Workshop

Frequency Information in Speech Perception

University of Freiburg, May 29 - 31, 2017
Großer Sitzungssaal, Werthmannstr. 8

frequenz effekte
graduiertenkolleg 1624

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Workshop Programme

Monday, May 29

9:30 – 9:45	Opening
9:45 – 11:45	Cynthia Connine (Binghamton University, New York) *Lexical and variant frequency in perceptual learning*
11:45 – 12:00	coffee break
12:00 – 12:45	Sophie Brand (Radboud University, Nijmegen) *The use of variant frequency in the comprehension of reduced speech by natives and foreign language learners*
12:45 – 14:00	lunch
14:00 – 16:00	Tessa Bent (Indiana University, Bloomington) *Nonnative accents and regional dialects: perceptual development and cognitive representations*
16:00 – 16:15	coffee break
16:15 – 17:00	Helena Levy (University of Freiburg) *Long-term effects of frequent accent exposure on children's perception of accented speech*
19:00	workshop dinner

Tuesday, May 30

9:30 – 11:30	Audrey Bürki *Exposure frequency in language perception and production: Evidence from pronunciation variants and syllables*
11:30 – 11:45	coffee break
11:45 – 12:30	Sophia Wulfert (University of Freiburg) *Frequency of sublexical units in speech perception and production: The case of consonant clusters*
12:30 – 13:00	Marten Juskan (University of Freiburg) *Frequency of remembrance in social priming*
13:00 – 14:30	lunch
14:30 – 15:15	David Lorenz (Univ. of Tartu/Univ. of Freiburg) & David Tizón-Cuoto (Univ. of Vigo) *The role of frequency (information) in the production and processing of reduced and coalesced forms: the case of the V-to-V_{inf} construction*
15:15 – 16:00	general discussion
18:30	guided tour of Freiburg

Wednesday, May 31

9:30	breakfast on the RTG terrace (Belfortstr. 18, 3rd floor)
afterwards	One-on-one sessions with keynote speakers and PhD students

Lexical and variant frequency in perceptual learning

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Experience with language shapes processing and representation of words and sounds. At the word level, lexical frequency predicts speed and accuracy of spoken word recognition. Experience with pronunciation variants is also found to influence spoken word recognition. These effects of frequency are malleable, however, and spoken language processing is influenced by recent language experience and context. Experiential influences are found in other levels of the system: a listener's experience with the distribution of acoustic-phonetic properties of sounds shapes speech perception. Perception of speech sounds is also malleable and since the seminal demonstration of perceptual learning by McQueen et al a large body of research has investigated the boundary conditions for re-tuning speech categories. Less is known about how lexical properties are used in perceptual learning and I will report some recent work that examines how experiential properties of words – lexical frequency and pronunciation variants – are used driving perceptual learning of speech. We find that perceptual learning of speech depends on lexical and variant frequency but that these effects are in turn influenced by the context of learning.

The use of variant frequency in the comprehension of reduced speech by natives and foreign language learners

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Words differ in how often they occur in a certain pronunciation variant. The frequency of occurrence of pronunciation variants may serve as a cue in speech processing. It has been shown that natives produce and recognize more frequent variants more quickly (e.g., Bürki, Ernestus & Frauenfelder, 2010; Ranbom & Connine, 2007; Pitt, Dilley & Tat, 2011). The question arises whether language learners, like natives, also use frequency information during the processing of spontaneous speech.

I tested French natives and Dutch learners of French in two different experiments to examine this question. In the first experiment, a lexical decision task with cross-modal identity priming, I investigated whether pronunciation variants of words ending in obstruent-liquid-schwa clusters are recognized more easily if they occur more frequently. In the second experiment, I asked participants to perform an auditory lexical decision task containing reduced and unreduced pronunciation variants of a word and a relative frequency estimation task (Brand & Ernestus, 2017). In the rating task, they estimated the relative frequencies of the two pronunciation variants of a word. I then investigated whether participants reacted faster and more accurately in the auditory lexical decision task to variants that according to them (as a group) occur more often.

