fully control for differences in coarticulation and coarticulatory resistance resulting from specific contextual conditions. Four different vowel qualities have been integrated in the analyses to check for the permeability of /l/ with regard to these diverging vowel characteristics. Degree of velarization has been measured in /ə/, as well as /l/ previous to these vowels. The vowel /ə/ serves as a precise indicator for the pattern of velarization and coarticulatory resistance. If its frequencies come closer to the formants of a neutral vowel, there is more coarticulatory resistance present in the stimulus in question.

Whereas in the Experimental Part 2 natural language stimuli have been created to verify the results gotten from non-word stimuli and to further account for differences in the degree of velarization in /l/ occurring in dissimilar phrase-/word-positions and being produced by speakers realizing different dialectal varieties of English.

EXPERIMENTAL PART 1

6. Experiment with English stimuli

6.1. Analysis 1: Degree of velarization in /əlV/ sequences across levels of proficiency measured in /ə/, taking non-words

6.1.1. Methods

6.1.1.1. Subjects

41 (11 less proficient [7 female, 4 male], 18 proficient [10 f, 8 m] and 12 average [7 f, 5 m] native German speakers (24 f, 17 m) were recruited for the analysis. They were 20 to 42 years old with a mean age of 25.7 years. Most of them grew up in the Swabian region, i.e. in the south of Germany, having in general a less dialectal manner of speaking due to exposure to Standard German speakers and having a high level of education. Speakers of Swabian dialect are known to produce a clear variety of the consonant /l/. All of them had an academic background. The subjects had beforehand taken part in extensive tests of phonetic language ability, which assessed their pronunciation accuracy (categories: proficient, average, less proficient) in English (Jilka 2009b), and their dialectal varieties had been revealed by means of auditive assessment. Depending on dialectal variety, Jilka (2009b) categorized these subjects as 1. GA – General American (high quality), 2. RP – Received Pronunciation (high quality), 3. German accent – no variety identifiable than German accent production, 4. German accent, but RP colouration identifiable, 5. German accent, but GA colouration identifiable or 6. Mid-Atlantic (MA) – no German accent, but mixture of RP and GA. 13 of the subjects produced GA, 5 RP, 13 German accented speech, 5 German RP accented speech, 4 German GA accented speech and 1 MA accented speech.

6.1.1.2. Materials

Formant frequency data were collected for the logotoms "*gelate, gelite, gelüte, gelute*". To control for pitch, duration and phonemes, a non-word was chosen. The target non-words were embedded in carrier sentences (*I have said [gelate/gelite/gelüte/gelute] twice.*) with stress on the second syllable.

This speech material was read five times by each speaker, resulting in 812 tokens (1 consonant /l/ x 4 vowel contexts x 5 repetitions x 41 speakers = 820). Eight tokens were dismissed due to imprecise articulation and hesitation errors. These test utterances contained German language phonotactic rules and the respective target word in a stressed position. Before starting the recordings the speakers were asked to set the focus on accentuation and speech rate (cf Cho 2004). Cho (2004) proposes additionally accounting for stress differences in language-specific examinations. Taking into consideration his results, the author (2004:168) suggested that duration, stress and prosodic boundaries should not be handled in the same way by reason of an obviously different relationship between coarticulation and duration. According to various authors (e.g. Fowler 1981; Kühnert & Nolan 1999; Cho 2004) speech rate and phonological boundaries strongly affect coarticulation patterns.

6.1.1.3. Procedure

At the beginning of each session, subjects were instructed to repeat a small text presented by a female university lecturer (56 y) speaking with a British English accent, to help speakers switch into the target language, and particularly to prime them in the foreign language.

Digital recordings were made at a 16 *kHz* sampling rate in a sound-proof recording room in the phonetics laboratory of the Institute for Natural Language Processing, Universität Stuttgart, Germany. The data were then segmented at the phone level by automatic forced alignment (Rapp 1995) and checked manually afterwards. Formant frequencies were measured every 10 ms with the *ESPS formant* program (Entropic Signal Processing System 2003). F_1, F_2 and F_3 were extracted from the middle of the steady state in /ə/ and /l/ following a standard procedure (Recasens 1999:327).

Before classifying the vowel productions of many speakers, Lobanov (1971:606) advised self-normalizing the F_1F_2 extraction. Self-normalization is most effective when not including anatomical/physiological information about the speakers' vocal tract shape, gender or physiology, as well as sociolinguistic information, i.e. information about the learners' group characteristics, such as regional origin or socioeconomic status (Adank et al. 2004:3099). For this investigation the author finally decided that self-normalization of point vowel formant frequency data after /l/ was not absolutely necessary because the author was intending to establish velarization differences in proficient vs. average vs. less proficient speakers. Furthermore, to carry out normalization on measurements out of the consonant /l/ was impossible.

According to Ziegler and von Cramon (1986:35) the formant frequencies in /ə/ are the most appropriate parameters to disentangle vowel-to-vowel coarticulation. F_2 frequency and the frequency distance between F_2 and F_1, F_v[2], served as indicators for the degree of consonantal

2 According to Fant (1960) F_2 correlates positively with tongue dorsum fronting and raising and is thus inversely related to the degree of velarization. F_v considers also the contribution of F_1 known to be

velarization.

In order to determine significant formant-dependent differences, one-way ANOVAs were submitted separately for F_2 and F_v, with proficiency level as the independent variable. Further, the interactions between the degree of velarization and each proficiency level were calculated by means of a correlation analysis (Scheffé tests) between the formant frequency values in /ə/. The purpose of this analysis was to investigate whether an increase in a given proficiency level was matched with an increase in degree of velarization, and less importantly, if velarization and proficiency level were strongly correlated.

Based on previous studies the author predicted that velarized native-like English [ɫ] should show weaker coarticulatory effects on /ə/ before /l[aɪ, eɪ, y, u:]/ than non-velarized, less proficient German-accented English /l/ (no active tongue dorsum gesture). Following these assumptions, the author predicted F_2 and F_v in low proficient non-native speakers to be higher than in high proficient speakers. Average speaker values were expected to lie between those of proficient and non-proficient speakers.

To ensure that /[aɪ, eɪ, y, u:]/ did not highly influence the degree of velarization in /ə/ over /l/, the author also calculated ANOVAs (Scheffé) separately for the four different vowels and diphthongs.

6.1.2. Results

Mean F_2 and F_v values for /ə/ before /l/ are shown in Table 2. The vowel exhibits a higher F_2 for less proficient speakers than for proficient speakers in both of the cases. Average speakers' mean value for F_v lies in between those of proficient and less proficient speakers, whereas the mean value of average speakers for F_2 is lower than that for proficient speakers.

---

inversely related to velarization (Recasens, Fontdevila & Pallarès 1995:41). F_2 and F_v decrease, when the degree of velarization rises.

Table 2. Mean values for F_2 and F_v in proficient vs. average vs. less proficient speakers. Standard deviations have been included in parentheses.

Parameter	Proficiency	Mean value [Standard deviation]
F_2	proficient	1881.728 *Hz* [320.7252]
	average	1880.236 *Hz* [298.6969]
	less proficient	1957.380 *Hz* [277.9978]
F_v	proficient	1493.318 *Hz* [331.6089]
	average	1504.619 *Hz* [319.4412]
	less proficient	1563.005 *Hz* [296.1957]

One-way ANOVAs across proficiency levels revealed significant differences in F_2 ($F(2) = 5.083$, $p < .006$) and F_v ($F(2) = 3.449$, $p < .032$ [$df_{bg} = 2$, $df_{wg} = 815$]) which could be shown by Scheffé-tests. F_2 and F_v allow a high percentage of a significant degree of velarization effects between less proficient vs. average/proficient speakers, while average vs. proficient speakers revealed no significant results.

Table 3. One-way ANOVA (Scheffé) test results comparing degree of velarization and level of proficiency in F_2 and F_v.

Parameter	Group	Significance	
F_2	1 - 2	$p < .025$	*
	1 - 3	$p < .015$	*
F_v	1 - 3	$p < .039$	*

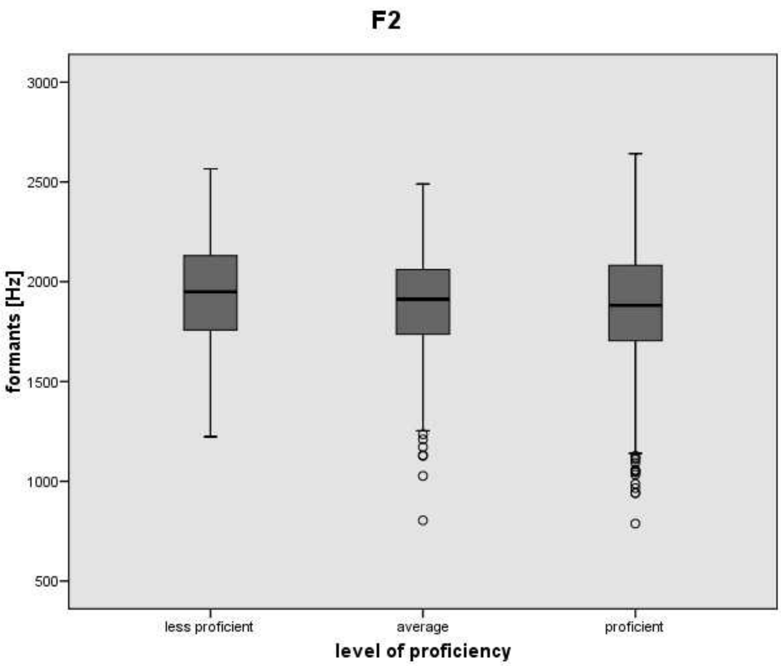


Figure 2. Distribution of F_2 in less proficient vs. average vs. proficient speakers.

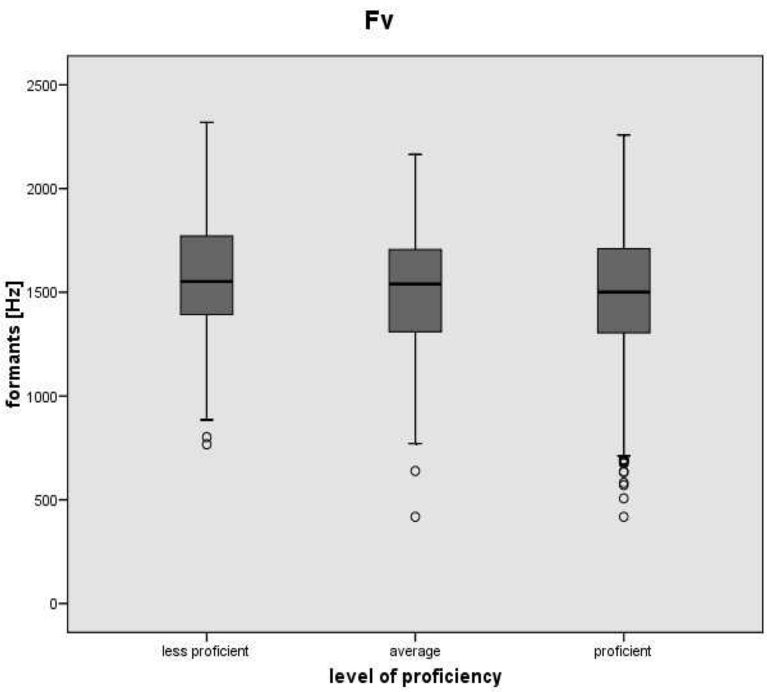


Figure 3. Distribution of F_v in less proficient vs. average vs. proficient speakers.

Separate one-way ANOVAs for all four vowels /[aɪ, eɪ, y, u:]/ following /l/ across proficiency levels revealed no significant differences in F_2 ($F(2) = .968$, $p < .382$) and F_v ($F(2) = 1.247$, $p <$

.290 [$df_{bg} = 2$, $df_{wg} = 201$]) for /aɪ/ and F_2 ($F(2) = 2.231$, $p < .110$), as well as F_v ($F(2) = 2.166$, $p < .117$ [$df_{bg} = 2$, $df_{wg} = 202$]) for /eɪ/. In contrast, separate one-way ANOVAs for /y/ in F_2 ($F(2) = 4.178$, $p < .017$) and F_v ($F(2) = 3.314$, $p < .038$) and /u:/ in F_2 ($F(2) = 5.205$, $p < .006$) and F_v ($F(2) = 3.314$, $p < .038$) following /l/ across proficiency levels gave significant differences. Table 4 shows that nevertheless comparisons are non-significant for /aɪ/ and /eɪ/ following /l/ across proficiency levels, the values for proficient speakers are lower than for less proficient speakers in these cases, which permits us to suggest that these vowels do not highly influence the measured degree of velarization in /ə/.

Table 4. Separated mean values across vowels following /l/ for F_2 and F_v in proficient vs. average vs. less proficient speakers. Standard deviations have been included in parentheses.

Vowel environment	Parameter	Proficiency	Mean value [Standard deviation]
/aɪ/	F_2	proficient	1878.815 *Hz* [307.6997]
		average	1948.358 *Hz* [313.7715]
		less proficient	1901.827 *Hz* [271.0293]
	F_v	proficient	1478.343 *Hz* [303.5675]
		average	1557.850 *Hz* [339.8117]
		less proficient	1488.973 *Hz* [298.6784]
/eɪ/	F_2	proficient	1818.767 *Hz* [279.1726]
		average	1864.067 *Hz* [313.3953]
		less proficient	1919.955 *Hz* [242.7584]
	F_v	proficient	1406.194 *Hz* [318.6217]
		average	1465.825 *Hz* [340.7427]
		less proficient	1515.409 *Hz* [263.9081]
/u:/	F_2	proficient	1955.439 *Hz* [315.7391]
		average	1817.725 *Hz* [273.5955]
		less proficient	1982.082 *Hz* [309.6323]
	F_v	proficient	1592.517 *Hz* [313.8323]
		average	1450.942 *Hz* [297.1215]
		less proficient	1608.836 *Hz* [316.1150]
/y/	F_2	proficient	1873.861 *Hz* [364.6262]
		average	1890.975 *Hz* [284.0303]
		less proficient	2025.655 *Hz* [274.2716]
	F_v	proficient	1496.050 *Hz* [365.1605]
		average	1544.525 *Hz* [290.2836]
		less proficient	1638.800 *Hz* [284.8443]

6.1.3. Discussion

The results of analyses confirmed the assumption of significant differences for vowel formant frequency values in /ə/ before /lV/ across most proficiency levels. Generally, proficient speakers realized lower formant frequencies for F_2 and F_v in /ə/ than less proficient speakers. Average speakers are situated in between the values of proficient and less proficient speakers for F_v, but in contrast they reached the lowest values for F_2. On the basis of Fant (1960), it is presumed that tongue dorsum backing decrease F_2 vowel formant frequency, i.e. an inverse relationship between vowel formant frequency and the degree of velarization is present. Furthermore, F_v also integrates the F_1 value, which according to Recasens, Fontdevila and Pallarès (1995:41) stands in transposed interdependence to velarization. Consequently, F_2 and F_v are found to be low, when the degree of velarization augments. The vowel formant frequencies obtained and the articulatory-acoustic connection described below lead to a confirmation of the hypothesis which called for proficient speakers inserting a higher degree of velarization in their L2 English than their less proficient counterparts. However, average speakers' vowel formant frequencies draw a less clear-cut image. Whereas F_2 indicated them to velarize even more than proficient speakers, F_v turned out as predicted, i.e. this value found in between those of proficient and less proficient speakers. This fact might be explained by the general difficulties of the average speakers' group to precisely navigate articulators to arrive close at the target stimulus.

As the vowels after /l/ differed, the author was encouraged to separate vowel formant frequency data for various proficiency levels out of /ə/ to ensure that the preceding results are not an anomaly resulting from dissimilar following vowel productions. Even if not all the comparisons resulted in significant outcomes, there was obvious tendency for proficient speakers' values to be lower than for less proficient speakers. Conclusively, the overall comparison not allowing for feasible differences in /ə/ preceding various vowels after /l/ did not considerably modify the measured degree of velarization. Once more average speakers' productions created an ambiguous picture which again supports the idea of average speakers being less exact in the realization of the pattern of velarization. The degree of velarization induced is attributable to tongue dorsum fronting (no velarization induced) and raising vs. tongue backing (velarization induced) causing changes with respect to vowel formant frequency heights. Conclusively, degree of velarization as conceptualized in phonetic theory is a good indicator of phonetic proficiency in a foreign language.

In the next chapter the same analyses across levels of proficiency will be calculated for the group of female informants only to focus on probable gender-related differences in vocal tract size.

6.2. Degree of velarization across proficient vs. average vs. less proficient female speakers only

Subjects, materials and procedure were the same as described in Chapter 6.1.1.3..

A separate analysis of the data of female subjects should give a clearer look at individual differences and account for assumed gender-related differences in vocal tract size.

6.2.1. Results

Separate one-way ANOVAs for the whole group of vowels followed by /l/ also resulted in significant differences (F_2 ($F(2) = 7.162$, $p < .001$) and F_v ($F(2) = 7.652$, $p < .001$ [$df_{bg} = 2$, $df_{wg} = 476$])) between less proficient vs. proficient speakers in F_2 and less proficient vs. proficient, as well as average vs. proficient learners in F_v (cf Table 5 for more detailed information).

Table 5. One-way ANOVA (Scheffé) test results comparing degree of velarization and level of proficiency in F_2 and F_v.

Parameter	Group	Significance	
F_2	1 - 3	$p < .001$	*
F_v	1 - 3	$p < .001$	*
	2 - 3	$p < .049$	*

Table 6 summarizes overall vowel formant frequency mean values for F_2 and F_v across all levels of proficiency. The author is thus faced with low vowel formant frequencies in F_2 and F_v for proficient speakers, whereas less proficient informants produce the highest values. In correspondence with the initial hypothesis, average speakers' values can be found in between those of proficient and less proficient speakers.

Table 6. Mean F_2 and F_v values (in *Hz*) for /ə/ before /aɪ/, /eɪ/, /y/, /u:/ across /l/ in less proficient vs. proficient speakers (female subjects only). Standard deviations have been included in parentheses.

Parameter	Proficiency	Mean value [Standard deviation]
F_2	proficient	1906.975 *Hz* [360.7645]
	average	1969.339 *Hz* [252.0572]
	less proficient	2036.493 *Hz* [287.2522]
F_v	proficient	1479.575 *Hz* [373.3557]
	average	1570.550 *Hz* [290.9950]
	less proficient	1619.514 *Hz* [318.2387]

6.2.2. Discussion

Mean values across proficiency levels confirmed the predicted tendency concerning the velarization scale owing that proficient female speakers insert more velarization into their production of /l/ than less proficient female learners. Moreover, by offering significant outcomes with regard to proficient vs. less proficient speakers in both comparisons, F_2 and F_v. An interesting result of this study including female speakers only is the observation that females of average proficiency level apparently behave more clear-cut – and in accord with the initial hypothesis - regarding their F_2 and F_v realizations as reflected by the appearance of their values in the centre of less proficient and proficient speakers' mean values (cf Table 6).

In sum, these calculations can be interpreted on the basis of the previous ones, which were summarized in Chapter 6.1.3.. These results underline in the same way the articulatory mechanisms derived from the previous measurements underlying vowel formant frequency heights. Considering the different behaviour of average speakers' values, the author is not able to draw any further conclusions depending on gender-related perception and/or articulation deviations which might have caused the conflicting outcomes.

6.3. Analysis 2: Degree of velarization in /əlV/ sequences across levels of proficiency measured in /l/, taking non-words

Subjects, materials and procedure were analogous to those of Analysis I.

6.3.1. Results

Within separate one-way ANOVAs for F_1 and F_2 measured in the steady state of /l/ across proficiency levels, significant differences for F_1 ($F(2) = 7.782$, $p < .000$) and F_2 ($F(2) = 5.222$, $p < .006$ [$df_{bg} = 2$, $df_{wg} = 815$]) were revealed. Furthermore, these noticeable trends were specified after conducting Scheffé tests showing that less proficient vs. average and less proficient vs. proficient speakers produced significantly different types of the /l/ variety. As can be seen in Table 8, degrees of velarization in F_1 and F_2 extracted out of /l/ exerted clear distinctions in mean vowel formant frequency height, depending on the level of proficiency. As predicted in the introduction, F_1 yielded higher values for proficient speakers than for less proficient speakers, average speakers reaching a mean value in between those extreme groups. In contrast, F_2 results have given a mirror image, with proficient speakers showing a lower mean value than less proficient speakers. Contrary to the hypothesis, average learners obtained a mean F_2-frequency, which was even lower than that of proficient speakers.

Table 7. One-way ANOVA (Scheffé) test results comparing degree of velarization in /l/ and level of proficiency in F_1 and F_2.

Parameter	Group	Significance	
F_1	1 - 2	$p < .016$	*
	1 - 3	$p < .001$	*
F_2	1 - 2	$p < .019$	*
	1 - 3	$p < .015$	*

Table 8. Mean F_1 and F_2 values (in *Hz*) for /l/ between /ə/ and /aɪ/, /eɪ/, /y/, /u:/ in less proficient vs. proficient speakers. Standard deviations have been included in parentheses.

Parameter	Proficiency	Mean value [Standard deviation]
F_1	proficient	324.774 [74.8727]
	average	320.496 [67.6170]
	less proficient	301.380 [67.6670]
F_2	proficient	1624.808 [430.2379]
	average	1618.695 [307.8531]
	less proficient	1723.268 [423.9948]

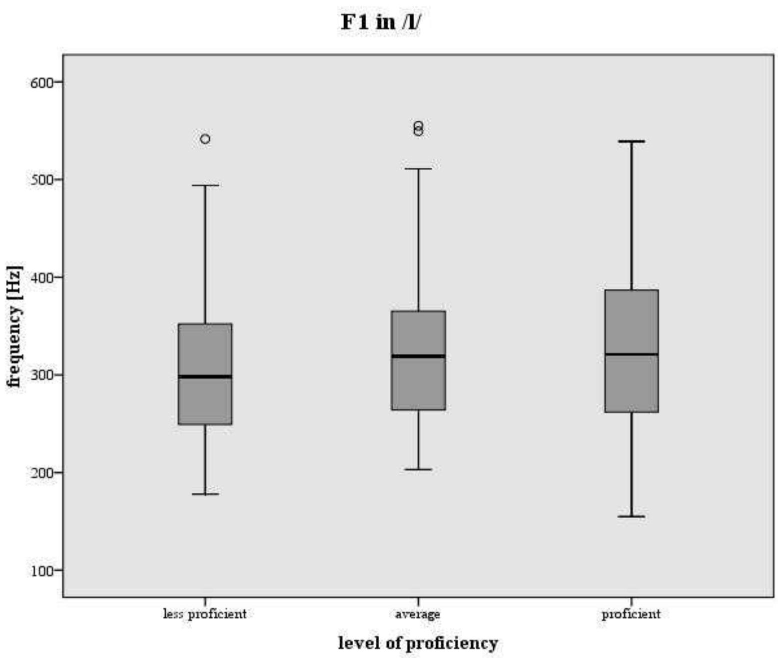


Figure 4. Distribution of F_1 in /l/ for less proficient vs. average vs. proficient speakers.

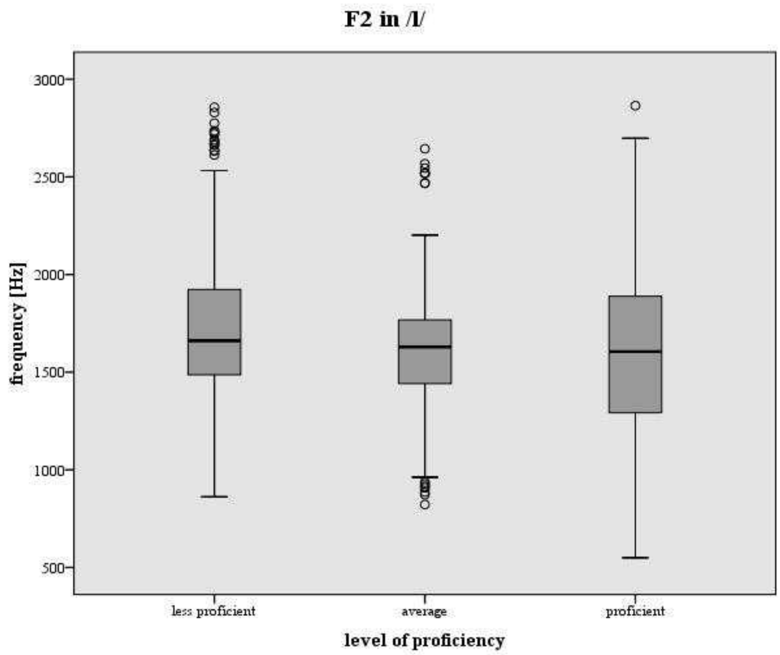


Figure 5. Distribution of F_2 in /l/ for less proficient vs. average vs. proficient speakers.

6.3.2. Discussion

The data reported in this section confirm the validity of the hypothesis in almost all respects. Proficient and less proficient speakers were assigned different mean value heights, depending on the vowel formant frequency. In accordance with Fant (1960), there is positive F_2-correlation with tongue dorsum fronting and raising and a high F_2 serves as indication of a low degree of velarization and vice versa. In contrast, F_1 is detected to be in direct relation to velarization (Recasens, Fontdevila & Pallarès 1995:41). Importantly, F_2 decreases, whereas F_1 increases, if the degree of velarization rises. Average speakers do not behave as predicted in F_2, but as in F_1. One-way ANOVA (Scheffé) test results shown in Table 7 reveal no significant differences between proficient vs. average learners and a higher F_2 in average than in proficient speakers. This statistical outcome indicates that average speakers come quite close to proficient speakers' language pronunciation aptitude. The higher F_2 in average speakers might occur to a minor extent for reasons of over-generalization than for differences in the production of the following vowels. These succeeding vowels are produced with more constriction in the frontal part of the tract due to a missing representation of their precise realization.

6.4. Accounting for individual differences in the pattern of velarization: a case comparison

Differences in degree of velarization or coarticulatory resistance in German and in English might not exclusively be a result of English proficiency or even phonetic talent, i.e. pre-existing individual differences in phonetic discrimination ability (Díaz et al. 2008), but also of individual differences in cognitive aspects such as empathy, mental flexibility, working memory capacity, intelligence, personality traits and biological aspects, musicality, convergence skills, prosody imitation abilities (Chapter 1), as well as age of learning onset (Chapter 1; Lenneberg 1967:176, 377), differences in vocal tract size and gender (Chapter 2). In this chapter a more detailed look will be taken at the most proficient speaker, AT, and the least proficient speaker, DB. While comparing AT (26 years) with DB (41 years), it seems to be obvious that experience and the amount of exposure to English has a great impact on pronunciation proficiency besides all the multiple factors mentioned above. When participating in the extensive experiments of the DFG project, AT was studying German, Anglistics and Politics at the University of Tübingen/Germany. The first foreign language she acquired in school was English, then also learning French as L3. From the age of seventeen onwards AT travelled many times to England and the United States for several weeks of stay, spending even one year at the University of Warwick in West Midlands/England after school. As a consequence she made a lot of friends in England and America to whom she still maintains regular contact including visits. Since 2005 she has had an American boyfriend, who she also lives with. This is the reason for her to talk half time English and half time German daily.

In comparison with AT, DB (41 years) acquired English at school, afterwards studying economy of advertisement and business management. She was working as an event manager while participating in the experiments. The informant only visited an English speaking country (L.A./USA) once for three months many years ago, in 1984.

It is worth noting that AT has stayed more often and also longer periods of time in English speaking countries and additionally lives together with a native speaker, whereas DB only travelled to an English speaking country once and does not have the opportunity to use English regularly in daily life.

Following Clark, Yallop and Fletcher (2007:96) in RP the clear variant occurs before a vowel (e.g. *lend*, *alight*, *believe*) in syllable-initial and/or phrase-initial position, and the dark variant before a consonant or syllable- or word-finally (e.g. *wild*, *halt*, *will*, *hall*). Opposed to this, General American (GA) /l/ is overall composed of the velarized variant [ɫ] of the consonant, independent of position (Cruttenden 2008:85).

Table 9. Mean F_2 and F_v values (in Hz) for /ə/ before /aɪ/, /eɪ/, /y/ and /u:/ across /l/ in the most and least proficient female speakers. Standard deviations have been included in parenthesis.

Parameter	***AT***	***DB***
F_2	2316.58 *Hz* [237.872]	1734.00 *Hz* [288.435]
F_v	1952.68 *Hz* [221.483]	1313.35 *Hz* [307.099]

Figures 6 and 7 show spectrograms produced by AT and DB. In contrast to the initial hypothesis, AT visibly realized a non-velarized type of the consonant [l] leading to a high F_2 value, while there is a lot of velarization in [ɫ] for DB, i.e. low F_2. AT was categorized as RP dialectal speaker and therefore might be conscious of the fact that in RP the clear variant is present before a vowel in syllable-initial and/or phrase-initial position, and the dark one before a consonant or syllable- or word-final. DB might know about the general rule claiming that /l/ is more velarized in English than in German which made her try to come close to these varieties. Degree of velarization in /ə/ across /l/ before /u:/ for AT (Figure 6), most proficient speaker (very talented), and for DB (Figure 7), least proficient speaker with no identifiable accent (clear anti-talent) is thus different in these cases. Formants in the steady state of /ə/ are dissimilar, owing to the degree of consonantal velarization being lower for AT than for DB (cf Table 9).

In their re-examination of predictors for pronunciation accuracy, Purcell and Suter (1980) correlated pronunciation accuracy with four background variables, namely (1) the first language (L1), (2) aptitude for oral mimicry (on the basis of self-report), (3) length of residence in the target language country and/or living with a native speaker of the target language, and (4) degree of concern for pronunciation accuracy accounting for 67% of the variance in a regression analysis. The authors underlined that exceptional learning such as optimal input, i.e. long residence in the foreign country in question and living with a native speaker, are significant features for a reduced or no degree of accent at all. Obviously, AT and DB subjects differ in the factors outlined, and it can finally be concluded that they therefore importantly diverge in their ability of English accent production and at the same time in their insertion of degree of velarization. Interestingly, AT did not adapt to the American accent of her boyfriend, but apparently kept the one she acquired during her stays in England. Even if DB's degree of velarization was calculated to be high, the acoustical impression ended up in no identifiable accent production, which leads to the question of the importance of velarization for the categorization in levels of proficiency and for the auditive perception of English accent (cf Chapter 6.5.2.).

The very proficient speaker, AT, who has undergone all the experiments of the *Language Talent and Brain Activity* project seems to have achieved her excellent pronunciation skills more by reason of her cognitive and personality factors, among other things her being a sociable person, than by structured, conscious learning effects and explicit knowledge about the sound system of the foreign language (cf Chapter 1.2.3.1.). Personality testings (cf Chapter 1.2.3.) have shown that personality factors have an enormously great impact on the phonetic-articulatory aspect of the second language, i.e. pronunciation talent. To sum up, it can be concluded that outstanding pronunciation skills depend on: either 1. systematical learning methods, a life long commitment to learning languages, or 2. certain characteristic cognitive and also personality traits, residence in the foreign country, living with a foreign person speaking the language in question, or 3. it is *talent* per se.

In the next chapter degree of velarization across dialectal varieties will be compared for the purpose of uncovering, if auditive perception of an accent matches with the degree of velarization assumed.

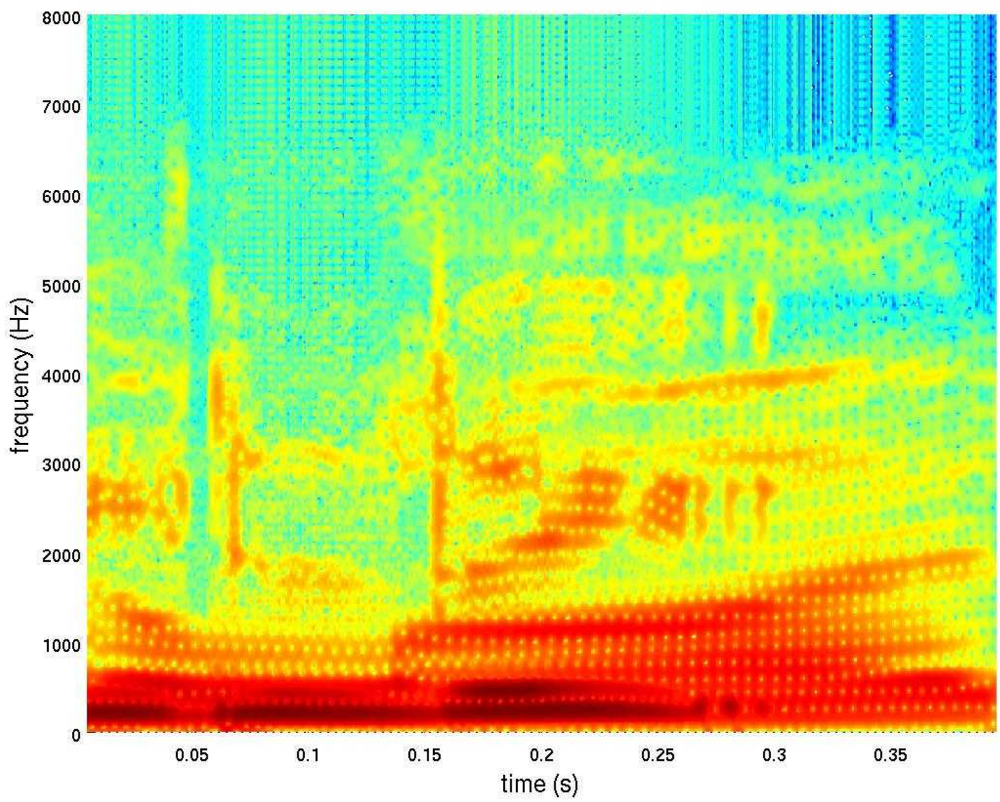


Figure 6. Spectrogram of the target stimulus "[*dʒəlut*]" produced by AT, a very talented RP speaker of English.

