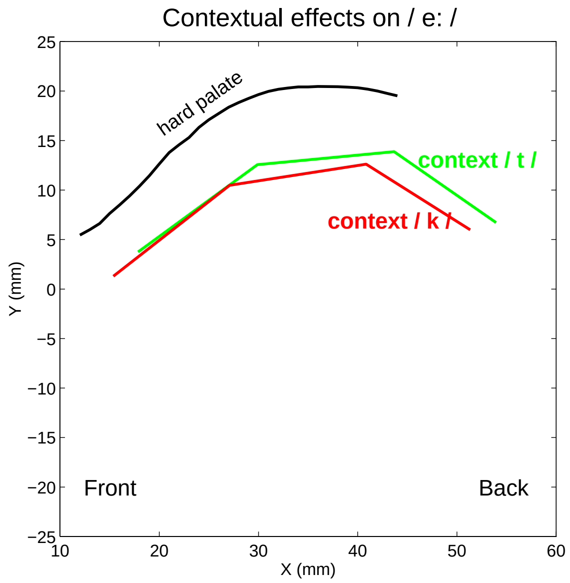
The Problem of Variability

"Awful or Lawful?"

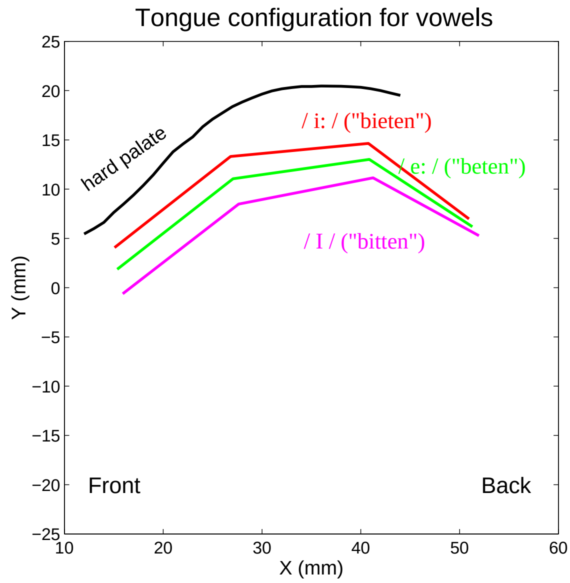
1. Coarticulation

(Refer also to separate handouts on velar and labial coarticulation).

Another example of lingual coarticulation (cf. EPG example from 1. Semester: /isi/ vs. /asa/):



Average tongue configuration for /e:/ in two different consonantal contexts (/te:t/ and /ke:k/)



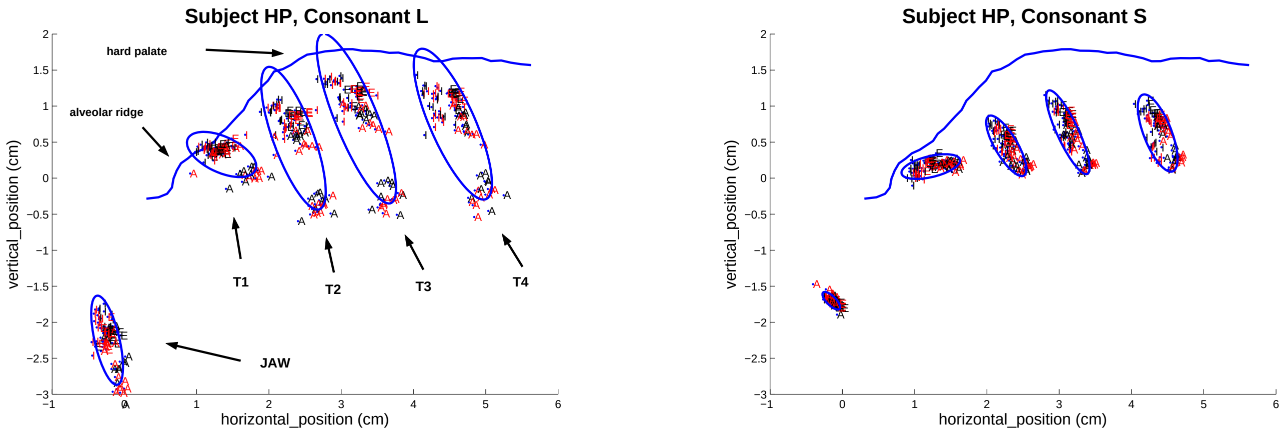
Average tongue configuration for 3 high front vowels in the same consonantal context (/pVp/)

Notes: 1. Difference between /e:/ in *different* contexts (left panel) may be as big as difference between /e:/ and /i:/ in *same* context (right panel)

2. Why is the tongue further back for /te:t/ than for /ke:k/?

1a. Why do some sounds show more influence of coarticulation than others?

