Lexical Diffusion and Neogrammarian Regularity

Mieko Ogura[1,2] & William S-Y. Wang[2]

[1]Linguistics Laboratory, Tsurumi University, Yokohama

[2]Joint Research Centre for Language and Human Complexity,

Chinese University of Hong Kong

1. Introductory Remarks

The most explicit hypothesis on the mechanisms of sound change was proposed by a group of linguists working in Europe in the 1870s, who called themselves the Neogrammarians. Their doctrine is clearly stated by the two leaders of the Noeogrammarian movement, Ostohoff and Brugmann: "… every sound change, inasmuch as it occurs mechanically, takes place according to laws that admit no exception". (1878; quote from 1967 version) In other words, the regularity is guaranteed by the mechanical nature of sound change. The idea is that all relevant words change at once, i.e., in a lexically abrupt fashion. But since we know language does not change in pronunciation overnight, the phonetic gradualness is an inevitable consequence of lexical abruptness.

Hocket (1965) restates this Neogrammarian position and calls the central production of this movement "the regularity hypothesis". Labov (1981, 1994: Part D) further made the regularity of sound change definite, claiming that regular sound change is conditioned only by phonetic environment. The Neogrammarian doctrine has been accepted by almost all major groups of historical linguists since that time, and it has passed down across the generations through Saussure, the structuralists and the generativists, in one form or another.

We will not repeat the various arguments that have been offered recently to show the difficulties of the Neogrammarian hypothesis –see Ogura (1987). In view of the unsatisfactory state of the mechanism that the Neogrammarians advocated, other processes for implementing sound change have been proposed. Empirical investigations over the past four decades on a variety of languages, using large amounts of data, have shown that there must be a process which is implemented in a manner that is lexically gradual, diffusing across the lexicon. This is an inevitable consequence of admitting phonetic abruptness; in his seminal article Wang (1969) called this process "lexical diffusion".

The chronological profile of lexical diffusion may be represented by the S-curve slope. When the change first enters the language, the number of words it affects may be small. The change gradually diffuses, going slowly at first. Then, as it spreads, it accelerates, picking up speed in mid-stream. In the most active period, the change moves quickly through a large number of lexical items. Then gradually, it slows down again, and tapers off at the end (Chen 1972).

Language change is basically a speaker-to-speaker social propagation in time and space. As early as 1917, Sturtevant (1917: 82) already stated that: "The two processes of spread from word to word and spread from speaker to speaker progress side by side until the new sound has extended to all the words of the language which contained the old sound in the same surroundings". Therefore lexical diffusion must have its trace in a population and its real mechanism should be studied both in the diffusion from word to word and in the diffusion from speaker to speaker in progress (Shen 1990).

In lexical diffusion, the change catches on gradually, both within a language and when moving from speaker to speaker in the community. The lexical diffusion model is defined along two dimensions: diffusion from word to word in a single speaker, which we call W(ord)-diffusion, and diffusion from speaker to speaker of a single word, which we call S(peaker)-diffusion. When W-diffusion is slower than S-diffusion, the difference is greater between words. When W-diffusion is faster than S-diffusion, the difference is greater between speakers. W-diffusion may proceed so fast that it is difficult to observe it. This shows what is called the Neogrammarian regularity. Figure 1 schematically shows the S-curve progress of 2-dimensional diffusion through time (t) when W-diffusion is faster than S-diffusion (W>S), W-diffusion is slower than S-diffusion (W<S), and the rate of W-diffusion and S-diffusion is equal (W=S) (Ogura & Wang 1998).

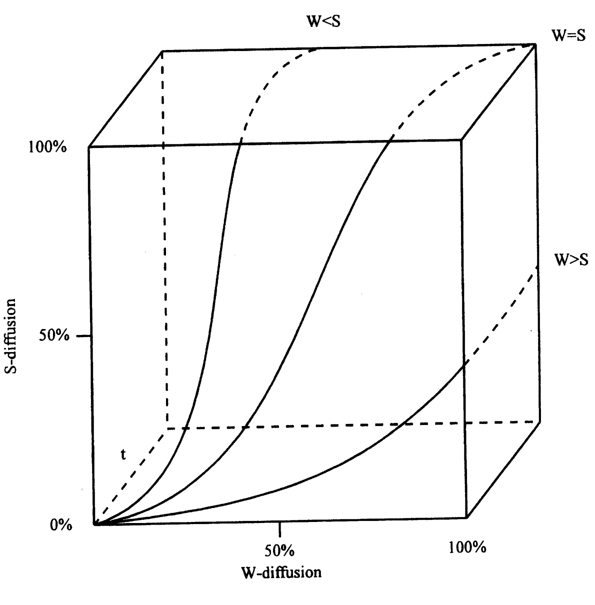

Figure 1: S-curve progress of 2-dimensional diffusion through time (Ogura & Wang 1998)

In this study, first we discuss S-curve progress and its snowball effect in lexical diffusion, based on the development of periphrastic *do* and the development of *-(e)s* in the third person singular present indicative in English. We also discuss the role of word frequency in lexical diffusion. Then we show word frequency effect is difficult to observe in Neogrammarian regularity; however the change can be observed while it is in progress across generation, and synthesize lexical diffusion and Neogrammarian regularity as the relative ratios of W-diffusion and S-diffusion. We suggest the constant rate effect in Neogrammarian regularity and integrate snowball effect in lexical diffusion and constant rate in Neogrammarian regularity.

2. S-curve Progress, Snowball Effect and Word Frequency in Lexical Diffusion

2.1 The development of periphrastic *do*

Kroch (1989), using a mathematical function, the logistic, examines whether changes occur sequentially across the various contexts, or occur simultaneously in all contexts. He further presents two possibilities in the latter scenario: either changes spread at the same rate or at different rates, and proposes that changes occur simultaneously and spread at the same rate in all contexts.

Ogura (1993) examines the validity of the simultaneous equal activation scenario for the S-curve progress that Kroch (1989) proposes, and claims that changes in the different contexts initiate at different times and the later a change begins, the greater the rate of change becomes. Our data as well as Kroch's are based on Ellegård's extensive and monumental study *The Auxiliary Do: The Establishment and Regulation of its Use in English* (1953). The results are summarized in Table 1, and displayed graphically in Figure 2.