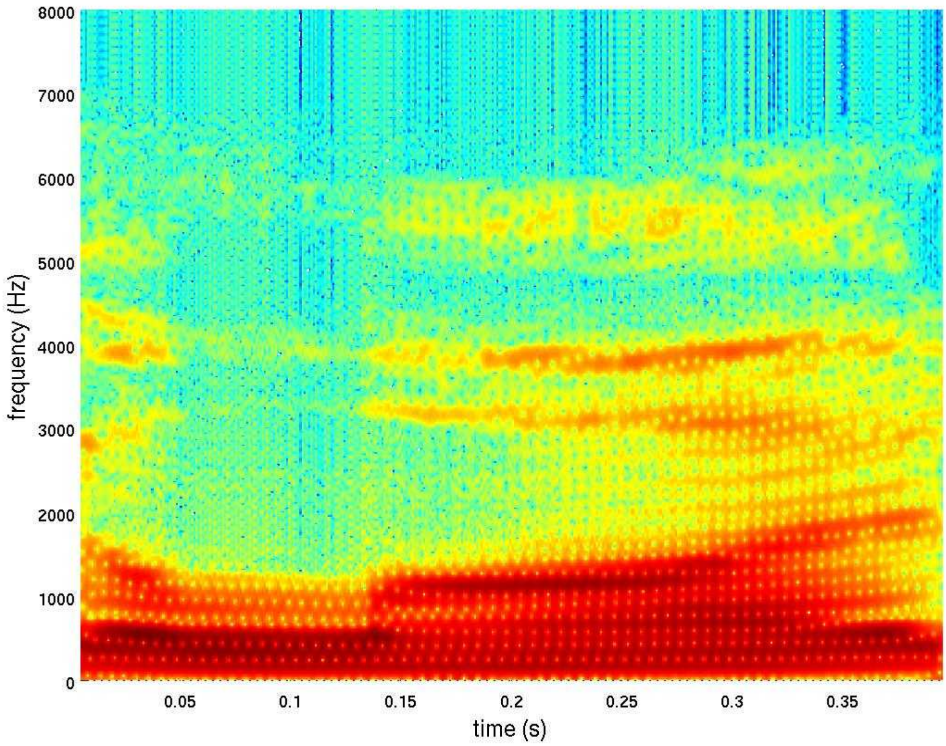


Figure 7. Spectrogram of the target stimulus "[*dʒəlut*]" produced by DB, a clear anti-talent with considerable English accent production.

6.5. Analysis 3: Degree of velarization in /əlV/ sequences across dialectal varieties and levels of proficiency

To create his data for the phonetic experiments, Jilka (2009b:23) interpolated clear /l/ in all positions because of its presence in syllable-/phrase-final position being an important signature for strongly German accented speech. Overall dialectal varieties differ according to the degree of velarization inserted in the consonant. Consequently, the English of Londoners and South Australians, for example, is characterized through a more intense degree of velarization than other dialectal varieties. RP and GA English can clearly be distinguished by means of the degree of velarization introduced in syllable-initial and/or phrase-initial position. Whereas in RP the clear variant occurs before a vowel (e.g. *lend*, *alight*, *believe*), and the dark variant before a consonant or syllable- or word-finally (e.g. *wild*, *halt*, *will*, *hall*) (Clark, Yallop & Fletcher 2007:96), in General American (GA) /l/ constantly consists of a velarized variant [ɫ] of the consonant, independent of position (Cruttenden 2008:85). That is why the author follows the assumption that the degree of velarization has a great impact on the auditive assessment of the dialectal variety intended to be realized and in the same line of exploration on the categorization of speakers in their levels of proficiency.

6.5.1. Degree of velarization in /əlV/ sequences across dialectal varieties

Based on previous studies (e.g. Recasens, Fontdevila & Pallarès 1995) and Cruttenden's description of the velarization pattern in GA, the author predicted that GA speech shows a higher degree of velarization than German GA accented speech, than Mid-Atlantic, RP, German RP accented speech or German speech. Furthermore, less proficient speakers realize more German accented speech within which no or very little velarization should be detectable compared to proficient speech (RP or GA or Mid-Atlantic). Average speakers produce German speech with RP or GA colouration and lie between proficient and less proficient speakers. Following these assumptions, the author assumed F_2 and F_v in German accented speech to be the highest, and in more German speech to be slightly lower, decreasing more and more with highly proficient speakers producing RP, MA or GA dialectal varieties, leading to the following order of vowel formant frequency heights ((1) < (5) < (6) < (2) < (4) < (3)). Combining previous outcomes with present assumptions, the author is assured of finding significant interactions also between degree of velarization and dialectal variety.

6.5.1.1. Subjects, materials and procedure

Subjects, materials and procedure were identical to Analysis I.

6.5.1.2. Results

One-way ANOVAs across dialectal varieties revealed significant differences in F_2 ($F(5) = 7.669$, $p < .000$) and F_v ($F(5) = 6.982$, $p < .000$), which were shown by Scheffé-tests. Figures 8 and 9 show significant one-way ANOVA (Scheffé) test results of F_2 and F_v ($df_{bg} = 5$, $df_{wg} = 812$, $p < .000$) after comparison of F_2 and F_v in GA (1); RP (2); German accent (3); German accent, but RP colouration identifiable (4); German accent, but GA colouration identifiable (5) and Mid-Atlantic (6) speakers of English.

Table 10. One-way ANOVA (Scheffé) test results comparing degree of velarization and dialectal variety in F_2.

Dialectal variety comparison	Significance	
1 - 5	$p < .024$	*
2 - 5	$p < .000$	*
3 - 5	$p < .000$	*
4 - 5	$p < .048$	*

Table 11. One-way ANOVA (Scheffé) test results comparing degree of velarization and dialectal variety in F_v.

Dialectal variety comparison	Significance	
1 - 5	$p < .003$	*
2 - 5	$p < .000$	*
3 - 5	$p < .000$	*
4 - 5	$p < .016$	*

Mean values in **(5)** (F_2: 1765.095 *Hz* [402.9530]; F_v: 1358.115 *Hz* [411.9531]) were significantly lower than those in **(1)** (F_2: 1893.329 *Hz* [254.0437]; F_v: 1516.371 *Hz* [260.5381]), **(4)** (F_2: 1906.875 *Hz* [205.2243]; F_v: 1524.830 *Hz* [219.8023]), **(3)** (F_2: 1932.210 *Hz* [319.5533]; F_v: 1557.681 *Hz* [338.8189]) and **(2)** (F_2: 2000.434 *Hz* [304.9347]; F_v: 1571.192 *Hz* [336.8198]), while (2) > (3) > (4) > (1) > (6) (F_2: 1772.639 *Hz* [304.8369]; F_v: 1417.750 *Hz* [288.3972]) > **(5)** (cf also Fig. 8 and 9), i.e. degree of velarization in F_2 and F_v was lower for (2) compared to (3), (4), (1), (6) and (5).

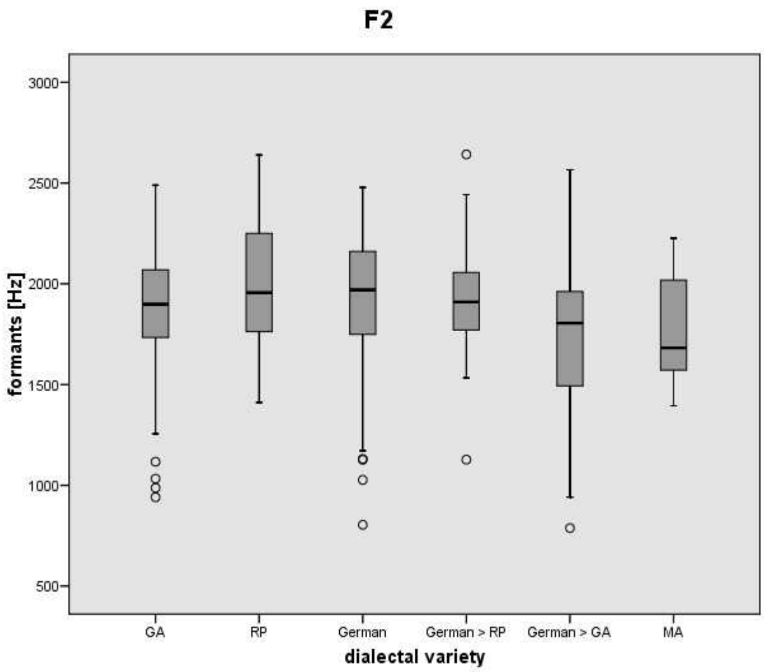


Figure 8. F_2 depending on dialectal varieties.

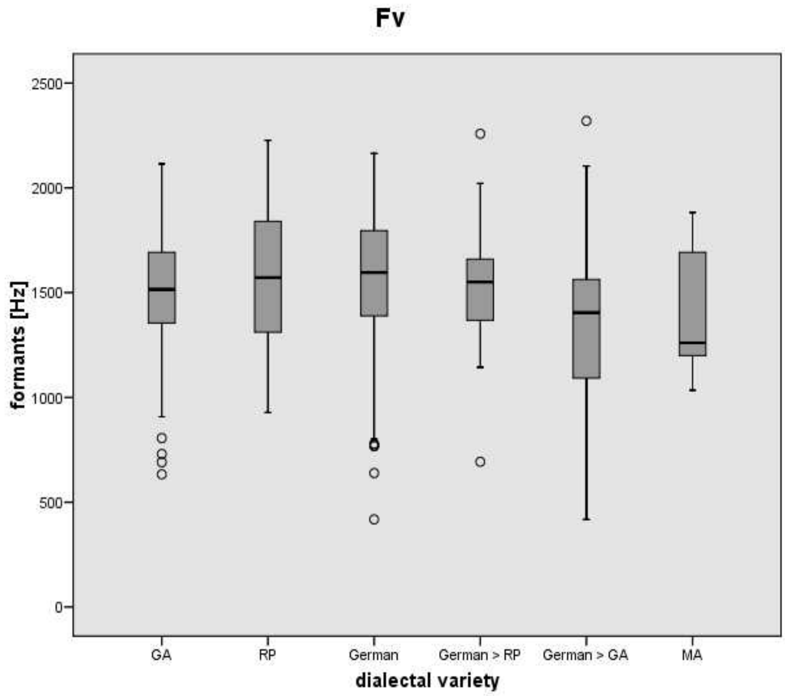


Figure 9. F_v depending on dialectal varieties.

6.5.2. Degree of velarization, dialectal variety and levels of proficiency

In a second step, in order to look for correlations between the degree of velarization, dialectal variety and level of proficiency another statistical analysis followed up. Based on previous findings (Baumotte 2009), the author expected proficient speakers to be more conscious of English having the velarized variant [ɫ] of the consonant than average and less proficient speakers. While previously analysing the correlation of the degree of velarization and dialectal varieties, the author did not take the levels of proficiency into account. With regard to the allophonic variants in dialectal varieties, the author however assumed less proficient speakers to realize German speech compared to proficient speakers producing RP or MA or GA. Average speakers were expected to articulate more German speech, but listeners might be able to perceive a tendency towards RP or GA accented speech. Taking into consideration the insights from the analyses conducted before and the outcome from the above paragraph, the author also presumed significant results between degree of velarization, dialectal variety and level of proficiency; degree of velarization also serving as a crucial sign for the categorization in levels of proficiency.

Subjects, materials and procedure were the same as in Analysis 1.

6.5.2.1. Methods

Descriptive statistics were called for to get a general idea of the distributions of vowel formant frequency mean values. A two-way variance analysis (saturated model) ANOVA (Scheffé) was calculated for the purpose of combining the factors *degree of velarization*, *dialectal variety* and *levels of proficiency*.

6.5.2.2. Results

Descriptive statistics for F_2 and F_v pointed to average and proficient speakers producing GA accented speech, to proficient speakers realizing RP accented speech and to German accented speech being articulated by less proficient and average speakers, as well as to German speech with RP and GA colouration being pronounced across the complete range of proficiency levels. In the group of MA accented speech, there was only one speaker who was categorized as proficient.

A two-way variance analysis (saturated model) ANOVA (Scheffé) of F_2 and F_v across proficiency levels and dialectal varieties revealed significant deviation from the mean of at least in one category of the factor in both comparisons (F_2: $F(11) = 14.319$, $p < .000$; F_v: $F(11) = 13.092$, $p < .000$ [($df_{bg} = 5$, $df_{wg} = 812$]). Tables 12 and 13 show significant two-way variance results, which were computed by Scheffé-tests.

Table 12. Two-way variance analysis (saturated model) ANOVA (Scheffé) test results comparing degree of velarization, dialectal variety and proficiency level (less proficient – 1, average – 2, proficient - 3) in F_2.

Velarization/ dialects – proficiency	Significance	
1 - 2	$p < .000$	*
2 - 3	$p < .040$	*
3 - 1	$p < .014$	*
3 - 2	$p < .024$	*
4 - 1	$p < .002$	*
5 - 1	$p < .006$	*
5 - 3	$p < .000$	*

Table 13. Two-way variance analysis (saturated model) ANOVA (Scheffé) test results comparing degree of velarization, dialectal variety and proficiency level in F_v.

Velarization/ dialects – proficiency	Significance	
2 - 3	$p < .035$	*
3 - 2	$p < .042$	*
4 - 1	$p < .021$	*
5 - 3	$p < .000$	*

Tables 12 and 13 show significant results for F_2 and F_v with regard to the several comparisons of degree of velarization, dialectal varieties and levels of proficiency.

The comparisons of degree of velarization, dialectal varieties and levels of proficiency showed that high quality accented speech in F_2 for GA and RP was significantly articulated by proficient and average, as well as in F_v for RP by proficient speakers of L2 English, while German accented speech in F_2 significantly interacted with less proficient and average speakers and in F_v with average speakers. For German RP accented speech there was a significant interaction between less proficient speakers for F_2 and F_v, whereas German GA accented speech was realized for F_2 by proficient and also less proficient, and for F_v by proficient speakers of L2 English.

6.5.3. Discussion

The comparison of degree of velarization and dialectal variety reported in this paper suggests that German L2 speakers of English converged with native English speakers while taking into account their ability to velarize /l/, depending on the variety of English they intended to realize. Compared to the hypothesis ((1) < (5) < (6) < (2) < (4) < (3)) velarization degree in dialectal varieties differs with regard to the position of GA and RP accented speech, while RP accented German speech and German occur in reversed order (result: (5) < (6) < (1) < (4) < (3) < (2)).

In contrast to the initial hypothesis, the anticipated ordering of dialectal varieties was not precisely confirmed. There are significant interactions between German GA accented speech and all the other varieties, except MA. The MA speaker was probably highly influenced by GA accented speech giving to a degree of velarization even higher than that in GA. The author has analyzed only one MA speaker and for this reason is not able to make any further conclusions. Additionally, German speakers with GA accent might know about the overall phonological rule of velarizing /l/ in all positions. Obviously, the speakers were able to highlight the characteristic feature of GA which makes their speech identifiable as coming close to GA speech, even if velarization might be exaggerated in German GA accented speech. At the same time, these speakers apparently disregarded other important patterns such as, e.g. prosody, fluency, vocabulary and grammar, and pronunciation of the remaining consonants and vowels (Anufryk 2009; Jilka 2009b).

Remarkably, less transparent results ensued from the inclusion of levels of proficiency regarding all significant outcomes. GA and RP of high quality accented speech in F_2 were produced by proficient and average and in F_v for RP by proficient speakers of L2 English, German accented speech in F_2 by less proficient and average speakers and in F_v by average speakers, as well. But, confusingly, German RP accented speech was realized by less proficient speakers for F_2 and F_v and German GA accented speech for F_2 by proficient and also less proficient, but for F_v by proficient speakers of L2 English only.

In conclusion, the correspondences between degree of velarization and dialectal variety as well as between degree of velarization, dialectal variety and levels of proficiency might be a substantial indication for the huge impact of the pattern of velarization on the auditive assessment of dialectal varieties and in addition on the categorization in levels of proficiency, even if the degree of velarization seems to give lesser hints to the level of proficiency than to the dialectal variety spoken.

6.6. Analysis 4: Coarticulatory resistance in /əlV/ clusters

6.6.1. Subjects, materials and procedure

Subjects, materials and procedure were identical to Analysis I.

Following Recasens, Fontdevila and Pallarès (1995:47), the author predicted that coarticulatory sensitivity was inversely related to the degree of consonantal velarization, i.e. /l/ would be more context-dependent in German low proficient speakers of English than in highly proficient learners. According to Recasens and Farnetani (1990, 1991), this general hypothesis is valid for languages with very different varieties of the consonant /l/, e.g. Italian and Catalan. In order to test the hypothesis, the author analyzed coarticulatory resistance of /eɪ/ vs. /u:/, /y/ vs. /eɪ/, as well as /y/ vs. /aɪ/ on /l/ in symmetrical VCV-sequences (*[dʒəlaɪt] [dʒəleɪt] [dʒəlyt] [dʒəlu:t]*) produced by non-native speakers of English. The vowel sequence /eɪ/ (lips are spread [Gimson 1980:129]) vs. /u:/ (lips are rounded [Gimson 1980:121]) has been chosen since it presents two maxima along the articulatory dimension concerning roundedness/unroundedness and backness/fronting. The vowel

/y/ (lips are rounded [Pompino-Marschall 1995:212]) and the diphthong /eɪ/ (lips are spread [Gimson 1980:129]) are both front vowels produced with a constricted pharynx differing in roundedness. /y/ (lips are rounded [Pompino-Marschall 1995:212]) vs. /aɪ/ (lips change from a neutral position to a loosely spread one [Gimson 1980:131]) integrates a loose difference in roundedness/unroundedness and a slight distinction in jaw opening/closing. Within the production of the RP diphthongal glide "/aɪ/" the lower jaw closes, coming closer to the position of RP associated /ɪ/ (Gimson 1980:131), but usually not reaching a tongue level closer than C [ë]. The front-close rounded vowel [y] (Pompino-Marschall 1995:212, 254) does not exist in any variety of English, either American or British (cf IPA transcriptions [German: Kohler 1999; Mangold 2005; British English: Gimson 1980]). The vowel [y] has been included because there is interest in examining if it continues to be articulated in the German-specific manner, bearing in mind that the English phonetic alphabet does not contain this vowel.

The author expected proficient speakers to velarize more, therefore their speech would be more coarticulatory resistant, i.e. /ə/ would emerge closer to its formant frequencies as a neutral vowel (F_1 = 560 *Hz*, F_2 = 1480 *Hz*, F_3 = 2520 *Hz* [Gimson 1980:101]). In contrast, less proficient speakers would coarticulate more because of a lesser degree of velarization while producing the non-velarized allophonic variant [l].

Consequently, coarticulatory distance was calculated using frequency measurements made from spectrograms in *Hz* by means of the following formula:

$$e.g.\ \mathrm{CD} = F_{2\text{əleɪ}} - F_{2\text{əluː}}$$

The author modified the MCD (mean coarticulatory distance) calculation proposed by Bladon and Al-Bamerni (1976:142). The so-called degree of coarticulation or coarticulatory distance is an appropriate measurement to distinguish the deviation from the canonical vowel (cf below) indicated by the decrease or increase of F_2 and F_2' in the neutral vowel /ə/.

F_2- and F_2'[3]-values would be positive in the case of /eɪ/ (/e/: F_2 = 2060 *Hz*, F_3 = 2840 *Hz,* F_2' = 2450 *Hz*; /ɪ/: F_2 = 2220 *Hz*, F_3 = 2960 *Hz,* F_2' = 2590 *Hz* [Gimson 1980:101]) vs. /uː/ (F_2 = 920 *Hz*, F_3 = 2200 *Hz,* F_2' = 1560 *Hz* [Gimson 1980:101]) and /y/ (F_2 = 1750 *Hz* [Delattre 1981:73]) vs. /aɪ/

3 According to Chistovich and Lublinskaya (1979) and the "center of gravity" hypothesis, F_2' ([F_2 + F_3]/2) was taken to make it similar to a single-formant stimulus because F_2 and F_3 are closely spaced.

(/ʌ/: F_2 = 1320 *Hz*, F_3 = 2500 *Hz,* F_2' = 1910 *Hz*; /ɪ/: F_2 = 2220 *Hz*, F_3 = 2960 *Hz,* F_2' = 2590 *Hz* [Gimson 1980:101, 131]), but not within the /y/ (F_2 = 1750 *Hz* [Delattre 1981:73]) vs. /eɪ/ (/e/: F_2 = 2060 *Hz*, F_3 = 2840 *Hz,* F_2' = 2450 *Hz*; /ɪ/: F_2 = 2220 *Hz*, F_3 = 2960 *Hz,* F_2' = 2590 *Hz* [Gimson 1980:101]) comparison.

In this study, high positive/negative values indicate coarticulation, while values around 0 *Hz* indicate coarticulatory resistance. In general, the closer the frequency value comes to 0 *Hz*, the more coarticulatory resistance is present in the given stimulus.

In order to measure whether the degree of coarticulatory resistance effects were significant, one-way ANOVAs were submitted separately for F_2 and F_2' in /əleɪ/ vs. /əlu:/, /əly/ vs. /əleɪ/ and /əly/ vs. /əlaɪ/, with proficiency level as the independent variable. Further, the interactions between the degree of coarticulation/coarticulatory resistance and each proficiency level were calculated by means of a correlation analysis (Scheffé tests) between the formant frequency value differences in /ə/. The purpose of this analysis was to investigate whether an increase in a given proficiency level was matched with an increase in the degree of coarticulatory resistance; and less importantly, if the degree of coarticulatory resistance and the proficiency level were strongly correlated.

6.6.2. Results

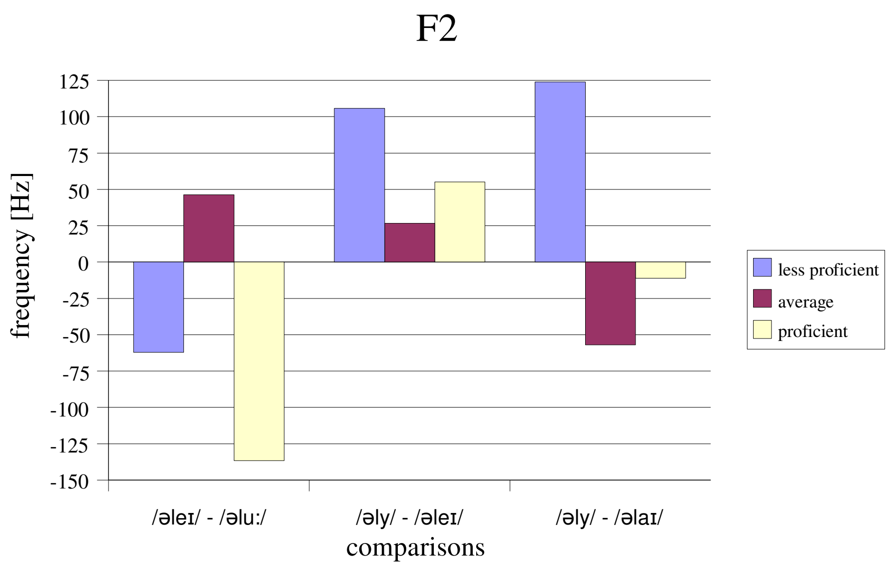
Significant interactions between average (2) and proficient (3) speakers in F_2 regarding /əleɪ/ vs. /əlu:/ ($F(2)$ = 6.543, $p < .002$ [df_{bg} = 2, df_{wg} = 202]); *mean values:* 2: 46.342 *Hz* [238.6699], 3: -136.672 *Hz* [316.2980]) and with regard to /əly/ vs. /əlaɪ/ ($F(2)$ = 5.188, $p < .006$ [df_{bg} = 2, df_{wg} = 200]); *mean values:* 1: 123.827 *Hz* [291.6895], 2: -56.915 *Hz* [324.7471], 3: -11.152 *Hz* [317.4112]) in less proficient (1) vs. average and proficient speakers.

F_2' differed significantly between average vs. proficient speakers in /əleɪ/ vs. /əlu:/ ($F(2)$ = 5.541, $p < .005$ [df_{bg} = 2, df_{wg} = 202]); *mean values:* 2: 52.5958 *Hz [175.96688],* 3: -57.7389 *Hz* [220.27336]) and between less proficient vs. average and proficient speakers in /əly/ vs. /əlaɪ/ ($F(2)$ = 4.878, $p < .009$ [df_{bg} = 2, df_{wg} = 200]); *mean values:* 1: 52.8909 *Hz* [259.26265], 2: -58.8432 *Hz* [215.91557], 3: -41.0618 *Hz* [161.28139]).

Furthermore, no significant correlations could be detected between F_2 and F_2' in /əly/ vs. /əleɪ/ and proficiency level.

Table 14. One-way ANOVA (Scheffé) test results after comparison CD of F_2 in /əleɪ/ vs. /əlu:/ in less proficient (1) vs. average (2) vs. proficient (3) non-native English speech.

Stimuli	***Parameter***	***Groups***	***Significance***	
	F_2			
/əleɪ/ vs. /əlu:/		2 - 3	$p < .002$	*
/əly/ vs. /əlaɪ/		1 - 2	$p < .010$	*
		1 - 3	$p < .044$	*
	F_2‘			
/əleɪ/ vs. /əlu:/		2 - 3	$p < .005$	*
/əly/ vs. /əlaɪ/		1 - 2	$p < .018$	*
		1 - 3	$p < .033$	*



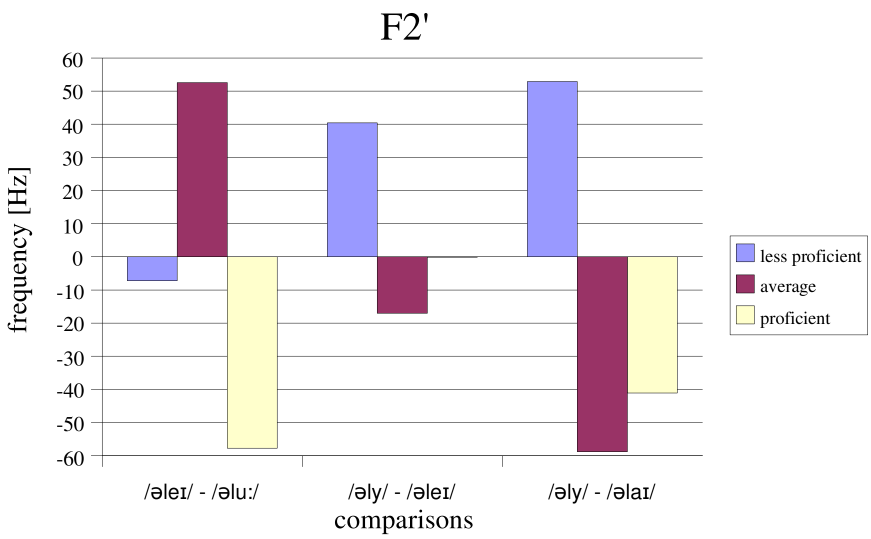


Figure 10. Coarticulatory resistance values for F_2 (above) and F_2' (below) comparisons of /əleɪ/ - /əlu:/, /əly/ - /əleɪ/ and /əly/ - /əlaɪ/ in less proficient vs. average vs. proficient learners.

Front close spread /əleɪ/ vs. back close rounded /əlu:/

For /eɪ/ vs. /u:/, i.e. the backness/fronting- and the roundedness/unroundedness-distinction, the degree of velarization does not tend to be in relation to proficiency level, thus refuting the initial hypothesis. Figures 9 and 10 clarify that less proficient speech is more coarticulatory resistant, while more proficient English speech shows a quite high amount of coarticulation in F_2 and F_2' to coarticulatory effects from /eɪ/ vs. /u:/. Average speakers' F_2' lies between the one of proficient and less proficient learners, their F_2 being even more coarticulatory resistant than that of less proficient speakers. A closer look at F_2 reveals a high degree of coarticulation in proficient speakers (*mean value:* -136.672 *Hz*) compared to less proficient speakers (*mean value:* -62.127 *Hz*) who are more coarticulatory resistant. Average speakers' value (*mean value:* 46.342 *Hz*) turned out to be the only one tending in a positive direction and the nearest to 0 *Hz*, i.e. being the most coarticulatory resistant. For F_2' CR mean value is the lowest for less proficient speakers (*mean value:* -7.2136 *Hz*) in comparison to proficient speakers, reaching a high degree of coarticulation (mean value: -57.7389 *Hz*), whereas average speakers coarticulated only slightly less than proficient speakers, but also obtained a positive mean value (52.5958 *Hz*). Comparisons for F_2 and F_2' in proficient vs. less proficient speakers were insignificant. According to the prediction, the values for F_2 and F_2' in proficient, average and less proficient subjects would be positive, but they were negative in the cases of F_2 and F_2' for less proficient learners and for proficient speakers (cf above). In contrast, average speakers reached positive CR values in both calculations (*mean value F_2:* 46.342 *Hz, mean value F_2':* 52.5958 *Hz*), with average vs. proficient speakers being significantly distinguishable in

F_2 and F_2'.

Front close rounded /əly/ vs. front close spread /əleɪ/

The /əly/ vs. /əleɪ/-comparison, i.e. roundedness vs. spreadness-distinction, in F_2 and F_2' for proficient vs. less proficient speakers tends towards the predicted direction concerning coarticulation and coarticulatory resistance values. Whereas average speakers' values for F_2' are according to the hypothesis within those of proficient and less proficient speakers, average learners' values for F_2 are even lower than those of proficient speakers. F_2- and F_2'-results for less proficient speakers are, contrary to the hypothesis, positive, while F_2'-values for average and proficient speakers turned out to be rather negative. No significant effects could be revealed for any of the F_2- and F_2'-comparisons for proficient (*mean value F_2:* 55.094 *Hz*; *mean value F_2':* -0.0889 *Hz*), less proficient (*mean value F_2:* 105.700 *Hz*; *mean value F_2':* 40.400 *Hz*) or average (*mean value F_2:* 26.720 *Hz*; *mean value F_2':* -17.0551 *Hz*) speakers.

Front close rounded /əly/ vs. front half-close loosely spread /əlaɪ/

Most significant effects occurred for these /y/ vs. /aɪ/ comparisons differing in closure and at the same time slightly in roundedness: F_2 and F_2' results were revealed to be significant in average vs. less proficient and proficient vs. less proficient speakers. F_2 and F_2' values for /y/ vs. /aɪ/-comparisons were, in contradiction to the hypothesis, exclusively positive for the group of less proficient speakers (*mean value F_2:* 123.827 *Hz*; *mean value F_2':* 52.8909 *Hz*), whereas the average (*mean value F_2:* -56.915 *Hz*; *mean value F_2':* -58.8432 *Hz*) and proficient speakers' (*mean value F_2:* -11.152 *Hz*; *mean value F_2':* -41.0618 *Hz*) blocks tend towards the negative direction. In line with the hypothesis, proficient speakers were more coarticulatory resistant than less proficient speakers in both comparisons. Average speakers lay between proficient and less proficient speakers for F_2, but the value for F_2' was even lower/the furthest away from the x-axis than that for proficient and less proficient speakers (*mean value F_2':* -58.8432 *Hz*), indicating the highest degree of coarticulation.

6.6.3. Discussion

Front close spread /əleɪ/ vs. back close rounded /əlu:/

Contrary to the hypothesis, there is more resistance in F_2 and F_2' for less proficient than for proficient speakers. At the same time, coarticulatory resistance values for F_2 and F_2' in less proficient and proficient speakers tend towards the negative direction, in contrast to those for average learners' values. If a constriction in the frontal part of the tract takes place, frequency values of F_2 increase. This is why F_2 reaches its maximum for front vowels such as /i/. Constriction in the back of the tract leads to a decrease in F_2, dependent on the degree of constriction. As was expected, back vowels such as /u:/ show low second formant frequencies. Proficient and less proficient speakers might not have pronounced an /eɪ/ in most of the cases, but instead a vowel with less constriction in the frontal part of the tract. The influence of F_2 on /ə/ before /leɪ/ is higher because of a considerably high degree of coarticulation. Obviously, average learners realized an [eɪ] with constriction in the frontal part of the tract, but, on the other hand, low F_2 values for [u:], which resulted in rather high positive values.

F_2' (mean value of F_2 and F_3) values do not exclusively include the constriction of the tract, but also integrate lip rounding. Lip rounding leads to a constriction of the tract, and at the same time includes lip protrusion which is commonly more extended in back rounded vowels than in front rounded vowels. The more lip rounding there is, the lower the F_2 and F_3 formant frequencies. In contrast to average speakers, proficient and less proficient speakers might have produced /u:/ with a low degree of lip rounding (high F_2 and F_3 values). It can be concluded that, while proficient speakers coarticulate more, compared to average and less proficient speakers, less proficient speech is more resistant to the coarticulatory effects of F_2 and F_2' on /ə/ from /eɪ/ vs. /u:/.