Example / **l** / vs. / **s** / :



Distribution of tongue positions recorded from 4 sensors on the tongue (T1 to T4) and one sensor on the jaw for multiple repetitions of the consonants / ***l*** */ (left panel) and /* ***s*** */ (right panel) in 5 different vowel contexts (plot symbol indicates preconsonantal vowel). Data points in red spoken louder*

Possible reasons:

1. Sound system (German has more fricatives than laterals)

   See Manuel for a cross-language counterpart to this in the articulation of vowels: Languages with more vowels in their vowel system tend to show less variability (Manuel, S. , 1990, *"The role of contrast in limiting vowel-to-vowel coarticulation in different languages"*. J. Acoust. Soc. Am., 88, 1286-1298).

2. Acoustic sensitivity to change of articulation.

   The fricative /s/ may be more sensitive than /l/. This probably applies not only to the tongue, but also to the jaw. It has often been observed that /s/ has a higher and more carefully controlled jaw position than /l/. This high position of the jaw may help to generate a turbulent airstream at the teeth, and at the same time also constrain the amount of variability shown by the tongue. (The lower jaw position for /l/ is probably also related to the fact that /l/ is more likely to be apical than /s/; cf. xray-movies.)

3. Biomechanics

   Probably not relevant for comparison of /s/ and /l/, but could be relevant for vowels: High front “palatal” vowels (e.g /i:/) often show lower variability than low and/or back vowels. This may be because the large amount of contact with the hard palate for /i/ acts as a support for positioning the tongue.

2. Assimilation and other connected speech processes

Refer also to separate handouts “Browman & Goldstein” (pp.5-9 below) and “Kohler”

“In the mouth or in the mind?”

1. Do connected speech processes arise from general principles of gestural reduction and overlap as speech becomes faster and more casual?
2. Or do they involve reorganization at a higher, more cognitive level?

__Examples:__

(0.)

Engl. *‘do not’* ➔ *‘don’t’*
Germ. *‘zu dem’* ➔ *‘zum’*
Germ. *‘mit dem’* ➔ *‘mim’* one day?
= morphology “in the mind”

1. r-insertion

Engl. *‘for him’*: [**fɔː hɪm**] ➔ [**fəɹɪm**]
“r” is usually regarded as a complex articulation, so not easily regarded as motivated by economy of effort. However, it has been argued that English /r/ has some similarities with schwa. So it may be the consonant that is least obtrusive when inserted between 2 vowels. r-insertion must be learnt behaviour (“in the mind”) as it does not happen automatically when speaking faster (i.e foreign learners of English have to learn to do it).
(Note that r-insertion also happens in cases where there is no ‘r’ in the orthography.)

2. Glottal opening ➔ Glottal closure

2a Glottalization in English
e.g Engl. *‘bet’*: [**bɛtʰ**] ➔ [**bɛʔ**]
It is difficult to see the glottal stop as an extreme form of reduction of the glottal opening for /t/, since it involves active constriction of the glottis, rather than just a scaling down of the opening movement.
➔ active phonological reorganization “in the mind”

2b Laryngealization in nasal-plosive sequences in German
Quite a common process in German involves words like *‘Lampen’, ‘könnten’*, i.e with sequences of nasal+voiceless plosive+schwa+nasal.

lampʰən ➔ lampm ➔ lamm̰m

Following schwa-elision and assimilation for place of articulation, a long bilabial nasal sequence results, with some laryngealization (creaky voice) in the middle portion (indicated by the diacritic under the middle ‘m’).
Once again, the replacement of the glottal opening for the voiceless plosive by glottal constriction must involve active articulatory reorganization. The changes seem to be clearly motivated by economy of articulatory effort. By using slight constriction at the glottis to

indicate the presence of complete closure for /p/ it is possible to reduce [_ **mpʰən**] to a single long nasal sequence, avoiding the necessity for raising the soft palate for /p/ between the two nasals.
This process can also occur in comparable English words (*'Clinton'*) but seems to be more widespread in German.
See Kohler (1994) for further discussion.