Period	Date	Aff.decl.		Neg.decl.		Neg.q.		Aff.q.		Neg.imp.	
		do	n	do	s	do	s	do	s	do	s
0	1390-1400	6	45000	0	--	0	--	0	--	0	--
1	1400-1425	11	4600	0	177	2	15	0	10	0	52
2	1425-1475	121	45500	11	892	2	23	6	136	3	279
3	1475-1500	1059	59600	33	660	3	24	10	132	0	129
4	1500-1525	396	28600	47	558	46	32	41	140	2	164
5	1525-1535	494	18800	89	562	34	22	33	69	0	101
6	1535-1550	1564	19200	205	530	63	21	93	114	0	72
7	1550-1575	1360	14600	119	194	41	7	72	56	4	39
8	1575-1600	1142	18000	150	479	83	45	228	150	8	117
9	1600-1625	240	7900	102	176	89	6	406	181	65	119
10	1625-1650	212	7200	109	235	32	6	116	24	5	10
11	1650-1700	140	7900	126	148	48	4	164	43	17	16
12	1710	5	2800	61	9	16	0	53	3	28	0

Aff.decl. = affirmative declarative sentences
Neg.decl. = negative declarative sentences, main group
Neg.q. = negative direct adverbial and yes/no questions
Aff.q. = affirmative direct adverbial and yes/no questions
Neg.imp. = negative imperatives, main group

Table 1: The development of periphrastic *do* in various types of sentences (Ellegård 1953)

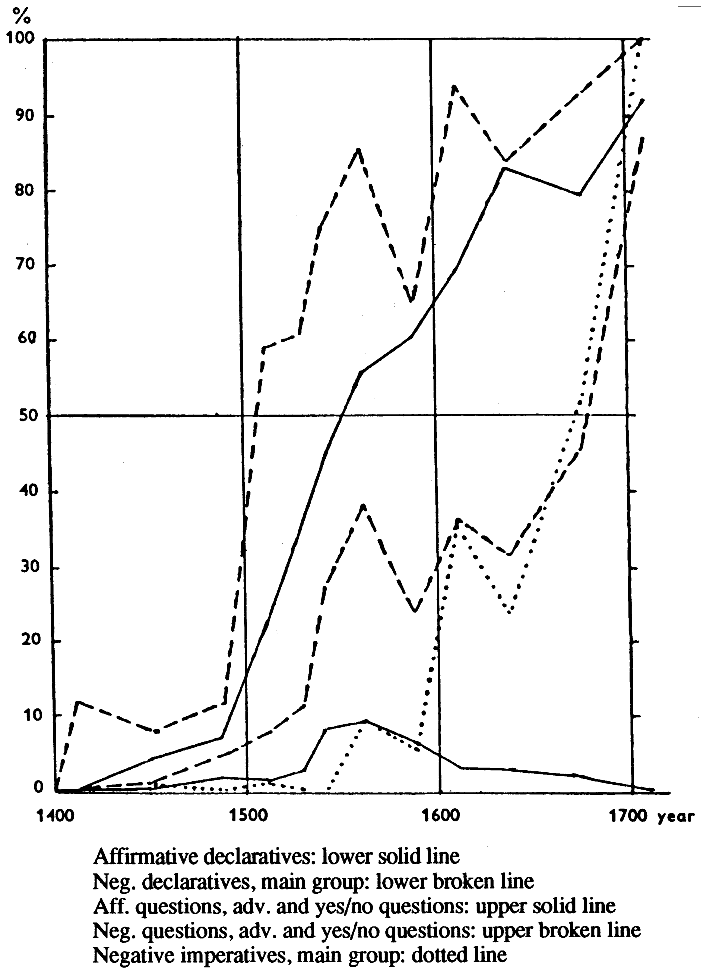

Figure 2: The development of periphrastic *do* (Ellegård 1953)

The data in Table 1 are fitted to the logistic function, which transforms the curve into a linear function of time by the so-called 'logistic transform of frequency'. Table 2 shows the slope and intercept parameters of the fits calculated by logit modeling in SAS. The slope represents the rate of change, whereas the intercept measures the frequency of the changed form at the fixed point in time, t=0 of the logistic function. When we compute the estimates for the parameters, we interpret the periods in Table 1 as the years from the reference point in time (t=0), in our case, the year 1175, when the first written example of all the sentence types appeared (see below).

	Affirmative declaratives	Negative declaratives	Negative questions	Affirmative questions	Negative imperatives
Slope	3.41	5.90	6.90	7.73	13.44
Intercept	-23.61	-36.45	-40.14	-46.15	-82.72

Table 2: Slope and intercept parameters of logistic regressions on the data in Table 1

Table 3 shows the estimates of the slope and intercept parameters obtained by Kroch (1989). He fixes the zero point in time at 1350, and uses a univariate version of the maximum likelihood fit in the VARBRUL program. He considers that there is a grammatical reanalysis in period 7, and cuts off the data after that. [1]

	Affirmative declaratives	Negative declaratives	Negative questions	Aff. trans. adv.& yes/no q.	Aff. intrans. adv.& yes/no q.	Affirmative wh-object q.
Slope	2.82	3.74	3.45	3.62	3.77	4.01
Intercept	-8.32	-8.33	-5.57	-6.58	-8.08	-9.26

Table 3: Slope and intercept parameters of logistic regressions obtained by Kroch (1989)

We take all the periods for which Ellegård provides data, and fit the data to the logistic curve. As shown in Table 2, it turns out that different contexts do have different slopes, i.e., different rates of change. When we look at the starting point of the changes, we find a clear correlation between each of them and the rates of change. According to Visser (1963-73: 1411-1476), the earliest dates of *do* periphrasis in writing were: affirmative declaratives, c.1175; negative declaratives, c.1280; negative questions, c.1370; affirmative questions, c.1380; negative imperatives, c.1422.

Our results in Table 2, together with the earliest dates of *do* periphrasis of the five sentence types show that the later a change starts the sharper its slope becomes, i.e., the later a change starts, the greater the rate of change becomes. This shows “snowball effect" of lexical diffusion, i.e., diffusion across more and more contexts at faster rates in later starting contexts.

Within each context, there is a significant tendency for the high frequency words to change late and therefore to have a sharper slope. Table 4 shows the development of the *do*-form in the *say*-group which consists of the high-frequency verbs *say, mean, do* and *think*, and the main group which consists of the rest of low-frequency words in affirmative *wh*-object questions. Blank means that the example has not been found yet. As mentioned above, the early example in the main group is found in c.1380, though the data on the main group in Table 4 do not show the occurrence of *do* periphrasis in periods 1 and 2. The first occurrence of *do* periphrasis in the *say*-group in Table 4 is found in period 3, which means that there is a lag of about one hundred years in the *say*-group.

Period	Date	*say*-group		main group	
		do	s	do	s
1	1400-1425		0	0	1
2	1425-1475		19	0	28
3	1475-1500	1	39	1	24
4	1500-1525	2	27	4	36
5	1525-1535	0	33	6	22
6	1535-1550	0	45	8	32
7	1550-1575	3	51	22	14
8	1575-1600	7	56	39	27
9	1600-1625	25	93	28	30
10	1625-1650	15	39	24	32
11	1650-1700	24	20	11	3
12	1710	7	4	4	0

Table 4: The development of the *do*-form in the *say*-group and the main group of affirmative *wh*-object questions (Ogura 1993)

Table 5 shows slopes and intercepts for the *say*-group and the main group. We can say that the high-frequency words resisted the *do*-form, but once they started to change, the rate of change turned out to be greater than that of the low frequency words. These results can be confirmed in negative declaratives.

	say-group	main group
slope	10.49	6.82
intercept	-65.19	-41.33

Table 5: Slope and intercept parameters of logistic regressions on the data in Table 4

2.2 The development of *-s* in the third person singular present indicative

The snowball effect and the interaction between word frequency and environments can also be found in the development of *-(e)s* in the third person singular present indicative. Based on the data from the Early Modern English (EModE) section of the Helsinki Corpus, Ogura & Wang (1996) give the overall distributions of the *-(e)th* and *-(e)s* forms by sub-periods for the non-sibilant verbs which are divided into three groups according to word frequency as shown in Table 8. The percentages of the *-s* forms for the total tokens for each sub-period are given for each of the three groups of the non-sibilant verbs.

freq	EModE I-th	EModE I-s	EModE II-th	EModE II-s	EModE III-th	EModE III-s
1084-21 (33 types)	1103 tokens	29 tokens (2.6%)	932 tokens	331 tokens (26.2%)	251 tokens	697 tokens (73.5%)
20-3 (176 types)	384 tokens	6 tokens (1.5%)	282 tokens	166 tokens (37.1%)	28 tokens	339 tokens (92.4%)
2-1 (262 types)	116 tokens	0 token (0%)	72 tokens	25 tokens (25.8%)	5 tokens	121 tokens (96.0%)

Table 8: The overall distributions of the *-(e)th* and *-(e)s* endings in non-sibilant verbs in EModE (Ogura & Wang 1996).

