

MIEKO OGURA / WILLIAM S-Y. WANG

Dynamic Dialectology and Complex Adaptive System*

1. Theoretical preliminaries

Ogura (1990) and Ogura / Wang / Cavalli-Sforza (1991) proposed a method of dynamic dialectology which unifies the study of language in its temporal and areal aspects, and showed how diffusion from word to word spreads spatially through time. Diffusion from word to word in the language progresses from speaker to speaker in the community. The change spreads gradually both within a language and when moving from speaker to speaker. Ogura / Wang (1998) defined it as a 2-dimensional diffusion model: 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.

Complexity is an inherently interdisciplinary concept that has penetrated a range of fields from physics to linguistics, but with no underlying, unified theory. Complex systems are made up of a large number of entities that by interacting locally with each other give rise to global properties that cannot be predicted or deduced from an even complete knowledge of the entities and of the rules governing their interactions. In many cases they are adaptive systems, that is, they tend to change in ways that depend on the particular environment in which they exist (Waldrop 1992, Vicsek 2002, Cangelosi / Parisi 2002).

* We wish to thank the participants of the 1st International Conference on English Historical Dialectology, and in particular the reviewers for valuable comments. This research is supported in part by the grant from the Human Frontier Science Program.

Gell-Mann (1992) points out that the selective effect is the central feature of complex adaptive systems, and selection provides a bottleneck that induces adaptation. He treats the objects over which selection is made as schemata. In his view, schemata unfold in the environment to produce effects or behavior which have consequences for the viability of the schema in terms of survival to a later generation.

In the *Origins of Species* (1859), Darwin noted that natural selection cannot directly promote altruistic acts where individuals reduce their own competitive ability but increase that of others. Yet cooperation is abundant in nature. Evolutionary game theory (Maynard-Smith 1982) has allowed biologists to analyze such dynamics. The minimal assumption is that the transmission of information between partners provides them with an advantage, for example, by exchanging know-how or coordinating their behavior, and that the advantage translates into more offspring, with similar communicative skills.

As opposed to the widely believed argument that a complex innately specified language acquisition device (LAD) must have evolved through natural selection (e.g. Pinker / Bloom 1990), Kirby (1998, 1999), based on the evolution of word order, claims that languages themselves adapt to aid their own survival in the transmission from speaker to speaker. Kirby applies Gell-Mann's (1992) view to linguistic selection, and maintains that the language that survives the transmission from generation to generation will naturally be adapted to being produced and parsed.

Language games as a paradigm for modeling language evolution are used by Hurford (1989), Steels (1997, 1998), Batali (1998), Nowak / Krakauer (1999), Tonkes / Wiles (2002) for the evolution of signs, de Boer (2000a, 2000b, 2001, 2002) for the evolution of vowel systems, and Nowak *et al.* (2000) for the evolution of syntax. They investigate how a stable communication system might evolve from repeated pairwise interactions.

We 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

generations. 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 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.¹

Kauffman (1995) contends that selection and self-organization – matter's incessant attempts to organize itself into ever more complex structure – are the forces of order that operate not only in biology but also in economic and cultural systems. He tries to understand how self-organization might interact with selection. Kirby (1998, 1999) considers that the behavior of linguistic selection is the emergent result of the interactions of the local, individual actions across time and space that conspire to produce non-local universal patterns (see the discussion in sections 2.1 and 4). Thus we may assume that self-organization is preeminently utilized by selection, and there is no fundamental conflict between self-organization and selection.

Since linguistic coherence emerges from rudimentary states through interactions among individuals, no innate organ is pre-supposed both in the evolutionary mechanisms of linguistic selection and language game. Recently, Hauser / Chomsky / Fitch (2002), based on comparative data on animal communication systems, submit that a distinction should be made between the faculty of language in the

1 Labov (1994, 2001) states that any general consideration of linguistic change must first distinguish between change from above and change from below. Changes from above are introduced by the dominant social class, often with full public awareness. Normally, they represent borrowings from other speech communities that have higher prestige in the view of the dominant class. They appear primarily in careful speech, reflecting a superposed dialect learned after the vernacular is acquired. Changes from below are systematic changes that appear first in the vernacular, and represent the operation of internal, linguistic factors. At the outset, and through most of their development, they are completely below the level of social awareness. Labov's changes from below correspond to the changes by linguistic selection, and changes from above correspond to the changes brought about by socially influential people.

broad sense (FLB) and in the narrow sense (FLN). They hypothesize that FLN only includes recursion and is the only uniquely human component of the faculty of language. But, as Bever / Montalbetti (2002) criticize, recursion appears in a wide range of human behaviors, and the sole central component of FLN is shared with other human cognitive domains and possibly other species. Thus we maintain that there is nothing particularly unique to human language. Chomsky has suggested that recursion itself is initiated in human language by the two mechanisms of narrow syntax: merge and displacement. But as Bever / Montalbetti state, Jakobson (1956) noted that these two main linguistic mechanisms also underlie cognitive behavior and emotion.²

In this paper we would like to synthesize linguistic selection and language games in the complex adaptive system of dynamic dialectology. Our discussion is based on simulation and historical data from English. In so doing, we will show how dialect differences emerge. Furthermore, we will explain why word diffusion advances up the S-shaped curve. Labov (2001, Ch.13) states that the transmission of change across generations has not been discussed or even recognized in the literature of historical linguistics. Trudgill (1999, Ch.1) poses the question that is often asked but is difficult as well as interesting to answer: where do different dialects come from? Why are there dialects? We will examine transmission problems and the emergence of dialect differences in the following sections.

2 Nowak *et al.* (2001) try to explore the evolution of innate Universal Grammar in coherent communication within a population by means of game theory. Contrary to Chomsky's ideal speaker-listener in a homogeneous community, Nowak *et al.* consider a heterogeneous population and its evolutionary dynamics. Their Universal Grammar is the result of interactions between individuals across time and their model can be applied without adopting an innatist position.

2. Linguistic selection

In this section we discuss the Great Vowel Shift (GVS), word order change from OV to VO, simplification of the inflectional endings of nouns and verbs, and development of *-ing* in the present participle where languages are adapted to the productive, perceptual and cognitive capacities of human beings in the transmission across generations. Even rare variants get adopted and spread through entire communities by means of a functionally biased learning strategy.