Front close rounded /əly/ vs. front close spread /əleɪ/

In the case of the front close rounded/spread vowel-distinction for F_2, there is less coarticulation from /y/ vs. /eɪ/ for proficient than for less proficient learners, but the differences are insignificant. In total, less proficient and proficient speakers coarticulate a lot, while average speakers are fairly resistant to the influence of the formant frequencies of the vowel following /l/ on /ə/. Lowered F_2 values for /eɪ/ might have led to positive F_2 values, taking into account the values for /y/ (F_2 = 1750 *Hz* [Delattre 181:73]) vs. /eɪ/ (/e/: F_2 = 2060 *Hz*, F_3 = 2840 *Hz*, F_2' = 2450 *Hz;* /ɪ/: F_2 = 2220 *Hz*, F_3 = 2960 *Hz*, F_2' = 2590 *Hz* [Gimson 1980:101]). F_2' results confirm the hypothesis of proficient speakers being more coarticulatory resistant than average and less proficient speakers, because of an increase of degree of coarticulation in F_2' reverse to proficiency level. In less proficient learners the influence of lip rounding in /y/ on /ə/ might not be high, or the vowel might be articulated in a lesser rounded manner (the higher F_2 and F_3, the less lip rounding there is), because F_2' tends towards the positive direction. In opposition to this, average and proficient speakers' F_2' formant frequencies are negative, indicating a higher degree of lip rounding in /y/ of these subjects.

Front close rounded /əly/ vs. front half-close loosely spread /əlaɪ/

According to the hypothesis, F_2 and F_2' differences in CR of proficient vs. less proficient and less proficient vs. average speakers on /ə/ across /l/ (/əly/ minus /əlaɪ/) are significant, while proficient speakers are more coarticulatory resistant than less proficient speakers. The average speakers' CR value is fairly resistant in F_2, in contrast to the F_2'-value showing a large degree of coarticulation which is even higher than that for less proficient speakers.

The calculation of coarticulatory resistance in F_2 and F_2' resulted in positive values in less proficient speakers (/y/: F_2 = 1750 *Hz* [Delattre 1981:73]; /aɪ/: /ʌ/: F_2 = 1320 *Hz*, F_3 = 2500 *Hz*, F_2' = 1910 *Hz*; /ɪ/: F_2 = 2220 *Hz*, F_3 = 2960 *Hz*, F_2' = 2590 *Hz* [Gimson 1980:101, 131]). Roundedness might not influence the frequency value of F_3 in /y/ to a noticeable extent, but if so, coarticulatory resistance values for F_2' should be negative, due to roundedness lowering the frequencies of F_3. In the beginning of /aɪ/-articulation, the jaws are considerably separated, while the lips are opened neutrally (similar to the articulation of RP type of /ʌ/ [Gimson 1980:131]). The tongue is elevated just above the fully open position with no contact to the upper molars. During the production of /ɪ/ the lower jaw closes continuously. In contrast, /y/ is characterized through roundedness and a constricted pharynx. It seems as if roundedness does not highly influence the formant frequency values of F_2' in less proficient speakers. In less proficient speakers F_2 and F_2' and in average as well as proficient speakers F_2' coarticulation of /y/ vs. /aɪ/ across /l/ is fairly irresistant; however, average and proficient speakers show a large degree of resistance in F_2 which could be an indication of these speakers realizing the stimuli with a more active tongue dorsum gesture.

To summarize, significant correlations for F_2 and F_2' in /əly/ vs. /əlaɪ/ and tendencies for coarticulation and coarticulatory resistance in /əly/ vs. /əleɪ/ might be attributable to the same mechanism of articulatory coordination pointed out for the degree of velarization results, in which proficient speakers velarize more than average as compared to less proficient speakers, even if average speakers do not lie between those of proficient and less proficient speakers in the case of F_2 for the comparison /əly/ vs. /əleɪ/ and F_2’ for /əly/ vs. /əlaɪ/.

/əleɪ/ vs. /əlu:/ results of proficient and less proficient speakers are in opposition to the results of the degree of velarization. These contradictory analysis results might account for the integration of two different vowel characteristics in their full amount: close [F_1 decrease] vs. open [F_1 increase], i.e. half-close, and spread [F_2 and F_3 increase] vs. rounded [F_2 and F_3 decrease]) which might somehow compete with each other (front close spread /əleɪ/ vs. front half-close rounded /əlu:/).

6.7. Analysis 5: Distribution of vowel formant frequencies in /əl*V*/ clusters

Bearing in mind that English vowels need to be produced differently from German vowels, the question arises of whether speakers of various proficiency levels realize the English vowels following /l/ in contrasting ways.

According to their International Phonetic Alphabets English and German vowel systems are clearly dissimilar and also RP as well as GA English can be distinguished as is pointed out in Chapter 2.2. (cf Appendix C: International Phonetic Association 1999; Roach 2004) and Chapter 2.3.. In this regard their vowel formant frequency values are different, even if the phonetic transcription is the same. In Table 1 the author gives an overview of vowel formant frequency values in German vs. RP English vs. American English.

Therefore, the subsequent paragraph carries out measurements of the formants in the English vowel productions after the consonant /l/ to expose their frequency distributions. Although, the author is aware of RP English vs. GA English being also distinguishable in vowel formant frequencies, dialectal differences are not considered in this work because of assuming that these are minor in L2 speakers of English than the distinctions made between German vs. English.

A more in-depth look will be taken on /y/ because this vowel is not present in the English vowel system and was selected for the experiment to be able to reflect if subjects are sensible to this circumstance and how they deal with it.

Based on the findings of Scherer and Wollmann (1977:155; cf also Chapter 2.2.) who have compared German with English vowels, the following differences are presumed for the vowels taken in proficient vs. average vs. less proficient L2 English speakers:

1. *front half-close loosely spread /aɪ/ (/ʌ/ - /ɪ/):*

For German speakers the pronunciation of /ʌ/ is difficult for the reason of its place of articulation repeatedly being realized inappropriately (Scherer & Wollmann 1977:155), the young generation produces this vowel as an open middle tongue vowel, in accordance /ʌ/ nearly matches the German short /a/ (formant frequency values: F_1 = 701.25 *Hz*, F_2 = 1398.75 *Hz*, F_3 = 2573.5 *Hz*, F_2' = 1986.13 *Hz* [Simpson 1998]), such as in *kann*.

Following Delattre (1965:53) comparable positions such as in /ɪ/ are located lower (more open) in English than in German, i.e. F_1 increase in comparison to German which is more closed (F_1 decrease).

Formant values for proficient speakers' /aɪ/ are assumed to be significantly higher (more close) than the ones of less proficient speakers. Average informants' vowel frequencies should be found in between those of proficient and less proficient speakers.

2. *front close spread /eɪ/ (/e/ - /ɪ/)*:

   The diphthong /eɪ/ is produced as a monophthong [e:] in General American (Cruttenden 2008:85).

   Comparable positions such as in /e/ and /ɪ/ as well as [e:] can be detected to be lower (more open) in English in contrast to German (Delattre 1965:53), i.e. F_1 increases in English compared to German speech.
   In general, more tongue lowering and backness as well as a lesser activity of the lips serve as distinctive features for English (Scherer & Wollmann 1977:156), i.e. F_1 increases (vowels are more *open*), F_2 and F_3 increase (vowels are more *spread*), which should lead to important differences in proficient vs. average vs. less proficient speakers' data.

3. *back close rounded /u:/*

   The number of the back (to middle) vowel phonemes is identical. However, the positions of the phonemes showing the same phonetic symbol are placed – except for /u:/ - wide apart, the widest apart for /ɔ/. /u:/ is less rounded in English than in German.

   /u:/ serves as the exception with respect to back (to middle) vowels, not being so far apart in the vowel trapezes which consider F_1 and F_2. But /u:/ should nevertheless be less rounded in English compared to German, i.e. higher F_2, F_3 and F_2'. As a consequence proficient vs. (average vs.) less proficient speakers should be found to differ significantly in F_2, F_3 and F_2'.

4. *front close rounded /y/*

The umlaut /y/ (Hütte) does not exist in English.

Proficient speakers should be sensible for /y/ not being present in English, while pronouncing it as it is common in German speech. Significant differences are supposed to be uncovered in proficient vs. less proficient speakers of L2 English.

6.7.1. Subjects, materials and procedure

Subjects and materials were identical to Analysis 1.

In contrast to the analyses above F_1, F_2 and F_3 were extracted 100 ms after the monophthong or diphthong onset following /əl/.

6.7.2. Results

As shown in Table 16, significant effects are found for the vowel formant frequency distributions measured in /aɪ/, /y/ and /u:/ after /əl/, whereas a different picture is obtained from /eɪ/ lacking significant distribution results in every comparison. Most interestingly, the frequencies of F_3 and F_2' in /y/ of [dʒəlyt] significantly differ in average vs. proficient speakers, which has also been shown in Figure 11. The mean values for average speakers (*mean values:* F_3 = 2502.41 *Hz* [335.953], F_2' = 2152.992 Hz [218.3415]) are lower in both cases than that for proficient speakers (*mean value:* F_3 = 2652.54 *Hz* [277.115], F_2' = 2243.706 *Hz* [222.0778]), less proficient speakers being in between those of average and proficient speakers (*mean values:* F_3 = 2582.25 *Hz*, F_2' = 2176.836 *Hz*).

Mean values for /aɪ/ revealed for F_1 a higher value for average speakers (*mean value:* 608.77 *Hz* [139.262]) than for proficient (*mean value:* 583.63 *Hz* [110.744]) and less proficient speakers (*mean value:* 547.07 *Hz* [105.534]). In opposition, the F_3 value for /aɪ/ in proficient speakers (*mean value:* 2911.57 *Hz* [223.514]) was higher than less proficient learners' (*mean value:* 2859.47 *Hz* [179.914]) and average speakers' mean values (2800.33 *Hz* [218.844]).

F_2 and F_3 for /u:/ showed the highest mean values for proficient speakers (F_2: 1760.01 *Hz* [385.708], F_3: 2713.49 *Hz* [258.469]) and lower mean values for less proficient speakers (F_2: 1528.49 *Hz* [423.666], F_3: 2613.87 *Hz* [383.397]). Average speakers' mean value was between those of proficient and less proficient speakers for F_2 (1592.87 *Hz* [358.134]), but not in the case of F_3 (2505.15 *Hz* [240.842]), in which it was even lower than that of less proficient speakers.

Table 16. One-way ANOVA (Scheffé) test results after comparison of F_1, F_2, F_3 and F_2' (in *Hz*) in /aɪ/, /eɪ/, /y/, /u:/ after /əl/ in less proficient (1) vs. average (2) vs. proficient (3) non-native English speech.

Stimuli	Parameter	$F(2)$ =	Significance	Group comparisons	
/əlaɪ/	F_1	3.920	$p < .021$	1-2: $p < .022$	*
	F_2	1.995	$p < .139$		
	F_3	4.993	$p < .008$	2-3: $p < .008$	*
	F_2‘	3.334	$p < .038$	2-3: $p < .060$	*
/əleɪ/	F_1	.978	$p < .378$		
	F_2	.287	$p < .751$		
	F_3	.385	$p < .681$		
	F_2‘	.473	$p < .624$		
/əlu:/	F_1	.530	$p < .589$		
	F_2	6.944	$p < .001$	1-3: $p < .003$ 2-3: $p < .038$	* *
	F_3	9.182	$p < .000$	2-3: $p < .000$	*
	F_2‘	11.029	$p < .000$	1-3: $p < .002$ 2-3: $p < .000$	* *
/əly/	F_1	.412	$p < .663$		
	F_2	.972	$p < .380$		
	F_3	4.626	$p < .011$	2-3: $p < .000$	*
	F_2‘	3.173	$p < .044$	2-3: $p < .063$	*

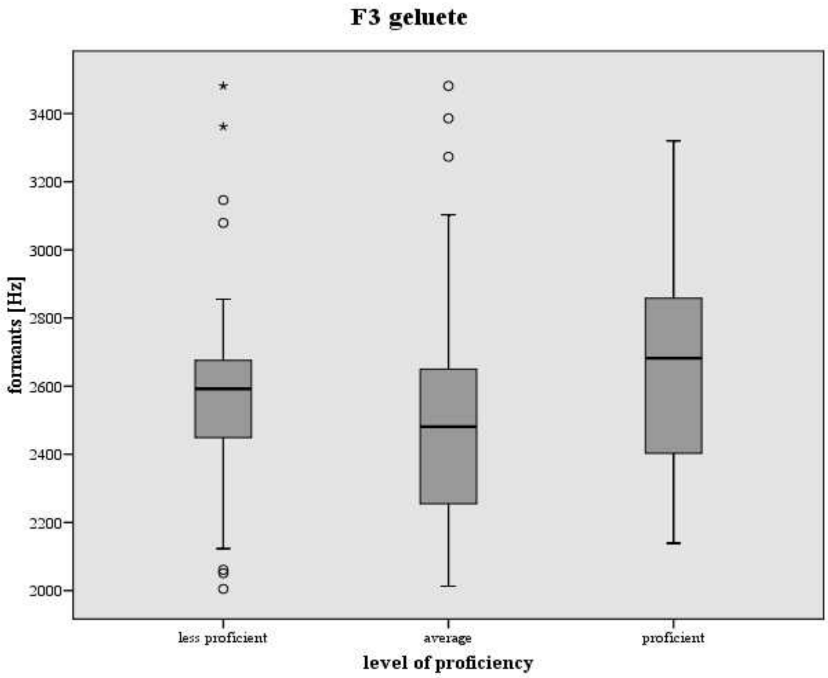


Figure 11. Distribution of F_3 in /y/ of *[dʒəlyt]* produced by less proficient vs. average vs. proficient speakers. Average and proficient speakers thus differ significantly.

6.7.3. Discussion

The results in Table 16 show that vowel formant frequency distributions can be significantly distinguished in /aɪ/, /y/ and /u:/ after /əl/, but significant effects were revealed exclusively for proficient vs. less proficient subjects in one comparison, namely in the frequencies of the vowel /u:/ preceded by /l/ in F_2 and F_2'. However, /u:/ also attained significant scores for the groups of average vs. proficient speakers in F_2, F_3 and F_2'.

/aɪ/ was determined to vary significantly in F_1 for less proficient (*mean value:* 547.07 *Hz* [105.534]) vs. average speakers (*mean value:* 608.77 *Hz* [139.262]) and in F_3 and F_2' for average (2800.33 *Hz* [218.844]) vs. proficient speakers (*mean value:* 2911.57 *Hz* [223.514]). Based on Delattre's (1965:53) finding that comparable positions such as in /ɪ/ are found to be lower (more open) in English than in German, F_1 could be discovered to be importantly higher in average than in less proficient speakers, interestingly proficient speakers being in between those of the average and less proficient speakers' group. While taking into consideration the feature of roundedness, there is significantly less roundedness in proficient than in average speakers. Proficient speakers might be sensitive to English being realized with lesser activity of the lips than German (Scherer &

Wollmann 1977:156), while less proficient speakers produce less rounded vowels than average speakers. The fact of the largest extent of roundedness in average speakers' vowels might appear due to these speakers perceiving a difference between German and English vowels, but not knowing in which direction it should exactly go, not having access to the appropriate variant and not being capable of correctly producing it in its fine phonetic details (Keating 1990).

Based on the assumptions below proficient vs. less proficient speakers' /u:/ should have been realized quite identically. Significant results for /u:/ thus refute the initial hypothesis. Proficient speakers reached the highest values for /u:/ (F_2: 1760.01 *Hz* [385.708], F_3: 2713.49 *Hz* [258.469]; less proficient speakers' F_2: 1528.49 *Hz* [423.666], F_3: 2613.87 *Hz* [383.397]). Average speakers behaved according to prediction in F_2 (1592.87 *Hz* [358.134]), but not in the case of F_3 (2505.15 *Hz* [240.842]) being lower than the vowel formant of less proficient speakers. Following Scherer and Wollmann (1977:155) /u:/ is the only exception of a back vowel phoneme possessing the same phonetic symbol in German and English and not being wide apart from its counterpart. But /u:/ is rounded to a lesser extent in English compared to German, i.e. F_2 and F_3 increase. As predicted, proficient speakers produced the vowel more like it is common in English inserting less roundedness which resulted in higher values for F_2 and F_3. Average speakers did not act in the same way with regard to F_2 and F_3, which could be a hint for them having stored a lot more vowel exemplars than less proficient speakers, but not getting access to and therefore not producing them appropriately. Notably, even so English and German /u:/ variants are not wide apart from each other, proficient L2 English speakers articulate the vowel more like it is necessary in English.

As mentioned in Chapter 6.6. and 2.2., the front-close rounded vowel [y] (Pompino-Marschall 1995:212, 254) does not exist in any variety of English, either in American or in British, but was inserted to observe whether it would be realized in the specific German manner. Differences in F_3 and F_2' for /y/ could be revealed for the comparisons of average (*mean values:* F_3 = 2502.41 *Hz* [335.953], F_2' = 2152.992 Hz [218.3415]) vs. proficient (*mean value:* F_3 = 2652.54 *Hz* [277.115], F_2' = 2243.706 *Hz* [222.0778]) speaker groups with vowel formant frequencies in /y/ being always lower for average than for proficient speakers. Noticeably, the formant frequencies collected from /y/ (F_3 = 2425 *Hz*, F_2' = 2024.25 *Hz)* by Simpson (1998) are both even lower than average speakers' values. Although knowing that the English vowel system does not contain /y/, the increase of F_2 and F_3 in proficient speakers might be a consequence of these speakers including the rule of English comprising generally more spread vowels in their productions.

The comparable positions in /e/ and /ɪ/, even if they are observable to be lower (more open) in English in contrast to German (Delattre 1965:53), could not be discovered to be significantly different in the course of this analysis. Probably, non-native speakers of English only slightly insert this difference in the English variants of their vowel productions.

With regard to these vowel distribution tendencies, it can, however, be claimed that the pronunciation of the vowels preceding /l/ (clearly) depend on the level proficiency. It is noteworthy that the frequencies of F_3 and F_2' in /y/ can importantly be distinguished in average vs. proficient speakers. Average speakers realize a more rounded vowel than proficient speakers, which probably hold in mind that English is less rounded than German.

6.8. General discussion and conclusion

The data on coarticulatory effects and coarticulatory resistance reported so far confirm the initial hypothesis that the tongue body is subject to more articulatory control for proficient speakers' English [ɫ] than for the more German [l] spoken by less proficient learners'. The degree of velarization trends measured in /l/ and /ə/ for proficient and less proficient speakers are in most cases in inverse agreement with differences in coarticulatory resistance investigations and at the same time with the notion that subjects have produced neither two ("dark" [ɫ]) or one (clear [l]) lingual gesture/s. As pointed out by Oh (2008:381) more experienced learners developed more native-like degrees of coarticulation than less experienced learners. She searched for coarticulation differences in native vs. non-native French and English speakers. In line with Oh's results proficient vs. less proficient speakers and proficient vs. average speakers in the study clearly differed in their ability to realize the velarization distinction. These data might suggest that proficient speakers more adequately acquire the fine-grained language-specific patterns of coarticulation. Probably, subjects categorized as less proficient or average might not immediately be capable of broadly widening their stored phonetic features or contextual and temporal information after having perceived a sound/context which is not identical to those which their mother tongue is constituted of. But obviously, they do indeed notice a certain divergence from the production of their native language vowel formant frequencies. Consequently, during L2 production lesser exemplars or contexts can be activated than is the case for proficient speakers (Pierrehumbert 2001).

The given data confirm the conclusion of Recasens et al. (1995:49) that the "clear"/"dark" distinction needs to be treated as a continuum starting from an extreme amount of tongue dorsum lowering and ending up with a considerably high magnitude of backing. Notably, the consonant /l/ is articulated along this continuum depending on several factors: speaker (e.g. DB, clear a anti-talent, German accented speech, low F_2 and F_v values; and AT, very talented, RP speech, high F_2 and F_v values [cf Figures 6 and 7]), language (German /l/ is generally clearer compared to English /l/, but the RP English dialect shows no velarization in syllable- or word-initial position), vowel context (in contrast, more velarization arises from back vowels than from front vowels), and syllable position (syllable-final [ɫ] is more velarized than syllable-initial [l]; cf Introduction, Experimental Part 2). Sancier and Fowler (1997) studied phonetic accommodation and at the same time almost involuntarily the correlation between the perception-production link. They argued that production and direct imitation results from speech perception transmit relevant linguistic (in this case phonetic and phonological) features. For the reason of a close link between perception and production (abilities), it might also be that the integration of tongue dorsum control, tongue dorsum fronting and raising is in correspondence with perception abilities. Keating (1990) goes even further than Pierrehumbert (2001, 2006) and Wade et al. (2010), proposing that the grammar of each language is associated with its language-specific phonetic details of various magnitudes, among other features *coarticulation*, in the form of values, the magnitude of which varies. Each physical articulatory dimension owns its own minimum and maximum mirroring the contextual variability of a given feature value. Keating (1990) called the possible range of spatial values for each segment a *window*. Average and less proficient language learners might thus have limited access to the large range of the continuum of /l/-variations having fewer numbers of intermediate values for precise specification within their minimum and maximum. Their *window* for the pattern of velarization might not be as wide as that of proficient speakers, i.e. they do not vary as much across context in their L2 English (RP English is non-velarized in syllable/word-initial position) and consequently lack the ability to realize varieties which diverge from their native language to a large degree.

Bladon and Al-Bamerni's concept of CR indices (1976) propose the CR value as being induced and stored within each extrinsic allophone which the speech production mechanism can make use of. Anticipatory or carry-over coarticulation has a high impact on the phones being subject of research, but they are inhibited if CR specification on some segments is strong. In connection with this investigation, the assumption suggests itself that in less proficient speakers fewer CR-values are stored, exclusively their native language-specific, and therefore they can only produce exemplars which are similar to these, being less correct than those of proficient speakers.

The results of the degree of velarization in /əlV/-sequences across dialectal varieties give evidence of the degree of velarization pattern being an unsubtle indicator, and notably not the only relevant feature for auditive assessment and categorization in dialects within the group of L2 speakers realizing English accented speech. For a more precise categorization of accents the degree of velarization cannot be taken alone, but it might give a hint of tendency. L2 speakers of English seem to be conscious of the fact that English speech is generally produced with a higher degree of velarization than German, but they do not significantly differentiate between German and GA, for example. Proficient RP speakers might also be aware of phonological rules about velarization of /l/ in different positions. It seems as if all of them made an effort to integrate this characteristic feature of a specific English dialect into their speech production (significant effects between German GA accent speech and all the other groups, frequency range being wide). Consequently, L2 speakers of English might have a general knowledge of some basic English phonological rules differing fundamentally from their mother tongue, but are not able to reach the fine-grained pattern tuning of those (supra-)segmental characteristic features. In line with *The Exemplar Theory*, the author assumes that subjects categorized as speakers with (a) German accent(ed speech) might not automatically be able to enlarge their exemplar clouds after having heard a sound which is not identical to those existing in their mother tongue. In turn, during their L2 production, perhaps not as many exemplars as necessary for the production of GA, RP or MA may be activated (Pierrehumbert 2001).

The inclusion of proficiency level to degree of velarization vs. dialectal variety leads to unclear test results for several comparisons. Unspecific interactions for GA accented speech in average speakers for F_2, German RP accented speech in less proficient speakers for F_2 and F_v and German GA accented speech in less proficient speakers for F_2 of L2 English might appear due to a wide range of other factors playing an important role for the categorization in levels of proficiency (cf Jilka 2009b, Appendix). Nevertheless, German accented speech in F_2 was significantly produced by less proficient and average speakers and F_v for average speakers, as well as RP in both cases by proficient speakers of English. In summary, a categorization of proficiency according to amount of velarization and dialectal variety can only remain vague. GA vs. average speakers, German vs. less proficient and German GA accented speech vs. less proficient speakers correlated in F_2, but not in F_v, which might be for reasons of higher influence of jaw opening/closing on F_2. F_1 and F_2 do not stand in proportionality to each other.

More balanced dialectal speakers' data and more speakers of MA accent are necessary to further test these analysis results. Additionally, it would be of importance to record more natural language stimuli with /l/ not exclusively in initial position of a stressed syllable, but also in medial and syllable-final and/or word-/phrase-final position.

In this work the author has had a close look at allophonic variations in subjects speaking different varieties of English, and has simultaneously intended to assure herself that allophonic variations of the consonant do not appear due to proficiency-dependent vocalic differences in the sequence /dʒəl[aɪ, eɪ, y, u:]t/, but because of differences in articulatory control which can be associated with the consonant. Although clear-cut differences in vowel productions between proficient vs. average vs. less proficient speakers could be detected within which proficient speakers realized the English vowels more like it is common in the foreign language, merely one significant effect in the frequencies of the vowel /u:/ preceded by /l/ in F_2 and F_2‘ for proficient speakers vs. less proficient could be found. And astonishingly, this important difference was even unexpected which let the author be more certain that differences in velarization - at least - between less proficient vs. proficient speakers cannot be derived from dissimilar productions of the vowels after /l/, but from divergent ways in controlling the articulation of the target consonant.

Furthermore, the author would like to discover whether coarticulation differences in less proficient vs. proficient speakers arise due to perceptual distinctiveness constraints or to independent learning of coarticulatory patterns, or whether it is talent in the sense of spontaneous adaptation to the coarticulation/perception loop characteristic of exemplar based speech learning mechanisms (Dogil 2007; Wade et al. 2010). Previous research of CVC and CV segments (e.g. Recasens 1984a, 1984b, 1985; Recasens, Fontdevila & Pallarès 1995) gave evidence of the inability to successfully define the presence vs. absence of coarticulation through phonological rules, because of its graded nature and the linguistically relevant aspects of coarticulation which are connected with it. This means, in different languages one segment would get a widespread range of degrees of coarticulation.

In summary, proficient learners’ speech production (more velarization, more coarticulatory resistance) suggests that coarticulatory resistance for /l/ clearly depends on the articulatory constraints on gestural production, complex velarized [ɫ] not being much affected by its surrounding segments.

7. Experiment with German stimuli

Díaz et al. (2008) have recently investigated brain mapping in the phonetic speech acquisition discipline and could find evidence for pre-existing individual differences in phonetic discrimination ability, i.e. phonetic "talent". Interestingly, individual differences between more or less "talented" or "able" phonetic perceivers not exclusively in the foreign, but also previously in their native language sound system followed from event-related potentials. From these outcomes an interdependence between native and non-native phonetic abilities can be inferred, insofar as the successful learning of a new (foreign) phonetic system can somehow be derived from native phonetic abilities. This is taken for granted to be a result of speech-specific rather than general acoustic mechanisms in phonetic control (Reiterer 2009:174). The author predicts that German native speakers who give the impression of general high talent will realize more variable speech than those speakers who achieved low grades in general talent impression. According to Keating (1990), this would result in narrower *windows* for less proficient than for average and proficient speakers and, thus, fewer allophonic varieties within the velarization dimension for low proficient learners. Furthermore, generally low talented German speakers might produce higher F_2 and F_v (vowel formant) frequencies in /ə/ and higher F_2 and lower F_1 in /l/ (no induction of velarization) than generally high talented German speakers (a slight induction of the velarization characteristic), i.e. extremer maxima and minima. Average speakers should reach values lying in between those for less proficient and proficient speakers.

7.1. Analysis 1: Degree of velarization in /əlV/ sequences across levels of proficiency measured in /ə/

7.1.1. Methods

The subjects were identical to those described in Experiment 1 (cf Chapter 6.1.1.).

7.1.1.1. Materials

Formant frequency data were again collected for the logotoms "*gelate, gelite, gelüte, gelute*". To control for pitch, duration and phonemes, a non-word was chosen. These target non-words were realized in carrier sentences (*Ich habe [gelate/gelite/gelüte/gelute] gesagt.*) with stress on the second syllable. This speech material was read five times by each speaker resulting in 767 tokens

(1 consonant /l/ x 4 vowel contexts x 5 repetitions x 41 speakers = 820). 53 tokens were dismissed due to imprecise articulation and hesitation errors. These test utterances contain German language phonotactic rules and the respective target words in a stressed position. Before starting the recordings, the speakers were asked to pay attention to accentuation and speech rate (cf Cho 2004).

7.1.1.2. Procedure

At the beginning of this session, subjects were instructed to repeat a short text presented by a female German speaker (28 years old) producing High German with hardly any dialectal colouration, to help speakers switch back to their mother tongue and especially prime them in Standard German speech.

The recording procedure was equivalent to that introduced previously.

7.1.2. Results

Mean F_2 and F_v values for /ɘ/ before /l/ are shown in Table 17. The vowel reached a higher frequency for less proficient speakers than for proficient speakers in both of the cases, F_2 and F_v, average speakers' mean values for F_2 and F_v being even lower than the ones of proficient learners.

Table 17. Mean values for F_2 and F_v in proficient vs. average vs. less proficient speakers. Standard deviations have been included within parentheses.

Parameter	Proficiency	Mean value [Standard deviation]
F_2	proficient	2120.39 *Hz* [288.161]
	average	1994.65 *Hz* [206.054]
	less proficient	2187.95 *Hz* [216.367]
F_v	proficient	1758.10 *Hz* [280.870]
	average	1643.85 *Hz* [200.979]
	less proficient	1817.68 *Hz* [215.649]

One-way ANOVAs across proficiency levels revealed significant differences in F_2 ($F(2) = 33.043$, $p < .000$ [$df_{bg} = 2$, $df_{wg} = 767$]) and F_v ($F(2) = 27.933$, $p < .000$ [$df_{bg} = 2$, $df_{wg} = 767$]) which could be further clarified within Scheffé tests. F_2 and F_v allow a high percentage of significant degree of velarization effects in all the comparison results.

Table 18. One-way ANOVA (Scheffé) test results comparing degree of velarization and level of proficiency in F_2 and F_v.

Parameter	Group	Significance	
F_2	1 - 2	*p* < .000	*
	1 - 3	*p* < .007	*
	2 - 3	*p* < .000	*
F_v	1 - 2	*p* < .000	*
	1 - 3	*p* < .018	*
	2 - 3	*p* < .000	*

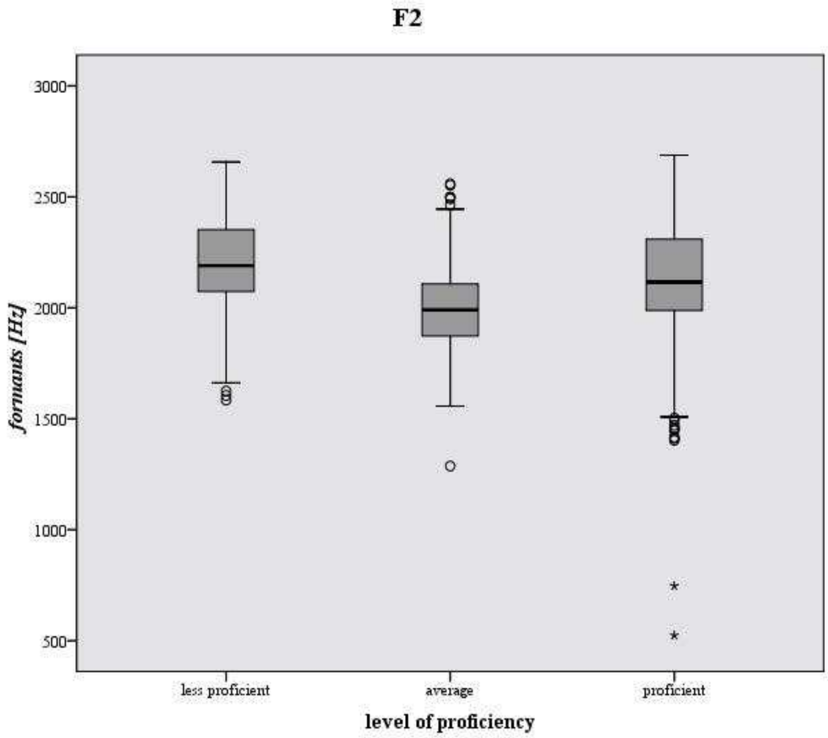


Figure 12. Distribution of F_2 in less proficient vs. average vs. proficient speakers.

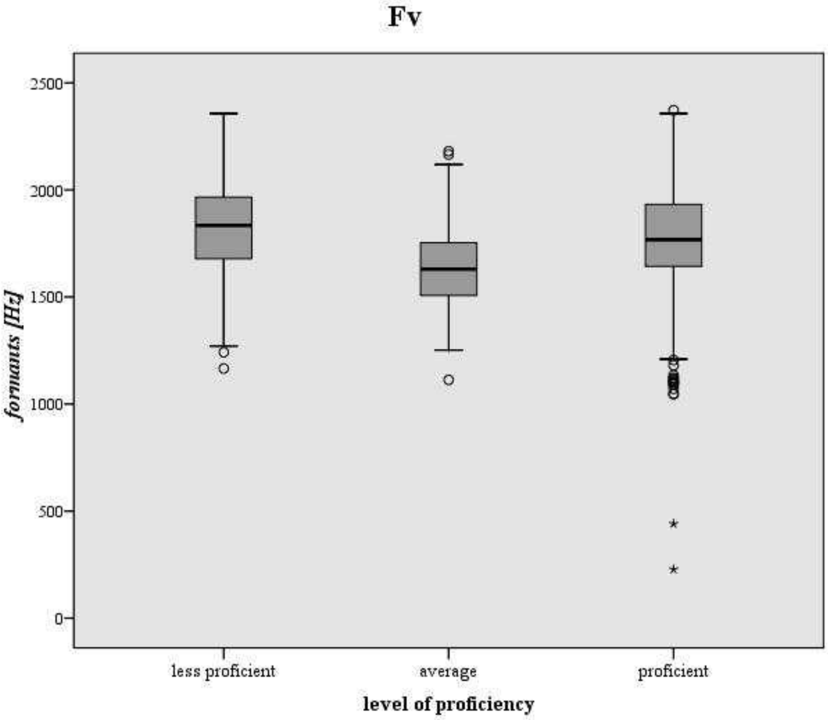


Figure 13. Distribution of F_v in less proficient vs. average vs. proficient speakers.