Within the non-sibilant verbs, most of the *-(e)s* forms in EModE I (1500-1570) occur in the most frequent 33 words, whose word frequency is from 1084 to 21. Only 3 words have *-(e)s* in EModE I among the 438 infrequent verbs. The change started slowly from a handful of high-frequency words. Holmqvist (1922) considers that *have*, *do* and *say* are the laggers of the change, which has become a well-established view so far. But our data show that *have, do* and *say* are by far the most frequent words, and that the most frequent verbs started to change first.

However, once the infrequent verbs got started, they changed more quickly than the frequent verbs. Most of the less frequent 176 verbs whose word frequency is from 20 to 3 show the *-(e)th* forms in EModE I. Many of them started to change in EModE II (1570-1640), and completed the change in EModE III (1640-1710). The least frequent 262 verbs whose word frequency is 2 or 1 never show the *-(e)s* forms in EModE I and rarely in EModE II. Many of them quickly changed into the *-(e)s* forms and completed the change in EModE III. The *-(e)th* forms are rare in EModE III in the 438 infrequent verbs. On the other hand, the most frequent 33 verbs often show the *-(e)th* forms still in EModE III. Especially the verbs *do* and *have* show the *-(e)th* forms nearly 50% and more than 50% of the total tokens respectively in EModE III.

Figure 3 is an idealized diagram of the snowball effect in lexical diffusion. The abscissa shows the time and the ordinate shows the percentage of changed variants. Each S-curve represents the rate of change of each word through the population (S-diffusion), and the time interval between each word represents the rate of change through the lexicon (W-diffusion). The acceleration effects on the rate of change operate both through the population and the lexicon.

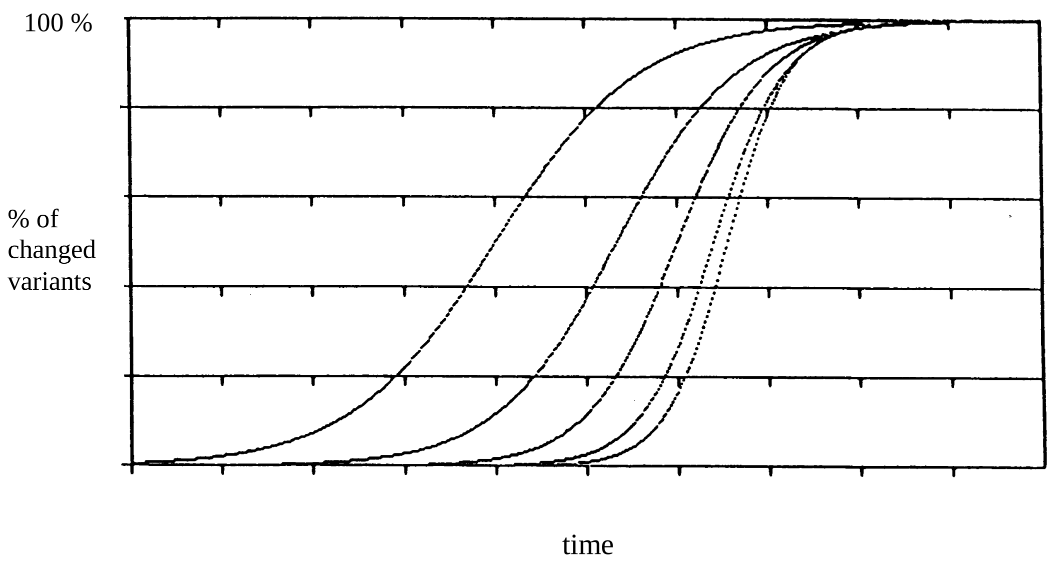

Figure 3: An idealized diagram of snowball effect in lexical diffusion (Ogura & Wang 1996)

2.3 Word frequency

Our next issue is to show that word frequency plays a role in determining the leaders and the laggers in W-diffusion. Based on Hooper (1976), Bybee (2002), Phillips (1984, 2001, 2006), Ogura (1987, 1993, 2012, forthcoming), Ogura and Wang (1995, 1996) and others, we may synthesize the investigations and assume that:

a) Productively or physiologically motivated change, pragmatically motivated change, and socially motivated change occur in high-frequency words first. Productively or physiologically motivated change, and pragmatically motivated change are the result of linguistic production, and socially motivated change affects linguistic production externally. If all of these changes are concerned with linguistic production, those words that are used frequently will have more opportunity to be affected by these processes.

b) Perceptually motivated change and cognitively motivated change affect low-frequency words first. Perceptually or cognitively unfavorable forms can be

> learned and maintained in their unfavorable forms if they are of high frequency in the input. However, if their frequency of use is low, they may not be sufficiently available in experience to be acquired. Thus they may be more susceptible to change on the basis of perceptually or cognitively favorable forms.

Speakers always observe frequent words, thus frequent words spread through interactions among people. When the change starts from high-frequency words, it takes a long time to complete because the unchanged variants of high-frequency words are maintained, thus frequent words also tend to become laggers, as shown in the development of *-(e)s* in the third person singular present indicative. When the change starts from low-frequency words, speakers observe unchanged variants of high-frequency words for a long time, and the high-frequency words become laggers of the change.

Finally, we would like to explain the rapid mid-stream change of S-curve progress. Ogura (1995) shows, based on the development of ME /i:/ and ME /u:/ words at 311 sites in England, that there is no significant ordering relation among words through which the change moves quickly in mid-stream, and the order of the change of words varies among individuals. Gell-Mann (1992) was perhaps the first to suggest the relevance of Kolmogorov Complexity to the study of language evolution. Kolmogorov Complexity has favored the development of methods for inductive inference, based on the search for the simplest interpretation of observed data, and has been applied to representations of any kind: logical, linguistic, probabilistic or pictorial. When regularity exists in the observed data, the hypothesis will capture this regularity, when justified, and allow for generalization beyond what was observed. Thus we assume that the speakers, after they observe a small number of changed words, generalize the change into more and more words without necessarily having observed all the relevant words, with the result that the order of the generalization varies among individuals. The spread of change into a large number of words implicates the rapid rate of change of each word, which produces snowball effect.