2.1. Great Vowel Shift

In the study of vowel systems, the principle of maximal contrast has a long tradition in linguistics (Jakobson 1941). The principle suggests that the vowel system tends to achieve a maximum perceptual contrast among the vowels in the system. Numerical and computational studies adopting this principle have been proposed and predicted results compare favorably with observed systems (Liljencrants / Lindblom 1972; Lindblom 1986, 1998; Ke / Ogura / Wang 2003).

Whether the initial impetus of the GVS was a drag-chain or a push-chain effect, once maximum perceptual contrast was no longer sustained, the vowel system tried to restore it by rotating its elements in the same direction for several generations. We assume that maximum perceptual contrast is the driving force of the GVS.

There has been considerable debate since the late 1980s as to whether the GVS can be interpreted as a single event in the history of English, or even if it has any real unity (Stockwell / Minkova 1988a, 1988b, Lass 1988, 1992a, 1992b etc.). The first GVS-type change, the raising of higher mid vowels and diphthongization of high vowels appeared in the thirteenth century, and was complete by the sixteenth century, but the shift of low and lower mid vowels was not complete until the seventeenth century. Thus Lass (1988, 1992a) casts doubt on the unity of the shift, and therefore perceptual organization involved.

We rather assume that the developments of Middle English (ME) long vowels implemented themselves gradually across the

lexicon for several centuries (see the discussion in § 4 and Ogura 1987, 1990), maximizing dispersion and producing shifts in the direction that was originally determined by the triggering event. Because the tendency to maximize perceptual contrast is so general, it seems inevitable that it governed language change from the earliest period (Labov 2002). The prototype of the chain shifting of segments which rotate in the same direction for several generations in vowel systems is the English GVS, followed today by the Southern Shift in Southern England, the Southern United States, Australia and New Zealand (Labov 2001, Ch.13).

One might argue that the vowel shift did not proceed in the same way in the dialects as it is assumed to have done in Standard English. But this is not factually correct. Based on the *Survey of English Dialects* (SED) (1962-1971), Ogura (1990) and Ogura / Wang / Cavalli-Sforza (1991) quantitatively examine the present-day reflexes of ME long vowels as these are distributed in 311 sites in England. When we plot out the most frequent reflexes of 7 ME long vowels on a map of England, there emerge various clines emanating from several known population centers throughout England.

An analysis of the materials reveals that ME long *i:* has 17 reflexes in England. On the basis of a variety of philological and phonetic considerations, we interpret the current reflexes to be related to each other diachronically as shown in Figure 1.

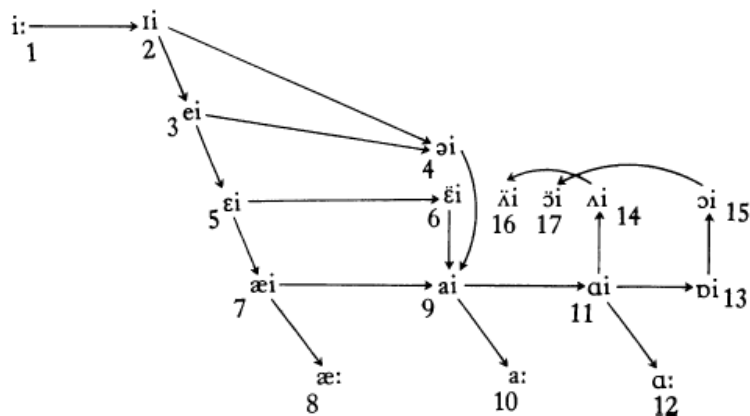
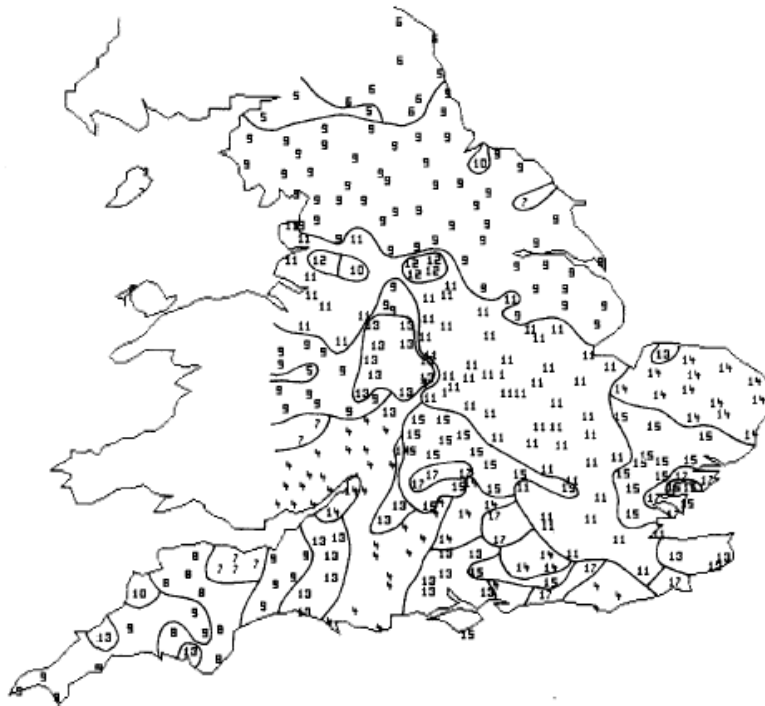


Figure 1. Relations among the reflexes of ME *i:* (from Ogura 1990).

We next tabulate the frequencies of the 17 vowel reflexes for 39 ME *i*: words.³ Map 1 shows the distribution of the first mode reflex, the most frequent vowel at a site, of 39 words.



Map 1. The first mode reflexes for ME *i*: (from Ogura 1990).