7.1.3. Discussion

The one-way ANOVA (Scheffé) test concerning degree of velarization measured in /ə/ and its illustrations in Figures 12 and 13 points out significant results in all the comparisons conducted, whereas F_2 and F_v in proficient speakers are significantly lower than in less proficient speakers. Neither for F_2 nor for F_v could average speakers' mean values be detected among proficient and less proficient speakers, but were in both conditions even lower than those of proficient speakers. If the amount of velarization increases, F_2 and F_v decrease and vice versa (Recasens, Fontdevila & Pallarès 1995:41). As a consequence for these analyses, most velarization is found in average compared to proficient and then less proficient speakers for F_2 and F_v. In accordance with the author's prediction less proficient speakers realized much higher vowel formant frequencies than proficient speakers, probably making very little use of the property of velarization, or even not at all, as is common in the German language, which is categorized as non-velarized (Recasens 1985; Recasens, Fontdevila & Pallarès 1995). Proficient speakers additionally fit into the hypothesis founded on the comparisons of German speech for the reason of having a wider mental representation of tokens which enable them to distinguish within the pattern of velarization, in contrast to what was assumed for less proficient speakers. Accordingly, they constructed non-velarized German stimuli not as strictly and in a small *window* range (Keating 1990:455) as less proficient speakers, but nevertheless there is generally more velarization in English than in German speech (cf also Chapters 6.1. and 6.3.). Average speakers' mean values are inapplicable with regard to the hypothesis, seeing that these speakers made use of formant frequency values which were lower than those of proficient speakers. It is possible that average speakers have, in comparison with less proficient speakers, a wider range of token representations concerning velarization varieties, but simply their access to these different varieties is less appropriate and precise than that of proficient speakers. This is why they pronounce German stimuli with a remarkably high degree of velarization, despite being obliged to activate and utter more non-velarized varieties of the consonant /l/.

7.2. Analysis 2: Degree of velarization in /əlV/ sequences across levels of proficiency measured in /l/

Subjects, materials and procedure were analogous to those mentioned in Analysis 1.

7.2.1. Results

Within separate one-way ANOVAs (Scheffé) for F_1 and F_2 measured in the steady state of /l/ across proficiency levels, significant differences for F_1 ($F(2) = 6.362$, $p < .002$) in less proficient vs. average speakers and for F_2 ($F(2) = 8.333$, $p < .000$ [$df_{bg} = 2$, $df_{wg} = 767$]) in less proficient vs. average and in average vs. proficient speakers were revealed (cf Table 19).

Table 19. One-way ANOVA (Scheffé) test results comparing degree of velarization in /l/ and level of proficiency in F_1 and F_2.

Parameter	Group	Significance	
F_1	1 - 2	$p < .002$	*
F_2	1 - 2	$p < .034$	*
	2 - 3	$p < .000$	*

Additionally, the F_1 mean value of proficient speakers was lower (*mean value:* 262.202 *Hz*) than that of less proficient speakers (*mean value:* 272.183 *Hz*), while the average speakers' value (*mean value:* 282.499 *Hz*) again exceeds that of less proficient speakers.

The picture of F_2 mean values presents itself the other way round with regard to proficient speakers (*mean value:* 1974.88 *Hz*) showing higher formant frequencies in contrast to lower values in less proficient speakers (*mean value:* 1936.75 *Hz*), whereas average speakers exhibited even lower values in this situation than less proficient speakers.

Table 20. Mean F_1 and F_2 values (in *Hz*) for /l/ between /ə/ and /a:/, /i:/, /y/, /u:/ in less proficient vs. proficient speakers. Standard deviations have been included in parentheses.

Parameter	proficiency	mean value [standard deviation]
F_1	proficient	262.202 *Hz* [54.4044]
	average	282.499 *Hz* [55.4302]
	less proficient	272.183 *Hz* [62.8834]
F_2	proficient	1974.88 *Hz* [413.416]
	average	1845.94 *Hz* [307.455]
	less proficient	1936.75 *Hz* [309.887]

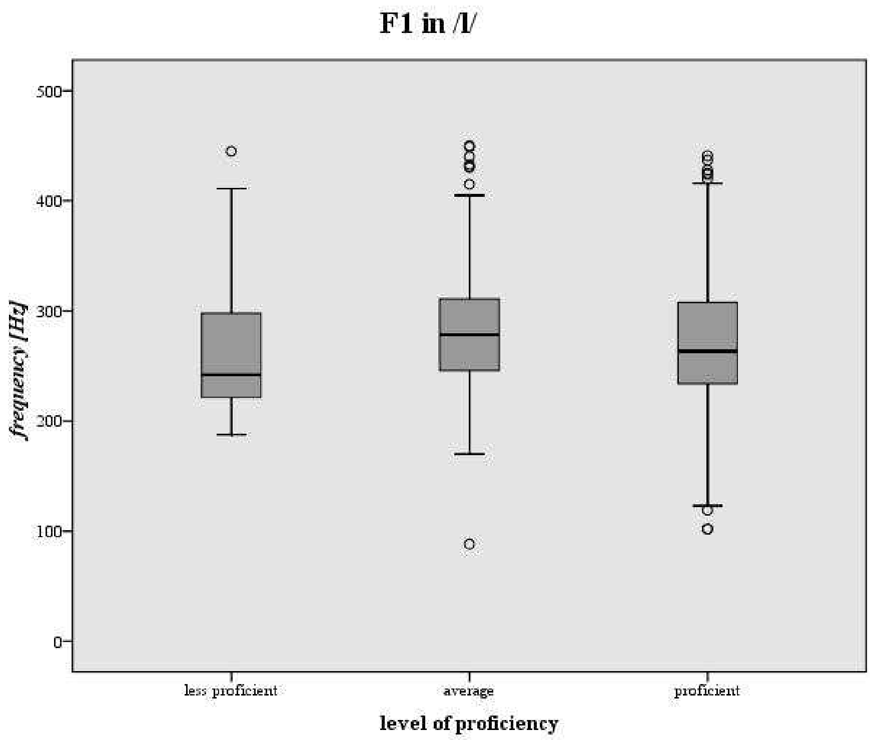


Figure 14. Distribution of F_2 in less proficient vs. average vs. proficient speakers.

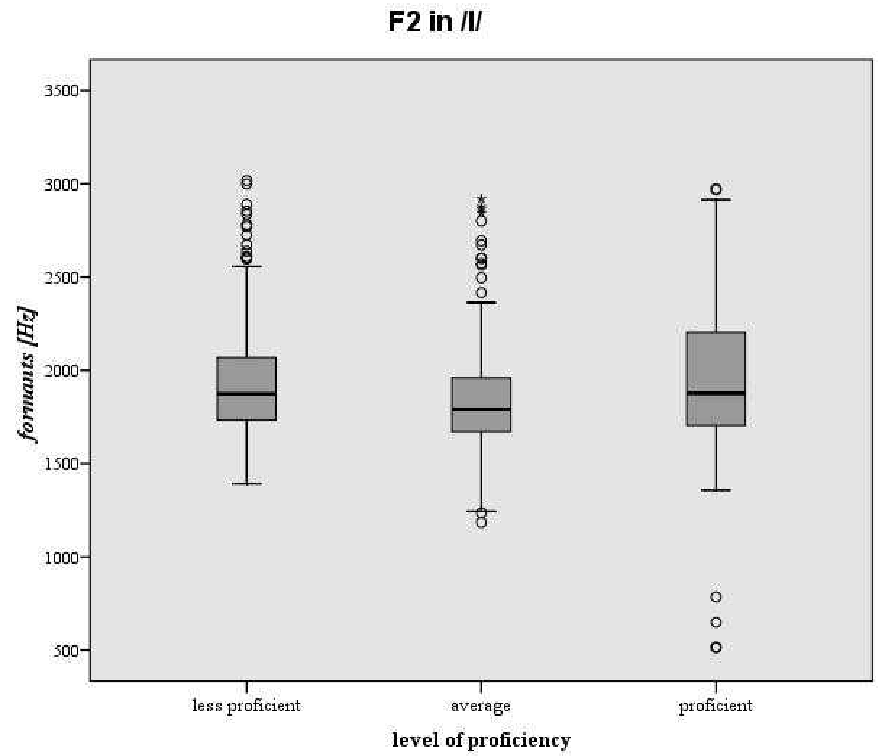


Figure 15. Distribution of F_2 in less proficient vs. average vs. proficient speakers.

7.2.2. Discussion

Based on the acoustic theory of speech production (Fant 1960; Stevens 1998) F_2 is positively connected with tongue dorsum fronting and raising, in contrast there is a transposed relationship regarding the degree of velarization. In opposition to F_2, Recasens, Fontdevila and Pallarès (1995:41) claimed F_1 to stand in direct interdependence to velarization. Consistent with these prerequisites, an F_2 reduction can logically be derived if degree of velarization grows. The author expected high F_2 and low F_1 formant frequencies in /l/ (no induction of velarization) for generally low talented German speakers compared to the reversed image in generally high talented German speakers (little induction of the velarization pattern). Presumably, average speakers should position themselves in the middle between high and low general impression speakers.

In contradiction to the author's hypothesis, high general impression speakers achieved low F_1 and in addition high F_2 mean values, while low general impression speakers were given high F_1 frequencies in contrast to low F_2-values, but not as low as the average general impression speakers' scores. In addition the F_1 mean value of average general impression speakers was located even higher than that of low general impression speakers. Consequently, these observations of F_1 and F_2

in /l/ show high general impression speakers to velarize finally less than low general impression speakers. The average speakers' F_1 frequency was found to be the lowest in contrast to their F_2 frequency which was the highest within the whole group of different general impression categories. As pointed out by Recasens (1985) and Recasens, Fontdevila and Pallarès (1995), German belongs to the category of non-velarized languages, therefore high general impression speakers in the case of /l/ behaving like it is necessary for realizing non-velarized stimuli. However, it is crucial to be conscious of high vs. low general impression speakers not attaining significant analysis-results, whereas F_1 and F_2 differ importantly in low vs. average and for F_2 also in average vs. high general impression speakers. The author supposes significant variation in calculations involving the average speaker group to be present due to these values being somehow immoderate and implying a relatively high degree of velarization compared to low and high general impression speakers. Moreover, low and high general impression speakers both indicate fairly low values for F_1 along with rather high values for F_2 within the velarization continuum, manifesting a considerable low degree of velarization measured in /l/. In negation of the hypothesis, high general impression speakers evidently do not imply a certain degree of velarization in German /l/ as opposed to average speakers who velarize to a noticeable extent.

At this point the question is now why the average general impression speakers insert such a high degree of velarization and, further, why, contrary to the initial hypothesis, high general impression speakers did not produce more variable tokens (i.e. little introduction of the pattern of velarization) than low general impression speakers. Obviously, the high general impression speakers behaved exemplarily, which is reflected by their lowest F_1 and highest F_2 not making use of their high inventory of allophonic variants of /l/, i.e. the large(r) *window* size, and their ability to change within this. Average speakers operated in a way completely contrasting, using velarized allophonic variants even when speaking German. These findings might simply falsify the author's hypothesis and show evidence of high general impression speakers producing allophonic variants of /l/ to be exclusively dependent on the language uttered, if being asked. There is the probability of average speakers possessing a *window* size which is almost as extensive as that available in high general impression speakers, i.e. a huge amount of allophonic variants of /l/. However, average general impression speakers might first of all not be as qualified as high general impression speakers to switch back from a more velarized language to their more non-velarized mother tongue, and secondly might have more difficulties in inhibiting their (more) velarized tokens which are not applicable in German speech. These facts might result in the excessive numbers for this speaker group.

After having looked only separately at the English and German stimuli and having observed quite a considerable degree of velarization in average general impression speakers producing German speech, there is interest in a collective analysis of both languages to gain a more explicit idea of the velarization distinction in German vs. English with regard to the stimuli taken so far (cf Chapter 7.).

7.3. Analysis 3: Coarticulatory resistance in /əlV/ clusters, taking non-words

7.3.1. Subjects, materials and procedure

Subjects, materials and procedure were exactly the same as above.

In accordance with Recasens, Fontdevila and Pallarès (1995:47), the author predicts that coarticulatory sensitivity is inversely coupled with the degree of velarization. As touched on in Chapter 3. Recasens and Farnetani (1990, 1991) postulated that this global assumption is cogent for languages with exceedingly dissimilar types of the consonant /l/, as, for example, Italian and Catalan. In order to check the hypothesis using German stimuli, the author took into consideration coarticulatory resistance of /i:/ vs. /u:/, /y/ vs. /i:/ and /y/ vs. /a:/ on /l/ in symmetrical VCV-sequences (*[gəla:tə] [gəli:tə] [gəlytə] [gəlu:tə]*) realized by German native speakers.

Once more, on the one hand high positive/negative values represent coarticulation, and on the other hand values around 0 *Hz* characterize coarticulatory resistance. As a rule, the more the frequency value approaches the 0 *Hz line*, the higher the degree of coarticulatory resistance in the stimulus considered.

Bearing in mind that the author exclusively investigated native German speech in this chapter, it would be logical not to expect any large discrepancies between the production of /l/ in low general impression vs. high general impression speakers. However, it might be the case that speakers who scored well in general talent impression, can in turn obtain a slightly larger number of tokens and therefore produce more distinguishable varieties of the consonant than average and low general impression speakers. Corresponding to former investigations, the author supposed average speakers' frequencies to be in the core of proficient and less proficient speakers' spectral data.

In line with Chapter 6.6.1. the sequence /i:/ (lips are spread, front vowel with high tongue position [Pompino-Marschall 1995:211]) vs. /u:/ (lips are rounded, back vowel with high tongue position [Pompino-Marschall 1995:211]) was chosen because of these vowels symbolizing two extremes along the articulatory scale with reference to roundedness/unroundedness and backness/fronting. The vowel /y/ (lips are rounded, front vowel with high tongue position [Pompino-Marschall 1995:212]) and the vowel /i:/ (lips are spread, front vowel with high tongue position [Pompino-Marschall 1995:211]) are both front vowels realized with a compressed pharynx, but diverging in roundedness. /y/ (lips are rounded, front vowel with high tongue position [Pompino-Marschall 1995:212]) vs. /a:/ (lips are unrounded, front vowel with low tongue position [Pompino-Marschall 1995:212]) integrate a loose difference in roundedness/unroundedness and a slight distinction in jaw opening/closing.

The author presumes speakers of high general talent impression to velarize and at the same time coarticulate more than those categorized as low or average general talent impression speakers, hence the speech of high general talent impression speakers is expected to be more coarticulatory resistant and simultaneously more coarticulated. Consequently, /ə/ in high general talent impression speakers should arise closer to and further away from its formant frequencies as a neutral vowel (F_1 = 375 *Hz*, F_2 = 1525 *Hz* [Neppert 1999:134 taken from Delattre 1965:49; Barry 1995:231, 233]) than in low general impression speakers. Coherently, average speakers' formant frequencies should once again be situated between the scores of low and high general impression speakers. In terms of descriptive statistics, this might result in higher mean values and wider formant frequency ranges for high general impression speakers in contrast to low general impression speakers

For the coarticulatory distance calculation, the same formula was employed as previously defined in chapter 6.6.1..

F_2- and F_3-values were derived from Simpson (1998; cf Table1) who had measured F_1, F_2 and F_3 separately in read vs. spontaneous speech of female vs. male subjects. From these four values reached for each vowel formant frequency (read vs. spontaneous speech, female vs. male), a mean value was finally calculated, and additionally out of the final F_2 and F_3 values the F_2' value was computed. Consequently, F_2- and F_2'-values were expected to be positive in the case of the /i:/ (F_2 = 2185.5 *Hz*, F_3 = 2691 *Hz,* F_2' = 2438.25 *Hz*) vs. /u:/ comparison (F_2 = 974.25 *Hz*, F_3 = 2539.25 *Hz,* F_2' = 1756.75 *Hz*) and in /y/ (F_2 = 1623.5 *Hz,* F_3 = 2425 *Hz*, F_2' = 2024.25 *Hz*) vs. /a:/ (F_2 = 1338 *Hz*, F_3 = 2527.25 *Hz*, F_2' = 1932.63 *Hz*), whereas the distinction bars of /y/ (F_2 = 1623.5 *Hz*, F_3 = 2425 *Hz*, F_2' = 2024.25 *Hz*) vs. /i:/ (F_2 = 2185.5 *Hz*, F_3 = 2691 *Hz*, F_2' = 2438.25 *Hz*) were predicted to move in the negative direction.

In order to determine whether the degree of coarticulatory resistance/coarticulation outcomes were significantly different or not, one-way ANOVAs were computed separately for F_2 and F_2' in /əli:/ vs. /əlu:/, /əly/ vs. /əli:/ and /əly/ vs. /əla:/, with general talent impression as the independent variable. In addition, the interactions between degree of coarticulation/coarticulatory resistance and each general talent impression level were again calculated by means of a correlation analysis (Scheffé tests) between the formant frequency differences in /ə/. This examination was run with the intention of resolving, whether an increase in a given general talent impression level corresponds with an increase/decrease in the degree of coarticulatory resistance and, less crucially, whether the amount of coarticulatory resistance and/or coarticulation and the general talent impression level can be matched.

7.3.2. Results

One-way ANOVA tests elucidated significant results considering the CD values of F_2 achieved from /əli:/ vs. /əlu:/ ($F(2) = 3.668$, $p < .027$ [$df_{bg} = 2$, $df_{wg} = 192$]) and F_2' ($F(2) = 4.578$, $p < .011$ [$df_{bg} = 2$, $df_{wg} = 192$]), as well as of F_2' gained from /əly/ vs. /əla:/ ($F(2) = 3.717$, $p < .026$ [$df_{bg} = 2$, $df_{wg} = 177$]) and levels of general talent impression. CD values vs. levels of general talent impression calculated from /əly/ vs. /əli:/ exhibited no significant differences in F_2 and F_2'. Table 21 shows one-way ANOVA Scheffé test results to further clarify (significant) differences between CD results and levels of general talent impression. The Scheffé test results point out that significances uniquely hold for the categories of low vs. high general talent impression German speakers.

Table 21. One-way ANOVA (Scheffé) test results after comparison CD of F_2 and F_2' in low (1) vs. average (2) vs. high (3) general impression native German speech.

Stimuli	*Parameter*	*Groups*	*Significance*	
	F_2			
/əli:/ vs. /əlu:/		1 - 3	$p < .032$	*
	F_2'			
/əli:/ vs. /əlu:/		1 - 3	$p < .014$	*
/əly/ vs. /əla:/		1 - 3	$p < .039$	*

Figures 16 and 17 display these results as bar charts which demonstrate for F_2 that there is for each CD comparison more coarticulation, i.e. higher frequency values, in high than in low general talent impression speakers. As predicted, in all three cases average learners can be found in between high and low general talent impression speakers.

Table 22. Mean values after comparison CD of F_2 vs. general impression scores in native German speech. Standard deviations have been included in parentheses.

CD comparisons	***Low***	***Average***	***High***
/əli:/ *vs.* /əlu:/	87.19 *Hz* [142.13]	179.53 *Hz* [208.50]	202.71 *Hz* [322.43]
/əly/ *vs.* /əli:/	-77.67 *Hz* [186.01]	-143.22 *Hz* [169.92]	-149.53 *Hz* [314.71]
/əly/ *vs.* /əla:/	-10.01 *Hz* [194.19]	-14.16 *Hz* [152.14]	56.44 *Hz* [290.70]

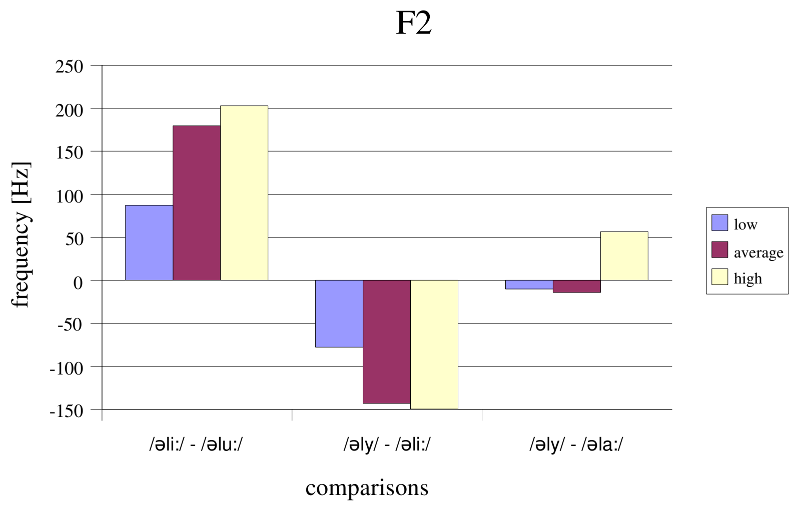


Figure 16. Coarticulatory resistance values for F_2 CD value-comparisons of /əli:/ - /əlu:/, /əly/ - /əli:/ and /əly/ - /əla:/ in low vs. average vs. high general impression speakers.

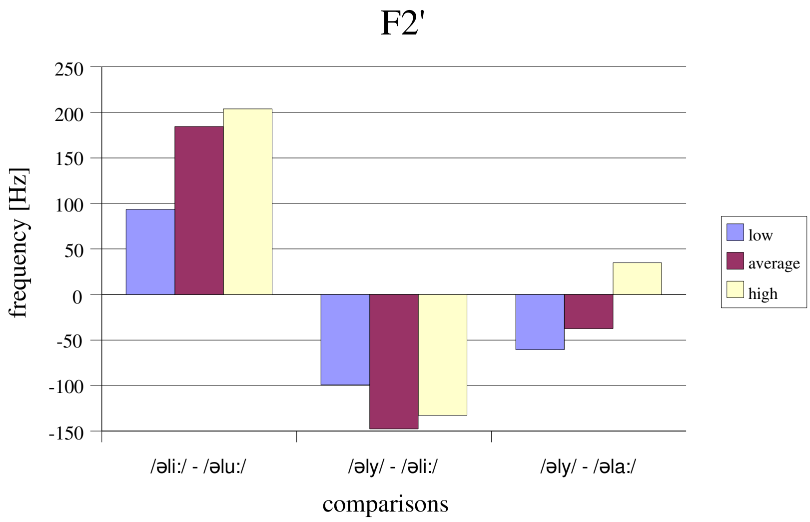


Figure 17. Coarticulatory resistance values for F_2' CD value-comparisons of /əli:/ - /əlu:/, /əly/ - /əli:/ and /əly/ - /əla:/ in low vs. average vs. high general impression learners.

Table 23. Mean values after comparison CD of F_2' vs. general impression scores in native German speech. Standard deviations have been included in parentheses.

CD comparisons	***Low***	***Average***	***High***
/əli:/ vs. /əlu:/	93.49 *Hz* [141.89]	184.55 *Hz* [243.56]	203.98 *Hz* [237.37]
/əly/ vs. /əli:/	-99.38 *Hz* [181.25]	-147.64 *Hz* [184.79]	-132.7 *Hz* [259.81]
/əly/ vs. /əla:/	-60.65 *Hz* [194.19]	-37.46 *Hz* [152.14]	34.94 *Hz* [290.70]

The image for CD mean values assessed from F_2' is less clear-cut (cf Figure 17 and Table 23). While in the /əli:/ vs. /əlu:/ comparison, formant frequency values for CD behaved as prognosticated, i.e. more coarticulation, and also in the /əly/ vs. /əla:/ comparison, i.e. more coarticulatory resistance, for high general talent impression speakers; /əly/ vs. /əli:/ CD comparisons were revealed to be contrary to the hypothesis, high general talent impression speakers lying in the midst of low and average general talent impression informants.

Front close spread /əli:/ vs. back close rounded /əlu:/

Looking at the /i:/ vs. /u:/, i.e. the backness/fronting- and the roundedness/unroundedness-contrast in F_2 and F_2', the degree of velarization/coarticulation effects affirm the hypothesis of German stimuli being of higher frequency values for strong general impression speakers (*F_2 mean values:* 202.71 *Hz*, *F_2' mean value:* 203.98 *Hz*) than for low general impression speakers (*F_2 mean values:*

87.19 Hz, *F_2' mean value:* 93.49 *Hz*). Figures 16 and 17 show that low general impression speakers generate more coarticulatory resistant. In contrast to these speakers, high general impression speakers manifest a fairly extreme quantity of coarticulation. In both of the cases, average speakers' formant frequency values could be found in between those of high and low general impression speakers (*F_2 mean values: 179.53 Hz*, *F_2' mean value: 184.55 Hz*). Moreover, the statistical analysis for F_2 and F_2' frequency values vs. general impression categorization led to significant results considering low vs. high general impression speakers (cf Tables 21-23), whereas the other comparisons produced insignificant outcomes. As was expected, F_2 and F_2' CR mean values reach positive scores in all of the designed conditions.

Front close rounded /əly/ vs. front close spread /əli:/

The /əly/ vs. /əli:/-distinction, i.e. roundedness- vs. spreadness-distinction, in F_2 and F_2' for high general impression vs. low general impression speakers has a tendency to behave as indicated, relating to coarticulation- and coarticulatory resistance-calculations. Whereas average speakers' values for F_2 are, in accordance with the hypothesis, identical to those of high and low general impression speakers for F_2 and F_2', average general impression speakers' scores for F_2‘ are even lower than those of high general impression speakers. In conformity with the initial assumption, F_2- and F_2'-results for low and high general impression speakers appeared to be negative in all six cases. No significant effects could be calculated for any of the F_2 and F_2' comparisons for high (*mean value F_2:* -149.53 *Hz*; *mean value F_2':* -132.7 *Hz)*, low (*mean value F_2:* -77.67 *Hz*; *mean value F_2':* -99.38 *Hz)* and average general impression (*mean value F_2:* -143.22 *Hz*; *mean value F_2':* -147.64 *Hz*) speakers.

Front close rounded /əly/ vs. front open unrounded /əla:/

One significant effect occurred to prove that these /y/ vs. /a:/-comparisons were distinguishable in a loose difference in roundedness vs. unroundedness and simultaneously a weak distinction in jaw opening vs. closing: F_2' outcomes were shown to be significant for low (*mean value F_2':* -60.65 *Hz*) vs. high *(mean value F_2':* 34.94 *Hz*) general impression speakers. Contrary to the hypothesis, F_2 and F_2'-values for /y/ vs. /a:/ comparisons were only positive for the group of high general impression speakers *(mean value F_2:* 56.44 *Hz*; *mean value F_2':* 34.94 *Hz*); average (*mean value F_2:* -14.16 *Hz*; *mean value F_2':* -37.46 *Hz*) and low general impression speakers (*mean value F_2:* -10.01 *Hz*; *mean value F_2':* -60.65 *Hz*) tending in the negative direction. In the F_2 condition high general impression speakers were less coarticulatory resistant than average and low general impression speakers; this in fact supported the initial hypothesis. In contrast to F_2 results and the initial assumption, F_2'-values presented a reverse image with low general impression speakers showing more coarticulation compared to average and high general impression speakers being rather coarticulatory resistant. With reference to F_2 and F_2' contrasts, average speakers are located in between high and low general impression speakers (cf Tables 22 and 23).

7.3.3. Discussion

Front close spread /əli:/ vs. back close rounded /əlu:/

According to the hypothesis, there is more resistance in F_2 and F_2' for low general impression speakers than for average and high general impression speakers, the values for low vs. high general impression speakers differing significantly for both frequency comparisons. Additionally, bars for all categories extend to the positive direction. A considerable constriction in the frontal part of the tract raises the F_2 frequency values. For that reason front vowels such as /i/ attain the highest possible F_2, in contrast to back vowels such as /u:/ which exhibit low second formant frequencies. Consequently, narrowing in the back of the tract causes F_2 lowering depending on its extent. Reaching higher F_2 vowel formant frequencies, high general impression speakers might produce /i/ inducing a remarkably higher degree of constriction in the frontal part of the tract vs. /u:/ incorporating an exceptionally low degree of constriction. Presumably, the degree of coarticulation is generally rather extreme, i.e. less velarization and reduced tongue dorsum activity, because of the consonant /l/ letting through and transferring on /ə/ the characteristics of the vowels /i:/ and /u:/ to a considerable extent.

F_2' insertion (mean value of F_2 and F_3) takes into account the degree of lip rounding. Roundedness causes a narrowing of the tract, with simultaneous lip protrusion being usually more drawn out in back rounded vowels than in front rounded vowels. If there is a great amount of lip rounding, F_2 and F_3 formant frequencies decrease. The inclusion of F_3 can only alter the F_2 analysis results insignificantly, thanks to /i:/ being a back vowel (high F_2) and unrounded (high F_3) in opposition to /u:/ being a front vowel (low F_2) and rounded (low F_3). The vowel formant frequency heights for F_2 and F_3 in front spread vs. back rounded vowels conclusively behave in the same way, which helps to interpret the differences in the CD values obtained.

Front close rounded /əly/ vs. front close spread /əli:/

Taking into consideration the CD values for the front close rounded vs. spread vowel comparison, low and high general impression speakers performed as previously predicted. High general impression speakers coarticulated more than low general impression speakers, average speakers behaving according to the assumption with regard to F_2, but not with regard to F_2'. Formant frequencies obtained negative values in agreement with the primary hypothesis. None of these analyses resulted in significant effects in one-way ANOVA (Scheffé) tests. Both /y/ and /i:/ belong to the class of front vowels reaching high F_2 values, but diverging in roundedness vs. unroundedness (/y/ rounded [low F_3] vs. /i:/ unrounded [high F_3]). Lower CD values for high than for low general impression speakers might be a result of high general impression speakers realizing more extreme vocal tract configurations for opening vs. closing and additionally distinguishing more between rounded and spread vowels. These circumstances highly influence the formant frequencies of the vowel following /l/ on /ə/. Average speakers' F_2 outcomes validate the hypothesis, in contrast to these speakers F_2' scores being even lower than those of high general impression speakers, which holds for more coarticulation in F_2' among average than among high general impression speakers. In average general impression speakers the roundedness vs. unroundedness differentiation might be again more elaborated than in high general impression speakers, and the influence of lip rounding in /y/ on /ə/ might be of a strong kind (the lower F_2 and F_3 are, the more lip rounding there is).

Front close rounded /əly/ vs. front open unrounded /əla:/

F_2' differences in CR and coarticulation on /ə/ across /l/ (/əly/ minus /əla:/) of high vs. low general impression speakers proved to be significant. For this distinction high general impression speakers are obviously more coarticulatory resistant than low general impression speakers, which is in compliance with the initial hypothesis. Average and low general impression speakers' CD mean values also resulted in bars going in the negative direction. Moreover, F_2 and average speakers' CD values operated as prognosticated regarding CR and coarticulation relations, except when these were negative in the case of average and low general impression speakers for F_2 and F_2'.

The calculation of coarticulatory resistance in F_2 resulted in negative values for low and average general impression speakers (/y/: F_2 = 1750 *Hz* [Delattre 1981:73] vs. /a:/: F_2 = 1250 *Hz* [Neppert 1999:134]). Both /y/ and /a:/ are part of the group of front vowels, which is the reason for them attaining high F_2 scores. Taking into account that /y/ is rounded (low F_3) in opposition to /a:/ (high F_3) and that roundedness also diminishes the frequency of F_2, this is presumably why F_2 values for average and low general impression speakers reach the negative region. The same explanation might apply for F_2' in average and low general impression speakers, where roundedness influences F_2', F_2 and F_3, even more than F_2 to a considerable extent, leading to lower values for average and low general impression speakers in F_2' than in F_2 (*F_2 mean values:* low general impression: -10.01 *Hz,* average: -14.16 *Hz; F_2' mean values:* low general impression: -60.65 *Hz*, average: -37.46 *Hz*). In contrast, high general impression speakers cause positive CD values inviting the supposition that /y/ is articulated more frontally than /a:/. Therefore, /y/ and /a:/ probably come closer to their ideal values generated from Delattre (1981:73) and Neppert (1999:134). In contrast to low and average general impression speakers, roundedness does not seem to play a more important role in high general impression speakers than fronting and slightly more backness, which might be the consequence for the F_2' mean value also finishing positively. Further, high general impression speakers are more resistant to the coarticulation of /y/ vs. /a:/ on /ə/ across /l/, which could be due to these speakers being more restricted for the property of roundedness to come through, the stimuli being articulated with a more active tongue dorsum gesture.

In conclusion, significant correlations for F_2 and F_2' in /əli:/ vs. /əlu:/ and coarticulation or coarticulatory resistance heights might underline the presence of more different varieties, i.e. a varying permeability, of /l/ and more wide-spread frequency values in the vowels following /l/ which high general impression speakers are capable of perceiving, storing, accessing and producing (Pierrehumbert 2001, 2006). According to Keating (1990), there is evidence to ascribe the formation of extreme varieties of vowel phonemes to the wider range of spatial values for each segment, to larger *windows*. Thus, vowel formant frequency representations of average and low general impression speakers might be more moderated, i.e. their *window* size is limited and their access to different varieties of the same vowel is diminished. Compared to the /əly/ vs. /əla:/-calculations, mean values for the other distinctions (/əli:/ vs. /əlu:/, /əly/ vs. /əli:/) symbolize a certain amount of coarticulation. In correspondence with the general rule of /l/ in German being non-velarized and hence being formed with no or less tongue dorsum activity, the author would moreover suggest more coarticulation appearing in German than in English CR calculations. But, apparently, this is not the case for bars in the CD values of /əly/ vs. /əla:/ being considerably low. The front close roundedness (/əly/) vs. front open unroundedness (/əla:/) differentiation, not including a distinction in fronting/backness, could restrict tongue movements and thus intensify the emergence of tongue control, high general impression speakers again reaching more extreme values for F_2' than average and low general impression speakers.