3. Assimilation

'zu Bett gehen' ➔ *'zu Beck gehen'*

Arguments for both views:

It can be a gradual process (not all or none) = "in the mouth"
Assimilation processes differ between languages and between dialects of the same language (i.e learnt behaviour) = "in the mind"

Further notes on this kind of assimilation:

Why are alveolar stops (and nasals) affected but not bilabials and velars?
Why aren't fricatives affected (*'Ausfahrt'* and *'Auffahrt'* stay distinct)
Why are e.g /kt/ and /pt/ sequences not affected?
See discussion in Handout "Kohler" (Kohler (1990) pp. 87-89).

References

Browman, C. & Goldstein, L. (1990). "Tiers in articulatory phonology with some implications for casual speech", in J. Kingston & M. Beckman (eds) Papers in laboratory phonology I, pp. 341-376. Cambridge, CUP.

Kohler, K. (1990). "Segmental reduction in connected speech in German: Phonological facts and phonetic explanations". In: W. Harcastle & A. Marchal (eds.), Speech Production and Speech Modelling. Dordrecht: Kluwer Academic Publishers, 69-92.

Kohler, K. (1994). "Glottal stops and glottalization in German. Data and theory of connected speech processes", Phonetica, 51, 38-51.

Kühnert, B. (1996). Die alveolare-velare Assimilation bei Sprechern des Deutschen und des Englischen: Kinematische und Perzeptive Grundlagen. FIPKM, 24, 175-392.

Nolan, F. (1992). "The descriptive role of segments: evidence from assimilation". In: G. Docherty and D. Ladd (eds.) Laboratory Phonology II. Gesture, segment, prosody. Cambridge, CUP, 261-280.

Nolan, F. (1996). "Overview of English connected speech processes". AIPUK (=Kieler Forschungsberichte), 31, 15-26.

Nolan, F., Holst, T. & Kühnert, B. (1996). "Modelling [s] to [ʃ] accommodation in English". J. Phonetics, 24, 113-137.

Excerpts (pp. 359, 360, 363-365) from:
Browman, C. & Goldstein, L. (1990). "*Tiers in articulatory phonology with some implications for casual speech*", in J. Kingston & M. Beckman (eds) Papers in laboratory phonology I, pp. 341-376. Cambridge, CUP.

19.3 Generalizations about casual speech

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Segments are routinely elided, inserted, and substituted for one another. The examples in (5) (taken from Brown 1977) show (a) consonantal deletion, (b) consonant assimilation, and (c) simultaneous deletion and assimilation.

(5)	(a) /**mʌst bi**/	→	[**mʌsbi**]	("must be")
	(b) /**hʌndrəd paʊndz**/	→	[**hʌndrəbpaʊndz**]	("hundred pounds")
	(c) /**graʊnd prɛʃɚ**/	→	[**graʊmprɛʃɚ**]	("ground pressure")

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We propose that most of the phonetic units (gestures) that characterize a word in careful pronunciation will turn out to be observable in connected speech, although they may be altered in magnitude and in their temporal relation to other gestures. In faster, casual speech, we expect gestures to show decreased magnitudes (in both space and time) and to show increasing overlap. We hypothesize that the types of casual speech alternations observed (segment insertions, deletions, assimilations and weakenings) are consequences of these two kinds of variation in the gestural score.

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Example (5a) is described as an example of segment deletion. However, looking at this change in terms of the gestures involved, we hypothesize that the alveolar closure gesture for the /t/ is still present in the fluent speech version, but that it has been completely overlapped, or "hidden," by the bilabial closure gesture. This means that the movement of the tongue tip towards the alveolar ridge and away again may occur entirely during the time that the lips are closed (or narrowed), so that there will be no local acoustic evidence of the alveolar closure gesture.

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19.3.1.1 EVIDENCE FOR HIDDEN GESTURES

If our analysis of the changes involved in examples like (5) is correct, then it should be possible to find articulatory evidence of the "hidden" alveolar gesture. We examined the AT&T X-ray database (described in section 2) for examples of consonantal assimilations and deletions of this kind, by listening to the sentences with candidate consonant sequences.