Experiments 1 and 2 demonstrate that the processing advantage for the unreduced variants is larger for learners than for natives. More importantly, the two experiments show that both natives and learners are sensitive to the frequencies of occurrence of pronunciation variants. Learners are especially sensitive to variants' frequencies that reflect their own exposure. These findings suggest that learners store frequency information, which is not native-like but reflects their own speech input, together with the variants' lexical representations.

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Nonnative accents and regional dialects: perceptual development and cognitive representations

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Substantial variability in the speech signal arises from within- and across-talker factors (e.g., speaking style, health status, gender, dialect, native language). Rather than viewing this variability as noise, there is now ample evidence that listeners encode both linguistic and social- indexical information in highly detailed cognitive representations and that these information sources interact in ways that typically give rise to robust speech comprehension. In this talk, I will discuss two lines of research that investigate how variability stemming from regional dialect and nonnative accent differences influences speech perception and cognitive representations.

In the first line of inquiry, children's and adults' abilities to extract linguistic information from unfamiliar regional dialects and nonnative accents was investigated using sentence and word recognition tasks (i.e., hear a word/sentence in quiet or in noise and repeat it back). Results showed that school-aged children do not have fully adult-like abilities to perceive nonnative- accented speech. In fact, fully mature word identification abilities may not emerge until adolescence. Further, the combination of an unfamiliar accent or dialect and noise causes children substantial difficulty and suggests that their representations of unfamiliar accents and dialects are fragile. Although children's abilities to map these unfamiliar pronunciations onto words in their lexicons are still developing, young children can capitalize on contextual cues when presented with nonnative-accented speech. However, early school-aged children's abilities to benefit from this top-down information during the perception of unfamiliar accents is not as robust as adults'. These studies suggest that children may not have developed the necessary cognitive-linguistic skills or accrued sufficient linguistic experience to promote fully mature bottom-up or top-down processing of speech that deviates from home dialect norms.

In the second line of work, adults' representations of a wide range of regional dialects and nonnative accents were assessed through free classification and ladder tasks. In the free classification task, listeners grouped auditory speech samples based on talkers' perceived regions of origin. In the ladder tasks, listeners ranked auditory samples by perceived distance from either Standard American English or Standard Southern British English. Results demonstrated that listeners were sensitive to the division between native and nonnative talkers, even when presented with a wide range of dialects and accents. The sub-groupings within these two broad clusters suggested that listeners employed several organizational schema including specific acoustic-phonetic talker characteristics, speaking rate, and distance from the local standard. On-going work is continuing to explore representations of native dialects with a focus on the influence of the listeners' home country and experience living abroad.

The research described in this talk sheds light on how nonnative accents and regional dialects influence speech perception and representation in children and adults. Continued investigations are needed to build speech perception models that can fully explain the interplay between linguistic processing and socio-indexical variables during speech comprehension, including cases in which there is a dialect or native language mismatch between the talker and listener.

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Long-term effects of frequent accent exposure on children's perception of accented speech

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We know from previous studies that both adults (Bradlow & Bent, 2008) and children (Bent, 2014; Bent & Atagi, 2015) have more difficulties recognizing words in accented speech than in unaccented speech. The impact of these perceptual difficulties is lowered by experience with a particular accent (Floccia et al., 2009; Hanulíková & Weber, 2012). Experience with accented speech implies frequent exposure to variable word forms, which from a usage-based perspective, leads to different representations in the mental lexicon for accented and standard word forms. A listener should be better able to access an accented word form if it closely resembles a previously heard form of this word (Sumner & Samuel, 2009). However, it is unclear whether accent experience also leads to an advantage for the processing of unfamiliar accents (Bent & Bradlow, 2003; Baese-Berk et al. 2013; but see Stibbart & Lee, 2006; Tao & Taft 2016). Firstly, this project is thus concerned with experience as equitable for input frequency and the question whether frequent accent exposure can lead to a processing advantage even when listening to an unfamiliar accent. Secondly, the project is concerned with the lexical frequency of words in the input, hypothesizing that high-frequency words that are heard in an unknown accent may potentially be understood better than low frequency words.