8. Experiment: German vs. English stimuli across all subjects

Based on Clark, Yallop and Fletcher (2007), as well as Cruttenden (2008), the author predicts German formant frequencies to be always higher, i.e. pronounced with lesser degree of velarization, than English formant frequencies, i.e. pronounced with higher degree of velarization. According to Clark, Yallop and Fletcher (2007:96) the clear variant appears in RP previous to a vowel (e.g. *lend*, *alight*, *believe*) in syllable-initial and/or phrase-initial position, and the dark variety before a consonant, or syllable- or word-finally (e.g. *wild*, *halt*, *will*, *hall*). In contrast to these findings, Cruttenden (2008:85) discovered that General American (GA) /l/ is constantly velarized, autonomous of position. Combining these views, the author hypothesizes German /l/ to be constantly less velarized than English /l/. Being conscious of the fact that RP English /l/ is non-velarized in syllable-initial and/or phrase-initial position, the author supposes even RP English /l/ to be generally more velarized than German /l/ because of the existence of a more velarized variant and the difference between RP in syllable-initial and/or phrase-initial position vs. syllable-final and/or phrase-final position being less extreme than that between the RP syllable-initial and/or phrase-initial variant vs. German /l/.

8.1. Analysis 1: Degree of velarization in /əlV/ sequences measured in /ə/

Subjects, materials and procedure were analogous to those used in Experiment 1.
Differences between English and German degree of velarization were analysed using *t*-tests for double sided, independent control samples. The mean values were obtained using the descriptive analysis tool of the SPSS 16.0 software.

8.1.1. Results

t-test results across German vs. English productions revealed significant differences for F_2 and F_v in /ə/ before /l[a:, i:, y, u:]/ (F_2: $F(2) = 18.124$, $p < .000$ [$df_{bg} = 2$, $df_{wg} = 1586$]), F_v: ($F(2) = 37.053$, $p < .000$ [$df_{bg} = 2$, $df_{wg} = 1586$]). F_2 and F_v allow a high percentage of significant degree of velarization effects in both comparisons. Furthermore, the F_2 mean value of German speech was significantly higher (*mean value:* 2106.22 *Hz*) than that of English (mean value: 1901.64 *Hz*), equally the F_v mean value for German (*mean value:* 1744.709 *Hz*) proved to be more dominant than that for

English speech (*mean value:* 1515.62 *Hz*). See Figure 16 for a more vivid picture.

Table 24. Mean F_2 and F_v values (in *Hz*) for /ə/ before /la:/, /li:/, /ly/, /lu:/ or /laɪ/, /leɪ/, /ly/, /lu:/ in German native speech vs. L2 English. Standard deviations have been included in parentheses (second column). *t*-test results comparing degree of velarization taken from /ə/ in German native speech vs. L2 English in F_2 and F_v (third column).

Parameter	Mean value [Std. deviation]	Significance	
F_2	German: 2106.22 *Hz* [258.960]	$p < .000$	*
	English: 1901.64 *Hz* [304.837]		
F_v	German: 1744.709 *Hz* [252.1187]	$p < .000$	*
	English: 1515.362 *Hz* [319.8227]		

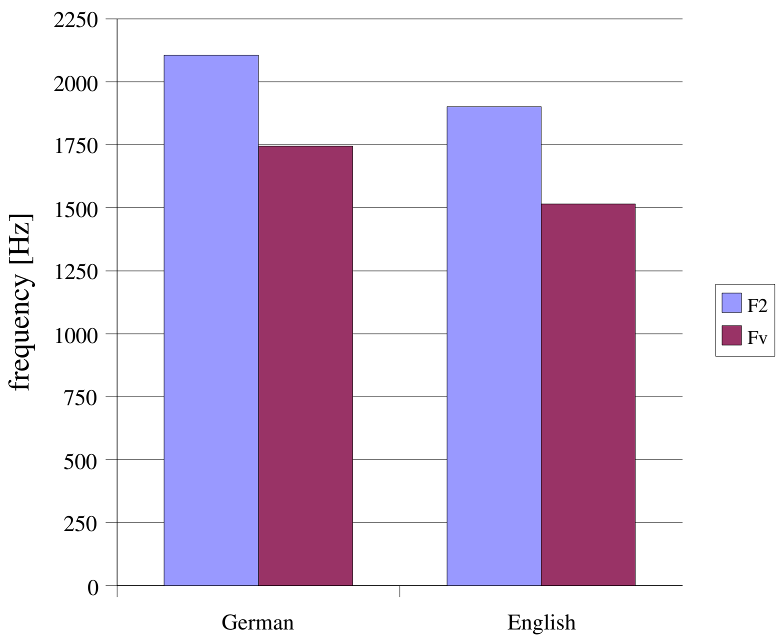


Figure 16. Distribution of F_2 and F_v mean values (in *Hz*) in /ə/ in German native speech vs. L2 English.

8.1.2. Discussion

Similarly to the assumptions in the previous chapters (Recasens 1985; Recasens, Fontdevila & Pallarès 1995), we also bear in mind at this stage of research that German is determined as a non-velarized language compared to English which is velarized. In accordance with Fant (1960) and

Recasens, Fontdevila and Pallarès (1995:41) vowel formant frequencies of F_2 and F_v in /ə/ before /l[a:, i:, y, u:]/ should be realized more intensely in German than in English. Tongue dorsum fronting and raising appears if no velarization takes place, and causes uprising F_2 and F_v frequencies. Analogously, F_2 and F_v decrease, if there is a higher amount of velarization.

To sum up the results above, native German and L2 English speech totally behaved in line with the hypothesis. Figure 16 demonstrates principally higher values for German F_2 and F_v, i.e. no or only very little inclusion of velarization, than for the corresponding English mean values, i.e. relatively high degree of velarization. As a consequence, this situation emphasizes the conclusions of previous studies (Recasens 1985; Recasens, Fontdevila & Pallarès 1995) which postulated that German is part of the category of non-velarized languages vs. English being a member of the category of velarized languages; this being the case although RP English /l/ in syllable-initial and/or phrase-initial position possesses more tongue fronting and raising. There were probably only few RP syllable-initial and/or phrase-initial /l/ variants which did not falsify these outcomes; or despite being less velarized, RP syllable-initial and/or phrase-initial /l/ appeared even more velarized than German /l/, in all instances in most of the articulated cases. Even when producing L2 English speech native German speakers are apparently capable of generally perceiving, storing, accessing and realizing the global distinction of German being non-velarized, compared to English being part of the velarized languages; this has been measured across all categories of proficiency levels or general talent impression.

8.2. Analysis 2: Degree of velarization in /əlV/ sequences measured in /l/, taking non-words

Subjects, materials and procedure were analogous to Experiment 1.

8.2.1. Results

t-tests comparing German with English stimuli achieved significant results for F_1 ($F(2) = 49.853$, $p < .000$ [$df_{bg} = 2$, $df_{wg} = 1586$]) and F_2 ($F(2) = 4.969$, $p < .000$ [$df_{bg} = 2$, $df_{wg} = 1586$]) measured in /l/ before /ə/.

Taking into consideration German stimuli, the F_1 mean value result was significantly lower (*mean value:* 272.08 *Hz*) than that for English stimuli (*mean value:* 317.23 *Hz*). In opposition to this distribution the F_2 mean value for German was significantly higher (*mean value:* 1929.66 *Hz*) than that of English stimuli (*mean value:* 1649.50 *Hz*) (cf Table 25).

Table 25. Mean F_1 and F_2 values (in *Hz*) for /l/ between /ə/ and /a:/, /i:/, /y/, /u:/ or /aɪ/, /eɪ/, /y/, /u:/ in German native speech vs. L2 English. Standard deviations have been included in parentheses (second column). *t*-test results comparing degree of velarization taken from /l/ in German native speech vs. L2 English in F_1 and F_2 (third column).

Parameter	Mean value [Std. deviation]	Significance	
F_1	German: 272.08 *Hz* [59.023]	$p < .000$	*
	English: 317.23 *Hz* [71.495]		
F_2	German: 1929.66 *Hz* [362.877]	$p < .000$	*
	English: 1649.50 *Hz* [398.646]		

Figure 17 illustrates the mean values of F_1 and F_2 in German native speech vs. L2 English in a bar chart showing that F_1 for native German speech is more reduced than F_1 for L2 English, and that for F_2 the reversed case exists.

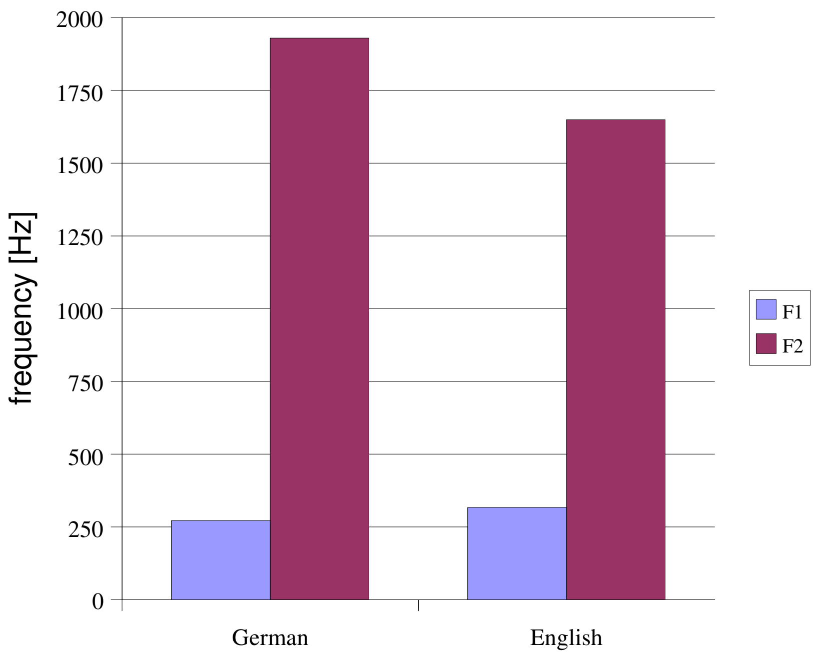


Figure 17. Distribution of F_1 and F_2 mean values (in *Hz*) for /l/ between /ə/ and /a:/, /i:/, /y/, /u:/ or /aɪ/, /eɪ/, /y/, /u:/ in German native speech vs. L2 English.

8.2.2. Discussion

Corresponding to the analysis of degree of velarization measured in /ə/, the author bases the results studied in /l/ on the findings of Recasens (1985) and Recasens, Fontdevila and Pallarès (1995). These authors attributed German to the category of non-velarized languages, whereas English was assigned to the velarized languages. According to Fant (1960) and Recasens, Fontdevila and Pallarès (1995:41) formant frequencies of F_2 in /l/ between /ə/ and /a:/, /i:/, /y/, /u:/ (German realizations) or /aɪ/, /eɪ/, /y/, /u:/ (English realizations) should turn out to be higher in German, i.e. with no or less velarization taking place, than in English, i.e. with a certain degree of velarization being observable. If tongue dorsum fronting and raising are present, no velarization emerges, and in turn F_2 frequency is elevated. On the contrary, the F_1 rises, if the degree of velarization diminishes.

In conclusion, the reversed picture of F_1 being low and F_2 being high in native German in comparison to F_1 being high and F_2 being low in L2 English (cf Figure 17) supports the initial hypothesis. As foreseen, German speakers integrated a lesser degree of velarization in their native language than they did in their L2 English. This stresses a second time (cf Chapter 3.) the insights of earlier investigations which discovered German as being part of the non-velarized languages vs. English being a member of the category of velarized languages (Recasens 1985; Recasens, Fontdevila & Pallarès 1995). Nevertheless, RP English /l/ in syllable-initial and/or phrase-initial position being less velarized, these effects could be observed. RP English speakers' tendency not to velarize in syllable-initial and/or phrase-initial /l/ position did not seem to have a strong impact on the global variants, because of the existence of the predicted effects for German vs. English, and even these were significantly different. Despite the fact of realizing L2 English speech, native German speakers were obviously able to perceive, store, access and produce the general differentiation of German being non-velarized in opposition to English, also generating the more velarized allophone of /l/. Remarkably, these results include frequency outputs having been unified from all levels of proficiency or general talent impressions.

EXPERIMENTAL PART 2

9. Experiment with natural language stimuli in English dialects (vs. German)

9.1. Degree of velarization measured in /l/, taking natural language stimuli

9.1.1. Methods

9.1.1.1. Subjects

10 (5 less proficient [3 female, 2 male], 5 proficient [3 f, 2 m] native German speakers (6 f, 4 m) were recruited for the recordings. They were 20 to 41 years old with a mean age of 25.6 years. These 10 speakers were taken from the whole group of 41 speakers invited to the previous experiment (cf Chapter 6.1.1.1.) which only dealt with non-words. Hence previous examinations, e.g. auditive assessments, origins of speakers, i.e. dialectal shapes, and academic careers were the same as those specified in Experimental Part 1.

Based on the dialectal variety classification derived by Jilka (2009b) (cf Chapter 1.2.1.2.) within the group of the 5 less proficient speakers: 4 realized German speech with no identifiable accent and 1 GA German accented speech, whereas in the group of the 5 proficient speakers: 2 produced GA accent of solid quality, 2 RP accent of substantial quality and 1 speaker of German accented speech with the recognizable aim of achieving an RP accent.

9.1.1.2. Materials

In accordance with previous investigations formant frequency data were extracted from the quasi-steady-state period in /l/ spoken in different contexts within seven natural language sentences (4 German vs. 3 English). Different context types included the consonant /l/ in initial, medial and syllable-/word-final position. While preparing the recording routine, subjects were instructed to construct these sentences as naturally as possible and to pay attention to accentuation and speech rate (cf Cho 2004). On the basis of Fowler (1981), Kühnert and Nolan (1999) as well as Cho (2004) stress and speech rate differences, as well as phonological boundaries might also highly affect (Cho 2004) coarticulation values within one language-specific investigation. According to Cho (2004:168) coarticulation and duration clearly react in divergent ways.

The author employed the English stimuli from the appropriate literature (Clark, Yallop & Fletcher 2007:96) which affirmed that the clear variant is present before a vowel (e.g. *lend*, *alight*, *believe*) and in syllable-initial and/or phrase-initial position. Additionally, the dark variant emerges before a consonant or syllable-/word-finally (e.g. *wild*, *halt*, *will*, *hall*). As a result from the examples of Clark, Yallop and Fletcher (2007:96) the given stimuli followed: “wild” [ˈwaɪɫd], “halt” [ˈhɔːɫt], “will” [ˈwɪɫ], “hall” [ˈhɔːɫ], “light” [ˈlaɪt], “lend” [ˈlent], “alike” [əˈlaɪk] instead of alight [əˈlaɪt] and “believe” [bɪˈliːv]. Parallel to this, the author created German stimuli containing similar vowels in analogue context positions, namely “Weile” [ˈvaɪlə], “hold” [ˈhɔlt], “will” [ˈvɪl], (“Holland” [ˈhɔlant],) “Leid” [ˈlaɪt], “Länder” [ˈlɛndɐ], “Geleit” [gəˈlaɪt] and “beliefern” [bəˈliːfɐn] to make English and German formant frequencies in /l/ comparable with each other. Previously, Jilka (2009b:23) also employed clear /l/ in all positions in his phonetic experimental data because of its appearance in syllable-/phrase-final position serving as a strong indicator for a heavy German accent.

9.1.1.3. Procedure

Subjects were instructed to read the seven sentences fluently, avoiding hesitations and speaking errors.

Digital recordings were made at a 16 *kHz* sampling rate in a sound-proof recording room in the phonetics laboratory of the Institute for Natural Language Processing, Universität Stuttgart, Germany. Identically to Experimental Part 1 the recorded data were then automatically aligned at the phone level with the help of software by Rapp (1995) and later controlled by hand. Formant frequencies were evaluated every 10 ms with the *ESPS formant* program (Entropic Signal Processing System 2003). F_1 and F_2 were derived out of the midst of the steady state in /l/ in accordance with usual procedure (Recasens 1999:327).

The author is conscious of the necessity of conducting the normalization procedure (Lobanov 1971; Adank et al. 2004) prior to the classification of vowel productions of many speakers, but was in this case not able to do so, because of the extraction of formant frequencies from a consonant, namely /l/.

On completion of Experimental Part 1 the author wanted to check, whether non-word testing was representative enough, and to explore /l/ in syllable-/word-initial vs. -final or -medial position being velarized in another way. For the purpose of discovering significant formant-dependent differences, *t*-tests for double sided, independent control samples were carried out separately for F_1 and F_2, with proficiency level as the independent variable. The aim of this investigation was to discover, whether an increase in F_1 and a decrease of F_2 or vice versa, i.e. a quite high degree of velarization or no velarization at the same time, can be attributed to the given proficiency levels, and less importantly, if velarization and proficiency level differed significantly.

Based on earlier research (Clark, Yallop & Fletcher 2007:96), the author forecasts that more velarized native-like English [ɫ] will arrive at higher formant frequencies for F_1 and lower frequencies for F_2 vs. non-velarized, less native-like English [l] to produce lower formant frequencies for F_1 and higher frequencies for F_2 in /l/ situated in syllable-/phrase-medial or syllable-/phrase-final position. In contrast to these assumptions, in syllable-/phrase-initial position [l] is assumed to be non-velarized in these 3 proficient speakers (2 RP accent of substantial quality, 1 speaker of German accented speech with the recognizable aim of achieving an RP accent) producing RP(-like) dialects. Unlike in RP [l], in General American (GA) [ɫ] there is regularly a certain degree of velarization inserted independent of position (Cruttenden 2008:85). The author, thus, anticipates that the 2 proficient learners speaking with a GA accent of solid quality and the one of German accented speech with the recognizable aim to end up in GA speech will not make use of the non-velarized variant in syllable-/phrase-initial position.

To enable the distinction between the different dialectal varieties of English themselves and to set these varieties in opposition to German native speech, the 2 RP accented speakers of substantial quality and 1 speaker of German accented speech with the recognizable aim to finish with RP accent were put together resulting in 3 RP(-like) dialectal informants. The same grouping was carried out with 2 L2 English speakers producing GA accent of substantial quality and 1 speaker of German accented speech with the recognizable aim to terminate with GA accented speech.

In a first stage analysis on the basis of the above hypothesis that more velarized native-like English [ɫ] reveals higher F_1 frequencies and lower F_2 frequencies in opposition to non-velarized less native-like English [l] baring F_1 and F_2 frequencies in /l/ situated in syllable-/phrase-medial or syllable-/phrase-final position, *t*-tests for double sided, independent control samples were computed separately for F_1 and F_2 in syllable-/phrase-medial position with proficiency level as the independent variable. Further, the mean values of English proficient vs. less proficient speakers were compared with the mean values of German formant frequencies within *t*-tests for independent control samples to uncover whether the ones of less proficient informants are more similar to the German mean values than the ones of proficient informants.

For [l] in syllable-/phrase-initial position the coarticulation status is less clear-cut, that is why a second stage analysis based on the above supposition that F_1 and F_2 vary in this position with respect to the dialectal variety spoken, the author computed a separate *t*-test for the English language split up in RP and GA dialectal varieties also considering both levels of proficiency. No analysis was set up for initial [l] while opposing the German and English language. The author presumed that the English formant frequencies are quite divergent depending on the dialectal variety preferred by the speakers. However, the German frequency values were suspected to be quite the same as those of RP English. Therefore two separate *t*-tests for double sided, independent control samples (German vs. GA English, German vs. RP English) should untwist the way speakers differentiate between their German mother tongue [l] and the GA English [ɫ] in initial position. The comparison of German vs. RP English was added up to verify the hypothesis that these [l]-types are realized in pretty much the same way. For the purpose of comparing dialectal varieties, RP and GA English groups have not been split up in proficient vs. less proficient speakers because the focus primarily emphasized accent identification. It should be noted in this regard that because of the inequality of speaker groups and, consequently, sample sizes, all cases were weighted to avoid non-representative outcomes, with dialectal variety and/or proficiency level being the frequency variable.

9.1.2. Results

9.1.2.1. Syllable-/phrase-medial or syllable-/phrase-final position

English [ɫ] in syllable-/phrase-medial or syllable-/phrase-final position less proficient vs. proficient informants

Comparisons between syllable-/phrase-medial or syllable-/phrase-final English [ɫ] in less proficient vs. proficient speakers revealed significant correlations for F_1 ($F(2) = 10.048$, $p < .036$ [$df_{bg} = 2$, $df_{wg} = 393$]) and F_2 ($F(2) = 24.276$, $p < .000$ [$df_{bg} = 2$, $df_{wg} = 393$]) with the mean values for formant frequencies in proficient speech being consistently lower than those in less proficient speakers (F_1: proficient: 423.00 *Hz* [402.903], less proficient: 591.20 *Hz* [473.625]; F_2: proficient: 1513.39 *Hz* [503.209], less proficient: 1882.74 *Hz* [314.690]). Figures 18 and 19 display the differences for both correlation analyses within boxplots.

Native-like/less native-like English [ɫ] vs. German [l] in syllable-/phrase-medial or syllable-/phrase-final position

Correlation analysis within *t*-tests for native-like English vs. German speech exhibited an insignificant interdependence (F_1: $F(2) = 7.413$, $p < .354$ [$df_{bg} = 2$, $df_{wg} = 73$]), but in contrast a significant interrelationship between less native-like English speech vs. German (F_1: $F(2) = 47.091$, $p < .003$ [$df_{bg} = 2$, $df_{wg} = 392$]) for F_1. Formant frequencies were lower for German speech (354.68 *Hz* [193.627]) compared to proficient (*mean value:* 423.00 *Hz* [402.903]) and less proficient speakers (*mean value:* 591.20 *Hz* [473.625]). Figure 18 contains the F_1 formant frequency values of native German compared to proficient and less proficient English speech, while displaying a wider distribution of formant frequencies in less proficient L2 English than in proficient L2 English and native German speech.

t-tests for F_2 taking into consideration native-like English speech vs. German mother tongue showed a significant interrelationship (F_2: $F(2) = 6.061$, $p < .010$ [$df_{bg} = 2$, $df_{wg} = 73$]), whereas no significant interdependence between less proficient English speech and German could be uncovered (F_2: $F(2) = 1.5$, $p < .097$ [$df_{bg} = 2$, $df_{wg} = 42.001$]). Less proficient speakers' formant frequencies in F_2 were higher (*mean value:* 1882.74 *Hz* [314.690] than those of German L1 (*mean value:* 1779.23 *Hz* [357.083]) and proficient L2 English speech (*mean value:* 1513.39 *Hz* [503.209]). Interestingly, less proficient speakers' F_2 formant frequencies turned out to be even higher than those of German L1 informants. Formant frequency values for F_1 and F_2 are revealed in the Figures 18 and 19.

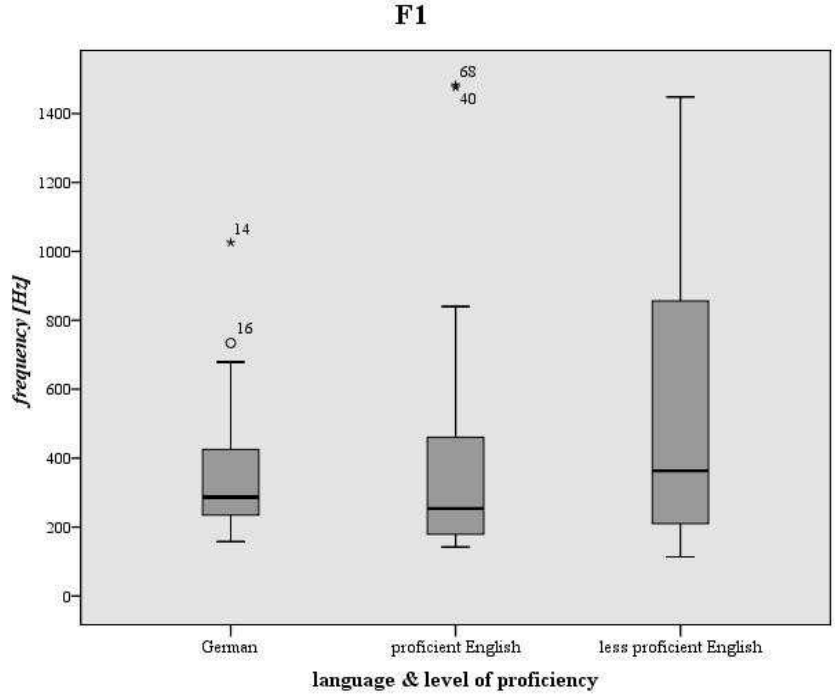


Figure 18. Distribution of F_1 in /l/ in German natural speech vs. proficient vs. less proficient natural L2 English speech.

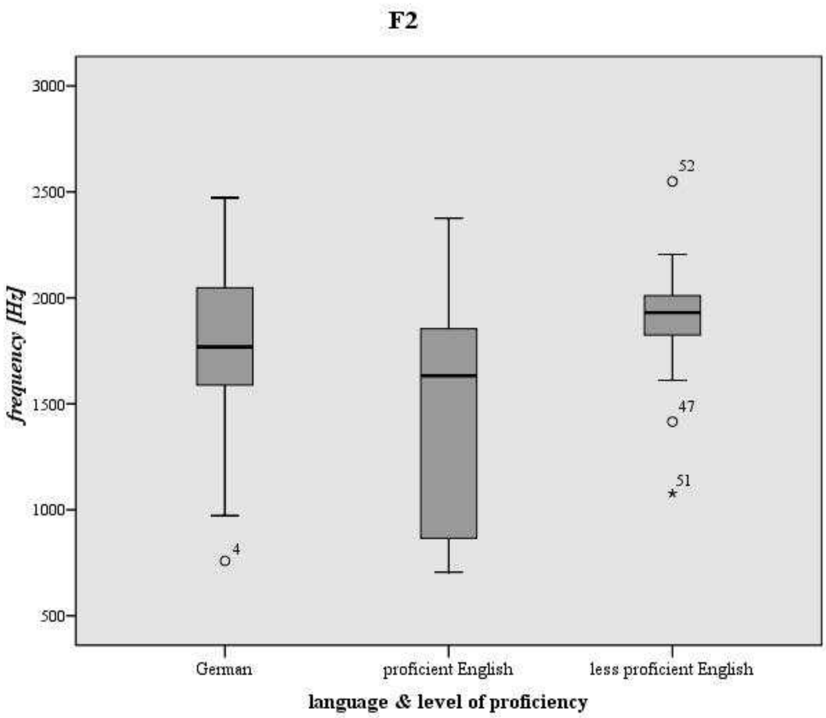


Figure 19. Distribution of F_2 in /l/ in German natural speech vs. proficient vs. less proficient natural L2 English speech.

Summing up the above results, English [ɫ] in syllable-/phrase-medial or syllable-/phrase-final position was produced in a significantly different way in F_1 and F_2 with respect to less proficient vs. proficient informants, while the proficient speakers articulated lower formant frequencies for /l/ than less proficient speakers.

Distinctions between German vs. less proficient English speech in F_1 and German vs. proficient English speech in F_2 reached significant outcomes, while proficient English speech could not be found to diverge from German native speech in F_1, and less proficient English did not turn out to deviate importantly from German in F_2. Overall, proficient L2 English speakers produced the lowest formant frequency values for F_1 and F_2, whereas for German and less proficient L2 English speech formant frequency heights for F_1 and F_2 were inversely ranked.

9.1.2.2. Syllable-/phrase-initial position

RP English [l] vs. GA English [ɫ] in initial position

Within the correlation analysis between RP English [l] vs. GA English [ɫ] in initial position no significant interrelationship appeared for F_1 ($F(2) = 1.483$, $p < .362$ [$df_{bg} = 2$, $df_{wg} = 42.883$]) and F_2 (F_2: $F(2) = .039$, $p < .380$ [$df_{bg} = 2$, $df_{wg} = 56$]). F_1 was discovered to be lower for RP English (RP English *mean value:* 528.23 *Hz* [290.270]; GA English *mean value:* 599.33 *Hz* [276.825]), whereas F_2 formant frequency values presented themselves in a reverse image (RP English *mean value:* 1941.77 *Hz* [382.837]; GA English *mean value:* 1854.96 *Hz* [322.193]).

RP English [l]/GA English [ɫ] vs. German [l] in initial position

On the whole, the comparisons of RP English [l]/GA English [ɫ] vs. German [l] in initial position did not yield any significant results:

1) <u>RP English vs. German:</u>

F_1:

$F(2) = 1.315$, $p < .765$ [$df_{bg} = 2$, $df_{wg} = 42.483$]

mean values:	RP English:	528.23 *Hz*	[290.270]
	German:	503.00 *Hz*	[271.988]

F_2:

$F(2) = .550$, $p < .847$ [$df_{bg} = 2$, $df_{wg} = 42.371$]

mean values: RP English: 1941.77 *Hz* [382.837]

German: 1917.59 *Hz* [453.028]

2) <u>GA English vs. German:</u>

F_1:

$F(2) = .028$, $p < .194$ [$df_{bg} = 2$, $df_{wg} = 47.640$]

mean values:	GA English:	599.33 *Hz*	[276.825]
	German:	503.00 *Hz*	[271.988]

F_2:

$F(2) = 1.456$, $p < .568$ [$df_{bg} = 2$, $df_{wg} = 36.144$]

mean values:	GA English:	1854.96 *Hz*	[322.193]
	German:	1917.59 *Hz*	[453.028]

RP English speech formant frequency values were in both cases, for F_1 and F_2, higher than for German native speech. Whereas F_1 was detected to be of a higher value in the GA dialectal variety, the F_2 values for GA represented themselves to be lower than the German formant frequencies.

9.1.3. Discussion

9.1.3.1. Syllable-/phrase-medial or syllable-/phrase-final position

English [ɫ] in syllable-/phrase-medial or syllable-/phrase-final position less proficient vs. proficient informants

On the basis of previous studies (Clark, Yallop & Fletcher 2007:96), the author prognosticated more velarized native-like English [ɫ] to be significantly differentiable from less native-like English and to be produced including higher formant frequencies for F_1 and lower ones for F_2. In opposition non-velarized less native-like English [l] was expected to attain lower formant frequencies for F_1 and higher ones for F_2 in /l/ situated in syllable-/phrase-medial or syllable-/phrase-final position.

In line with the author's prediction, distinctions between syllable-/phrase-medial or syllable-/phrase-final English [ɫ] in less proficient vs. proficient speakers were uncovered to be significant in both cases. As was singled out in the result section above, formant frequencies in proficient informants were lower in F_1 and F_2 than in less proficient informants. These results concerning formant frequency heights do not confirm the initial hypothesis. While proficient speakers employed a lower formant frequency for F_1 than less proficient speakers, they were supposed to reach higher formant frequencies than less proficient speakers. Fant (1960) stated that there is a positive correlation between F_2 and tongue dorsum fronting and raising, thus being in inverse dependency to the degree of velarization, i.e. a high F_2 operates as an indicator for a lesser degree of velarization and vice versa. Opposed to F_2, Recasens, Fontdevila and Pallarès (1995:41) characterized F_1 as being in direct connection to velarization (Recasens, Fontdevila & Pallarès 1995:41). Summing up the articulatory findings of the authors mentioned, there is a decrease in F_2 and an increase in F_1, if degree of velarization rises. The striking observation that proficient F_1 formant frequency was lower than the one of less proficient speakers, even though the author expected it to be higher, i.e. more velarization should have been elicited from proficient speakers compared to less proficient speakers, brought to light a less transparent attitude considering the two formant frequencies. As evident from the data provided, proficient speakers seemed to have realized F_2 incorporating a considerable constriction in the back part of the tract, i.e. frequency values of F_2 decrease, whereas they simultaneously produced a constriction in the frontal half of the tube leading to a decrease in F_1 (Neppert 1999:132 f.).

Native-like/less native-like English [ɫ] vs. German [l] in syllable-/phrase-medial or syllable-/phrase-final position

Referring to the comparisons of native-like/less native-like English [ɫ] vs. German [l] in syllable-/phrase-medial or syllable-/phrase-final position, the author followed the hypothesis that less native-like English should turn out to be more likely the same as German, i.e. no significant correlation should yield from these analyses, whereas native-like English [ɫ] vs. German [l] should be significantly differentiable. Finally, a surprising totally reversed effect was found for both correlation analyses of F_1; whereas native-like English vs. German speech revealed an insignificant outcome, a significance was uncovered regarding less native-like English speech vs. German for F_1. Formant frequencies thus underlined this unexpected image (*mean values:* German speech 354.68 *Hz* [193.627]; proficient English speech: 423.00 *Hz* [402.903]); less proficient English speech: 591.20 *Hz* [473.625]).

In opposition to the above findings for F_1, F_2-results confirmed the initial hypothesis of a significant correlation between native-like English speech vs. German and an insignificant outcome for less native-like English speech vs. German mother tongue. Accordingly, less proficient speakers' formant frequencies in F_2 were higher (*mean value:* 1882.74 *Hz* [314.690] than those of German L1 (*mean value:* 1779.23 *Hz* [357.083]) and proficient English speech (*mean value:* 1513.39 *Hz* [503.209]). Still another peculiarity the author ought to mention in this respect is German speech attaining a lower F_2, i.e. more velarization, formant frequency value than less proficient English speech, which the author would rather intuitively have assumed to be more velarized than German speech.