3. Word Frequency and Constant Rate Effect in Neogrammarian Regularity

3.1 Word frequency and Neogrammarian regularity

Drawing upon the newly created Philadelphia Neighborhood Corpus (PNC) which assembles data on over a hundred years of sound change of 359 speakers from 59 neighborhood studies carried out yearly from 1973 to 2010, Labov (2012) tries to show empirical evidence for the regularity of sound change which most textbooks on historical linguistics from the Neogrammarian perspective have not reported. The PNC data set of 29,000 tokens of /eyC/ was divided into two halves by date of birth (before and after 1940) and submitted to mixed model regression analysis with the lexicon of 1,600 words as a random variable. Five phonetic features of the onset remained as significant factors at the .0001 level in both halves, along with date of birth. The coefficients were examined for 47 most common words that were represented by at least 50 tokens. Figure 4 shows the regular advance of mean front diagonal values in the first and second period.

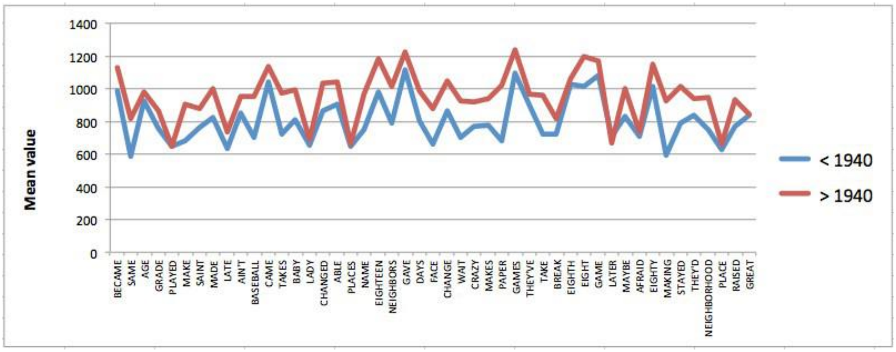

Figure 4 Mean front diagonal values for 47 most common words with checked /eyC/ for speakers in the Philadelphia Neighborhood Corpus born before and after 1940 (taken from Labov 2012)

Labov concludes that this case of regular sound change in progress shows (1) that the change affects all words containing the given phoneme in the phonetically defined environment in accordance with Neogrammarian thinking; and (2) that the differentiation of words beyond their phonetic composition or frequency is a normal associate of this regular process. Actually we cannot observe the word frequency effect in Neogrammarian regularity; however, the change can be observed while it is in progress across generations, as shown in the different mean values for speakers born before and after 1940 in Figure 4 and the continuous linear incrementation along the date of birth dimension in Figure 6 below. The 2-dimentional lexical diffusion model assumes that W-diffusion proceeds so fast that it is difficult to observe it within each individual, but the change can be observed while it is in progress across generations .

Figure 5, which is reproduced from Figure 17.8 in Labov et al., *ANAE*, is empirical evidence for the rapid W-diffusion in front upgliding vowel of /eyC/ in Philadelphia.   The two allophones of /ey/ have become separated over time; apparent time distributions show a strong shift upward and frontward of /eyC/, while /eyF/ has remained open. The words *eight, patients, baby* are squarely in the /iyC/ distribution. On the other hand, *day* and *say* show low nuclei.

We assume that the /eyC/ tokens show the most active stage when the change moves quickly through a large number of lexical items and the /eyF/ tokens show the stage when the change slows down. There is no significant ordering relation among the words through which the change moves quickly in mid-stream (see section 2.3). Thus no effect of word frequency can be found among these words, and this is not an indication of the absence of lexical diffusion.

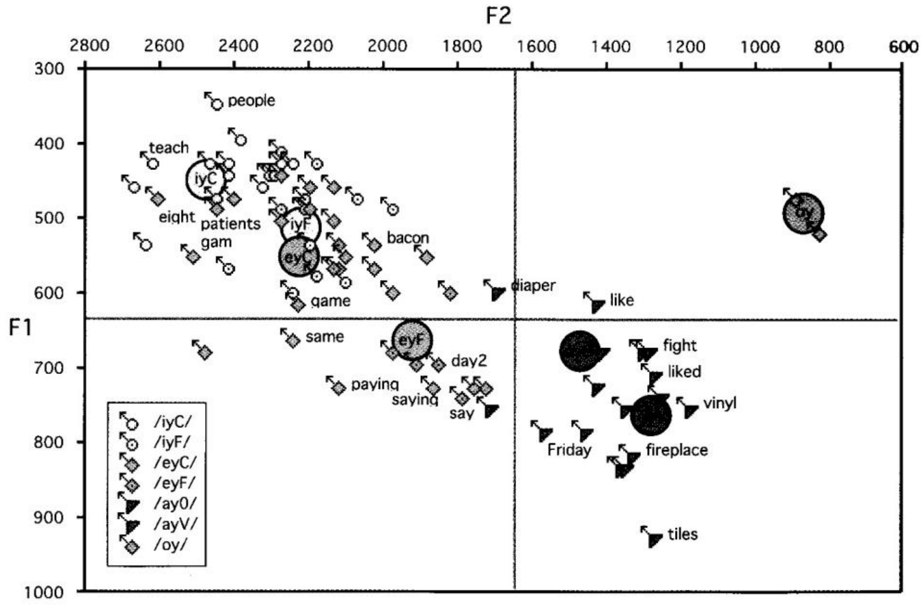

Figure 5 Front upgliding subsystem of Rosanne V., 30, Philadelphia, PA (taken from Labov et al. 2007)

Figure 6, which is reproduced from Labov’s (2013) Figure 10, shows front diagonal values by regression analysis of raising of checked /eyC/, classified by sex and date of birth. There is not any significant difference in values by sex. However, we can observe the increasing height of /eyC/ along the date of birth dimension. The pattern shows a continuous linear incrementation, i.e., phonetically gradual change from 1888 to 1991.

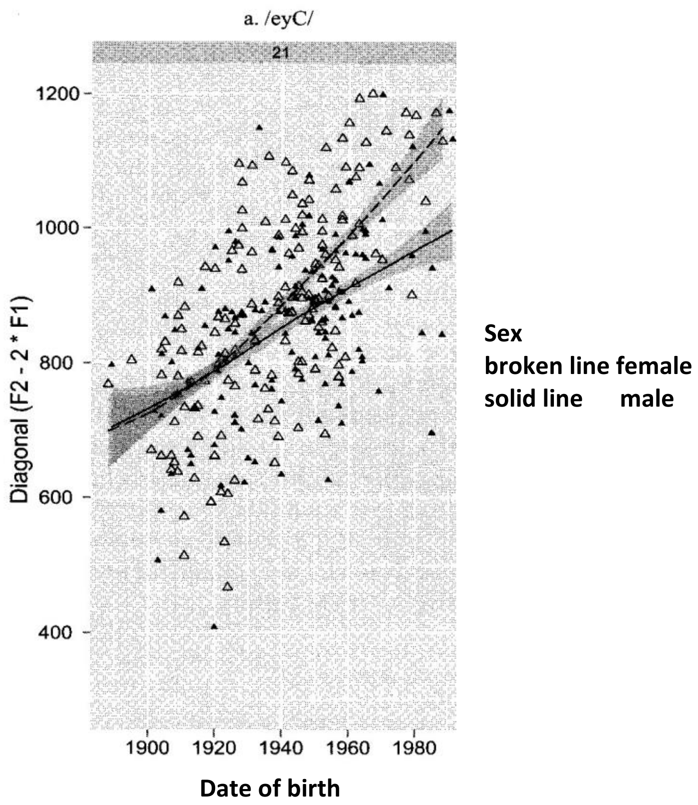

Figure 6 Front diagonal values of /eyC/ allophones by date of birth and sex in Philadelphia Neighborhood Corpus

Labov (1994) considers that the chain shifts and many of the mergers discussed in Parts B and C show the regularity of the sound changes and phonetic conditioning. However, Labov's instrumental measurements of spontaneous speech show that the individual vowel systems are quite different, especially along the age dimension as shown in his Figures 4.9a, 4.9b, 6.1, 6.2, 6.7, 6.9, 6.10, 6.11, 6.18, 6.19, 6.20, 11.5. Figures 7a and 7b, which are reproduced from Labov's (1994) Figures 4.9a and 4.9b, show the typical progress of the Northern Cities Shift, one of the most vigorous changes in progress in the United States, across generations. We can observe a new and vigorous change, the upward shifting of the entire /æh/ in the vowel system of the son. Labov (2007) states that *ANAE* study (2006, Ch. 14) of the Northern Cities Shift as a whole shows significant age coefficients at the .01 level for the raising of /æ/.