In a sentence-repetition experiment, children's comprehension of sentences in unfamiliar foreign and regional accents was tested. Experience with accents was operationalized as a continuous variable. 65 German primary school children (mean age 9 years, 10 months) were asked to repeat sentences spoken by three different speakers: one who spoke standard German, one with a foreign accent (Korean accented German) and one with a regional accent in German (Palatinate German). All of the children had experience with regional and foreign accents but the amount of accent exposure to both kinds of accents varied considerably. None of the children had any experience with Palatinate or Korean accented German. Half of the children were monolingual, the other half were bilingual. The sentences were constructed using frequent and infrequent words according to the childlex corpus (Schroeder et al., 2015). Results showed that bilingual children performed significantly worse than monolingual children across conditions. However, those bilingual children who had more regional accent experience performed better than those with less regional accent experience. The first emerging frequency effect thus seems to be that frequent exposure to accented speech can be facilitative for the comprehension of unfamiliarly accented speech, at least in bilingual children. The second question that was asked here concerns lexical frequency. In the standard and foreign accent condition, the frequency effect was as expected: frequent words were understood better than infrequent words. However, in

the regional accent condition, the effect pointed in the other direction, meaning that infrequent words were understood better. When analyzing the accented stimuli using Levenshtein distances, an explanation for this could be found: the frequent stimuli produced by the regional accent speaker show stronger accent features than the infrequent ones. This explains why infrequent stimuli, in this condition, were understood better by the children. Lexical frequency, it seems, is not a straightforward indicator of which words listeners can understand better. Accent features such as reduction may influence the production of frequent words more strongly than the production of infrequent words (Pluymaekers et al., 2005), and this in turn affects perception.

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Exposure frequency in language perception and production: Evidence from pronunciation variants and syllables

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Speed and accuracy in spoken language recognition and production tasks are influenced by language use. This influence provides unique insights into the cognitive processes and representations underlying language processing tasks. An important aim of psycholinguistic research is to better understand which aspects of language use shape subsequent behaviors, and how. This presentation contributes to this endeavor by examining the role of exposure frequency in two different contexts. In the first part of this presentation, I will discuss the role of exposure frequency in the recognition of pronunciation variants. Words in connected speech are often produced in a way that differs from the pronunciation listed in standard dictionaries. I will discuss data collected in four experiments, in which participants had to react to existing or novel French words realized with or without a schwa. Many words in French can be produced both with the schwa (e.g., the word fenêtre 'window' realized as [fənɛtʀ]) and without ([fnɛtʀ], see for instance Racine & Grosjean, 2002). These experiments show (1) that the relative frequency of the two variants of schwa words is a robust predictor of processing times, (2) no evidence that canonical forms (schwa variants) have a processing advantage once the effect of variant frequency is factored out, and (3) that the context in which the variant is encountered does not have a major influence on response times. These results will be discussed in the light of other empirical data on the recognition of schwa words (e.g., role of spelling, Racine, Bürki, & Spinelli, 2013) and in the light of current proposals regarding the nature of lexical representations.

In the second part of the talk, I will focus on the role of exposure on the production of syllables. Previous studies reported that the time it takes speakers to produce syllables depends on their frequency, and that at least part of this effect originates in the phonetic encoding process (e.g., Bürki, Pellet-Cheneval, & Alario, 2015; Laganaro & Alario, 2006). I will present data from an experiment designed to test whether repeated exposure to syllables influences the time to subsequently produce these syllables, and whether this influence differs if the exposure involves the overt production of the syllables or their mere auditory processing. The results suggest that exposure in the production but not in the auditory modality influences the subsequent production of syllables. These results will be discussed in the light of existing proposals regarding the interface between production and perception processes.