Overall, the results imply that, as far as F_2 is concerned, native-like English [ɫ] in syllable-/phrase-medial or syllable-/phrase-final position was pronounced using tongue backness (resulting in low F_2), i.e. it was thus a high degree of velarization inserted in the consonant regarding F_2. Unexpectedly, for F_1 formant frequency values the highest degree of velarization was included in less proficient speakers, while proficient English speech was realized less velarized compared to less proficient speech, i.e. more constriction in the frontal half of the tube can be derived from proficient speakers' vowel formant frequencies (*mean value:* 423.00 *Hz* [402.903]) than from less proficient ones (*mean value:* 591.20 *Hz* [473.625]) and German speech. Apart from that, in line with the presumption German speakers imposed the least velarization in the consonant (*mean value:* German speech 354.68 *Hz* [193.627]), i.e. these speakers induced the most constriction to the frontal half of the tube (Neppert 1999:132 f.).

Since F_1 and F_2 do not create a transparent picture which explains the degree of velarization tendency, this F_1 bias might be caused by vowels preceding or following [l] not being accounted for.

9.1.3.2. Syllable-/phrase-initial position

On the whole, none of the six correlation analyses between RP English [l] vs. GA English [ɫ] and RP English [l]/GA English [ɫ] vs. German [l] in initial position turned out to be significant. The experimental results will be discussed more in detail in the following paragraphs.

RP English [l] vs. GA English [ɫ] in initial position

On the one hand, for the comparisons of F_1 and F_2 in RP English [l] vs. GA English [ɫ] in initial position the experimental results did not turn out to confirm the initial hypothesis of reaching significance, however on the other hand they did not entirely concur with the assumption in the way of degree of velarization tendencies.

RP English F_1 (*mean value:* 528.23 *Hz* [290.270]) arrived at a lower, whereas F_2 in RP (*mean* *value:* 1941.77 *Hz* [382.837]) at a higher formant frequency mean value. In opposition to RP findings, GA English attained a higher formant frequency mean value in F_1 (*mean value:* 599.33 *Hz* [276.825]), while F_2 in GA English (*mean value:* 1854.96 *Hz* [322.193]) could be observed to be lower than that of RP English. Keeping in mind that a lesser constriction in the frontal half of the tube (F_1 high) and a higher one in the back part of the mouth make up the patterns of velarization (F_2 low) (Fant 1960; Neppert 1999:132 f.; Recasens, Fontdevila & Pallarès 1995:41), GA English speakers velarized more than RP English speakers.

As a final remark, the author points out that although the correlation analysis did not turn out to be significant, formant frequency values showed tendencies for GA English [ɫ] in initial position to be more velarized in these subjects than RP English [l]. It might be worth noticing that further analyses are needed for clarification purposes including higher numbers of subjects in each comparison group to underline the above outlined results and to additionally reach a significant correlation.

RP English [l]/GA English [ɫ] vs. German [l] in initial position

Both analyses of RP English [l] vs. German [l] and GA English [ɫ] vs. German [l] in initial position showed no significant differences. While RP English [l] vs. German [l] in initial position were not expected to end up in an important correlation according to prediction, GA English [ɫ] vs. German [l] were suspected to be significantly dissimilar in this position.

RP English F_1 formant frequency in [l] attained a higher value (*mean value:* 528.23 *Hz* [290.270]) than the German mother tongue equivalent (*mean value:* 503.00 *Hz* [271.988]), the same holds for F_2, i.e. RP English F_2 (*mean value:* 1941.77 *Hz* [382.837]) being higher than that of German mother tongue speech (*mean value:* 1917.59 *Hz* [453.028]). Thus, however, taking into consideration *p*-value heights, it can be accounted for RP English vs. German mother tongue formant frequencies being quite similar, in the way of examining the degree of velarization.

Contrary to prediction, GA English [ɫ] vs. German [l] in initial position seemed to concur with the initial hypothesis because of not reaching a significant effect. However, formant frequencies showed a tendency to prove the previous assumption of German being less velarized than L2 GA English in initial position. In opposition to German speech, F_1 was higher for GA speech, whereas F_2 created an inverse image (German: *mean values:* F_1: 503.00 *Hz* [271.988], F_2: 1917.59 *Hz* [453.028]; GA English: *mean values:* F_1: 599.33 *Hz* [276.825], F_2: 1854.96 *Hz* [322.193]).

Consequently, GA speech was realized with a lesser extent of constriction in the frontal half of the tube and at the same time a certain amount of constriction in the back part of the mouth; German speech being articulated drawing an inverse image of constriction properties. As described in the paragraph above this could be a hint for GA speech of L2 speakers being generally produced including more velarization, but future studies are necessary comprising a considerable number of subjects for this formant frequency tendency to prove it to be true and to - in the next step - come to a significant correlation result.

Overall, results of comparisons of RP English [l] vs. GA English [ɫ] and RP English [l]/GA English [ɫ] vs. German [l] in initial position imply that, as far as the formant frequency tendencies are concerned, the RP English variety group and German mother tongue speakers realized /l/ in this position in a quite similar way, i.e. non-velarized, whereas GA English informants have chosen the velarized variety of the consonant.

9.1.4. Conclusion

Comparing formant frequencies in /l/ in contrasting syllable or phrase positions while taking into consideration natural language stimuli quite likely led to the foreseen tendencies and also to some significant correlations (within the syllable-/phrase-medial, -final comparisons) with respect to F_2 in syllable-/phrase-medial, -final or initial position. However, one unpredictable, but steady trend was discovered taking into account F_1 in syllable-/phrase-medial or syllable-/phrase-final position which was consistently realized higher for less proficient speakers than for proficient speakers. Besides German speech compared to less native-like English did not behave in accordance with the initial hypothesis in the case of syllable-/phrase-medial or -final position for F_2 formant frequency in /l/. Moreover, a significant correlation was detected for less native-like English speech vs. German for F_1 (*mean values:* German speech 354.68 *Hz* [193.627]; proficient English speech: 423.00 *Hz* [402.903]); less proficient English speech: 591.20 *Hz* [473.625]), less proficient English speakers importantly having velarized more than German speakers; and in addition less proficient speakers' F_2 formant frequencies ended up being even more elevated than those of German L1 informants, i.e. lesser velarization in less proficient than in German speech, but this distinction was insignificant in syllable-/phrase-medial or -final position. Since the constriction in the frontal half of the tube, which as a consequence decrease the F_1 formant frequency (Neppert 1999:132 f.), is one factor necessary to imply the velarization distinction; this bias might be caused by jaw opening vs. closing not taking place so fixed in natural language stimuli being fluently produced. The uncontrolled environment of the consonant in syllable-/phrase-medial position could have influenced the precision of articulation to a non-foreseen extent, especially because of /l/ in medial position is distorted by anticipatory or carry-over coarticulation if CR specification on some segments is weaker, i.e. constrictions are less severe and allow for the features of the surrounding vowels and/or consonants to go through.

Speaking in exemplar theoretic terms and also bearing in mind the surprising outcomes apropos of a lesser degree of velarization in English of less proficient speakers in F_2 than in German, one might think about these speakers choosing even less velarized exemplars from memory rather than relying on exemplars stemming from more velarized stored variants of the consonants. Velarization thus does not seem to generalize both formant frequencies in all speaking styles, i.e. non-words and natural language stimuli, and dialectal varieties, and remains a phenomenon being almost always clearly distinguishable in less proficient vs. proficient speakers, while the results considering F_1 and less velarized speaking styles are less obvious. This could also be a hint of velarization being a property to introduce considerably more difficult in F_1 in natural language than in non-word stimuli and in F_2. Comparing formant frequencies measured in natural language and therein in consonants in the described form of course has its limitations. These limitations could additionally be responsible for some biases in the data obtained.

10. General conclusion and outlook

The main research interest in the present thesis is to obtain evidence for a difference in the degree of velarization and coarticulatory resistance through /l/ in proficient vs. average vs. less proficient speakers of L2 English. The need for a velarization and coarticulatory resistance proposal comes from the phonetic proficiency assessment searching for differences in speech production and speech perception, as well as speech production and speech perception combined, language aptitude and English proficiency test within the DFG project "Language Talent and Brain Activity (The neural basis of pronunciation talent)" at the Universität Stuttgart and University of Tübingen. Jilka (2009b:34) investigated performance while exclusively taking into account and drawing further conclusions from perceivable events with the help of raters within which instrumental analysis was of relevance. For the purpose of discovering explicit phonetic phenomena, such as coarticulation and/or coarticulatory resistance, and at the same time to shed light on the presence of various talent levels, it is however inevitable to implement instrumental analysis. In the framework of the project non-native speakers were chosen to discover the reason they performed differently in their L2 English. The finding of cross-language (Öhman 1966; Manuel 1990; Recasens, Fontdevila & Pallarès 1995) and individual (Baumotte et al. 2007) differences in coarticulation and coarticulatory resistance (Bladon & Al-Bamerni 1976) resulting from tongue dorsum activity included in a consonant production was the reason for taking a close look at the velarization and coarticulatory resistance characteristics in /l/ (Stevens & House 1963). The incessant allophonic variation of the consonant /l/ in German vs. English (Kenyon 1950; Recasens 1985; Clark, Yallop & Fletcher 2007:96; Cruttenden 2008:85) was thus the core motivator to consider variability in this consonant. In order to reconcile the bulk of experimental findings with a theory of speech production and perception, numerous theoretical proposals have been suggested.

As was shown in Chapter 1, phonetic proficiency assessment (such as speech production, speech perception, speech perception and production combined tests), psychological factors (such as intelligence, empathy, mental flexibility, working memory, personality traits) and language aptitude and English proficiency tests (such as Modern Language Aptitude Test (MLAT), TOEFL Listening Comprehension, TOEFL "Structure-"Test of written English [grammar, vocabulary and expression]) serve as an excellent test battery to build up categories for pronunciation proficiency. Additionally, brain imaging studies (such as fMRI-studies) have succeeded in bringing to light neuronal correlates of pronunciation talent. However, regardless of how elaborate these approaches are, none of them seems to be able to offer satisfying solutions to the profound pronunciation differences in levels of proficiency and their fine phonetic details.

The analyses in the present thesis were designed to further investigate these issues, focusing on the impact of the consonant /l/ on foreign accent strength. Moreover, in addition to well-established procedures like vowel formant frequency measurements, the CD calculation derived from Bladon and Al-Bamerni's MCD value computation (1976:142) was used which had not been a method of research in previous observations of L2 pronunciation proficiency. Degree of velarization was calculated in /ə/ and /l/ of the respective non-word and natural language stimuli in German and/vs. English, and also coarticulatory resistance measurements were carried out in order to reveal a precise picture of differences in the production of /l/ in proficient vs. average vs. less proficient German L2 speakers of English. The method allows insights into the realization of articulatory movements via the interpretation of vowel formant frequency heights (the acoustic theory of speech production). Additionally, it was accounted for gender-specific and individual differences in the pattern of velarization while taking an in-depth look at only female velarization outcomes and especially on two individual speakers which diverged the most from each other with respect to proficiency assessment rate. Moreover, degree of velarization and dialectal varieties (as well as levels of proficiency) were correlated to discover whether the degree of velarization had an essential impact on the categorization into various dialectal varieties based on auditive assessment. To get evidence for differences in the degree of velarization not appearing due to unlike vowel distributions succeeding /l/, but from differences in articulatory control of the consonant, their frequencies have been analysed in more detail. Natural language English stimuli have been finally created to further lay bare whether speakers of a certain English dialectal variety are able to articulate the different /l/ variants in syllable-/phrase-initial vs. -medial or -final position in their appropriate manner.

10.1. Conclusions, open questions and a general outlook

The analyses in the present thesis provide evidence for differences in the pattern of velarization between proficient vs. average vs. less proficient L2 speakers of English. By examining velarization in /l/, taking non-word stimuli, it was investigated whether L2 informants of various pronunciation abilities are differentiable with regard to the inclusion of degree of velarization. In addition, the need for a velarization proposal, taking natural language stimuli, was derived from the findings of Clark, Yallop and Fletcher (2007:96), as well as Cruttenden (2008:85) who stated that there are differences with respect to the degree of velarization across dialectal varieties of English, i.e. in RP vs. GA English dialects, and also between /l/ in various positions (syllable-/phrase-final, -medial, -initial).

Based on the experimental results within this work, the main conclusions and theoretical implications are summarized in this section:

Within Keating's *Window model of coarticulation* phonological feature values are the main finding to select *windows*. Keating (1990:466) integrated the elementary knowledge of coarticulatory resistance in her *Window model* affirming that a huge degree of coarticulatory resistance corresponds with a tight *window*, in contrast to missing coarticulatory resistance causing a broad *window*. Each physical articulatory dimension, e.g. jaw position or tongue backness, owns its minimum and maximum, within which the contextual variability of a given feature value can be mirrored.

Acoustic differences, i.e. differences in vowel formant frequencies, in the pattern of velarization are caused due to articulatory control functioning in dissimilar ways. If less velarization is induced in the consonant /l/, the tongue moves towards a front position and is raised to a considerable extent. Whereas a certain amount of velarization causes tongue backness and therefore a constriction in the back part of the mouth.

The Exemplar Theory (Pierrehumbert 2001, 2006) proclaims that in less proficient speakers less exemplars are stored, are accessible and can be reproduced than in proficient speakers. Pierrehumbert (2001:141) introduced the assignment of a resting activation level to each exemplar, namely the associated *strength*. Exemplars having only recently been encoded get higher resting activation levels than exemplars of infrequent and temporally remote experiences. A new token is classified in *Exemplar Theory* according to its similarity, i.e. its distance in the parameter space to the exemplars already stored. The importance of similarity between newly perceived phonetic feature values and those being already stored is also underlined by Baddeley (2003). The author points to the fact that if existing memory traces remain, it is also dependent on the phonological characteristics of the material: when encoding unrelated letters, listeners recall sequences of dissimilar sounding letters (e.g. X, K, R, Y, Q) better than sequences of similar ones (e.g. P, B, T, etc.). While memorizing meaningless material, listeners need to pay attention to its phonological characteristics.

Taking into consideration Keating's *Window model of coarticulation,* proficient vs. average vs. less proficient speakers do not pick up *windows* of identical ranges while attempting to realize the different allophones of the consonant /l/. Contextual variability of this feature value does not seem to be present to a similar magnitude in speakers of different levels of proficiency, i.e. the physical articulatory dimensions – in this case: jaw position or tongue backness/fronting -. Minimum and maximum values are assigned to the *windows*. While a high degree of coarticulatory resistance is characterized within *The window model* through a tight *window*, i.e. low contextual variability of the segment, missing coarticulatory resistance causes a broad *window*, i.e. high contextual variability of the segment. A certain amount of velarization resulting from tongue backness leads to a constriction in the back part of the mouth. Then /l/ is more susceptible or resistant to potential interference from the neighbouring segments (Farnetani & Recasens 1999:32), coarticulatory resistance is present in the given stimulus.

To sum up, the choice of which features can be stored, the speaker can have access to and reproduce (Pierrehumbert 2001, 2006), and how great the extent of the contextual variability given is (Keating 1990), seems to be a consequence of the phonetic information being available. Furthermore, the pool of phonological feature values under disposal is dependent on what has been previously heard, if it is frequently perceived and how similar the feature is compared to what has been stored before (Pierrehumbert 2001, 2006). In conclusion, perception differences in speakers of various levels of proficiency are meant to be the reason for dissimilar articulatory-phonetic realizations.

10.2. Issues for future research and second language learning

In order to further investigate the influence of L1 coarticulation and coarticulatory resistance properties on L2 speakers' pronunciation abilities more analyses need to be carried out in future research.

Regarding the pattern of velarization and the resistance features over the consonant /l/, it was suggested that differences in the degree of velarization occur with respect to proficient vs. average vs. less proficient speakers. While also looking at more consonantal data in non-word and also natural language stimuli in different syllable-/phrase-positions, the assumption of the L2 speakers' lack of storing, accessing and producing variants deviating from those existing in their native language should be further evaluated and outlined. Ideally, these experiments will be carried out in a similar way compared to those conducted in this study to be able to draw further conclusions with regard to the acquisition of a foreign language from the whole corpus of data obtained. However, differences between other consonants taken into account might be less clear-cut than for the consonant /l/ because of the articulatory-acoustic distinctions across languages being less precisely distinguishable. The auditive assessment of a strong foreign accent, and in line with this the categorization of subjects in the groups of less proficient vs. average vs. proficient learners results for the reason of the pattern of velarization not being pronounced as is common for the language in question. Accordingly, Jilka (2009b:23) inserted clear /l/ in all positions in his phonetic experimental data due to its appearance in syllable-/phrase-final position being a strong indicator for a heavy German accent.

The conclusions raised from the measurements of velarization or coarticulatory resistance respectively in combination with the results of previous investigations within the *Language Talent and Brain Activity*-project finally serve to not merely indicate proficiency, but also be a sign for talent per se. Studies of velarization and coarticulatory resistance were expected to not merely be an indicator for proficiency, but also for various talent levels, because of the velarization distinctions being a primary factor for the perception of a foreign accent.

Jilka (2009b) conducted a large range of tests including German, English and Hindi exercises while Hindi serves as a language with which none of the subjects had experience with. Speech perception and speech production, as well as speech perception and production combined tasks drew a picture of the overall subjects‘ proficiency and allowed to categorize subjects in proficient vs. average vs. less proficient speakers of L2 English. Furthermore, the subjects‘ production were rated via a perceptual evaluation of a representative sample of 200 expert raters also categorizing subjects in different groups of English accents. Moreover, alongside with linguistic skills personal traits could be shown to be prominent indicators for second language acquisition (SLA) behaviour while highly influencing the phonetic-articulatory aspect of the second language and at the same time the pronunciation talent (Hu & Reiterer 2009). Nardo and Reiterer (2009:246) intended to figure out the relationship between musical abilities and pronunciation proficiency while uncovering that pitch perception and singing capacity, as well as pronunciation talent, pronunciation performance/proficiency, phonetic encoding ability and even grammatical sensitivity and proficiency are highly related. The same subjects were demanded to participate in in-depth neuroanatomical and neurofunctional examinations (cf Chapter 1.2.4.). The results pointed to language aptitude (proficiency and expertise) correlating with reduced effort in speech production, and increased cortical efficiency (Reiterer et al. 2005, Reiterer et al. 2009, cf Reiterer 2009 Fig. 1).

Overall, studies of phonetic convergence, intonational variation and velarization/coarticulatory resistance were finally based on the information taken from the previous tests (especially Jilka 2009b), while the instrumental analysis of the specific phonetic phenomena was supposed to give additional evidence for not exclusively proficiency in the second language, but also various talent levels. Anufryk‘s attempt to inquire into the variability of intonation categories on the phonetic and phonological level in speakers with different scores in pronunciation ability brought to light significant differences in the distribution of the ToBI categories and in the realization of the individual F_0 curve parameters. Lewandowski (2009) investigated phonetic convergence in these L2 speakers of English while following the hypothesis that talented speakers of the L2 are more convergent than less talented speakers. In a first test run she could not detect any significant results and therefore infered that phonetic convergence rather is a conversational phenomenon, but might not be visible in other speaking modes.

The *Language Talent and Brain Activity*-project has shed light on psychological and cognitive factors which can now importantly advance the acquisition of the L2 English and needs to be taken into consideration more thoroughly in foreign language teaching. At the same time researchers have attempted to uncover the "nature" of phonetic talent while analyzing the ability of producing L2 English, the unknown language Hindi and different speaking styles in German and also while considering the perception ability with regard to subtle phonetic differences.

However, in each case perception training will certainly serve as an efficient method to widen the subjects' stored phonetic features, i.e. the large clouds of remembered tokens (cf Chapter 4.1.), and simultaneously ensure the access to an enlarged number of phonetic features, not exclusively comprising those existing in the informant's native language. While doing this there is a great chance that subjects reduce or completely get rid of their foreign accent (Iverson et al. 2004). Consequently, foreign language teaching should take into account the findings derived from the *Language Talent and Brain Activity*-project and also from this thesis sensibly bearing in mind differences in the articulation and therefore acoustic features of several phonemes, prosody and the ability of subjects to converge with a (near) native speaker.

Rota (2009:344) described real-time fMRI to be *"[...] a tool for shaping plasticity and promoting enhancement[.]"*. In consideration of her results of study and those of others, Rota (2009:340f.) affirms that individuals can be trained in how to control activation in any given area of the brain, while modifying their blood supply. This claim should serve as the core motivator for less proficient and also average L2 English speakers not to strongly believe in the abilities of pronunciation talents being unattainable for them, but to concentrate on training, be it auditory or neuro-feedback training. Future investigations should combine the conclusions of the earlier findings while attempting to treat various language problems regarding language acquisition and re-acquisition also through real-time fMRI. With respect to this thesis special emphasis would lay on the training of less proficient speakers to voluntarily break and loose their accent in a foreign language. This brings us to the most pressing question which arose from the *Language Talent and Brain Activity*-project: Are innate talented speakers' language skills unattainable for untalented speakers, or can less proficient subjects come (really) close to talented speakers' pronunciation abilities? In on-going studies the brain networks accountable for second language pronunciation need to be exactly singled out to be able to develop neurofeedback tools to train such centers for the purpose of improving linguistic performances. It is of immense importance for future research to uncover to what extent neurofeedback-training can be employed to stimulate and/or strengthen a wide range of cognitive skills (Dogil & Rota 2009:54). On the basis of the research outlined above and the description of future experimental ideas the author suggests that the improvement of untalented speakers pronunciation abilities will be feasible to a certain extent. They can be trained by means of perception training and rtfMRI to overcome their untalented speakers‘ pronunciation skills which can be changed into better ones to a considerable extent.

Summary in English

The present PhD proposes a reason for German native speakers of various proficiency levels and multiple English varieties producing their L2 English with different degrees of a foreign accent. The author took into account phonetic measurements to investigate coarticulation and coarticulatory resistance in German and English, taking non-words and natural language stimuli. To get an impression of the differences between the productions of proficient, average and less proficient speakers in German and English, degree of velarization in /əlV/ non-word sequences measured in /ə/ and /l/ were compared with each other. Additionally, the distribution of vowel formant frequencies in /əlV/ clusters was taken into consideration. Moreover, it was attempted to shed light on the impact of velarization on the production of minor or major foreign accents. Finally, it was investigated in which way English and German productions differ across all levels of proficiency.

In the first analysis of Experimental Part 1 the author calculated the mean F_2 and F_v values for /ə/ before /l/. Chapter 6 attempted to explore whether the degree of velarization in /əlV/ sequences measured in /ə/ varies. It took into account non-words across levels of proficiency, while also bearing in mind that vowels following /l/ differ. In a series of analyses an overwhelming trend for proficient speakers gaining lower formant frequencies for F_2 and F_v in /ə/ than less proficient speakers was observed. The trend was uninfluenced by the various types of vowels succeeding /l/. By contrast, no reliable preference was obtained for average speakers which lay in the midst of proficient and less proficient speakers for F_v, but they got the lowest values for F_2. The same analyses across levels of proficiency were calculated for the group of female informants only to be attentive to probable gender-related differences in vocal tract size. These results were mirrored for this group of speakers. Measurements of vowel formant frequencies revealed lower vowel formant frequencies for F_2 and F_v in proficient female speakers, i.e. more velarization, than in less proficient female learners, i.e. less velarization. But, interestingly, this time a preference was detected for average female speakers for F_2 and F_v both presenting themselves in between proficient and less proficient speakers' values. Considering F_1 and F_2 heights in /l/, the trend was clearly visible for proficient speakers velarizing more than less proficient speakers, i.e. high F_1 and low F_2 values were found for proficient speakers. Again, average speakers did not create a clear picture: F_1 value could be observed in the midst of proficient and less proficient speakers, but F_2

was even lower than the one for proficient speakers.

Both analyses of vowel formant frequencies in /ə/ and /l/ in non-word stimuli ruled out significant differences between proficient and less proficient speakers in the predicted direction. Therefore, the results showed more velarization in proficient than in less proficient speakers. However, vowel formant frequency productions in average speakers were less clear.

Additionally, the most and least proficient female speaker were suggested to diverge from each other assuming the same rivaling velarization tendencies. Whereas for AT, the most proficient speaker, high vowel formant frequencies were carried out, i.e. less velarization, DB, the least proficient speaker, showed low frequencies indicating a lot of velarization. It has to be noted in this respect that proficient informant AT was categorized as being an RP accented speaker of substantial quality, RP being non-velarized in syllable-/phrase-initial position. By contrast, DB probably attempted to reach the production of an English accent, while inserting a high degree of velarization, being typical for GA English. This observation plausibly led to the next experiment (6.5.) exploring whether the degree of velarization can be attributed to be the decisive factor for the auditive assessment of a specific dialectal variety and whether the degree of velarization, dialectal variety and level of proficiency decisively correspond to each other. The comparison of degree of velarization and dialectal variety tended to take the presumed direction. Therefore, degree of velarization seem to have been a decisive factor guiding the auditive assessment of the various types of English dialectal varieties. Finally, German L2 speakers of English seem to restrict their degree of velarization and to put in the consonant according to the needs of the dialectal variety attempted to be produced. However, the degree of velarization in accord with dialectal variety did not uniformly reflect the level of proficiency. This observed effect provides evidence for the degree of velarization and an auditively identifiable dialectal variety sometimes nevertheless being in conflict with the level of proficiency.

Moreover, coarticulatory resistance or coarticulation respectively for F_2 and F_2' were looked at in /əleɪ/ vs. /əlu:/, /əly/ vs. /əleɪ/ and /əly/ vs. /əlaɪ/ across levels of proficiency (less proficient, average and proficient informants). As was expected, most analysis results confirmed the initial hypothesis of proficient speakers being more coarticulatory resistant, i.e. velarizing more, than average and less proficient speakers. This preference for coarticulatory resistance in proficient informants manifested itself in significant correlations for F_2 and F_2' in /əly/ vs. /əlaɪ/ and tendencies for coarticulation and coarticulatory resistance in /əly/ vs. /əleɪ/. It was suggested that these results might be plausibly attributed to the same mechanism of articulatory coordination, i.e. tongue fronting and raising vs. tongue backness, affecting degree of velarization results. The comparisons described above provided evidence for proficient speakers velarizing generally more than less proficient speakers, while average speakers could not be found in between those of proficient and less proficient speakers in all of the cases. In F_2 for the comparison of /əly/ vs. /əleɪ/ and F_2' for /əly/ vs. /əlaɪ/ average speakers behaved differently with respect to the earlier expectation.

Considering /əleɪ/ vs. /əluː/ results of proficient and less proficient speakers the degree of velarization outcomes are not supported. It seems reasonable to presume that these findings might occur for reason of the incorporation of two different vowel features in their big scale: close [F_1 decrease] vs. open [F_1 increase], i.e. half-close, and spread [F_2 and F_3 increase] vs. rounded [F_2 and F_3 decrease]). Finally, these characteristics might have gotten in conflict with each other (front close spread /əleɪ/ vs. front half-close rounded /əluː/), therefore the interplay turned out in opposed effects.

Astonishingly, with respect to the distribution of vowel formant frequencies in /əlV/ clusters proficient speakers seemed to have a tendency to differentiate between English and German vowel features in most of the cases. But significant differences in vowel productions could only be revealed by proficient vs. less proficient speakers in the frequencies of the vowel /uː/ preceded by /l/ in F_2 and F_2‘ for proficient vs. less proficient speakers; this all the more refuting the initial hypothesis. Finally, this observation might serve as an indisputable sign for differences in velarization between non-native speakers of English not emerging due to unlike productions of the vowels after /l/, but because of articulatory control of the consonant /l/ being realized in dissimilar ways across levels of proficiency.

In the whole series of measurements, an overwhelming trend for proficient speakers velarizing more and more precisely pronouncing English vowel characteristics than less proficient speakers was present, while average speakers did not continuously behave according to prediction, as a result of being sometimes “worse” than less proficient speakers.

On the basis of Díaz et al. (2008) who pled for pre-existing individual differences in phonetic discrimination ability which enormously influence the achievement of a foreign sound system, it is claimed for a derivation of foreign language from native phonetic abilities. Within the author’s research stream a replication of the same experiments in German suggested itself in order to address this issue of whether proficient vs. less proficient speakers in L2 English can also be differentiated in their German native language. A subsequent analysis therefore explored F_2 and F_v vowel formant frequencies to discover the degree of velarization in /əlV/ sequences measured in /ə/, taking German non-words. The speech of German native speakers of generally high talent was presumed to show more variability than that of speakers having gotten low grades in general talent impression, with average speakers being observable in between generally low and high general talent impression speakers. As proficient and less proficient speakers behaved very contrastingly which could be reflected by significant correlation results and tendency for proficient speakers' vowel formant frequencies to be lower than the ones of less proficient speakers, the assumption could finally be confirmed. However, the initial hypothesis has to be revised for average speakers which were carried out to realize even lower vowel formant frequencies than proficient speakers.

Moreover, F_1 and F_2 out of /l/ in /əlV/ clusters were also taken for comparison which were supposed to turn out according to the earlier formulated hypothesis with regard to velarization. Within this hypothesis high talent impression speakers were associated with more variable speech, i.e. higher F_1 and lower F_2, than low talent impression speakers, i.e. lower F_1 and higher F_2. Considering the measurements reached, no significant correlations regarding proficient vs. less proficient speakers could be brought to bear, and additionally the outcomes of these speaker groups stood in conflict with the initial assignment and results revealed out of /ə/. Consequently, low and high talent impression speakers did not velarize a lot at all. Whereas significant correlations were examined with respect to average vs. low talent impression speakers for F_1 and F_2 as well as for F_2 in average vs. high talent impression speakers. Astonishingly, average talent impression speakers got the highest F_1, i.e. high degree of velarization, and the lowest F_2 value, i.e. high degree of velarization. To sum up: the vowel frequencies measured in /ə/ have drawn an inverse image regarding formant heights' tendencies to those calculated in /l/ in high and low talent impression speakers, while average talent impression informants showed high degrees of velarization within both phonemes. However, outcomes derived out of /l/ were non-significant, but significant for /ə/, so that the initial assignment could not be finally disproved.

Identical to the coarticulatory resistance measurements in /əlV/ clusters for English non-words, equivalent evaluations were computed for German non-word stimuli (cf above). It might be tempting to examine whether high general talent impression speakers realize more excessive frequencies for coarticulation or coarticulatory resistance considered in the CD value comparisons than low general talent impression speakers. These tendencies for coarticulation or coarticulatory resistance are mirrored in CD value comparison heights and especially within significant correlations for F_2 and F_2' in /əli:/ vs. /əlu:/. Finally, CD values for high general talent impression speakers underlined the inference of very different varieties of /l/ and probably broader frequency ranges in the vowels succeeding /l/. Opposed to the /əly/ vs. /əla:/-computations, mean values for the remaining CD distinctions (/əli:/ vs. /əlu:/, /əly/ vs. /əli:/) reflect a considerable degree of coarticulation. In view of the general rule of /l/ in German being non-velarized and because of this being articulated with no or less tongue dorsum activity, there should presumably be more coarticulation present in German than in English CR calculations. However, it is worth noting that there is obviously a lot of coarticulatory resistance in the /əly/ vs. /əla:/ comparison, which was not expected in German being part of the non-velarized languages, i.e. /l/ should be permeable for the feature values of the subsequent vowels. These results were interpreted to be caused by the front close roundedness (/əly/) vs. front open unroundedness (/əla:/) differentiation which does not comprise a distinction in fronting/backness. Furthermore, this could be the reason for restrictive tongue movements and in the same line of action rising tongue control (cf Chapter 6.3.3.).

Based on the high number of studies which cope with velarization distinctions across different languages (e.g. Recasens 1985; Recasens, Fontdevila & Pallarès 1995; Clark, Yallop & Fletcher 2007; Cruttenden 2008; cf introduction into Chapter 7), the author intended to verify if the observed effects also emerge from L2 English speech and German native speaker stimuli recorded in the experiment established within this thesis. Therefore, the informants' native speech vs. L2 English results out of previous investigations were taken to get an insight look into the broader velarization differences in /ə/ and /l/ between the whole groups of subjects. Given statistical analyses taking F_2 and F_v values extracted out of /ə/ and also F_1 and F_2 values collected from /l/ the hypotheses are fully replicated. It seems reasonable to infer that German native speech is more non-velarized in these speakers of all proficiency levels than their L2 English productions are.

Contrary to non-word analyses in Experimental Part 1, Experimental Part 2 finally carried out analyses with natural language stimuli to achieve a more complex and rounded picture of the velarization distinction between speakers of various levels of proficiency, of diverse dialectal varieties and in different syllable-/phrase positions such as syllable-/phrase-final and -medial or syllable-/phrase-initial. Within this Chapter 8 it was investigated whether the observed differences in auditive assessment can be associated with the appropriate degree of velarization in a certain syllable-/phrase position, while taking into account that degree of velarization should well be distinguishable between RP English [l] and GA English [ɫ] in initial position. *Experiment 2*, the comparisons of formant frequencies in /l/ in contrasting syllable or phrase positions practically replicated the findings of the previous *Experiment 1*, while reaching the predicted tendencies and also some significances (within the syllable-/phrase-medial, -final comparisons) regarding F_2 in syllable-/phrase-medial, -final or initial position.