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For example, figure 19.13a shows the vertical displacements of lead pellets placed on the velum, tongue dorsum rear, tongue blade, lower lip and lower teeth, along with the acoustic signal, for the utterance "perfect memory," spoken as a sequence of two words separated by a pause. The phonetic transcription aligned with the acoustic waveform indicates that the /t/ at the end of “perfect” is completely audible and its release is visible in the waveform. The time-course of the velar closure gesture associated with the /k/ in “perfect” is assumed to be reflected in the vertical displacement of the tongue dorsum (tongue rear) pellet. The relevant portion of this pellet trajectory is underlined in the figure and is labeled with the appropriate gestural symbol. Similarly, the portion of the tongue blade displacement associated with the alveolar closure gesture of the /t/ in “perfect”, and the portion of the lower lip displacement associated with the bilabial closure gesture for the initial /m/ in “memory” have been marked and labelled in the figure. Note that the velar and alveolar gestures partially overlap, indicating that velar closure is not released until the alveolar closure is formed. Thus, the *onset* of the alveolar gesture is acoustically “hidden” (it takes place during the velar closure), but its release is audible. Note the large amount of time between the release of the alveolar gesture and the onset of the bilabial gesture.

Figure 19.13b shows the same two word sequence spoken as part of a sentence. Here, the final/t/ in perfect is deleted in the traditional sense - careful listening reveals no evidence of the /t/, and no /t/ release can be seen in the waveform. However, the alveolar gesture can still be seen quite clearly in the figure. It is even of roughly the same magnitude as in figure 19.13a. What differs here is that the bilabial gesture for the initial /m/ now overlaps the release of the alveolar gesture. Thus, both the closure and release of the alveolar gesture are now overlapped and there is, therefore, no acoustic evidence of its presence.