We can discern several regions where the change is more advanced. One such region is the coast of Essex. There the first mode reflex has reached 17(=/ɔ̄i/). This focal area is surrounded by sites where the first mode reflex is 15 (=/ɔ̄i/), which in turn borders with sites where the first mode reflex is 14 (=/ʌi/) or 11 (=/ai/). A similar situation can be

3 The 39 words are as follows: *dry, sky, fire, iron, five, hive, ivy, wife, knife, time, nine, mine, ice, icicle, mice, slice, lice, beside, hide, spider, slide, Friday, white, writing, scythe, eye, died, flies, stile, thigh, might, fight, right, light, night, sight, -wright, lightning, dike.*

seen around Oxford. Here again, the first mode reflex has reached 17 (= /ɪ/) in a focal area that is surrounded by sites where earlier reflexes occur. Another focal area revealed by the first mode reflexes is around Manchester and Sheffield; yet another around Birmingham. We may refer to such regions as exhibiting a ‘gradient’, which allows us to make inferences concerning historical developments. Typical of such gradients is the observation that the inner areas are more advanced in the change.

de Boer (2000a, 2000b, 2001, 2002) shows the self-organization of a vowel system through language games of imitation. A group of agents converge to a coherent vowel system by iterative interactions with each other. In de Boer’s implementation, small populations of twenty vowel learners interact with each other and no form of spatial structure is used. Livingstone (2002) extends de Boer’s simulation, including a larger population of one hundred agents that spread across a spatial array. One hundred agents are arranged in a single row, the end of which are not connected. The algorithm for agent learning is not altered from de Boer’s original, other than to enable the neighborhood-based selection of partners. The partner is selected from a position along the line on either side of the original, from within a range of ten agents to either side. The results of the simulation by Livingstone show that different vowel systems are used by different subgroups of the population. In Figure 2 the phonemes used by the twenty agents of the first and the last groups are shown together as white and black dots respectively, to emphasize the differences of the vowel systems that exist across the population.

However, our examination of the gradients of ME long vowels show similar patterns of wave-like propagation from several population centers throughout England. The sites go through the same stages of development. Thus we maintain that the GVS was not implemented by the language games of imitation. If the vowel shift had been implemented by the interactions of individuals in the neighborhood, it would not have proceeded in the same way as in Standard English. The GVS spread throughout England except the Northern area where the reflexes of ME *u:* is /u:/ and the reflex of ME *o:* is a front vowel. However, maximum perceptual contrast was kept in the vowel system in the Northern area as well.

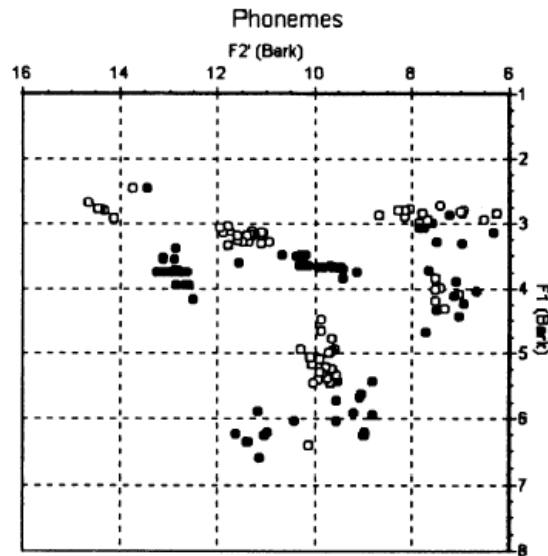


Figure 2. The emergent vowel systems of the first and last subgroups of the population (from Livingstone 2002).

2.2. Word order change from *OV* to *VO*

Ogura (2001, 2003) shows that the interaction between the evolution of relative clauses and perceptual factors caused the word order change from *OV* to *VO* in Old English (OE). The relative clauses in English started out essentially as correlative relatives. The head noun and the relative clause originated in separate positions as shown in (1), rather than being generated together and then separated by Extraposition of the relative clause or moved by Heavy NP Shift of an entire Noun Phrase – the heads are underlined and the relative clauses are italicized.

- (1) 7 Dolfin ut adraf *þe æror þær þes landes weold*
 and Dolfin out drove who earlier there the lands rule
 (*Anglo-Saxon Chronicle*, hence A.S. 1092/3-4)
 ‘and drove out Dolfin who had formerly ruled that district’

The supporting evidence for positing the paratactic stage of adjunction is paratactic clauses with a non-relativized shared NP as shown in (2) where relative clauses would be expected in Present-day English (PDE). In (2a) the full NP *se ylca Raulf* appears in the second clause. In (2b) the shared NP is replaced with an anaphoric demonstrative pronoun, and the presence of a coordinating conjunction marks it not as a relative pronoun but as an anaphoric demonstrative pronoun.

- (2a) On þisum geare Willelm cyng geaf Raulfe eorle Willelmes
 In this year William king gave Ralph earl William's
 dohtor Osbearnes sunu. 7 se ylca Raulf wæs Bryttisc on his moder healf.
 daughter Osbern's son this same Ralph was Breton on his mother's side
 (A.S. 1075)
 'In this year King William gave the daughter of William Fitz Osbern in
 marriage to Earl Ralph: this same Ralph was a Breton on his mother's side.'
- (2b) Eac þis land wæs swiþe afylled mid munecan.
 also this land was exceedingly filled with monks
 7 þa leofodan heora lif æfter scs Benedictus regule.
 and they lived their lives after St Benedict's rule (A.S. 1086)
 'This land too was filled with monks living their lives after the rule of St
 Benedict.'

In the OV structure, the head noun and the relative clause could not be united by moving the relative clause back into the main sentence, since this creates center-embedding. Instead, to reduce the risk of perceptual ambiguity, the head noun was pulled to a position before the relative clause, which produced the VO clauses as shown in (3). The change from OV to VO is an adaptation to perceptual constraint.

- (3) 7 sceawode þet madmehus 7 þa gersuman þe his fæder ær gegaderode:
 and inspected the jewell-house the treasures which his father formerly gathered
 (A.S. 108[7]/167-89)
 'and inspected the treasury and the riches which his father had accumulated.'