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Frequency of sublexical units in speech perception and production:

the case of consonant clusters

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It has long been acknowledged that the frequency of lexical entities plays a role in their processing, with high-frequency lexemes and morphemes displaying a processing advantage both in speech production (Oldfield and Wingfield 1965, Dell 1990) and perception (e.g. Grosjean 1980). An influence of sublexical (e.g. phoneme, syllable) frequencies and phonotactic probabilities on speech production has also been found (e.g. Cholin, Levelt and Schiller 2006). Their influence on speech perception, on the other hand, has received less attention (but see Newman, Sawusch and Luce 2000, Vitevitch and Luce 1998).

This study is concerned with syllable-initial consonant clusters (CCs) as sublexical units and investigates how the frequency of a CC and other factors (such as number of graphemes: <x> vs. <schm> or status as an affricate vs. a true consonant cluster: /t͡s/ vs. /tr/) influence its production and perception. The German language allows for a large number of syllable-initial CCs, albeit with great differences in frequency. For example, /ʃt/ - the single most frequent CC in German- is more than twice as frequent as the second most frequent CC according to several corpus-based frequency measures, while some CCs such as /ps/ and /sl/ have a very low frequency and occur only in loanwords. It is hypothesized in this talk that high-frequency CCs will be be produced and perceived with greater accuracy, whereas more errors will occur for low-frequency CCs. The errors occurring, on the other hand, will most likely result in the (production and perception of) high-frequency CCs because they are experienced as the default category in everyday speech. To test for effects of rule-based phonotactic knowledge, the concept of sonority is used as an additional – and partly competing – predictor. A sonority-based account would predict that initial CCs falling in sonority (e.g. /ʃt/) cause more errors because they violate phonological principles. Preliminary results from an experiment examining the production of CCs in tongue twisters wll be reported. These results indicate that, among other factors, the frequency of a CC in German usage does indeed have an effect on how accurately it can be produced under stressful conditions (i.e. in a tongue twister). The effect of sonority, on the other hand, is much less robust and is not in the expected direction.

In perception studies, CCs have mostly been inspected regarding their legality in subjects' L1, showing that illegal clusters are harder to perceive and may even trigger perceptual illusions such as phoneme substitution or schwa epenthesis, which reinstate legality of the sequence (e.g. Dupoux et al. 2001, Moreton 2002). This shows that listeners are sensitive to the phonotactics of their L1 and that this sensitivity influences their speech perception. There is ongoing discussion about whether this phonotactic knowledge is of a statistical nature (i.e. keeping track of frequencies in language use) or of a more abstract kind involving application of phonological rules, for example “the consonants of a syllable-initial cluster must rise in sonority”. Mostly, legality effects have been ascribed to rule-based and generalized phonotactic knowledge (Pitt 1998, Moreton 2002, Kabak and Idsardi 2007). In the present study, the notion of phonotactic legality will be extended to phonotactic probability in the sense of CC frequency in German usage. Based on the results from the

production experiment, I will present the design of a perception experiment using the same CCs to test the effects of frequency and sonority in speech perception and examine whether they are comparable to those in production.

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Frequency of remembrance in social priming

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Listeners' perceptions of linguistic variables can be influenced by providing social information about the speaker (Niedzielski 1999, Hay and Drager 2010). Within exemplar theory (cf. Pierrehumbert 2006) these results are explained by phonetically detailed exemplar clouds, which are stored in memory and indexed with social information. Activating a concept cognitively foregrounds matching exemplars and makes it more likely that new input will be perceived as belonging to the same category. However, replications of the seminal studies have not always found priming effects where they were to be expected (Lawrence 2015).