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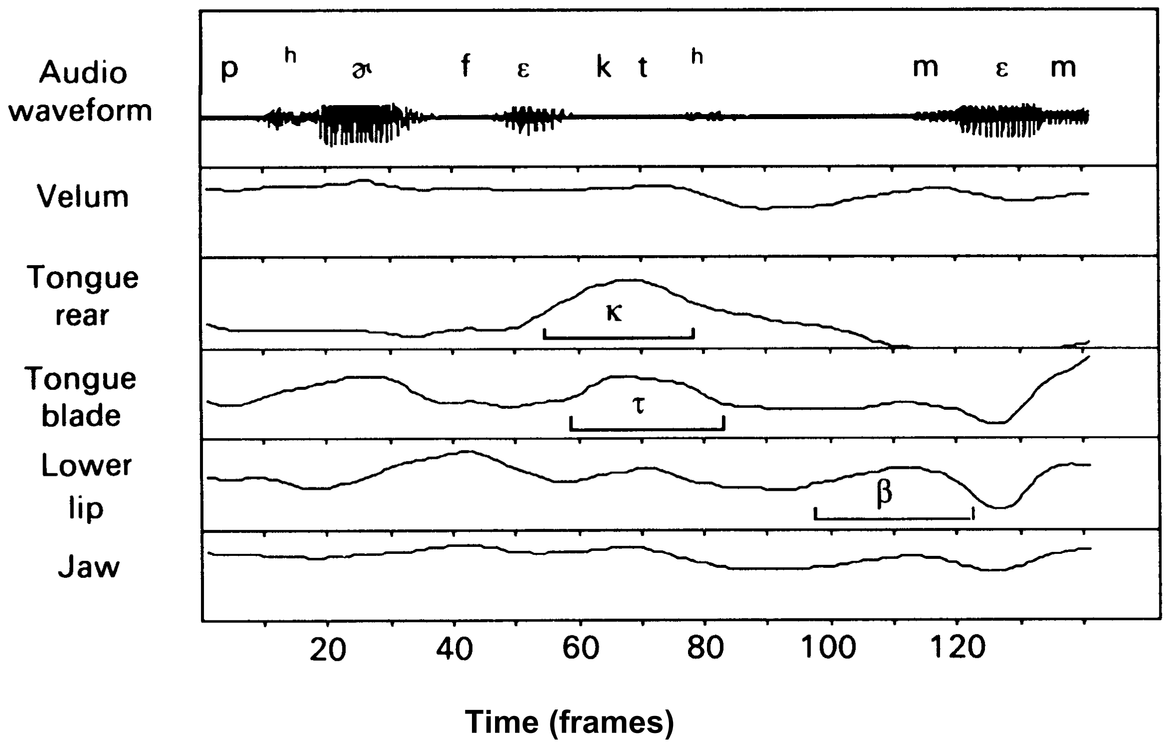
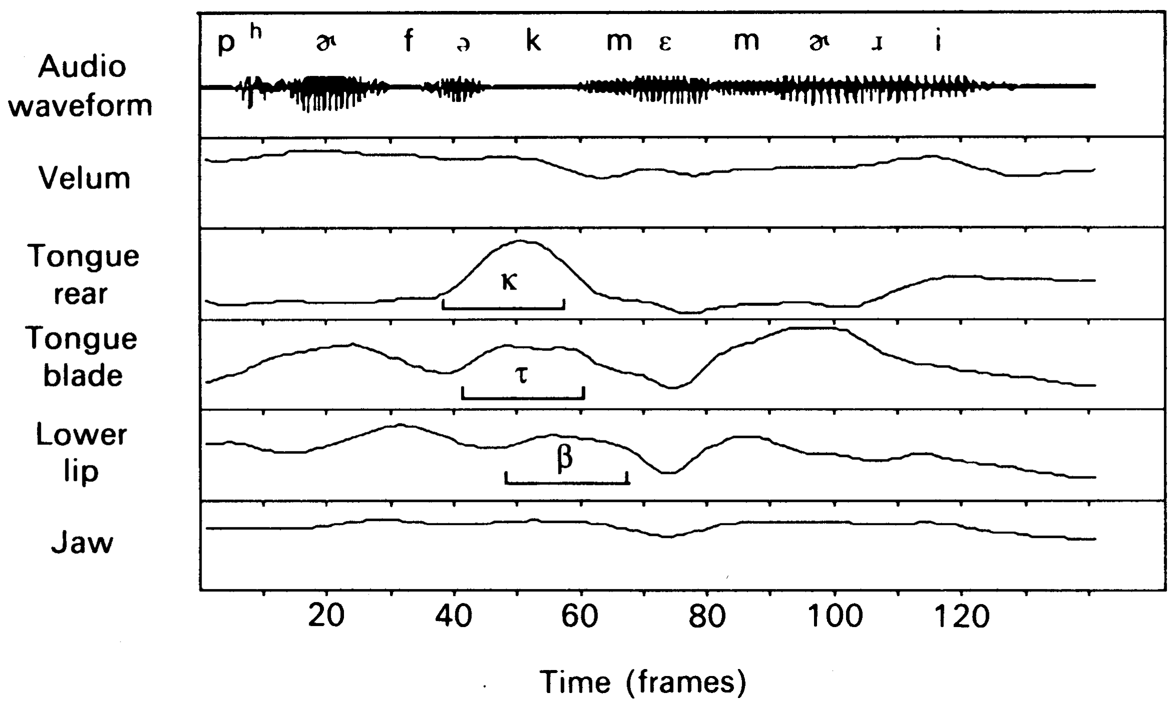
Another example of alveolar stop “deletion” where the alveolar closure gesture remains can be seen in figure 19.14. The same pellet trajectories are shown as in the previous figure. Here, the speaker (the same one shown in the previous figure) is producing the phrase “nabbed most” in a sentence. As indicated by the phonetic transcription, the /d/ at the end of “nabbed” has been deleted. The bilabial gestures associated with the /b/ of “nabbed” and the /m/ of “most” here overlap (forming a continuous closure), and the alveolar closure gesture, while quite robust kinematically, is once again irrelevant acoustically.