Carlton (1970) investigates the occurrence of VO and OV word orders based on the analysis of OE charters. Table 1 lists all the texts, their location in the sources, date, dialect and number of lines. When there

are characteristics of two dialects, the letters representing the dialects are hyphenated, and the predominant dialect is put first.⁴ Table 2 gives the percentage of occurrences of VO and OV word orders in simple sentences, independent clauses and Class I, Class II, and Class III dependent clauses of initial and sequence sentences by centuries. Initial sentences occur at the beginning of documents and never begin with a connective word. Sequence sentences follow the initial sentence and are usually introduced or linked by a connective word. The Class I dependent clause functions as the basic elements of the sentence which usually are nouns or pronouns. The Class II dependent clause functions as clauses which modify nouns, pronouns, verbs, adjectives and adverbs. The Class III dependent clauses function in a subordinate relation to the complete statement of the independent clause.

Ninth-century charters are predominantly in Mercian or Kentish, and those of the tenth and eleventh centuries in West Saxon, except for one Northumbrian charter. If the change from OV to VO had propagated through the interaction among Mercian and West Saxon people, it would have spread in West-Saxon slowly in the tenth and eleventh centuries. However, the data from West Saxon in the tenth and eleventh centuries in Table 2 show that:

1. In initial sentences, the change almost finished in simple sentences and independent clauses and progressed greatly in Class I and Class II dependent clauses.
2. In sequence sentences, VO order was much more frequent than OV in simple sentences, and the change from OV to VO progressed greatly in independent clauses and Class I dependent clauses.

From this we may assume that dialect differences are not prominent in Mercian, Kentish and West Saxon in the ninth, tenth and eleventh centuries.

4 The dialects are abbreviated: WS = West Saxon; M = Mercian; K = Kentish; N = Northumbrian.

	<i>Source</i>	<i>No.</i>	<i>Page (vol.)</i>	<i>Grantor</i>	<i>Date</i>	<i>Dialect</i>	<i>Lines</i>
1.	Birch	318	446 (I)	Æðelnoð	805-31	M-K	12
2.	B	330	459-60 (I)	Osuulf	805-10	M-K	44
3.	B	403	560 (I)	Ealhburg	850	K-M	15
4.	B	404	560-61 (I)	Eadwald Oshering	850	K-M	15
5.	B	405	562-63 (I)	Lufa	850	K-M	19
6.	B	412	575-77 (I)	Abba	833	M-K	56
7.	B	416	583 (I)	King Wiglaf	936	M	10
8.	B	417	583-4 (I)	Badanoð Beotting	850	K-M	21
9.	B	452	35-36 (II)	King Berchtwulf	848	M	14
10.	B	496	101 (II)	King Ethelbearht	858	K-WS	7
11.	B	507	117-8 (II)	Eadwald	863	K-WS	4
12.	B	558	195-7 (II)	Ælfred (dux)	870	M-WS	55
13.	B	591	236-7 (II)	(Narrative)	901-24	WS	68
14.	B	609	268 (II)	Bishop Werfrid	904	WS-M	10
15.	B	631	306 (II)	Aldred (presbyter)	909	N	17
16.	B	639	315 (II)	Æthelstan	925	WS	6
17.	B	678	366-7 (II)	Wulfgar (thane)	931	WS	31
18.	B	1010	213 (III)	Æthelwyrd	958	WS-K	23
19.	B	1063	282-3 (III)	(Narrative)	960-2	WS	43
20.	B	1064	284-5 (III)	Queen Eadgifu	961	WS	45
21.	B	1097	328-9 (III)	King Æthelbryht	961-95	WS	37
22.	B	1233	523-4 (III)	Bishop Oswold	969	WS	20
23.	B	1267	560-2 (III)	King Eadgar	970	WS	57
24.	B	1306	629-31 (III)	Ælfhelm	973-4	WS	51
25.	B	1317	652-3 (III)	Wulfgat	1000-99	WS	28
26.	B	1318	653 (III)	Convent (Worcester)	1000-99	WS	9
27.	Robertson	66	136&138	Wynflaed	990-2	WS	37
28.	R	75	148	Godwine	1020	WS	9
29.	R	81	156	Abbot Ælfweard	1023	WS	20
30.	R	83	162&164	Bishop Æthelstan	1023	WS	49
31.	R	87	172	Bishop Brihtheah	1033	WS	9
32.	R	94	180	Bishop Leofine	1040	WS	23
33.	R	101	188&190	Archbishop Eadsige	1044	WS	38
34.	R	102	190	Abbot Ælfstan	1044-5	WS	18
35.	R	103	192	Godric	1044-8	WS	12
36.	R	108	204	Archbishop Eadsig	1048	WS	15
37.	Harmer	1	120	King Edward	1053	WS	5
38.	H	24	164-5	King Edward	1065-6	WS	16
39.	H	27	182-3	Archbishop Wulfstan	1020	WS	8
40.	H	28	183	King Cnut	1020	WS	10
41.	H	55	245	King Edward	1053	WS	9
42.	H	63	269	Bishop Æthelric	1001-12	WS	12
43.	H	96	360-1	King Edward	1062-6	WS	8
44.	H	115	410-1	King Edward	1062	WS	9
45.	Whitelock	6(1)	42	Æthelric	995-9	WS	19
46.	W	16(2)	44&46	King Ethelred	995	WS	33
47.	W	20	56,58,60,62	Ætheling Æthelstan	1015	WS	91
48.	W	30	78	Thurstan	1042	WS	16
49.	Earle	-	240-1	Bishop Ælfric	1038	WS	38
50.	Sweet	-	175	Ælfred(dux)	870	M-WS	15

Table 1. List of documents (from Carlton 1970).

		9th c.		10th c.		11th c.	
		VO	OV	VO	OV	VO	OV
Initial	Simple sentence	100	0	100	0	100	0
	Indep. clause	100	0	85.7	14.3	100	0
	Class I dep. cl.	0	100	80	20	88.9	11.1
	Class II dep. cl.	0	100	44.4	55.6	27.3	72.7
	Class III dep. cl.	0	100	0	0	0	0
	Sequence	Simple sentence	80	20	82.9	17.1	72.7
	Indep. clause	75	25	85.1	14.9	94.7	5.3
	Class I dep. cl.	45.5	54.5	58	42	75	25
	Class II dep. cl.	0	100	5.5	94.5	8.7	91.3
	Class III dep. cl.	16	84	23.7	76.3	0	100

Table 2. Occurrence of VO and OV word orders (from Carlton 1970).