However, some biases were caused by:

F_1: in syllable-/phrase-medial or syllable-/phrase-final position:

1. In proficient speakers' F_1, i.e. lesser velarization, was lower than in less proficient speakers.
2. Interestingly, for F_1 native-like English vs. German resulted in an insignificant correlation result, in contrast to the comparison of less native-like English vs. German which turned out to be significant.

F_2: in syllable-/phrase-medial or syllable-/phrase-final position:

3. F_2: German speech could be detected to be more velarized than less proficient speech in F_2 in syllable-/phrase-final or -medial position.

These biases might have been caused by the constriction in the frontal part of the tube, i.e. jaw opening vs. closing, leading to a F_1 decrease, not having been taken place as controlled as in non-word stimuli. In addition, less proficient speech might be less velarized than German speech because of these speakers not inserting the pattern of velarization at all being less conscious of English needing to be velarized in syllable-/phrase-medial or -final position, i.e. there is no backness of the tongue body present.

Summary in German

Die vorliegende Dissertation eruiert die Ursache, warum deutsche Muttersprachler mit unterschiedlichen Sprachfertigkeiten und verschiedenen englischen Varietäten ihre englische L2 mit unterschiedlicher Akzentstärke produzieren. Die Autorin führte phonetische Messungen mit Hilfe von Nicht- und natürlichen Wörtern durch, um Koartikulation und koartikulatorische Resistenz im Deutschen und Englischen zu untersuchen. Um einen Eindruck der unterschiedlichen Produktionen von sprachgewandten, mittelmäßig sprachgewandten und weniger sprachgewandten Sprechern im Deutschen und Englischen zu erhalten, wurden die Velarisierungsgrade in /əlV/ Nicht-Wort-Sequenzen gemessen in /ə/ und /l/ miteinander verglichen. Zusätzlich wurde die Verteilung der Vokalformantenfrequenzen in /əlV/-Klustern mitberücksichtigt. Zudem wurde versucht, den Einfluss der Velarisierung hinsichtlich geringer oder auffälligerer Akzente zu ergründen. Danach wurde überprüft, auf welche Weise sich englische und deutsche Produktionen hinsichtlich aller Sprachgewandtheitsniveaus unterscheiden.

Innerhalb der ersten Analyse im Experimentellen Teil 1 errechnete die Autorin die Mittelwerte von F_2 und F_v für /ə/ vor /l/. Kapitel 6 intendierte zu erforschen, ob der Velarisierungsgrad in /əlV/-Sequenzen gemessen in /ə/ variiert. Dabei bezog sie Nicht-Wörter über die verschiedenen Sprachgewandtheitsgrade hinweg mit ein und ließ die Tatsache, dass die Vokale, die nach /l/ artikuliert werden, sich voneinander unterscheiden, nicht unberücksichtigt. In einer Analysereihe konnte der überragende Trend beobachtet werden, dass sprachgewandte Sprecher niedrigere Formantenfrequenzen für F_2 und F_v in /ə/ erlangen als weniger sprachgewandte Sprecher. Dieser Trend wurde durch die verschiedenen Vokaltypen, die /l/ folgten, beeinflusst. Im Gegensatz dazu wurde keine zuverlässige Präferenz für mittelmäßig sprachgewandte Sprecher erzielt. Diese befanden sich in Bezug auf F_v zwischen sprachgewandten und weniger sprachgewandten Sprechern, erhielten jedoch die niedrigsten Werte für F_2. Die gleichen Analysen über die Sprachgewandtheitsgrade hinweg wurden ausschließlich für die Gruppe der weiblichen Probanden errechnet, um auf mutmaßliche geschlechtsabhängige Unterschiede in der Vokaltraktgröße aufmerksam werden zu können. Die entsprechenden Ergebnisse wurden für die jeweilige Sprechergruppe dargestellt. Die Messungen der Vokalformanten offenbarten niedrigere Frequenzen für F_2 und F_v in sprachgewandten weiblichen Sprechern, d.h. es trat mehr Velarisierung auf als in weniger sprachgewandten weiblichen Sprechern mit demgegenüber weniger Velarisierung. Jedoch präsentierten sich hier interessanterweise die Werte sowohl für F_2

als auch für F_v gebildet von mittelmäßig sprachgewandten weiblichen Sprechern mittig zu denen von sprachgewandten und weniger sprachgewandten Sprechern. Im Hinblick auf die Höhen von F_1 und F_2 in /l/ wurde der eindeutige Trend ersichtlich, dass sprachgewandte Sprecher mehr velarisieren als weniger sprachgewandte Sprecher. Dementsprechend wurden hohe F_1- und niedrige F_2-Werte für sprachgewandte Sprecher festgestellt. Für mittelmäßig sprachgewandte Sprecher zeichnete sich kein eindeutiges Bild ab: Lag der F_1-Wert in der Mitte sprachgewandter und weniger sprachgewandter Sprecher, war der F_2-Wert sogar niedriger als der sprachgewandter Sprecher.

Die beiden Analysen von Vokalformantenfrequenzen in /ə/ und /l/ in Nichtwort-Stimuli erzielten signifikante Unterschiede zwischen sprachgewandten und weniger sprachgewandten Sprechern in der vorhergesagten Richtung. Folglich zeigten die Ergebnisse einen höheren Velarisierungsgrad im Vergleich von sprachgewandten zu weniger sprachgewandten Sprechern. Die Vokalformantenproduktion bei mittelmäßig sprachgewandten Sprechern stellte sich weniger eindeutig dar.

Zudem wurde vermutet, dass die sprachgewandteste und die am wenigsten sprachgewandte weibliche Sprecherin voneinander abweichen sollten. Wie zuvor wurden dieselben rivalisierenden Velarisierungstendenzen vorausgesetzt. Wohingegen für AT, die sprachgewandteste Sprecherin, sich hohe Vokalformantenfrequenzen realisierten, d.h. weniger Velarisierung, zeigte DB, die am wenigsten sprachgewandte Sprecherin, niedrige Frequenzen, was einen Rückschluss auf viel enthaltene Velarisierung zuließ. Hinsichtlich dessen muss beachtet werden, dass die sprachgewandte Probandin AT als mit RP Akzent von erheblicher Qualität sprechend kategorisiert wurde, wobei RP in silben- bzw. phraseninitialer Position nicht velarisiert wird. Im Vergleich dazu bemühte sich DB, eine möglichst englische Akzentproduktion zu erzielen, und fügte dabei einen hohen Velarisierungsgrad hinzu, der ein typisches Zeichen für GA Englisch ist. Diese Beobachtung führte in logischer Folge zum nächsten Experiment (6.5.), das untersuchte, ob dem Velarisierungsgrad zugeschrieben werden kann, der entscheidende Faktor bei der auditiven Einschätzung einer spezifischen dialektalen Varietät zu sein und ob der Velarisierungsgrad, die dialektale Varietät und das Sprachgewandtheitsniveau entscheidend miteinander im Einklang stehen. Der Vergleich des Velarisierungsgrades und der dialektalen Varietät schlug die angenommene Richtung ein. Folglich schien der Velarisierungsgrad der ausschlaggebende Faktor zu sein, der die auditive Einschätzung von Typen von englischen dialektalen Varianten leitete. Schlussendlich schienen deutsche Muttersprachler ihre L2 Englisch mit Blick auf den Velarisierungsgrad insoweit zu modifizieren, als dass sie versuchten, den Konsonanten entsprechend seines Gebrauchs in verschiedenen Dialekten in ihre Produktionen einzufügen.

Jedoch reflektierte die dialektale Varietät verbunden mit dem Velarisierungsgrad nicht übereinstimmend den Sprachgewandtheitsgrad. Dieser zu beobachtende Effekt liefert den Beweis dafür, dass der Velarisierungsgrad und die auditiv identifizierbare dialektale Varietät trotzdem manchmal dem Sprachgewandtheitsniveau widersprechen.

Außerdem wurde koartikulatorische Resistenz bzw. Koartikulation mit Blick auf F_2 und F_2' in /əleɪ/ vs. /əlu:/, /əly/ vs. /əleɪ/ und /əly/ vs. /əlaɪ/ über alle Sprachgewandtheitsniveaus (weniger sprachgewandte, mittelmäßig sprachgewandte und sprachgewandte Probanden) betrachtet. Wie erwartet, bestätigten die Analyseergebnisse größtenteils die initiale Hypothese, dass sprachgewandte Sprecher koartikulatorisch resistenter sind, d.h. dementsprechend mehr velarisieren als mittelmäßig sprachgewandte und weniger sprachgewandte Sprecher. Diese Vorliebe für koartikulatorische Resistenz in sprachgewandten Probanden manifestierte sich in signifikanten Korrelationen für F_2 and F_2' in /əly/ vs. /əlaɪ/ und Tendenzen für Koartikulation und koartikulatorische Resistenz in /əly/ vs. /əleɪ/. Es wurde nahegelegt, dass diese Ergebnisse überzeugend dem gleichen Mechanismus der artikulatorischen Zuordnung zugeschrieben werden können, d.h. Zungenvorschub und -hebung vs. Zungenrücklage, was die Resultate bezüglich des Velarisierungsgrades beeinflusst. Die oben beschriebenen Vergleiche verschaffen Anhaltspunkte dafür, dass sprachgewandte Sprecher gemeinhin mehr velarisieren als weniger sprachgewandte Sprecher, während mittelmäßig sprachgewandte Sprecher in keinem Fall zwischen den sprachgewandten und weniger sprachgewandten ausfindig gemacht werden konnten. In F_2 für die Gegenüberstellung von /əly/ vs. /əleɪ/ und F_2' für /əly/ vs. /əlaɪ/ verhielten sich mittelmäßig sprachgewandte Sprecher anders als zuvor erwartet wurde.

Im Hinblick auf die Resultate aus /əleɪ/ vs. /əlu:/ von sprachgewandten und weniger sprachgewandten Sprechern unterstützen die Ergebnisse bezüglich der Velarisierungsgrade nicht die Hypothese. Anzunehmen ist daher, dass die Resultate aufgrund eines Zusammenspiels zweier unterschiedlicher Vokalmerkmale auf ihrer großen Skala vorkommen: geschlossen [F_1 Abfall] vs. offen [F_1 Anstieg], d.h. halb-geschlossen und gespannt [F_2 und F_3 Anstieg] vs. gerundet [F_2 und F_3 Abfall]). Letztendlich mögen diese Charaktereigenschaften miteinander in Konflikt geraten sein (vorderes geschlossenes gespanntes /əleɪ/ vs. vorderes halb-geschlossenes gerundetes /əlu:/), weshalb deren Interaktion zu den entgegengesetzten Effekten geführt hat.

Mit Blick auf die Verteilung der Vokalformantenfrequenzen in /əlV/-Konstellationen schienen sprachgewandte Sprecher erstaunlicherweise die Tendenz zu verfolgen, meist zwischen englischen und deutschen Vokaleigenschaften unterscheiden zu können. Aber signifikante Unterschiede in den

Vokalproduktionen konnten nicht nur zwischen sprachgewandten vs. weniger sprachgewandten Sprechern in den Frequenzen des Vokals /u:/ vor /l/ in F_2 und F_2‘ aufgedeckt werden, was erneut die initiale Hypothese widerlegte. Schließlich mag diese Beobachtung als unbestreitbares Zeichen für Velarisierungsunterschiede zwischen nicht-muttersprachlichen Sprechern des Englischen dienen, die nicht nur beruhend auf ungleichen Vokalproduktionen nach /l/ sichtbar werden, aber aufgrund von artikulatorischer Kontrolle über den Konsonanten /l/, der über die verschiedenen Sprachgewandtheitsniveaus hinweg auf unterschiedliche Art und Weise realisiert wird.

Innerhalb der gesamten Messreihe wurde der alles übergreifende Trend deutlich, dass sprachgewandte Sprecher mehr velarisieren und auch englische Vokaleigenschaften präziser aussprechen als weniger sprachgewandte Sprecher, wohingegen mittelmäßig sprachgewandte Sprecher sich nicht kontinuierlich entsprechend der Vorhersage verhalten, stattdessen manchmal sogar schlechter sind als weniger sprachgewandte Sprecher.

Auf der Basis von Díaz et al. (2008), die für so etwas wie prä-existierende individuelle Unterschiede in der phonetischen Diskriminierungsfähigkeit plädierten, die auf die Erlangung eines fremdsprachlichen Lautsystems einen enormen Einfluss haben, wird von einer Herleitung der Fremdsprache aus den muttersprachlichen phonetischen Fähigkeiten ausgegangen. Im Rahmen des Forschungsstranges der Autorin liegt eine Replikation der gleichen Experimente für das Deutsche nahe, um den Sachverhalt zu erforschen, ob sprachgewandte vs. weniger sprachgewandte Sprecher in ihrer L2 Englisch auch in ihrer deutschen Muttersprache voneinander unterschieden werden können. Daher untersuchte eine Folgeanalyse F_2 und F_v Vokalformantenfrequenzen, um den Velarisierungsgrad in /əlV/-Sequenzen, gemessen in /ə/ in deutschen Nichtwörtern, zu erforschen. Die Autorin nahm an, dass das Sprechen deutscher Muttersprachler von allgemein großem Talent mehr Variabilität aufweisen sollte als das von Sprechern mit einem geringeren Eindruck des Talentgrades. Mittelmäßig sprachgewandte Sprecher sollten sich zwischen denen mit Werten eines allgemein niedrigeren und allgemein höheren Talentgrades befinden. Da sprachgewandte und weniger sprachgewandte Sprecher sich sehr gegensätzlich verhielten, was sich sowohl in signifikanten Korrelationsergebnissen als auch in der Frequenztendenz von sprachgewandten Sprechern widerspiegelte, niedriger zu sein als die von weniger sprachgewandten Sprechern, bestätigte sich schließlich die Annahme. Revidiert werden musste die ursprüngliche Hypothese für mittelmäßig sprachgewandte Sprecher, bei denen sich sogar niedrigere Vokalformantenfrequenzen zeigten als bei sprachgewandten Sprechern.

Überdies wurden F_1 und F_2 in /l/ in /əlV/-Konstellationen für Vergleiche herangezogen. Es wurde vermutet, dass die Ergebnisse hieraus den vorhergehend formulierten Hypothesen mit Blick auf die

Velarisierung entsprechen würden. Im Rahmen der Hypothese wurden hochtalentierte Sprecher mit einer variableren Sprechweise in Verbindung gebracht. Dies bedeutet, dass F_1 höher ausfällt und F_2 wiederum niedriger als bei Sprechern, die einen geringeren Talentniveaueindruck vermitteln, d.h. niedrigerer F_1 und höherer F_2. Unter Einbezug der erlangten Messwerte konnten keine signifikanten Korrelationen hinsichtlich sprachgewandter vs. weniger sprachgewandter Sprecher geltend gemacht werden, und zusätzlich standen die Resultate dieser Sprechergruppen im Konflikt mit der initialen Annahme und mit den Ergebnissen, die aus /ə/ hervorgingen. In der Folge velarisierten weniger talentierte und talentierte Sprecher überhaupt nicht. Wohingegen signifikante Korrelationen für mittelmäßig vs. weniger talentierte Sprecher hinsichtlich F_1 und F_2 und auch in F_2 für mittelmäßig talentierte vs. hochtalentierte Sprecher erzielt wurden. Herausragend ist, mittelmäßig talentierte Sprecher erreichten den höchsten F_1, d.h. den höchsten Grad der Velarisierung, und den niedrigsten F_2-Wert, d.h. den höchsten Velarisierungsgrad. Zusammenfassend: Die Vokalfrequenzen, gemessen in /ə/, zeichneten ein entgegengesetztes Bild mit Blick auf die Formantenhöhentendenzen verglichen mit denen, die in hoch- und weniger talentierten Sprechern in /l/ berechnet worden sind, während mittelmäßig talentierte Sprecher die höchsten Velarisierungsgrade in beiden Phonemen aufwiesen. Trotzdem waren die aus /l/ hergeleiteten Ergebnisse nicht signifikant, jedoch aber signifikant für /ə/, so dass die initiale Zuweisung nicht endgültig widerlegt werden konnte.

Identisch zu den Messungen der koartikulatorischen Resistenz in /əlV/-Konstellationen von englischen Nicht-Wörtern, wurden äquivalente Wertbestimmungen ebenfalls für deutsche Nichtwortstimuli berechnet (cf oben). Es war von Interesse, zu überprüfen, ob hochtalentierte Sprecher extremere Frequenzen für Koartikulation oder koartikulatorische Resistenz - integriert in die CD-Wertvergleiche - realisieren als weniger talentierte Sprecher. Diese Tendenzen bezüglich der Koartikulation oder koartikulatorischen Resistenz spiegelten sich im Vergleich der Höhe des CD-Wertes wider und vor allem auch in signifikanten Korrelationen für F_2 und F_2' in /əli:/ vs. /əlu:/. Schließlich unterstrichen die CD-Werte für allgemein hochtalentierte Sprecher das Zusammenspiel von sehr unterschiedlichen Varietäten von /l/ und gegebenenfalls größeren Frequenzbreiten hinsichtlich der Vokale, die auf /l/ folgen. Im Gegensatz zu den /əly/ vs. /əla:/-Berechnungen drücken die Mittelwerte der verbliebenen CD-Unterscheidungen (/əli:/ vs. /əlu:/, /əly/ vs. /əli:/) einen beträchtlichen Koartikulationsgrad aus. Im Hinblick auf die allgemeine Regel, dass /l/ im Deutschen nicht velarisiert wird und aufgrund dessen, dass dies eine Artikulation ohne oder nur mit wenig Zungenaktivität nach sich zieht, sollte mehr Koartikulation in den deutschen als in den englischen CR-Kalkulationen vorhanden sein. Dennoch muss herausgestellt werden, dass offenbar viel koartikulatorische Resistenz im /əly/ vs. /əla:/ Vergleich aufgetreten ist, die für eine nicht-velarisierte Sprache wie die deutsche nicht erwartet wurde, in der das /l/ für die Eigenschaften der Folgevokale durchlässig sein sollte. Diese Resultate wurden auf die vordere geschlossene gerundete (/əly/) vs. vordere offene ungerundete (/əla:/) Differenzierung zurückgeführt, die nicht die Unterscheidung in vorne/hinten mit einschließt. Dies könnte in eingeschränkten Zungenbewegungen und gleichzeitig in einem Anstieg der Zungenkontrolle begründet liegen (cf Kapitel 6.3.3.).

Auf der Basis der großen Anzahl von Studien, die sich mit Velarisierungsunterschieden über unterschiedliche Sprachen hinweg beschäftigen (z.B. Recasens 1985; Recasens, Fontdevila & Pallarès 1995; Clark, Yallop & Fletcher 2007; Cruttenden 2008; cf Einführung in Kapitel 7), verfolgte die Autorin die Absicht, zu verifizieren, ob die zuvor beobachteten Effekte ebenfalls mit Blick auf die englischen L2 und die muttersprachlich-deutschen aufgenommenen Stimuli innerhalb der Experimente dieser Dissertation sichtbar werden. Daher wurden die Resultate aus der Muttersprache mit der englischen L2 aus vorhergehenden Untersuchungen dafür genutzt, einen Einblick in die umfassenderen Velarisierungsunterschiede in /ə/ und /l/ innerhalb der gesamten Probandengruppe zu erlangen. Die erzielten statistischen Analyseergebnisse, die mit Hilfe von F_2 und F_v in /ə/ und auch aus F_1- und F_2-Werten aus /l/ heraus extrahiert wurden, replizierten die Hypothese vollständig. Daher scheint es angemessen zu sein, den Schluss zu ziehen, dass muttersprachliches Deutsch in den Sprechern aller Sprachgewandtheitsniveaus nicht-velarisierter produziert wird als in deren L2 Englisch.

Im Gegensatz zu den Nicht-Wort-Analysen im Experimentellen Teil 1 wurden im Experimentellen Teil 2 letztlich natürliche Stimuli untersucht, um ein komplexeres und abgerundeteres Bild der Velarisierungsunterschiede zwischen Sprechern verschiedener Sprachgewandtheitsniveaus, verschiedenartiger dialektaler Varietäten und in unterschiedlichen Silben- bzw. Phrasenpositionen wie silben-/phrasenfinal und -medial oder -initial zu gewährleisten. In Kapitel 8 wurde ermittelt, ob die beobachteten Unterschiede in der hörbaren Einschätzung mit dem passenden Velarisierungsgrad innerhalb einer bestimmten Silben-/Phrasenposition in Verbindung gebracht werden können. Gleichzeitig wird hierbei mit einbezogen, dass der Velarisierungsgrad zwischen RP Englisch [l] und GA Englisch [ɫ] in initialer Position gut unterscheidbar sein sollte. Die Vergleiche der Formantenfrequenzen in /l/ in gegensätzlichen Silben- oder Phrasenpositionen aus *Experiment 2* replizierten nahezu die Feststellungen aus dem vorhergehenden *Experiment 1*. Die vorhergesagten Tendenzen und auch einige Signifikanzen (innerhalb der Vergleiche: silben-/phrasenmedial, -final) hinsichtlich F_2 in silben-/phrasenmedialer, -finaler oder -initialer Position konnten erzielt werden.

Im Widerspruch zur Ursprungshypothese traten die folgenden Ergebnisse auf:

F_1: in silben-/phrasen-medialer oder silben-/phrasen-finaler Position:

1. In sprachgewandten Sprechern war F_1 niedriger, d.h. es enthielt einen geringeren Velarisierungsgrad, als in weniger sprachgewandten Sprechern.
2. Interessanterweise wurden für F_1 im muttersprachlichen Englisch vs. Deutsch eine nicht-signifikante Korrelation erzielt, im Gegensatz zu dem Vergleich von weniger muttersprachlichem Englisch vs. Deutsch, was sich als signifikant herausstellte.

F_2: in silben-/phrasen-medialer oder silben-/phrasen-finaler Position:

3. F_2: Die deutsche Sprache erwies sich als velarisierter als weniger sprachgewandtes Sprechen in F_2 in silben-/phrasen-finaler oder -medialer Position.

Diese Widersprüche könnten in der Verengung im vorderen Teil des Sprachrohres begründet liegen, d.h. Kieferöffnung vs. Kieferverschluss. Dieser führt zu einem Absinken von F_1, was in natürlichen Stimuli nicht ebenso kontrolliert geschieht wie in Nicht-Wort-Stimuli. Zudem mag es sein, dass weniger sprachgewandtes Sprechen sich weniger velarisiert darstellt als das Deutsche, da diese Sprecher das Merkmal der Velarisierung überhaupt nicht einsetzen. Sie sind sich der Tatsache weniger bewusst, dass im Englischen in silben-/phrasen-medialer oder -finaler Position velarisiert werden muss, d.h. es ist keine Zungenrückverlagerung vorhanden.

References

Abbot-Smith, K. & Tomasello, M. (2006): Exemplar-learning and schematization in a usage-based account of syntactic acquisition. *The Linguistic Review*, 23, 275-290.

Abu-Rabia, S. & Kehat, S. (2004): The Critical Period in Second Language Pronunciation: Is there such a Thing? Ten Case Studies. *Educational Psychology*, 24 (1): 77-98.

Acker, B. (2001): *Sprachverständnis und Sprachbegabung. Von der Analyse vorhandener Verfahren zu einem neuen Test (Psychologie, Bd. 25).* Landau: Verlag Empirische Pädagogik.

Adank, P., Smits, R. & Van Hout, R. (2004): A comparison of vowel normalization procedures for language variation research. *Journal of the Acoustical Society of America*, 116 (5), 3099-3107.

Amunts, K., Schleicher, A. & Zilles, K. (2004): Outstanding language competence and cytoarchitecture in Broca's speech region. *Brain and Language*, 89: 346-353.

Anufryk, V. (2009): Prosodic factors in language proficiency: intonational variation as a signature of pronunciation talent. In: Dogil, G. & Reiterer, S.: *Language Talent (and Brain Activity)*. Berlin: De Gruyter.

Ashby, M. & Maidment, J. (2005): *Introducing Phonetic Science.* Cambridge: Cambridge University Press.

Atkins, W. B. & Baddeley, A. D. (1998): Working memory and distributed vocabulary learning. *Applied Psycholinguistics*, 19, 537-552.

Baddeley, A. D. & Hitch, G. J. (1974): Working memory. In: *Recent advances in learning and motivation.* New York: Academic Press, Vol. 8, pp 47-89.

Baddeley, A. D. (1986): *Working memory.* New York, NY: Oxford University Press.

Baddeley, A. D. (2003): Working memory: looking back and looking forward. *Nature reviews. Neuroscience,* 4, 829-839.

Bailey, P., Onwuegbuzie, A. J. & Daley, C. E. (2000): Using learning style to predict foreign language achievement at the college level. *System*, 28 (1), 75-99.

Barry, W. J. (1995): Schwa vs. Schwa + /r/ in German. *Phonetica*, 52, 228-235.

Baumotte, H. (2009): Segmental factors in language proficiency: Coarticulatory resistance as a signature of talent. In: Dogil, G. & Reiterer, S.: *Language Talent (and Brain Activity)*. Berlin: De Gruyter, pp. 279-304.

Baumotte, H., Lenz, M., Dogil, G. & Reiterer, S. (2007): Coarticulatory resistance as a basis for a foreign accent: V-to-V coarticulation in German VCV-sequences: A pilot study. In: Van Daele, S., Housen, A., Kuiken, F., Pierrard, M. & Vedder, I. (eds): *Complexity, Accuracy and Fluency in Second Language Use, Learning & Teaching.* Koninklijke Vlaamse Academie van Belgie voor Wetenschappen en Kunsten. Wetteren: Universa Press, pp. 11-25.

Benguerel, A.-P., Hirose, H., Sawashima, M. & Ushijima, T. (1977a): Velar coarticulation in French: an electromyographic study. *Journal of Phonetics*, 5, 159-167.

Benguerel, A.-P., Hirose, H., Sawashima, M. & Ushijima, T. (1977b): Velar coarticulation in French: a fiberscopic study. *Journal of Phonetics*, 5, 149-158.

Best, C. (1995): A Direct-Realist View of Cross-Language Speech Perception. In: Strange, W. (ed.): *Speech Perception and Linguistic Experience: Theoretical and Methodogical Issues.* Timonium, MD. York Press, 171-204.

Birbaumer, N. & Cohen, L. G. (2007): Brain-computer interfaces: communication and restoration of movement in paralysis. *The Journal of Physiology*, 579: 621-636.

Birdsong, D. (1992): Ultimate Attainment in Second Language Acquisition. *Language,* 68 (4): 706-755.

Bladon, R. A. W. & Al-Bamerni, A. (1976): Coarticulation resistance in English /l/. *Journal of Phonetics*, 4: 137-150.

Bladon, R. A. W. & Nolan, F. (1977): A videofluorographic investigation of tip and blade alveolars in English. *Journal of Phonetics*, 5: 185-193.

Bod, R. (2006): Exemplar-based syntax: How to get productivity from examples. *The Linguistic Review*, 23, 291-320.

Bongaerts, T., Planken, B. & Schils, E. (1995): Can late starters attain a native accent in foreign language? A test of the critical period hypothesis. In: Singleton, D. & Lengyel, Z. (eds.): *The age factor in second language acquisition.* Clevedon: Multilingual Matters, pp. 30-50.

Bongaerts, T. (1999): Ultimate Attainment in L2 Pronunciation: The Case of Very Advanced Late L2 Learners. In: Birdsong, D. (Ed.): *Second Language Acquisition and the Critical Period Hypothesis*. Mahwah. Lawrence Erbaum Assoc.

Bongaerts, T., Mennen, S. & van der Slik, F. (2000): Authenticitiy of Pronunciation in Naturalistic Second Language Acquisition. *Studia Linguistica*, 54 (2): 298-308.

Bradlow, A. R., Baker, R. E., Choi, A., Kim, M. & van Engen, K. J. (2007): The Wildcat Corpus of Native- and Foreign-Accented English. *Journal of the Acoustical Society of America*, 121(5), Pt.2, 3072.

Brunner, J., Fuchs, S. & Perrier, P.. On the relationship between palate shape and articulatory behaviour. *Journal of the Acoustical Society of America.* forthcoming.

Bybee, J. (2002): Word frequency and context of use in the lexical diffusion of phonetically conditioned sound change. *Language Variation and Change*, 14, 261-290.

Bybee, J. (2005): *From usage to grammar: The mind‘s response to repetition.* LSA Presidential Address.

Bybee, J. (2006): From usage to grammar: the mind‘s response to repetition. *Language Variation and Change*, 82(4), 711-733.

Carroll, J. & Sapon, S. (1959): *Modern Language Aptitude Test (MLAT): Manual.* New York. The Psychological Corporation.

Carver, C. S. & White, T. L. (1994): Behavioural inhibition, behavioural activation, and affective responses to impeding reward and punishment: the BIS/BAS scales. *Journal of Personality and Social Psychology*, 67, 319-333.

Catford, J. C. (2001): *A practical introduction to Phonetics.* 2. ed. New York: Oxford University Press Inc.

Chistovich, L. A. & Lublinskaya, V. A. V. (1979): The center of gravity‘ effect in vowel spectra and critical distance between the formants: Psychoacoustical study of the perception of vowel-like stimuli. *Hearing Research*, 1, 185-195.

Cho, T. (2004): Prosodically conditioned strengthening and vowel-to-vowel coarticulation in English. *Journal of Phonetics*, 32: 141-176.

Clark, J., Yallop, C. & Fletcher, J. (2007): *An Introduction to Phonetics and Phonology.* Oxford: Blackwell Publishing.

Costa, P. T. &McCrae, R. R. (1992): *Revised NEO Personality Inventory (NEO PI-R) and NEO Five Factor Inventory: Professional manual.* Odessa, Florida: Psychological Assessment Resources.

Cruttenden, A. (2008): *Gimson's Pronunciation of English.* Malta: Macmillan Company.

Cruz-Ferreira, M. (1987): Difficulties in comprehension of L2 intonation: diagnosis and prediction in English. *Proceedings of the 11th International Congress of Phonetic Sciences*, 5: 146-148. Tallinn: Academy of Sciences of the Estonian SSR.

Crystal, D. (2003): *The Cambridge Encyclopedia of the English Language.* 2. ed. Cambridge: Cambridge University Press.

Delattre, P. (1965): *Comparing the phonetic features of English, German, Spanish and French*. Heidelberg: Julius Gross Verlag.

Delattre, P. (1981): *Studies in Comparative Phonetics: English, German, Spanish and French.* Heidelberg: Julius Groos Verlag.

Dewaele, J. M. & Furnham, A. (1999): Extraversion: The unloved variable in applied linguistic research. *Language Learning*, 49 (3), 509-544.

Díaz, B., Baus, C., Escera, C., Costa, A. & Sebastián-Gallés, N. (2008): Brain potentials to native phoneme discrimination reveal the origin of individual differences in learning the sounds of a second language. *Proceedings of the National Academy of Sciences USA*, 105: 16083-16088.

Docherty, G. J. (1992). *The Timing of Voicing in British English Obstruents.* Berlin: Fortis.

Dogil, G. & Möbius, B. (2001): Towards a model of target oriented production of prosody. In: *Proceedings of the European Conference on Speech Communication and Technology* (Aalborg, Denmark), 1, 665-668.

Dogil, G. (2003): Understanding Prosody. In: Rickheit, G., Herrmann, T. & Deutsch, W. (Eds.): *Psycholinguistics: An International Handbook.* Berlin: Mouton de Gruyter, pp. 544-566.

Dogil, G.: *Hard-wired phonology: limits and latitude of phonological variation in pathological speech.* (in prep.)

Dogil, G. (2007): Phonetic dimensions of segmental strength. *Proceedings of the 16th International Congress of Phonetic Sciences (ICPhS).* Saarbrücken, Germany.

Dogil, G. (2009): Beyond talent: a short language biography of Prof. Max Mangold. In: Dogil, G. & Reiterer, S. (Eds.): *Language Talent and Brain Activity.* Berlin: Mouton de Gruyter.

Dogil, G. & Reiterer, S. (2009): *Language Talent and Brain Activity.* Berlin: Mouton de Gruyter.

Dogil, G. & Rota, G. (2009): Direct brain-feedback and prosody processing. In: Fuchs, S., Loevenbruck, H., Pape, D. & Perrier, P. (eds.): *Some aspects of speech and the brain.* Frankfurt am Main: Peter Lang Verlag.

Dörnyei, Z. (2005): *The psychology of the language learner – individual differences in second language acquisition.* Mahwah, NJ: Lawrence Erlbaum Association.

Edmondson, W. J. & House, J. (1993): *Einführung in die Sprachlehrforschung.* Tübingen/Basel. Francke.

Entropic Signal Processing System (ESPS) and Waves (2003): *Entropic Research Laboratory, Washington Research Laboratory: http://www.entropic.com/*

Eysenck, M. W. (1979): Anxiety, learning and memory: A reconceptualization. *Journal of Research in Personality*, 13, 363-385.

Fan, J., Fossella, J., Sommer, T., Wu, Y. L. & Posner, M. I. (2003): Mapping the genetic variation of executive attention onto brain activity. *Proceedings of the National Academy of Sciences*, 100, 7406-7411.

Fant, G. (1960): *Acoustic Theory of Speech Production.* The Hague: Mouton.

Farnetani, E. (1997): Coarticulation and Connected Speech Processes. In: Hardcastle, W. J. & Kent, R. D. (1977): *Coarticulation in recent speech production models.* Oxford: Blackwell Publishers, pp. 115-133.