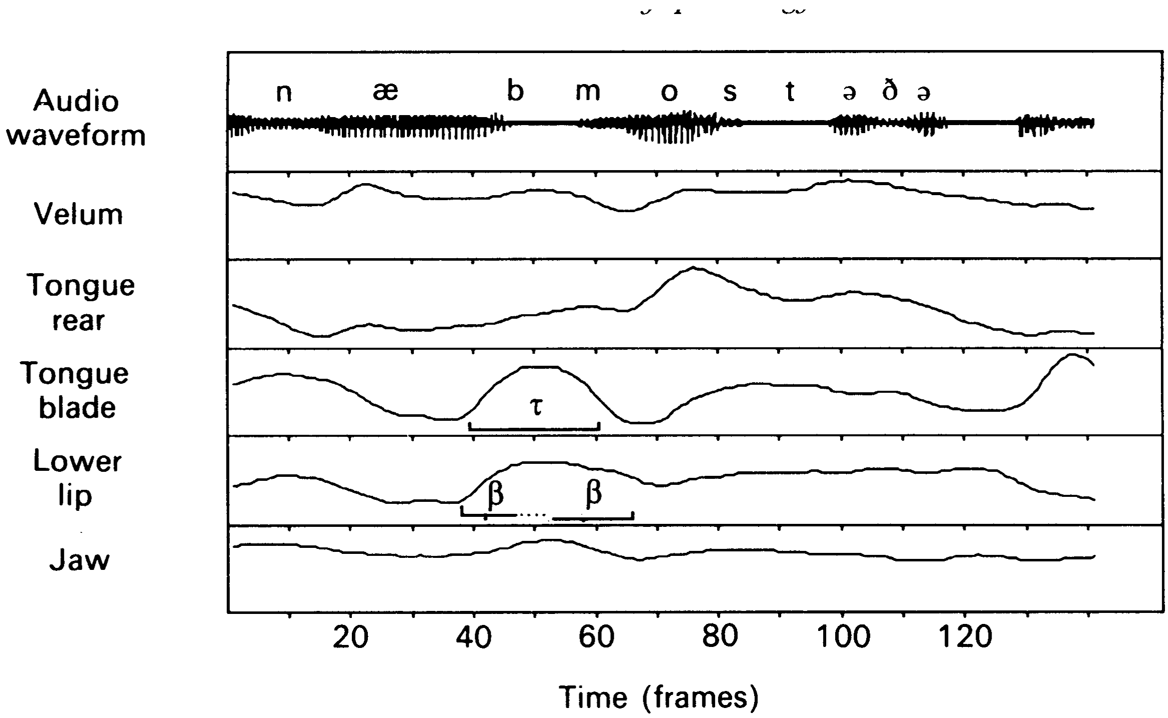


(a)



(b)

Figure 19.13 X-ray pellet trajectories for "perfect memory." (a) Spoken in a word list ([**pɚfɛkt# mɛm**...]), (b) spoken in a phrase ([**pɚfɛkmɛm**...])



(b)

Figure 19.14 X-ray pellet trajectories for “nabbed most” ([**nɑæbmost**]), spoken in a phrase.

3. Speaker-to-Speaker and Language-to-Language Variability

Als Beispiel: Untersuchungen von Dart (1991 a.b)

Diese Erläuterungen aus Hoole (1996), FIPKM 34, S.11-13.

In zwei Arbeiten legt S. Dart eine artikulatorische und akustische Untersuchung der koronalen Konsonanten /t, d, n, s, z, l/ im Englischen und Französichen vor.

Phonetische Lehrbücher machen selbstverständlich Angaben für die Artikulation dieser Laute; wie von Dart festgehalten wird, sind die Ansichten nicht absolut deckungsgleich, aber die allgemeine Meinung geht doch dahin, daß Französich eine dentale, laminale Artikulation, Englisch eine alveolare, apikale Artikulation bevorzugt. Es gibt aber erstaunlich wenige Versuche, die tatsächliche Artikulation instrumentell zu erfassen.

Diese unsichere empirische Lage ist, wie Dart anmerkt, aus mindestens zwei Gründen bedenklich: erstens finden phonetische Lehrbücher breite Anwendung im Fremdsprachenunterricht; zweitens werden akustische Untersuchungen oft vor großen Interpretationsschwierigkeiten stehen, wenn nicht davon ausgegangen werden kann, daß eine gegebene Sprecherstichprobe aus artikulatorischer Sicht homogen ist.

Dart bediente sich der Methode der direkten Palatographie und der Linguagraphie. In dem einen Fall wird die Zunge, in dem anderen Fall der harte Gaumen mit einer Substanz bestrichen (meist auf Kakaobasis o.ä); die gewünschte Lautkombination wird artikuliert; anschließend werden Ort des Kontaktes am Gaumen sowie artikulierender Teil der Zunge photographisch festgehalten.

Die Kontaktmuster am Gaumen wurden den Kategorien dental, alveolar und post-alveolar zugeordnet, die Muster an der Zunge den Kategorien apikal, laminal und apikolaminal, was in etwa mit zunehmender Ausdehnung der artikulierenden Zungenfläche einhergeht.

Die Ergebnisse für /t,d,n/ zeigten zwar, daß die aus der Literatur zu erwartenden Artikulationen tatsächlich am häufigsten vorkommen, machen aber deutlich, daß andere Muster sehr gut vertreten sind, im Französischen v.a. werden über 40% der Äußerungen nicht dental, sondern alveolar artikuliert.
Bei den Frikativen tritt für beide Sprachen eine besonders bevorzugte Artikulation noch weniger deutlich hervor.