2.3. Simplification of the inflectional endings of nouns and verbs and the development of -ing in the present participle

Simplification of noun declensions took place in ME. The earliest was the change of final *-m* to *-n* in the dative plural, and this *-n* was then dropped. At the same time vowel distinctions in inflectional endings were neutralized. As a result, only the *-s* forms of the genitive singular of the strong masculine and neuter nouns and of the nominative and accusative plural of the strong masculine nouns were retained in early ME. Taking *doom* as an example, the historical development of the strong masculine noun declensions is as follows:⁵

⁵ The example is from Moore (1951). The analogical forms are distinguished from the forms that developed through phonetic change by underlining.

		<i>OE</i>	<i>eME</i>	<i>IME</i>
Sing.	Nom.	dom	doom	doom
	Gen.	domes	doomes	doomes
	Dat.	dome	doome	<u>doom</u>
	Acc.	dom	doom	<u>doom</u>
Pl.	Nom., Acc.	domas	doomes	<u>doomes</u>
	Gen.	doma	doome	<u>doomes</u>
	Dat.	domum	doome(n)	<u>doomes</u>

The changes began in the North and by the end of the twelfth century they were generally carried out in most dialects. Germanic tendency for word-initial stress may have caused the reduction of stress on other syllables, which brought about vowel reduction in inflectional endings. But mere phonological change does not explain morphological simplification. A group of speakers shifting to a target language fails to learn the target language (TL) perfectly (Thomason / Kaufman 1988: § 3.1). Thus we may assume that simplification is the result of imperfect learning of English by Scandinavian settlers.

Thomason / Kaufman state that the errors made by members of the shifting group in speaking the TL then spread to the TL as a whole when they were imitated by original speakers of that language. We do not consider that the simplified noun declensions are imitated by the English because they would not have spread quickly throughout England by imitation (cf. the development of *-s* in the third person singular present indicative in § 3.2). We rather assume that the simplified noun declensions were more likely to be learned by the English than the complex OE noun declensions because of adaptation to cognitive ability in the transmission across generations. The disappearance of noun inflections in early ME made the language easier to speak and learn, but harder to understand. Thus, in order to reduce ambiguities for the listener, *-s* of the genitive singular of the strong masculine and neuter nouns and of the nominative and accusative plural of the strong masculine nouns was extended to almost all genitive and plural forms in late ME. We find that language is in a state of flux in which different requirements from the speaker, the learner and the listener are simultaneously satisfied.

Simplification of weak verb declensions was also motivated by phonological change, imperfect learning by Scandinavian settlers, and

cognitively biased learning by the English. Taking *love* as an example, the historical development of weak verb inflections is as follows:⁶

		OE		ME
Pres. Ind.	Sing	1	lufie	luvie
		2	lufast	luvest
		3	lufaþ	luveþ
	Plur		lufiaþ	luvieþ
Pres. Subj.	Sing		lufie	luvie
	Plur		lufien	luvie(n)
Pret. Ind.	Sing	1	lufode	luvede
		2	lufodest	luvedest
		3	lufode	luvede
	Plur		lufodon	luvede(n)
Pret. Subj.	Sing		lufode	luvede
	Plur		lufoden	luvede(n)

In inflectional endings, vowels were neutralized (as in the case of noun inflections), but consonants in OE inflectional endings were kept well into ME. Final *-n* in verbs dropped much later than in nouns. Unlike most of the OE noun endings that were multiply ambiguous and were not uniquely recognizable as belonging to a particular case / number category, the morphology of OE weak verbs was extremely simple. The conceptual basis of the weak conjugation was marking of the past by a suffix containing a dental consonant, usually /t/ or /d/. Thus we may suppose that the inflectional endings of verbs were less complex than those of nouns, and verb inflections leveled later.

The extension of the verbal noun *-ing(e)* ending to the present participle form *-and(e)*, *-end(e)* and *-ind(e)* in ME was actuated by the interaction between imperfect learning by the child and perceptual saliency. The change started in the South where the present participle form was *-ind(e)*. We assume that there was confusion in learning the present participle *-ind(e)* with the verbal noun *-ing(e)*, because they were similar in phonological form.

It took some time for *-ing(e)* to spread from the Southern dialects to the Midlands, where *-end(e)* was the usual form, and to the

6 The example is from Moore (1951). The inflectional endings are distinguished by the use of italics.

more Northern dialects, where *-and(e)* was the usual form. Chaucer exclusively used *-ing(e)* in the late fourteenth century and after his time the new *-ing(e)* form spread over the greater part of England. However, Gower, who was a contemporary of Chaucer, used *-ende* in most cases. Map 57 present participle (3) in LALME shows the development of the present participle *-ing(e)* in the East Midlands. While some sites still use the old form exclusively or as a major variant, other sites use exclusively *-ing(e)* in the same community. One might argue that the coexistence of old and new forms reflects the time depth inherent in LALME. We rather assume that the change of the present participle ending to *-ing(e)* made the language easier to learn, but harder to understand. Thus, in order to reduce ambiguities for the listener, the different endings for the verbal noun and the present participle were maintained in some speakers.

Labov (1989) states that the *working/workin'* alternation is not characterized by the deletion of an underlying /g/ but is grammatically conditioned. /ɪn/ is favored most in progressives and participles, less in adjectives, even less in gerunds and least of all in nouns like *ceiling*. Thus, /ɪn/ in *workin'* is the result of sound change operating on the OE present participle *-ind(e)*: by reduction of /e/ to schwa, loss of final schwa, and simplification of the *-nd-* cluster in unstressed syllables. On the other hand, /ɪŋ/ is the regular reflex of the verbal noun spelled *-ing(e)* or *-yng(e)*. Thus there is a correlation between the /ɪŋ/ ~ /ɪn/ alternation in PDE and in late ME the distribution of *-ing(e)* and *-ind(e)*.

3. Language games

In this section we discuss vocabulary emergence, the development from *-th* to *-s* in the third person singular present indicative and the development of West Germanic **a* before nasals in languages spread by cooperation in repeated interactions of individuals. Successful changes tend to spread locally.