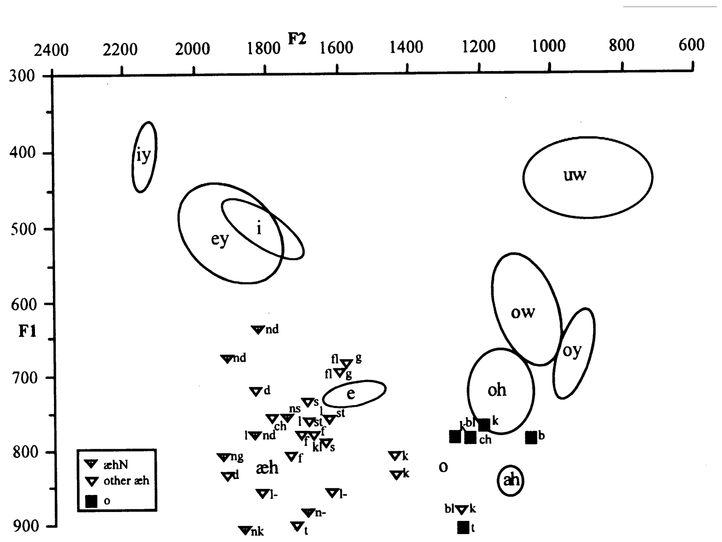

Figure 7a Vowel system of James Adamo, 55, Detroit [A Quantitative Study of Sound Change in Progress, 1968-1972] (taken from Labov 1994)

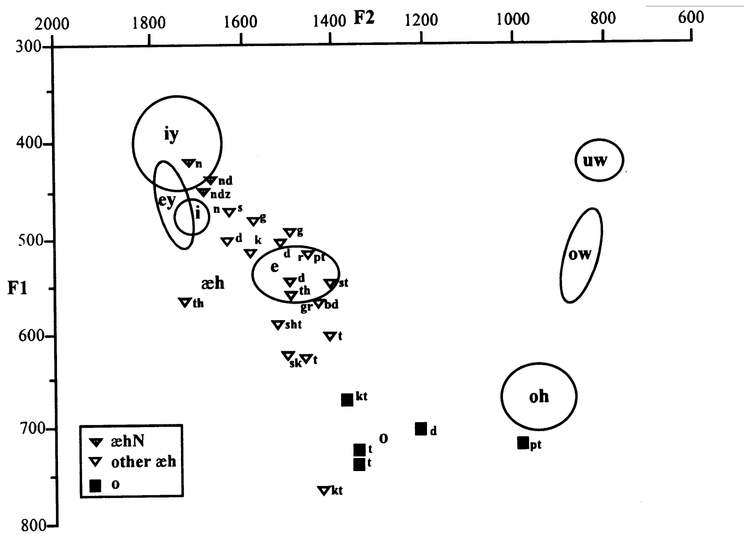

Figure 7b Vowel system of Chris Adamo, 13, Detroit [A Quantitative Study of Sound Change in Progress, 1968-1972] (taken from Labov 1994)

We can also see the empirical evidence of the rapid W-diffusion in Figures 7a and 7b. Figure 7a shows the vowel system of the father. The /æh/ word class shows a globular distribution in low front position. Clear indications of raising are found only for the most favorable environments – before word-final apical nasals, as in *hand* and *stand*. Figure 7b shows the vowel system of the son. The entire /æh/ class is shifted upward in an elliptical distribution. The most advanced tokens occur before word-final /n/ and /nd/, and they reach lower high position, overlapping the nucleus of /iy/. The least advanced tokens, for words like *tapped* and *grabbed*, are in lower mid position. The rest of the tokens are spread out in a pattern that allows every phonetic influence to be registered, which leads Labov to the conclusion that the mechanism involved is regular sound change. The least advanced tokens are those with following voiceless stops, with following velars lagging behind following apicals. We assume that the tokens which Labov interprets as showing regular sound change are those that change quickly in the most active stage in lexical diffusion.

With respect to the mechanism of merger, the most revealing data come from comparing the speech of the father with that of his son. Figures 8a, 8b, which are reproduced from Labov's (1994) Figure 11.5, show the distribution of /o/ ~ /oh/ tokens in the spontaneous speech of the father and the son at Tamaqua, Pennsylvania. For the father, the two vowel classes show very little overlap; for the son, they show complete overlap. Labov states the tensing shows a high degree of phonetic conditioning, affecting common words with following back nasals and voiceless fricatives, so that the /o/ phoneme has only the less common words of this type (*pin-pong* and *King Kong* with /o/ vs. *strong, song, wrong* and *long* with /oh/; *Goth, doff,* and *foss* with /o/ vs. *cloth, off,* and *loss* with /oh/). We rather assume that the merger started from the high-frequency words and proceeded rapidly. Lexical diffusion does not rule out the possibility of phonetic conditioning. The interplay between word frequency and the phonological environments is the most important factor in the implementation of the change.[2]