Flege, J. & Hammond, R. (1982): Mimicry of Non-Distinctive Phonetic Differences between Language Varieties. *Studies in Second Language Acquisition*, 5 (1): 1-17.

Flege, J. & Hillenbrand, J. (1987): Limits on Phonetic Accuracy in Foreign Language Speech Production. In: Ioup, G. & Weinberger, S. (Eds.): *Interlanguage Phonology*. Cambridge, MA: Newbury House, 176-203.

Flege, J. (1987): A Critical Period for Learning to Pronounce Foreign Languages? *Applied Linguistics*, 8 (2): 162-177.

Flege, J. (1995): Second language speech learning: Theory, findings and problems. In: Strange, We. (Ed.): *Speech perception and linguistic experience: Theoretical and methodological issues.* Timonium, MD: York Press, pp. 233-277.

Flege, J., Munro, M. J. & MacKay, I. (1995): Factors Affecting Strength of Perceived Foreign Accent in a Second Language. *Journal of the Acoustic Society of America*, 97 (5): 3125-3134.

Fowler, C. A. (1981). Production and perception of coarticulation among stressed and unstressed vowels. *Journal of Speech and Hearing Research 46*, 127-139.

Fuchs, S. & Toda, M. (2007). Do differences in male versus female /s/ reflect biological factors or sociophonetic ones? In: Fuchs, S., Shadle, C., Toda, M. & Zygis, M. (eds). *Phonetics and phonology of turbulent sounds.* Berlin: Mouton de Gruyter.

Gardner, H. (1983): Frames of Mind: The Theory of Multiple Intelligences. New York: Basic Books.

Gardner, R. C. (1985): *Social Psychology and second language learning: The role of attitudes and motivation.* London: Edward Arnold.

Giles, H. (1973): Accent mobility: A model and some data. *Anthropological Linguistics*, 15, 87-105.

Giles, H., Coupland, N. & Coupland, J. (1991): Accommodation Theory: Communication, context, and consequence. In: Giles, H., Coupland, J. & Coupland, N. (Eds.): *Contexts of Accommodation: Developments in Applied Sociolinguistics.* Cambridge: Cambridge University Press, pp. 1-68.

Gimson, A. Ch. (1980): *An Introduction to the Pronunciation of English.* 3. ed. London: Edward Arnold.

Goble, Ch. & Ní Chasaide, A. (1999). Voice source variation in the vowel as a function of consonantal context. In: Hardcastle, W. J. & Hewlett, N. (eds). *Coarticulation. Theory, Data and Techniques.* Cambridge: Cambridge University Press, pp. 122-143.

Goble, Ch. & Ní Chasaide, A. (1999). Techniques for analysing the voice source. In: Hardcastle, W. J. & Hewlett, N. (eds). *Coarticulation. Theory, Data and Techniques.* Cambridge: Cambridge University Press, pp. 300-321.

Goldinger, S. (1996): Words and Voices: Episodic Traces in Spoken Word Identification and Recognition Memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 22(5), 1166-1183.

Goldinger, S. (1997): Words and voices – Perception and production in an episodic lexicon. In: Johnson, K. & Mullennix, J. W. (eds.): *Talker Variability in Speech Processing.* San Diego: Academic Press, pp. 33-66.

Goldinger, S. (1998): Echoes of Echoes? An Episodic Theory of Lexical Access. *Psychological Review*, 105(2), 251-279.

Golestani, N., Paus, T. & Zatorre, R. J. (2002): 'Anatomical correlates of learning novel speech sounds.', *Neuron*, 35(5), 997-1010.

Golestani, N. & Zatorre, R. J. (2004): 'Learning new sounds of speech: reallocation of neural substrates.', *Neuroimage*, 21(2), 494-506.

Gray, J. A. (1981): A critique of Eysenck's theory of personality. In: Eysenck, H. J. (Ed.): *A model for personality.* Berlin: Springer-Verlag, pp. 246-276.

Gray, J. A. (1982): *The neuropsychology of anxiety: An enquiry into the functions of the septo-hippocampal system.* New York: Oxford University Press.

Gray, J. A. (1987): Perspectives on anxiety and impulsivity: A commentary. *Journal of Research in Personality*, 21, 493-509.

Gray, J. A. & Braver, T. S. (2002): Personality predicted working-memory-related activation in the caudal anterial cingulated cortex. *Cognitive, Affective, and Behavioral Neuroscience*, 2 (1), 64-75.

Guiora, A. Z., Beit-Hallahmi, B., Brannon, R., Dull, C. & Scovel, T. (1972): The effects of experimentally induced changes into ego states on pronunciation ability in a second language: an exploratory study. *Comprehensive Psychiatry*, 13, 421-428.

Guiora, A. Z. (1979): Personality and language behavior: A restatement. *Language Learning*, 29 (1), 193-204.

Guiora, A. Z. (1990): A Psychological Theory of Second Language Pronunciation. Toegepaste Taalwetenschap in Artikelen, 37: 15-23.

Hardcastle, W. J. & Hewlett, N. (1999): *Coarticulation. Theory, Data and Techniques.* Cambridge: Cambridge University Press.

Harrison, N. (1979): *A study to find out if a correlation exists between the study of music and aural-oral ability in French.* M.A.T. of F. Simon Fraser U.

Hess, W. (1983): *Pitch determination of speech signals, algorithms and devices.* Berlin: Springer-Verlag.

Hinterberger, T., Veit, R., Weiskopf, N., Wilhelm, B., Betta, E., Birbaumer, N. (2005): An EEG-driven brain-computer interface combined with functional magnetic resonance imaging (fMRI). *IEEE transactions on bio-medical engineering*, 51 (6), 971-974.

Hoole, P., Gfroerer, S. & Tillmann, H.-G. (1990). Electromagnetic articulatography as a tool in the study of coarticulation. *Forschungsberichte des Instituts für Phonetik, Munich*, 28: 107-122.

Hoole, P. (1999). Laryngeal coarticulation. In: Hardcastle, W. J. & Hewlett, N. (eds). *Coarticulation. Theory, Data and Techniques.* Cambridge: Cambridge University Press, pp. 107-121.

Hu, X. & Reiterer, S. (2009): Personality and pronunciation talent. In: Dogil, G. & Reiterer, S.: *Language Talent and Brain Activity.* Berlin: Mouton de Gruyter, pp. 97-130.

International Phonetic Association (1999): *Handbook of the International Phonetic Association. A Guide to the Use of the International Phonetic Alphabet.* Cambridge: Cambridge University Press.

Iverson, P., Bannister, K. & Hazan, V. (2004): Auditory training with phonetic variability and acoustic enhancement: A comparison of /r/ -- /l/ training for Japanese adults. *The Journal of the Acoustical Society of America*, 116, 2573.

Jilka, M. (2000): *The Contribution of Intonation to the Perception of Foreign Accent.* PhD Dissertation. Arbeiten des Instituts für Maschinelle Sprachverarbeitung, 6 (3), University of Stuttgart.

Jilka, M. (2009a): Talent and proficiency in language. In: Dogil, G. & Reiterer, S.: *Language Talent and Brain Activity.* Berlin: Mouton de Gruyter, pp. 1-16.

Jilka, M. (2009b): Assessment of phonetic ability. In: Dogil, G. & Reiterer, S.: *Language Talent and Brain Activity.* Berlin: Mouton de Gruyter, pp. 17-66.

Johnson, J. & Newport, E. (1989): Critical Period Effects in Second Language Learning: The Influence of Maturational State on the Acquisition of English as a Second Language. *Cognitive Psychology*, 21: 60-99.

Johnson, K. (1997): Speech perception without speaker normalization: An Exemplar Model. In: Johnson, K. & Mullennix, J. W. (Eds.): *Talker variability in speech processing.* San Diego: Academic Press, pp. 145-165.

Johnson, K. (2006): Resonance in an exemplar-based lexicon: The emergence of social identity and phonology. *Journal of Phonetics*, 34(4), 485-499.

Jones, D. (1918): *An Outline of English Phonetics.* Cambridge: Cambridge University Press, With 116 Illustrations.

Karimer, L. (1984): Can southeast Asian students learn to discriminate between English phonemes more quickly with the aid of music and rhythm?. *Language Key to Learning*, 5: 41-48.

Keating, P. A. (1990): The window model of coarticulation: Articulatory evidence. In: Kingston, J. & Beckman, M. E. (eds): *Papers in laboratory phonology I: Between the grammar and physics of speech.* Cambridge: Cambridge University Press., pp. 451-470.

Kenyon, J. S. (1950): *American Pronunciation.* Ann Arbor: George Wahr Publishing Company.

Klein, W. & Perdue, C. (1997): The Basic Variety (or: Couldn't natural languages be much simpler?). *Second Language Research*, 13(4), 301-347.

Kohler, K. J. (1999): German. In: *International Phonetic Association* (Ed). Handbook of the International Phonetic Association. A Guide to the Use of the International Phonetic Alphabet. Cambridge: Cambridge University Press, pp. 86-89.

Krashen, S. D. (1973): Lateralization, Language Learning, and Critical Period: Some New Evidence. *Language Learning*, 23: 63-74.

Kuhl, P. K. (1991): Human Adults and Human Infants Show a Perceptual Magnet Effect for the Prototypes of Speech Categories, Monkeys do not. *Perception and Psychophysics*, 50 (2): 93-107.

Kuhl, P. K., Williams, K. & Lacerda, F. (1992): Linguistic Experience alters phonetic perception in infants at 6 months of age. *Science*, 255: 606-608.

Kuhl, P. K. & Iverson, P. (1995): Linguistic Experience alters phonetic perception in infants at 6 months of age. *Science*, 255: 606-608.

Kühnert, B. & Nolan, F. (1999). The origin of coarticulation. In Hardcastle, W. J. & Hewlett, N. (Eds.), *Coarticulation. Theory, Data and Techniques*, (pp. 7-30). Cambridge: Cambridge University Press.

Ladefoged, P. (1999): American English. In: *International Phonetic Association* (Ed). Handbook of the International Phonetic Association. A Guide to the Use of the International Phonetic Alphabet. Cambridge: Cambridge University Press, pp. 41-44.

Ladefoged, P. (2003): *An introduction to the sounds of languages.* Los Angeles: Blackwell Publishing, University of California.

Ladd, D. R. & Morton, R. (1997): The Perception of Intonational Emphasis: Continuous or Categorical? *Journal of Phonetics*, 25: 313-342.

Larson, G. (1984): *The Far Side Gallery 1.* London: Warner Books.

Lehiste, I. (1964): *Some Acoustic Characteristics of Selected English Consonants.* Research Center in Anthropology, Folklore and Linguistics, Indiana University, 34.

Leibetseder, M., Laireiter, A. R., Riepler, A. & Köller, T. (2001): E-Skala: Fragebogen zur Erfassung von Empathie – Beschreibung und psychometrische Eigenschaften. *Zeitschrift für Differentielle und Diagnostische Psychologie*, 22.

Leibetseder, M., Laireiter, A. R. & Köller, T. (2007): Structural analysis of the E-scale. *Personality and Individual Differences*, 42: 547-561.

Lenneberg, E. (1967): *Biological Foundations of Language.* New York: Wiley.

Levelt, W. J. M. (1999): Producing spoken language: A blueprint of the speaker. In: Brown, A. & Hagoort, P. (eds.): *The neurocognition of language.* Oxford: Oxford University Press.

Lewandowski, N. (2009): Sociolinguistic factors in language proficiency: phonetic convergence as a signature of pronunciation talent. In: Dogil, G. & Reiterer, S.: *Language Talent (and Brain Activity)*. Berlin: De Gruyter.

Lobanov, B. M. (1971): Classification of Russian Vowels Spoken by Different Speakers. *Journal of the Acoustical Society of America*, 49, 2 (2): 606-608.

Lu, C. H. & Proctor, R. W. (1995): The influence of irrelevant location information on performance: A review of the Simon and spatial Stroop effects. *Psychonomic Bulletin and Review*, 2, 174-207.

MacIntyre, P. D. & Gardner, R. C. (1991): Methods and results in the study of anxiety in language learning: A review of literature. *Language Learning*, 41 (1), 85-117.

MacIntyre, P. D. & Gardner, R. C. (1994): The subtle effects of language anxiety on cognitive processing in the second language. *Language Learning*, 44 (2), 283-305.

MacNeilage, P. (1970): Motor control of serial ordering of speech. *Psychology Review*, 77: 182-196.

Majewski, W., Rothman, H. B. & Hollien, H. (1977): Acoustic comparisons of American English and Polish. *Journal of Phonetics,* 5, 247-251.

Mangold, M. (2005): *Duden, Ausspracheworterbuch.* 6. ed. Mannheim: Dudenverlag.

Markham, D. (1997): *Phonetic Imitation, Accent, and the Learner.* PhD Dissertation. Travaux de l'Institut de Linguistique de Lund 33. Lund University Press.

Maybury, R. I. (1993): First language acquisition after childhood differs from second language acquisition: the case of American sign language. *Journal of Speech and Hearing Research*, 36: 1258-1270.

Milovanov, R., Tervaniemi, M., Takio, F. & Hämäläinen, H. (2007): Modification of dichotic listening (DL) performance by musico-linguistic abilities and age. *Brain Research*, 1156; 168-173.

Milovanov, R., Huotilainen, M., Välimäki, V., Esque, P. A. & Tervaniemi, M. (2008): Musical aptitude and second language pronunciation skills in school-aged children: Neural and behavioral evidence. *Brain Research*, 1194: 81-89.

Möbius, B. & Dogil, G. (2002): Phonemic and postural effects on the production of prosody. In: Bel, B. & Marlien, I. (eds.): *Proceedings of the Speech Prosody Conference 2002* (Aix-en-Provence), 523-526.

Möhler, G. (2001): *Improvements of the PaIntE model for F_0 parametrization.* Research Papers from the Phonetics Lab, AIMS Universität Stuttgart.

Montrul, S. & Slabakova, R. (2001): Is Native-Like Competence Possible in L2 Acquisition? *Proceedings of the 25th Boston University Conference on Language Development 200*: 1-12.

Moyer, A. (1999): Ultimate Attainment in L2 Phonology: The Critical Factors of Age, Motivation, and Instruction. *Studies in Second Language Acquisition*, 21, 81-108.

Moyer, A. (2004): *Age, Accent and Experience in Second Language Acquisition. An Integrated Approach of Critical Period Inquiry.* Second Language Acquisition 7. Series Editor: Singleton, D., Trinity College, Dublin/Ireland. Clevedon: Multilingual Matter Ltd..

Myers, I. B. & Briggs, K. (1976): *The Myers-Briggs Type Indicator, Form* G. Paolo Alto, CA: Consulting Psychologists Press.

Nardo, D. & Reiterer, S. M. (2009): Musicality and phonetic language aptitude. In: Dogil, G. & Reiterer, S.: *Language Talent (and Brain Activity).* Berlin: De Gruyter.

Neppert, J. M. H. (1999): *Elemente der Akustischen Phonetik*. Hamburg: Helmut Buske Verlag.

Neufeld, G. (1987): On the Acquisition of Prosodic and Articulatory Features in Adult Language Learning. In: Ioup, G. & Weinberger, S. (Eds.): *Interlanguage Phonology*. Cambridge, MA: Newbury House, 321-332.

Novoa, L., Fein, D. & Obler, L. (1988): Talent in Foreign Languages: A Case Study. In: Obler, L. & Fein, D. (Eds.): T*he Exceptional Brain: The Neuropsychology of Talent and Special Abilities.* New York. Guildford, 294-302.

Oh, E. (2008): Coarticulation in non-native speakers of English and French: An acoustic study. *Journal of Phonetics*, 36: 361-384.

Öhman, S. E. G. (1966): Coarticulation in VCV utterances: Spectrographic measurements. *Journal of the Acoustical Society of America*, 39, 151-168.

Oyama, S. (1976): A Sensitive Period for the Acquisition of a Non-native Phonological System. *Journal of Psycholinguistic Research*, 5:261-283.

Papagno, C. & Vallar, G. (1995): Verbal Short-term Memory and Vocabulary Learning in Polyglots. *Quarterly Journal of Experimental Psychology*, 48 A (1), 98-107.

Pastuszek-Lipinska, B. (2008): Influence of music education on second language acquisition. *Acoustics 08*, Paris.

Pétursson, M. & Neppert, J. (2002): *Elementarbuch der Phonetik.* Hamburg: Helmut Buske Verlag.

Pierrehumbert, J. (1980): *The Phonology and Phonetics of English Intonation.* PhD Dissertation, M.I.T., Cambridge, M.A.

Pierrehumbert, J. (2001): Exemplar dynamics: Word frequency, lenition and contrast. In: Bybee, J. & Hopper, P. (eds): *Frequency and the Emergence of Linguistic Structure.* Amsterdam: Benjamins, pp. 137-157.

Pierrehumbert, J. B. (2006): The next toolkit. *Journal of Phonetics*, 34(4), 516-530.

Piske, T., MacKay, I. & Flege, J. (2001): Factors Affecting Degree of Foreign Accent in an L2: a Review. *Journal of Phonetics*, 29: 191-215.

Pompino-Marschall, B. (1995): *Einführung in die Phonetik.* Berlin: Walter de Gruyter Verlag.

Purcell, E. & Suter, R. (1980): Predictors of pronunciation accuracy: A re-examination. *Language Learning*, 30, 271-287.

Quay, H. C. (1993): The psychobiology of undersocialized aggressive conduct disorder: A theoretical perspective. *Development and Psychopathology*, 5, 165-180.

Rapp, S. (1995): *Automatic phonemic transcription and linguistic annotation from known text with Hidden Markov Models/ An Aligner from German.* In: Proceedings of ELSNET goes east and IMACS Workshop "Integration of Language and Speech in Academia and Industry", Moscow.

Raven, J. C. (1938): *Progressive matrices: A perceptual test of intelligence*. London. H.K. Lewis.

Recasens, D. (1984a): V-to-C coarticulation in Catalan VCV sequences: an articulatory and acoustical study. *Journal of Phonetics*, 12, 61-73.

Recasens, D. (1984b): Vowel-to-vowel coarticulation in Catalan VCV sequences. *Journal of the Acoustical Society of America*, 76, 1624-1635.

Recasens, D. (1985): Coarticulatory patterns and degrees of coarticulatory resistance in Catalan CV sequences. *Language and Speech*, 28 (2): 97-114.

Recasens, D. & Farnetani, E. (1990): Articulatory and acoustic properties of different allophones of /l/ in American English, Catalan and Italian. *Proceedings of the ICSLP 90,* 2, 961-964. Acoustic Society of Japan.

Recasens, D. & Farnetani, E. (1991): Spatiotemporal properties of different allophones of /l/. Phonological implications. *Quaderni del Centro di Studio per le Ricerche di Fonetica,* Padova, 11, 236-251.

Recasens, D., Fontdevila, J. & Pallarès, M. D. (1995): Velarization degree and coarticulatory resistance for /l/ in Catalan and German. *Journal of Phonetics*, 23: 37-52.

Recasens, D. (1999): Acoustic analysis. In: Hardcastle, W. J. & Hewlett, N. (eds). *Coarticulation. Theory, Data and Techniques.* Cambridge: Cambridge University Press, pp. 322-336.

Reiterer, S. M. (2009): Brain and Language talent: a synopsis. In: Dogil, G. & Reiterer, S.: *Language Talent (and Brain Activity)*. Berlin: De Gruyter, pp. 155-192.

Reiterer, S., Berger, M., Hemmelmann, C. & Rappelsberger, P. (2005): Decreased EEG Coherence between prefrontal electrodes: A correlate of high language proficiency? *Experimental Brain Research,* in press.

Révész, G. (1953): I*ntroduction to the psychology of music.* London: Longmans, Green.

Roach, P. (1992): *Introducing Phonetics.* New York: Penguin Books.

Roach, P. (2004): British English: Received Pronunciation. *Journal of the International Phonetic Association*, 34 (2): 239-245.

Rota, G., Sitaram, R., Veit, R., Erb, M., Weiskopf, N., Dogil, G. & Birbaumer, N. (2008): Self-regulation of regional cortical activity using real-time fMRI: the right inferior frontal gyrus and linguistic processing. *Human brain mapping*, to appear.

Rota, G. & Reiterer, S. M. (2009): Cognitive aspects of language talent. In: Dogil, G. & Reiterer, S.: *Language Talent (and Brain Activity)*. Berlin: De Gruyter, pp. 67-96.

Rota, G. (2009): Direct brain feedback and language learning from the gifted. In: Dogil, G. & Reiterer, S.: *Language Talent (and Brain Activity)*. Berlin: De Gruyter, pp. 337-349.

Sancier, M. L. & Fowler, C. A. (1997): Gestural drift in a bilingual speaker of Brazilian Portuguese and English. *Journal of Phonetics*, 25, 421-436.

Saville-Troike, M. (2005): *Introducing Second Language Acquisition.* Cambridge: Cambridge University Press.

Scherer, G. & Wollmann, A. (1977): *Englische Phonetik und Phonologie. Grundlagen der Anglistik und Amerikanistik.* Neuburg (Donau): Erich Schmidt Verlag.

Schneider, W., Eschman, A. & Zuccotto, A. (2002): *E-Prime User's Guide.* Pittsburg: Psychology Software Tools Inc.

Schneider, K., Lintfert, B., Dogil, G. & Möbius, B. (2006): Phonetic grounding of prosodic categories. In: Schneidermann, E. & Desmarais, C. (1988): A Neuropsychological Substrate for Talent in Second-Language Acquisition. In: Obler, L. & Fein, D. (Eds.): *The Exceptional Brain: The Neuropsychology of Talent and Special Abilities.* New York: Guildford, pp. 103-126.

Schneidermann, E. & Desmarais, C. (1988): A Neuropsychological Substrate for Talent in Second-Language Acquisition. In: Obler, L. & Fein, D. (Eds.): *The Exceptional Brain: The Neuropsychology of Talent and Special Abilities.* New York: Guildford.

Selinker, L. (1972): Interlanguage. In: *IRAL*, 10(3), 209/231.

Shepard, C. A., Giles, H. & Le Poire, B. A. (2001): Communication Accommodation Theory. Robinson, W. P. & Giles, H. (Eds.): The New Handbook of Language and Social Psychology. Chichester, John Wiley & Sons, pp. 33-56.

Silverman, K., Beckman, M., Pitrelli, J., Ostendorf, M., Wightman, C., Price, P., Pierrehumbert, J. & Hirschberg, J. (1992): ToBI: A Standard for Labelling Prosody. P*roceedings of ICSLP*, 867-870.

Simon, J. R. & Rudell, A. P. (1967): Auditory S-R compatibility: The effect of an irrelevant cue on information processing. *Journal of Applied Psychology*, 51, 300-304.

Simon, J. R. (1969): Reactions toward the source of stimulation. *Journal of Experimental Psychology*, 81 (1), 174-176.

Simpson, A. P. (1998): Phonetische Datenbanken des Deutschen in der empirischen Sprachforschung und der phonologischen Theoriebildung. In: Kohler, K. J.: *Arbeitsberichte des Instituts für Phonetik und digitale Sprachverarbeitung (AIPUK*), 33.

Slevc, L. R. & Myiake, A. (2006): Individual differences in second-language proficiency. Does musical ability matter? *Psychological Science*, 17 (8): 675-681.

Spearman, C. (1904): "General Intelligence," Objectively Determined and Measured. *American Journal of Psychology*, 15, 201-293.

Spielberger, C. D. (1983): *Manual for the State-Trait Anxiety Inventory (Form Y).* Paolo Alto, CA: Consulting Psychologists Press.

Stevens, K. N. & House, A. S. (1963): Perturbation of vowel articulations by consonantal context: An acoustical study. *Journal of Speech and Hearing Research*, 6, 111-128.

Stevens, K. N. (1998). *Acoustic Phonetics.* Cambridge: MIT Press.

Strand, E. A. (1999). Uncovering the role of gender stereotypes in speech perception. *Journal of Language and Social Psychology*, 18 (1): 86-99.

Stuart-Smith, J.. Empirical evidence for gendered speech production: /s/ in Glaswegian. In: Cole, J. & Hualde, J. (eds). *Change in Phonology. Laboratory Phonology*, 9. Berlin: Mouton de Gruyter. in press.

Swanson, H. L. (2006): Cross-sectional and incremental changes in working memory and mathematical problem solving. *Journal of Educational Psychology*, 98, 265-281.

Thurstone, L. L. (1938): *Primary mental abilities*. Chicago IL, University of Chicago Press.

Ullman, M. (2007): The Neurocognition of Second Language: New Evidence from Training and Aptitude. *Invited Lecture at Language Processing in First and Second Language Learners.* Max Planck Institute for Psycholinguistics, Nijmegen.

Vollmer, K. (1993). *Untersuchung der Koartikulation bei gestörter Sprache: Experimentalstudie.* Magisterarbeit im Fach Linguistik, Universität Bielefeld.

Vollmer, K. (1997). *Koartikulation und Glottale Transparenz.* Dissertationsschrift zur Erlangung der Würde eines Doktors, Fakultät für Philosophie, Universität Stuttgart.

Wade, T., Dogil, G., Schütze, H., Walsh, M. & Möbius, B. (2010): Syllable frequency effects in a context-sensitive segment production model.

Watson, D., Clark, L. A. & Tellegen, A. (1988): Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality and Social Psychology*, 54, 1063-1070.

Weiskopf, N., Mathiak, K., Bock, S. W., Scharnowski, F., Veit, R., Grodd, W., Goebel, R., Birbaumer, N. (2004): Principles of a brain-computer interface (BCI) based on real-time functional magnetic resonance imaging (fMRI). *IEEE transactions on bio-medical engineering*, 51 (6), 966-970.

Wells, J. C. (1962): *A study of the formants of the pure vowels of British English.* Submitted in partial fulfilment of the requirements for the degree of M.A.. University of London.

Wode, H. (1997): Perception and production in learning to talk. In: Hannahs, S. J. & Young-Scholten, M. (Eds.): *Focus on phonological acquisition.* Amsterdam/Philadelphia: John Benjamins, pp. 17-46.

Ziegler, W. & von Cramon, D. (1985). Anticipatory Coarticulation in a Patient with Apraxia of Speech. *Brain and Language*, 26: 117-130.

Ziegler, W. & von Cramon, D. (1986). Disturbed Coarticulation in Apraxia of Speech: Acoustic Evidence. *Brain and Language, 29*: 34-47.

Ziegler, W. (1989). Anticipatory Coarticulation in Aphasia: More Morphology: A Reply to Sussman et al. (1988) and Katz (1988). *Brain and Language*, 37: 172-176.

Appendix A

Materials for *Experimental Part 1*

German

1. Ich habe *gelate* gesagt.
2. Ich habe *gelite* gesagt.
3. Ich habe *gelüte* gesagt.
4. Ich habe *gelute* gesagt.

English

1. I have said *gelate* twice.
2. I have said *gelite* twice.
3. I have said *gelüte* twice.
4. I have said *gelute* twice.

Appendix B

Materials for *Experimental Part 2*

German

1. Russland will mehrere Länder mit Gas aus einer 3300 Kilometer langen Leitung beliefern.
2. In Holland ist Sterbehilfe schon seit einer Weile erlaubt, um kranken Menschen Leid zu ersparen.
3. US-Präsident Barack Obama erhält als erster schwarzer Präsident in der Öffentlichkeit Geleit.
4. Holde waren durch ihre Tätigkeiten auf dem Hof, Acker und im Wald sowie durch ihre Zinspflicht stark belastet.

English

1. Laura will turn off the light in the hall when she leaves.
2. I believe we can halt the wild fluctuations in the financial markets.
3. Bill can lend me his older brother's bicycle because we are alike in many ways.

Appendix C

Vowel trapezes of the languages dealt with

German IPA

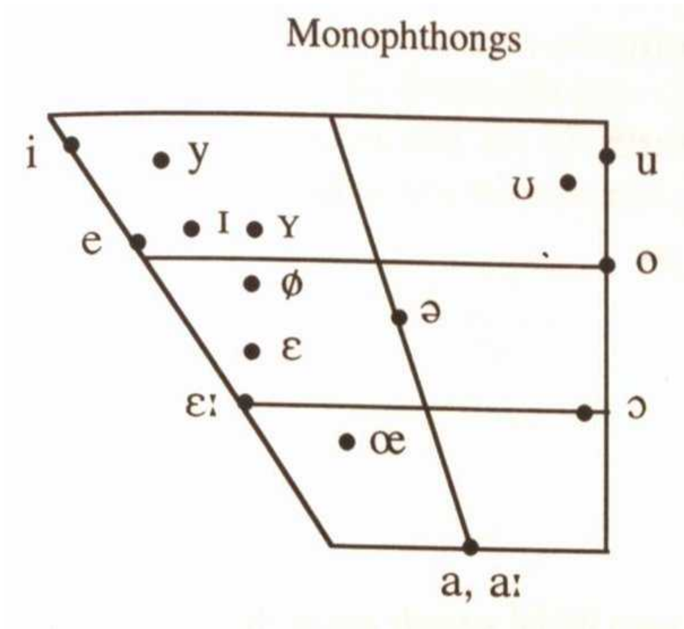


Figure 20. German International Phonetic Alphabet (Kohler 1999:86 ff)

RP IPA

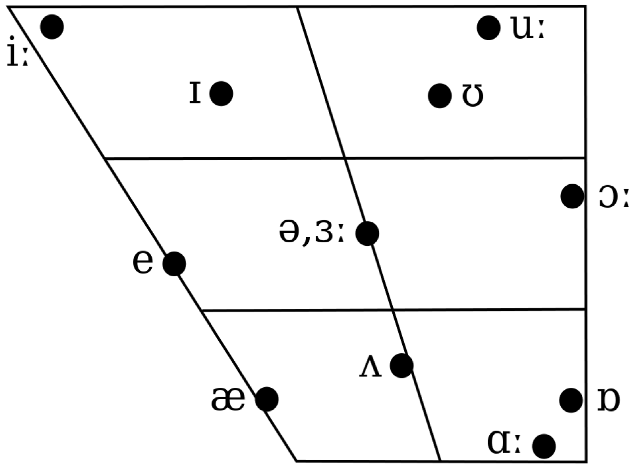


Figure 21. RP English vowel trapeze (Roach 2004:242).

American IPA

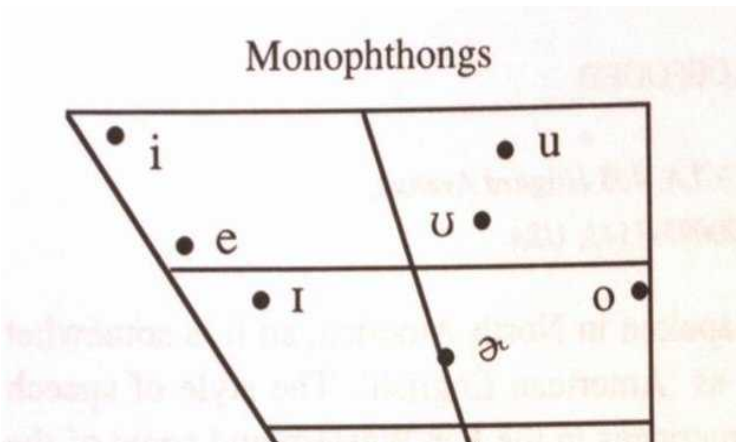


Figure 22. American English International Phonetic Alphabet (Ladefoged 1999:41 ff)

German vs. English vowel system: a comparison

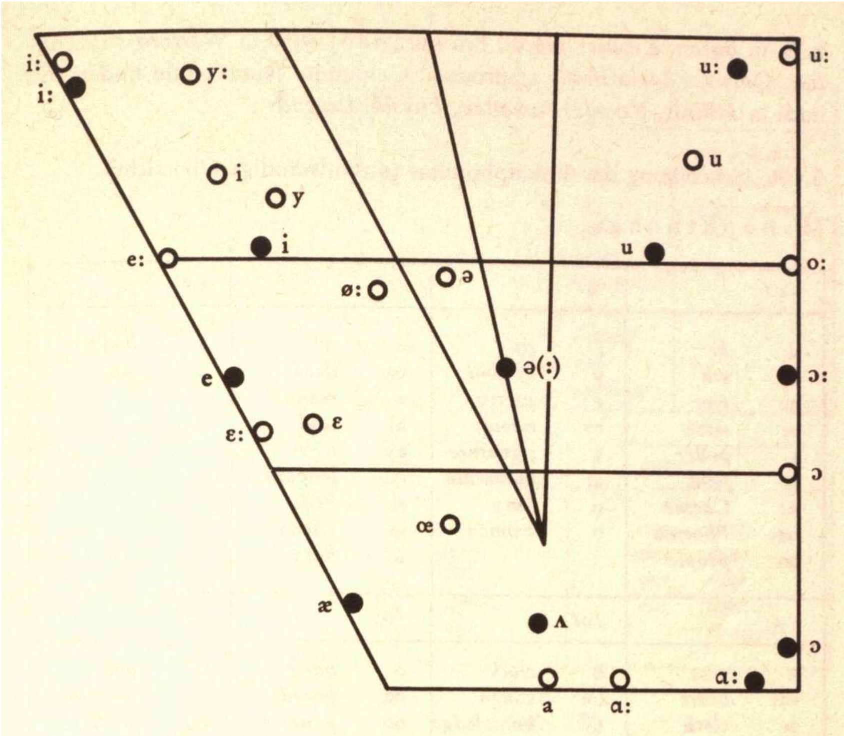


Figure 23. Relative positions of German and English monophthongs for a comparison (Scherer & Wollmann 1977:157). White points indicate German, whereas black points mark English vowels and their respective positions.