Arguably, this is because a 'theory of priming' (Cesario 2014) is still lacking, which means that we simply do not yet know the complete set of factors that needs to be kept constant for successful replication. One likely candidate for this set is sociolinguistic salience, which - in an exemplar framework – essentially translates to 'frequency of remembrance' (Pierrehumbert 2006). This paper reports the results of a priming experiment that investigates the perception of four phonological variables of Liverpool English: /k/ lenition, the NURSE-SQUARE-merger, happY-tensing and /ŋ(g)/. The former two are generally classified as considerably more salient than the latter two (cf. Honeybone and Watson 2013, Trudgill 1999).

Priming only works with the two variables that presumably have a higher frequency of remembrance, indicating that these salient variables do indeed get indexed and stored more often, thereby dominating long-term memory structure. Non-salient variables, on the other hand, attract lower levels of attention, which result in lower numbers of remembered exemplars that are insufficient to create significant priming effects. Frequency of remembrance, as governed by social salience, thus seems to have a measurable impact on our mental representations of linguistic variation.

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The role of frequency (information) in the production and processing of reduced and coalesced forms: the case of the V-*to*-V_{inf} construction

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This study addresses the issue of coalescence, or chunking, of frequent collocations (e.g. *want to* > *wanna*) and its consequences for their realization, perception and mental representation (cf. Bybee 2002, 2006, Ellis 2002, Ellis et al. 2009). It consists of two modules (corpus-based and experimental) that compare full and reduced forms of the V-*to*-V_{inf} construction with the aim of providing an insight into (a) how speakers and hearers use probabilistic and frequency information to cope with reduction in speech and (b) how chunking and reduction interact with each other.

The corpus-based module investigates the realization of 'semi-modal' instantiations of the type V-*to*-V_{inf}, namely *have to*, *used to*, *trying to* and *need to*, in American English. We consider the effects of both speech-internal and extra-linguistic factors (speech rate, stress accent, phonological context, speech situation, age of the speaker), as well as possible effects of analogy with established contractions like *gonna*, *wanna*. The results show a high degree of coalescence in the items under study, but no clear pattern of contraction. Even in highly frequent and strongly coalesced items, reduction (articulatory ease) is restricted by a tendency to retain cues to morphological structure (explicitness). This shows the limitations of reduction as a frequency effect (cf. Lorenz & Tizón-Couto 2017).

The experimental module of the study reports a word recognition experiment which tests how string frequency and transitional probability affect the import of reduction on speech perception. Previous word recognition experiments (Sosa & MacFarlane 2002, Kapatsinski & Radicke 2009) have shown that listeners treat highly frequent sequences as chunks and, thus, are slower at recognizing the last element in the sequence (e.g. *of* in *kind of*). These studies, however, did not consider the effect that reduction might have on perception (e.g. "kinda"). Moreover, the question remains whether recognition relies solely on surface frequency or might also draw on additional association measures, such as transitional probability.

We measured response times to hearing the word *to* in target sequences of the type V-*to*-V_{inf} from 40 native speakers of American English. Target sequences of varying frequencies were presented with a full or reduced *to* (e.g. "need to" or "needa"). Reduction, frequency of the sequence and transitional probability (from V to *to*) serve as independent variables. The results show that reduction generally delays detection, but this delay is mitigated in some

circumstances. Thus, in cases of high transitional probability the element is predictable and the effect of reduction mitigated. Similarly, in sequences of mid-high frequency, *to* is highly predictable and reduction can be expected. At the highest frequencies, however, a chunking effect sets in which inhibits recognition of a reduced *to* within the (chunked) sequence. Thus, it seems that listeners use different kinds of frequency information to recognize elements in speech, and they can draw on chunked or compositional representations.

Taken together, the studies suggest that reduction of chunked sequences is not just a mechanical process but is subject to intuitive negotiations in speaker-hearer interaction. Speakers tune their (reduced) speech signal to the 'needs' of the hearer; preferences in speech production inform speech perception in various ways. In particular, these effects go beyond the well-known 'chunking effect' of surface frequency.

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