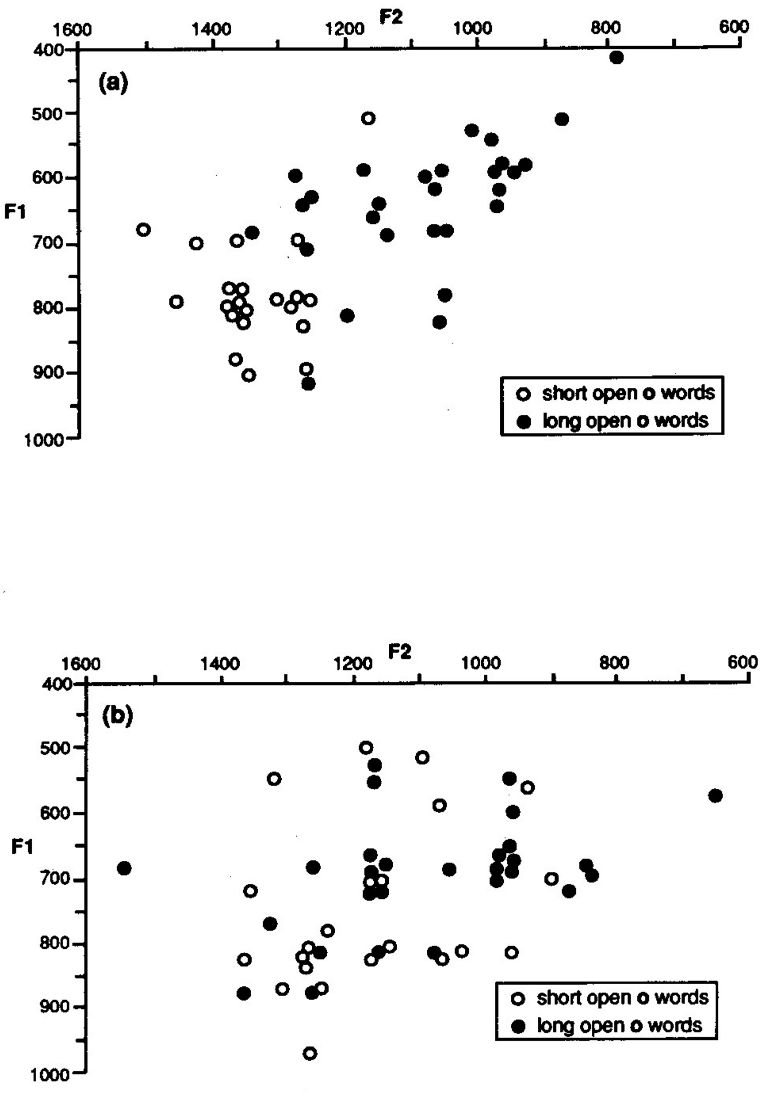

Figure 8 /o/ and /oh/ in spontaneous speech for two generations of speakers from Tamaqua, Pennsylvania. (a) J. Hogan, 81, (b) W. Hogan, 46 (taken Labov 1994)

Labov (1994, Ch. 15) and Labov et al. (2006, Ch. 13) state that in the Middle Atlantic states, the raising and tensing affect only some short-*a* words, following a complex set of conditions that vary systematically from New York to Philadelphia to Baltimore. Figures 9a and 9b, reproduced from Labov et al (2006)'s Figures 13.5 and

13.6, show the tensing and raising of short-*a* of a 62-year-old New Yorker and that of a 30-year-old Philadelphia subject respectively. Both show the tense /æh/ in syllables closed by nasals and voiceless fricatives (including palatals in New York City), and the limited set before /d/ (along with some words ending in voiced stops in New York City). The lax /æ/ class includes the other voiced stops, vowels before nasals in open syllables, along with the remainder of the historical short *a* class and some exceptions.

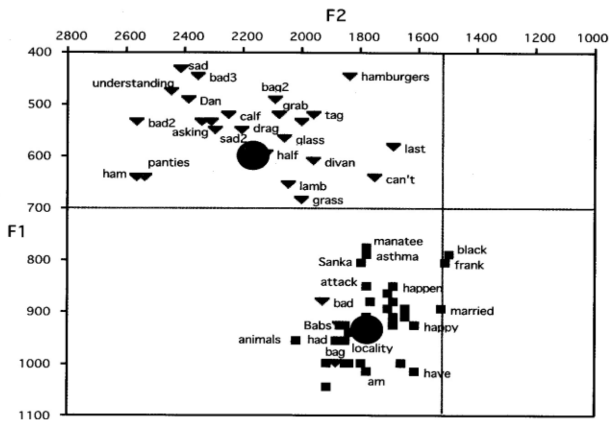

Figure 9a Split /æ/ - /æh/ system of Nina B., 62 [1996], New York City (taken Labov et al. 2006)

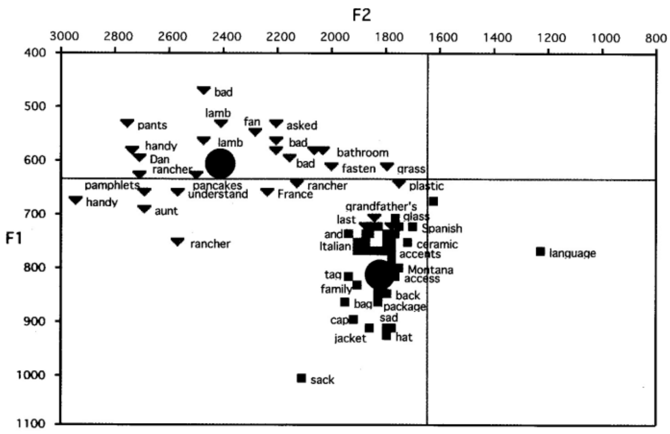

Figure 9b Split /æ/ - /æh/ system of Rosanne V., 30 [1996], Philadelphia

In addition to the basic conditioning of the following consonant, Labov (1994, Ch.15) lists an extensive set of special phonetic, grammatical, and lexical conditions for tensing to apply. But at the same time, he states that the present configuration of tense /æh/ and lax /æ/ in Philadelphia leads to the strong inference that lexical diffusion operated at some earlier state in the history of this redistribution. The investigation of sound changes in progress in Philadelphia in 1973-1977 shows that lexical diffusion is at work in the _NV subclass and _LV subclass in open syllables as shown in Labov (1994)'s Tables 15.4 and 15.6. A linguist may succeed in classifying tense /æh/ and lax /æ/, but speakers may not be conscious of all the distinctions. We assume that the tensing of short-*a* proceeded gradually from the high-frequency words within the basic following consonants in Middle Atlantic states.

In Middle Atlantic states the tensing of short-*a* does not occur within all following consonants, and thus we assume that W-diffusion is slower than S-diffusion. As we expect, we find that the pattern of the 30-year-old Philadelphia subject is similar to that of the 62-year-old New Yorker, though the basic conditioning of the following consonant is a little generalized in New York City. On the other hand, in Northern Cities Shift in which W-diffusion proceeds fast, the vowel system of the son is quite different from that of the father, i.e., the individual vowel systems are quite different along the age dimension. Our 2-dimensional diffusion model, depending on the relative ratios of W-diffusion and S-diffusion, synthesizes lexical diffusion and Neogrammarian regularity.

Labov (1994, Ch.18) states how one can explain the fact that short-*a* underwent lexical splitting into /æ/ and /æh/ in the Mid-Atlantic states, but in the Northern Cities submitted as a whole to a regular, phonetically conditioned sound change, and this was an insoluble puzzle. Labov (2007) suggests that this is due to the difference between the transmission of linguistic change within a speech community and the diffusion across communities. Northern Cities Shift is change from below, i.e. internal change generated by the process of incrementation, in which successive cohorts and generations of children advance the change beyond the level of their caretakers and role models, and in the same direction over many generations. In Mid-Atlantic states, the continuity of the New York City short-*a* system from 1896 to the present and the uniformity of the Mid-Atlantic short-*a* system in Philadelphia, Reading, Wilmington, and Baltimore all indicate that such patterns can be faithfully transmitted across generations through children's language learning abilities. There is evidence, however, that a pattern of this complexity cannot be learned as a second dialect, even by children, and children dilute the uniformity of the original pattern. The studies of the spread of the Now York City short-*a* system and the Northern Cities Shift have allowed Labov to differentiate the diffusion of linguistic change across communities in the spread of the Now York City short-*a* system from the transmission of sound change within the speech community in the Northern Cities Shift.