3.1. Vocabulary emergence

The variety of vocabulary in the traditional dialects of England is enormous. But where did all these different words come from in the first place? What are the reasons for the development of regional variations in vocabulary? According to Trudgill (1999, Ch.5), one explanation is that the differences have always been there, i.e. the differences have been there ever since English was spoken in Britain. This is the case with the Northern word *oxter* (< OE *oxta*) ‘armpit’. The Anglo-Saxon invaders already bore with them dialectal variations according to where on the North Sea coast they came from. By means of simulation, we will discuss how vocabulary differences emerged in Germanic dialects.

Tonkes / Wiles (2002) simulate, using simple recurrent networks, the emergence of the association of symbols with meanings. They argue against Kirby’s (2000, 2002) simulation of the emergence of compositionality where generalization from a limited subset of exemplars takes place. They state that if meanings and utterances are randomly associated, then there is nothing on which to base a generalization mechanism. We think that Kirby’s hypothesis of generalization from a limited subset of the exemplars as the learning bottleneck is parallel to functional selection as a bottleneck that induces adaptation. Meanings and utterances are randomly associated, and the association is not established by the biased learning strategy. Furthermore, his simulation is concerned with only two individuals, one speaker and one listener, at any time. This is, as it were, an ideal speaker-listener in a homogeneous speech community.

Tonkes / Wiles (2002) represent meanings as values between 0 and 1, which for simplicity are restricted to 100 values of 0.01 increments (i.e. 0.00, 0.01, 0.02, ..., 0.99). These meanings are numerically related so that it is possible to measure the similarity of two meanings by taking their numeric difference (for example, 0.00 is more similar to 0.01 than it is to 0.30). The utterances consist of sequences of up to six symbols which are taken from an alphabet of four letters. They train simple recurrent networks to associate symbols with meanings. Each agent is modeled by a simple recurrent network and can communicate with two neighbors so that the population forms a ring. The initial population of networks disagree on which utterance

corresponds to a given meaning. One of the agents is then replaced with a new individual and the new individual is trained on a set of examples produced by its neighbors. After several agents have been replaced and new ones trained, contiguous sections of the population begin to have reasonably high agreement on which utterances to use for which meanings. Often, one contiguous subset of the population will use one symbol for a region of the meaning space, while the remainder of the population will use a different symbol. For instance, Table 3 shows the utterances used by a neighborhood of a population for a subset of the meaning space.

Concept	Agent 1	Agent 2	Agent 3	Agent 4	Agent 5	Agent 6
0.00	BBBBBB	BBBBBB	BBBBBB	DDDDDD	DDDDDD	DDDDDD
0.01	BBBBBB	BBBB	BBBBBB	DDDDDD	DDDDDD	DDDDDD
0.02	BBBBBB	BBB	BBB	DDDDD	DDDDDD	DDDDDD
0.03	BBBBBB	BB	BBB	DDDD	DDDDDD	DDDDDD
0.04	BBBBBB	BB	BB	DDDB	DDDD	DDDDDD
0.05	BBBBBB	BB	BB	DDD	DDD	DDDDDD
0.06	BBBBBB	B	BB	DDD	DDD	DDDDDD
0.07	BBBBBB	B	B	DDD	DD	DDDDDD
0.08	BBBB	B	B	DDB	DD	DDDDDD
0.09	BBB	B	B	DDB	DD	DDDDDD
0.10	BBB	B	B	DDB	DD	DDDDDD
0.11	BB	B	B	DD	DD	DDDDDD
0.12	BB	B	B	DD	D	DDD
0.13	BB	BDB	B	DD	D	DDD
0.14	BB	BDB	B	DD	D	DD
0.15	BDD	BDB	B	DD	D	DD
0.16	BDD	BDB	BDB	D	D	DD
0.17	BD	BDB	BDB	D	D	DD
0.18	BD	BD	BD	D	D	DD
0.19	BD	BD	BD	D	D	D
0.20	B	BD	BD	DB	D	D
0.21	B	BD	BD	DB	D	D

Table 3. The utterances used by a neighborhood of a population for a subset of the meaning space (from Tonkes / Wiles 2002).

This small sample shows two competing language forms. Where the first three agents use symbols beginning with B for meanings with low numerical values, the other three agents use strings beginning with D.

Agent 4 shows some familiarity with both languages, using strings with both D and B throughout the meaning values from 0.00 to 0.21. This example also demonstrates that even within one language there is significant variability. We may interpret the strings with B and D in Agents 1, 2, 3 as dialectal borrowings because they are limited to meaning values from 0.13 to 0.21.

The differences in time to convergence can be attributed to greater propagation delays towards convergence associated with the increase in population size. Once a population forms two or more distinct languages it also takes a greater time before one comes to dominate. Assuming that the languages are equally learnable, one comes to dominate only through providing a disproportionate number of examples in the training corpora of new individuals. Instead of using neighbors to provide the training data for new individuals, a 'teacher selection' principle is applied. Figure 3 shows the degree of communicative error of populations over 2,500 time-steps, or 2,500 generations when new individuals are taught by the better communicators in the population. Convergence is rapid, even for larger populations.

Returning to regional differences in vocabulary in England, we would like to discuss dialect variations in a particular area due to the replacement of an older, long-established word by a newer, incoming one. Old Norse (ON) was influential in the growth of geographical patterns of variation. Such common ON words as *they*, *egg*, *skirt*, *take*, etc. are now used in all English dialects. However, the heaviest Scandinavian linguistic influence seems to have been on the dialects of the Lower North where Vikings heavily settled. For example, Scandinavian *lake* or *laik* divides the original English *play* area into two in the Lower North. *Bairn* 'child' occurs in a much larger area than just the Lower North and extends into Scotland. In the North, contact between OE and ON occurred at the oral level for nearly 250 years especially after the ninth century. Here ordinary English people encountered, in face-to-face interaction, their Danish counterparts. In many places the Scandinavian population exceeded 50% (Bailey / Maroldt 1977). Thus a good number of Scandinavian words were introduced into English. This is a case when a population forms two or more languages and one comes to dominate only through providing a disproportionate number of examples in the above simulation.