Wichtig an dieser Untersuchung ist meiner Meinung nach viel weniger die Tatsache, daß die Omnipräsenz der Sprecher-Sprecher Variabilität noch einmal belegt wird, sondern vielmehr, daß erstens die Spannweite der prinzipiell zu erwartenden Realisationen erkennbar wird, und daß zweitens diese verschiedenen Erscheinungsformen mit der Wahrscheinlichkeit ihres Auftretens verknüpft werden können.

Die oben zu findende Darstellung der Ergebnisse ließe den Schluß zu, daß in vielen Fällen die französische und englische Artikulation eines gegebenen koronalen Lautes sich nicht unterscheidet. Besonders befriedigend an der Arbeit von Dart ist die Tatsache, daß sie dann noch einen Schritt weitergeht, indem sie zeigt, daß diese Schlußfolgerung nicht unbedingt gerechtfertigt ist.

Aufgrund der akustischen Analyse der Äußerungen sowie einer erweiterten palatographischen Analyse kam sie zum Schluß, daß ein genereller Unterschied zwischen Französisch und Englisch darin bestehen könnte, daß der Raum unmittelbar hinter der Konstriktion enger ist im Französischen, verbunden mit einer größeren Weite des Rachenraums. Dieser Unterschied kann vorhanden sein, auch wenn Identität in Hinblick auf die zwei Dimensionen der obigen Matrizen besteht. Dies unterstreicht die Tatsache, daß die Gesamtkonfiguration der Zunge manchmal entscheidender sein kann als die genaue Artikulationsstelle im üblichen Sinne.

Ich möchte die Besprechung dieser Untersuchung mit einem Hinweis auf zwei Detailergebnisse abschließen:

Erstens: aus den angegebenen Matrizen für /l/ läßt sich im Französischen eine sehr eindeutige

Zurückverlagerung dieses Lautes gegenüber den anderen koronalen Lauten erkennen. Für das Englische gibt es eine Tendenz in die andere Richtung. Somit ist es wahrscheinlicher, daß ein englisches /l/ dental artikuliert wird als ein französisches. Dieser Befund, insbesondere zum Französischen, läßt sich durchaus an vereinzelten Stellen in der Literatur bestätigen, hat aber anscheinend so gut wie keinen Eingang in allgemeinere Darstellungen der französischen Phonetik gefunden.

Zweitens: Angesichts der Subtilität ihrer phonetischen Analysen mag es fast verblüffen, daß Dart erst nachträglich feststellte, daß einige Versuchspersonen den artikulatorischen Verschluß mit der Unterseite der Zunge bildeten (=dental apicosublaminal!)

Dart, S. (1991a), "Articulatory and acoustic properties of apical and laminal articulations", UCLA WPP, Vol. 79, pp. 1-155.
Dart, S. (1991b), "Articulatory generalizations in acoustic phonetic research: a comparison of data from French and English", Proceedings XIIth International Congress of Phonetic Sciences, 3, 66-69.
Für eine Beschreibung (mit Bildern) der Methoden der Palatographie und der Linguagraphie s.
Ladefoged, P., "*Phonetic Data Analysis: An introduction to phonetic fieldwork and instrumental techniques*", www.jladefoged.com. (Auszüge hier)

Aus Dart, 1991b, S. 67, Table 1:
Percent of the total number of tokens for each place of articulation and apicality classification. Bold outline for highest frequency cell of each sound category.
A = Apical, **L** = Laminal, **AL** = Apicolaminal

French

	/t d n/				/ s z /			/ l /		
	A	**L**	**AL**		**A**	**L**		**A**	**L**	**AL**
dental	6.3	12.7	**39.7**		15.8	26.3		2.4	0	2.4
alveolar	13.5	16.7	11.1		7.9	**30.3**		**69**	2.4	0
post-alveolar	0	0	0		7.9	11.8		23.8	0	0

English

	/t d n/				/ s z /			/ l /		
	A	**L**	**AL**		**A**	**L**		**A**	**L**	**AL**
dental	6.7	6.7	4.2		20	2.5		**34.2**	2.6	13.2
alveolar	**59.6**	5	12.6		22.5	**31.2**		31.6	0	15.8
post-alveolar	5	0	0		0	23.8		2.6	0	0