Ogura & Wang (2004) assume that both linguistic selection and language games are important mechanisms in language evolution. Linguistic selection is unconscious functional selection between available variants by the learners. Languages become adapted to the productive, perceptual and cognitive abilities of human beings in the transmission across generation. Languages tend towards uniformity rather than diversity because every language will discover the same optimal functionally selected compromise.

The changes arising from random variation or social factors spread by language games, i.e., the cooperation in the repeated pairwise interactions of the individuals. The size of the neighborhood determines the number of the individuals that interact, and socially influential people have an increased probability of being imitated by their neighbors. Hence, successful changes spread locally. There may be a number of places that are locally optimal, onto which dialects or languages may settle.

The development of short-*a* in Mid-Atlantic states is a latter case. Learners tend to use changed and unchanged forms probabilistically proportional to the impact of adults. This leads to different subsystems of the New York City system that are locally optimal in Philadelphia, Reading, Wilmington, and Baltimore. Labov et al. (2013) state that resorting to the tendency toward maximal dispersion of vowels in phonological space cannot explain the raising of /eyC/, because it would lead to the lowering of /eyC/. Also the withdrawal of /æh/ from the upper mid target occurs in Philadelphia. The withdrawal is not general for all /æh/ words. Instead, many younger speakers with higher education convert their short-*a* pattern into the nasal system, in which vowels before nasal consonants are raised to upper mid position, while all others remain in low front position. We may assume that the raising of /eyC/ and short-*a* are motivated by the cooperation in the repeated pairwise interactions of the individuals. If they had been motivated by the functional bias of maximum perceptual contrast, the reversal of the changes would not have happened.

The Northern Cities Shift is a former case. Maximum perceptual contrast among the vowels is the driving force of the Northern Cities Shift. The first report of the Northern Cities Shift appeared in an unpublished paper of Fasold (1969). Fasold's findings are:

the lower-middle-class women were leading in both the raising of /æ/ and the fronting of /o/; the parallel movement of these vowels was the first indication that they were structurally linked (Labov et al. 2007, Ch.14, Figure 14.2). Labov assumes the raising of /æ/ was the trigger of the fronting of /o/, but he states that different orders may be operating in different cities and different social groups. We assume that the fronting of /o/ to resist the merger with /oh/ is the trigger of the raising of /æ/. Fasold's investigation shows that the percentage of the advanced form of /o/ is more than 20 % larger than that of /æ/ in the upper and lower middle classes and the working class both in women and men. The strong functional bias of maximal perceptual contrast caused the shifting of the short-*a* vowels as a whole to mid front position. This development can be seen in Figures 7a, 7b. We assume that the stronger the functional bias, the more categorical the learner becomes, and the weaker the functional bias, the more probabilistic the learner becomes. If functional bias is so strong, word diffusion proceeds fast. This occurs in the Northern Cities Shift. The raising spreads in the wide region of the North, and within the Inland North, the homogeneity of raising is high.[3]

3.2 Constant rate effect

Santorini (1992), Pintzuk & Taylor (2006), among others, following Kroch (1989), show that when a new syntactic variant begins to enter the grammar, its use may be more or less favored in different contexts, and it increases in frequency in every context at the same rate over time (the "Constant Rate Effect"). Fruehwald et al. (2009) show that the Constant Rate Effect holds in phonology as well.

We assume that Santorini (1992) and Pintzuk & Taylor (2006) show Neogrammarian regularity of syntactic change. In many cases of Neogrammarian regularity of sound change, the phonetic gradualness is an inevitable consequence of lexical abruptness because language does not change in pronunciation overnight. In Neogrammarian regularity of syntactic change, the constant rate effect is an inevitable consequence of lexical abruptness. The fact that the new variant increases in frequency in every context at the same rate over time in syntactic change, which they describe as grammar competition, corresponds to the continuous linear incrementation, i.e., phonetically gradual change in the Neogrammarian regularity of sound change shown in Figure 6.

The same mean front diagonal values for 47 most common words with checked /eyC/ in Figure 4 implicate that 47 words change at the same rate. If they changed at different rates, the mean front diagonal values would be different. We may assume that Neogrammarian regularity of sound change both phonetically gradual and abrupt and syntactic change proceeds at a constant rate. In lexical diffusion, however, the later a change starts, the greater the rate of change. This shows the “snowball effect”, i.e., diffusion across more and more contexts at faster rate in later starting contexts. There is little probability that lexical diffusion proceeds at a constant rate. Thus we may state that the faster the change proceeds within and across the contexts, the less the difference of the rate of change in each word becomes. We further suggest that the stronger the functional or social bias becomes, the faster the word diffusion proceeds. If functional or social bias is so strong, word diffusion proceeds fast. This shows Neogrammarian regularity, in which changes start simultaneously and proceed at a constant rate in all contexts.

4. Concluding Remarks

After a critical survey of the Neogrammarian hypothesis, we have proposed a chronological profile of lexical diffusion. We have defined lexical diffusion model along two dimensions: diffusion from word to word in a single speaker, which we call W(ord)-diffusion, and diffusion from speaker to speaker, which we call S(peaker)-diffusion. W-diffusion may proceed so fast that it is difficult to observe it. This shows what is called the Neogrammarian regularity.

Based on the development of periphrastic *do* and *–s* in the third person singular present indicative, we have shown that the changes in the different contexts begin at different times, and the later a change begins, the greater the rate of change becomes ("snowball effect"). Within each context, high frequency words change late in the periphrastic *do*, while high frequency words change first in the third person singular present indicative. We have further discussed why some changes start in frequent words, while others in infrequent words, and explained the rapid mid-stream change.

Labov (1981, 1994, 2012, 2013) considers that the chain shifts and many of the mergers show the regularity of the sound changes and no effect of word frequency. The 2-dimensional lexical diffusion model assumes that in these cases W-diffusion proceeds so fast that it is difficult to observe word diffusion and word frequency effect within each individual, but word diffusion can be observed while it is in progress across generations. Our model, depending on the relative ratios of W-diffusion and S-diffusion, synthesizes lexical diffusion and Neogrammarian regularity.

Santorini (1992), and Pintzuk & Taylor (2006) show that when a new syntactic variant begins to enter the grammar, its use may be more or less favored in different contexts, and it increases in frequency in every context at the same rate over time ("Constant Rate Effect"). Fruehwald et al. (2009) show that the Constant Rate Effect holds in phonology as well. We have assumed that they show Neogrammarian regularity of change. We have supposed that the faster the change proceeds within and across the contexts, the less the difference of the rate of change in each word becomes. We have further suggested that the stronger functional or social bias becomes, the faster word diffusion proceeds. Our 2-dimensional diffusion model can uniformly explain Neogrammarian regularity.