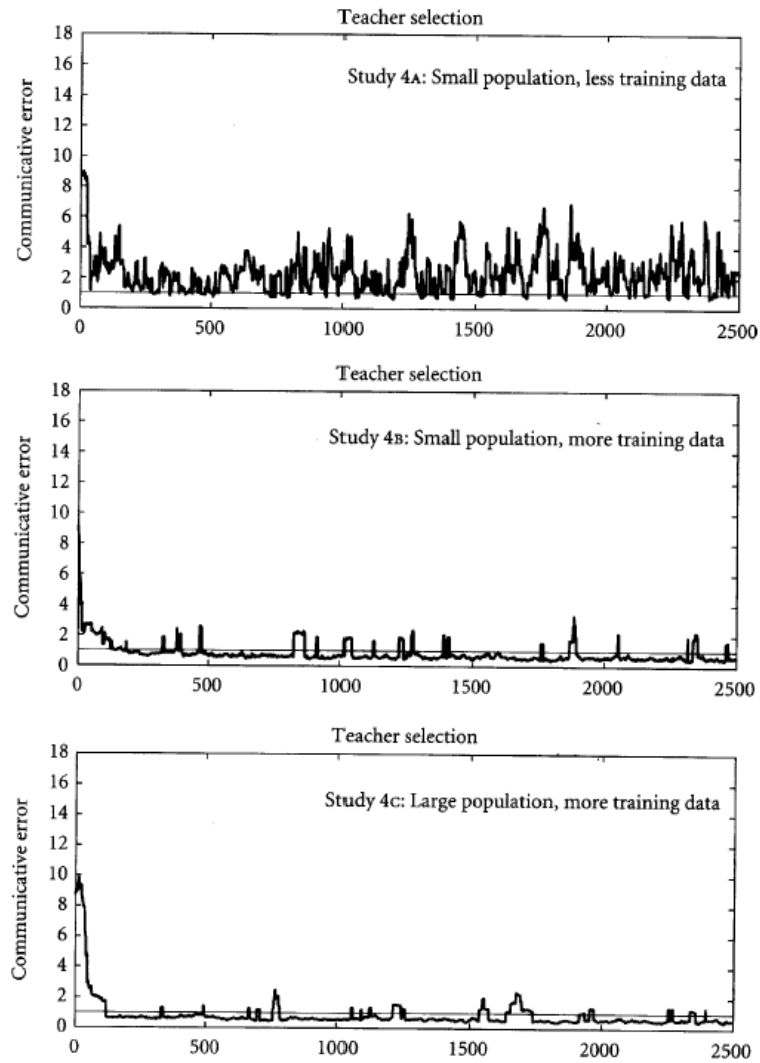


Figure 3. Communicative error of populations over time when new individuals are taught by the better communications in the population
(from Tonkes / Wiles 2002).

The other language, in addition to ON, which was also influential in the geographical patterns of variation was French. After the Norman Conquest, Anglo-French was the official language of the court, justice and politics for 300 years. By the late fourteenth century, when English had re-emerged in official use, many hundreds of French words had become established in the English vocabulary throughout England. Norman settlers were few in number, perhaps 5% (Lockwood 1975), and never exceeded 10% of the whole population of England (Berndt 1969), but they immediately seized positions of national political power. Thus French words spread quickly throughout England. This is a case of ‘teacher selection’ in the above simulation. The rapid spread of French words shows a striking contrast to the slow spread of the Scandinavian words.

In cultural evolution there are migrations of people (with their ideas) or migrations of ideas (customs and the like). These migrations might be referred to as ‘demic’ and ‘cultural’ (Cavalli-Sforza / Feldman 1981, Ch. 1). As French was the upper language in medieval England, it soon became established as a written language. The written medium of French may have enhanced the spread of many hundreds of French words by cultural diffusion.

3.2. The development of *-s* in the 3rd person singular present indicative

Several views have been presented on the origin of *-s*; see, for instance:

- (a) sound change of *th* to *s*;
- (b) analogical influence of the 2nd singular *-s* in Germanic to the 3rd singular, and to the plural;⁷
- (c) morphological change of *-th* to *-s* (Jespersen 1942: § 3.5);
- (d) analogical influence of the verb *is* (Wyld 1936: 336);
- (e) influence of ONhb *-es* (*-as*) (Dobson 1968: 375).

If the change had been motivated functionally or propagated by socially influential people, it would have spread quickly throughout

7 Both a) and b) are critically discussed in Holmqvist (1922, Ch. 1).

England even from a small number of *-s* forms. But the situation is different. The third-person singular ending *-s* first emerged in the tenth century in Northumbrian texts. The change had not yet spread even to the northernmost part of the East Midlands at the beginning of the thirteenth century, but in the course of the thirteenth and fourteenth centuries the *-s* form gradually displaced the old ending over the whole of Lincolnshire (Holmqvist 1922, Ch. III). In the century from 1350 to 1450, *-th* was the regular ending in Norfolk, but we can also find *-s* there (Holmqvist 1922, Chs. III / VI, LALME, vol. III). In fifteenth-century prose written in London English, the *-s* ending is very seldom found (Holmqvist 1922, Ch. VII), but early instances of the *-s* form in prose appear in the first half of the sixteenth century.

We assume that the change must have propagated through interaction between ordinary people with the *-th* form and those with the *-s* form, and a considerable number of the latter would have been necessary for the propagation of the *-s* form. Thomason / Kaufman (1988: 3.1) state that if there is strong long-term cultural pressure from source-language speakers on the borrowing-language speaker group, then structural features may be borrowed as well, and even features of inflectional morphology.

The change started in the North, and we may conclude that the *-s* form is an adoption from ON in face-to-face interactions of ordinary English people with their Danish counterpart. Since there was enormous immigration from the Eastern Midlands to London during the second half of the fourteenth century (Darby 1936, Ekwall 1951), the *-s* form spread in London after the fifteenth century.⁸

ON third person singular present indicative ends with *-ar* and it is plausible that English speakers replaced the unfamiliar ON ending *-ar* with *-es(-as)*. Old Northumbrian *-es(-as)* is the result of this. There are also correspondences of ON *-ar* with OE *-es* between ON weak / strong declensions and OE strong declensions in the nominative plural, and between ON *ar*-ending in the present indicative second singular form of a verb and OE *est*-ending. Furthermore, some nouns

4 Nevalainen (1999) shows the older form *-th* as opposed to the innovative *-s* in the works of male writers between 1540 and 1559, and we can see that the new form is preferred by men of lower social rank.

that declined otherwise as masculine *a*-stem had the genitive singular in *-ar*, or *-s* interchanging with *-ar*, as *skogr*, *smiðr*, *vegr*, and many personal names (Gordon 1956, Grammar 80). We assume that the replacement of the ON ending *-ar* with OE *-es(-as)* was plausible, since ON *r* originated from Germanic *z* and the sound was probably close to /z/ (Gordon 1956, Grammar 19).