Notes

1. For criticisms of Kroch's view, see Ogura (1993).

2. Labov (1994, Ch.11) adresses the mechanism of mergers. He gives three processes: merger by approximation, merger by transfer and merger by expansion. The merger of approximation is the gradual approximation of the phonetic targets of two phonemes until they are nondistinct. The merger may result from the coalescence of two vowels, as happened with French /a/ and /ɑ/. Merger of transfer is a unidirectional process in which words are transferred gradually from one phonemic category to another. This process is observed in the ongoing merger of /ã/ and /ɑ̃/ in Shanghainese (Shen 1990), and the merger of ME /ɛ:/ and /e:/ (Ogura 1987). Merger of expansion is the rapid merger of two phonemes as shown in the merger of /o/ and /oh/ above. The phoneme range of the new phoneme is roughly equivalent to the union of the range of the two phonemes that merged. Labov states that the task of future research is to see how these mechanisms are related to the steady expansion of merger, bearing in mind that they operate at different rates. Merger by transfer is the slowest; merger by approximation may take three or four generations; and merger by expansion appears to be complete in a single generation. We assume that the merger by transfer and merger by expansion are the results of lexical diffusion and Neogrammarian regularity respectively. The faster the word diffusion takes, the more categorical the merger becomes, and the stronger the functional or social bias becomes, the faster the word diffusion proceeds.

3. Based on the data presented in Ogura (1987), Labov (1992, 1994) reanalyzes the distribution of ME /i:/ and /u:/ words at 311 sites in England and maintains that the mathematical analysis supports the regularity hypothesis as well as the claim of

phonetic conditioning of sound change. Ogura (1995) shows that diffusion from word to word and diffusion from site to site progress side by side, and that lexical diffusion from word to word along the time dimension is reflected in the spatial distribution of the words through sites. We compare a given pair of ME /i:/ and /u:/ words by counting the number of sites where the pair of words is pronounced differently, which strongly indicates lexical diffusion at work.

References

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

Chen, Matthew (1972). The time dimension: Contribution toward a theory of sound change. *Foundation of Language* 8: 457-498.

Chen, Matthew Y. & William S-Y. Wang (1975). Sound change: Actuation and implementation. *Language* 51: 255-281.

Ellegård, Alvar (1953). *The Auxiliary Do: The establishment and regulation of its use in English.* Stockholm: Almqvist & Wiksell.

Fruehwald, Josef, et al. (2009). Phonological rule change: The constant rate effect. Paper presented at the 40th annual meeting of the North East Linguistic Society. Massachusetts Institute of Technology, November 13-15.

Gell-Mann, Murray (1992). Complexity and complex adaptive systems. In: *The Evolution of Human Language*, edited by. John A Hawkins and Murray Gell-Mann, 3-18, Redwood City, Ca.: Addison-Wesley.

Hockett, Charles F. (1950). Age-grading and linguistic continuity. *Language* 26: 449-457.

Holmqvist, Erik (1922). *On the History of the English Present Inflections Particularly -th and -s*. Heidelberg: Carl Winter.

Hooper, Joan (1976). Word frequency in lexical diffusion and the source of morphophonological change. In: *Current Progress in Historical Linguistics* edited by William Christie, 95-105. Amsterdam: North Holland.

Kroch, Anthony (1989). Reflexes of grammar in patterns of language change. *Language Variation and Change* 1: 199-244.

Labov, William (1981). Resolving the Neogrammarian controversy. *Language* 57, 267-308.

---------- (1992). Evidence for regular sound change in English dialect geography. In: *Historoy of Englishes: New methods and interpretations in historical linguistics,* edited by Matti Rissanen et al., 42-71. Berlin: Mouton de Gruyter.

---------- (1994). *Principles of Linguistic Change, Vol.1: Internal Factors*. Oxford: Blackwell.

---------- (2012). The role of the lexicon in regular sound change, Paper presented at the 41st Annual Conference of New Ways of Analyzing Variation, Indiana University, Bloomington.

---------- (2013). One hundred years of sound change in Philadelphia: Linear incrementation, reversal, and reanalysis. *Language* 89, 30-65.

Labov, William, Sharon Ash & Charles Boberg (2006). *The Atlas of North American English: Phonetics, Phonology, and Sound Change: A Multimedia Reference Tool*. Berlin: Walter de Gruyter.

Ogura, Mieko (1987). *Historical English Phonology: A lexical perspective*. Tokyo: Kenkyusha.

---------- (1990). *Dynamic Dialectology: A study of language in time and space*. Tokyo: Kenkyusha.

---------- (1993). The development of periphrastic *Do* in English: A case of lexical diffusion in syntax. *Diachronica* 10: 51-85.

---------- (1995). The development of Middle English *i:* and *u:* A reply to Labov (1992, 1994). *Diachronica* 12: 31-53.

---------- (2012). The timing of language change. In: *The Handbook of Historical Sociolinguistics*, edited by Juan Manuel Hernández-Campoy & Juan Camilo Conde-Silvestre, 427-450. Oxford: Wiley-Blackwell.

---------- (forthcoming). *Language Evolution as a Complex Adaptive System: A multidisciplinary approach to the history of English*. New York: Oxford University Press.

Ogura, Mieko & William S-Y. Wang (1995). Lexical diffusion in semantic change: With special reference to universal changes. *Folia Linguistica Historica* 16: 29-73.

---------- (1996). Snowball effect in lexical diffusion: The development of *-s* in the third person singular present indicative in English. In: *English Historical Linguistics 1994: Papers from the 8th International Congress on English Historical Linguistics*, edited by Derek Britton, 119-141. Amsterdam: John Benjamins.

---------- (1998). Evolution theory and lexical diffusion. In: *Advances in English Historical Linguistics*, edited by Jacek Fisiak & Marcin Krygier, 315-344. Berlin/New York: Mouton de Gruyter.

---------- (2004). Dynamic Dialectology and Complex Adaptive System. In: *Methods and Data in English Historical Dialectology*, edited by Marina Dossena & Roger Lass, 137-170. Bern: Peter Lang.

---------- (2008). Dynamic dialectology and social networks. In: *English Historical Linguistics 2006, Vol. III: Geo-Historical Variation in English*, edited Marina Dossena *et al.*, 131-151. Amsterdam/Philadelphia: John Benjamins.

Phillips, Betty S. (1984). Word frequency and the actuation of sound change. *Language* 60: 320-342.

--------- (2001). Lexical diffusion, lexical frequency, and lexical analysis. In: *Frequency and the Emergence of Linguistic Structure*, edited by Joan Bybee & Paul Hopper, 123-136. Amsterdam/Philadelphia: John Benjamins.

---------- (2006). *Word Frequency and Lexical Diffusion*. New York: Palgrave.

Ostohoff, Hermann & Karl Brugmann (1878). Preface to *Morphological Investigations in the Sphere of the Indo-European Languages,* vol. I. In: *A Reader in Nineteenth Century Historical Indo-European Linguistics*, edited by Winfred P. Lehmann (1967), 197-209. Bloomington: Indiana University Press.

Pintzuk, Suzan & Ann Taylor (2006). The loss of OV order in the history of English. In: *The Handbook of the History of English*, edited by Ans van Kemenade & Bettelou Los, 249-278. Oxford: Blackwell.

Santorini, Beatrice (1993). The rate of phrase structure change in the history of Yiddish. *Language Variation and Change* 5, 257-283.

Shen, Zhogwei (1990). Lexical diffusion: A population perspective and a mathematical model. *Journal of Chinese Linguistics* 18(1): 159-200.

Sturtevant, E. H. (1917). *Linguistic Change.* Chicago: The University of Chicago Press.

Visser, Frederick Th. (1963-73). *An Historical Syntax of the English Language*. 4 vols. Leiden: E.J.Brill.

Wang, William S-Y. (1969). Competing changes as a cause of residue. *Language* 45: 9-25.