3.3. *The development of West Germanic <*a> before nasals in the Mercian speech community*

Toon (1983) shows the progress of West Germanic <*a> before nasals throughout the period of its change from <a> to <o> under Mercian domination. The sound change probably began in the North and diffused through the Mercian speech community. The early eighth-century *Epinal Glossary*, whose language may reflect an even earlier period (c. 700), has <a> consistently and is unaffected by the change. The other glossaries contain data mirroring the development of <a> to <o>. The data in the *Corpus Glossary* argues for the change by the turn of the eighth century. The <o> spelling predominates in Mercian charters from 736 on, and is found exclusively from 812 to 845.

Early West Saxon exhibits fluctuation between <a> and <o>. Of more global interest is the fact that Mercian political domination could effect linguistic change in Kent. The data from Kentish charters before the period of Mercian control are scant but unanimously use <a> forms. But there is a change in charters produced under Mercian domination. The data almost exclusively have <o> spellings between 803-824. During the first years of 833-850, after Mercian influence began to decline, there is fluctuation between <o> and <a> spellings. In the data for the second generation of 859-868, after the beginning of the Mercian exodus, <a> spellings predominate. Late Kentish charters in the tenth and eleventh centuries exhibit only <a> for nasal *a* in fully stressed words; <o> appears regularly in weakly stressed words in early West Saxon texts of the period. The rise and decline of <o> spellings are concomitant with Mercian supremacy. The politically motivated process was reversed by West Saxon domination toward the end of the OE period, except in the West Midlands, the

Mercian homeland, where <o> spellings are found throughout the ME period.

Lowe (2001) criticizes the dating difficulties raised by Toon's data. Toon groups the charter dated 867x870 with charters dating from 833-850. If it were placed with later charters dating from 859-868, this would yield a ratio, not of 13:3 in favor of <a> forms, but of 15:11, and the ratio for earlier charters dating from 833-850 would correspondingly fall from 23:65 to 21:57 in favor of <o> forms. The charter dated 845x853 and grouped with charters dating from 833-850 by Toon might be a later copy. If so, Toon's ratio for earlier charters dating from 833-850 would fall to 21:44 in favor of <o> forms.

Lowe's criticisms of Toon's dating of charters are correct, and accordingly Toon's statistics should be revised. But we still find that charters dating from 833-868 show fluctuation between <o> and <a>, and the data give evidence for the heterogeneous progress of change through the Kentish speech community. Thus Toon's major point that linguistic change in Kent is concomitant with Mercian political domination still holds true.

It is usually assumed that the linguistic system stabilizes at the 'critical age' of 17-20. However, according to Labov (2001, Ch. 14), the lability of speakers aged 30 to 50 may be characteristic of changes from above as opposed to changes from below (see fn 1). Changes introduced by the dominant social class often reflect a superposed dialect learned after the vernacular is acquired. We may assume that the <o> pronunciation was a superposed pronunciation in the adult speakers of Old Kentish and the <a> pronunciation was again used after the decline of the Mercian political dominance.

4. Speaker diffusion and word diffusion

So far our focus has been on speaker diffusion. Both linguistic selection and language games are the emergent result of interactions of individuals across time and space. However, in linguistic selection, non-intentional functionally biased results of local actions of

individuals tend to conspire to produce non-local universal patterns, while in language games intentional, cooperative interactions of individuals, especially the imitation of socially influential people by their neighbors, tend to produce locally spread changes.

In changes not brought about by the socially influential, it is assumed that after first learning of the vernacular by children, the increment advances from the period when children first emerge from the linguistic domination of their parents at the age of 4-5 to the time when their linguistic system stabilizes at the age of 17-20. However, changes propagated by the influential are expanded to adult speakers aged 30-50.

As for word diffusion, we assume that an innovation starts slowly, affecting relatively few words, and then gathers momentum when a large number of words are affected in a relatively short time-span, and slows down again towards the end, which shows a characteristic S-curve. 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. As a purely abstract theory, Kolmogorov Complexity has led to methods for inductive inference, based on the search for the simplest interpretation of observed data, and has applied to representations of any kind: logical, linguistic, probabilistic or pictorial. When regularity exists in the observed language, the hypothesis will capture this regularity, when justified, and allow for generalization beyond what was observed. Thus we assume that speakers, after they observe a small number of changed words, generalize the change into more and more words without observing all the relevant words, and thus the order of the generalization varies among individuals. By means of Kolmogorov Complexity we can explain the rapid mid-stream change, which is something like a phase transition.

Speakers always observe frequent words, thus frequent words spread through interactions between people. When the change starts from low-frequency words, as shown in the development of periphrastic *do* (Ogura 1993), speakers observe unchanged variants of

high-frequency words for a long time, and the high-frequency words become laggards of the change. When the change starts from high-frequency words, as shown in the development of *-s* in the third person singular present (Ogura / Wang 1996) and the shortening of Early Modern English *u*: (Ogura 1987, Ch.5), it takes a long time to complete the change, thus frequent words also tend to become laggards.

Janda / Joseph (2003: 115) state that “while there often are diffusionary effects in the spread of phonological change through the lexicons of speakers, such effects are actually epiphenomenal, being the result of already-needed mechanisms of analogical change and dialect borrowing.” They believe that the Neogrammarian regularity hypothesis is the fundamental mechanism of sound change, and homogeneity of the speech-community is a prerequisite for linguistic analysis. Thus they explain the exceptions by such devices as analogy and borrowing, whose result is lexical diffusion. But at the same time they insist that language change always (and only) takes place in the present, and lament that little discussion has been done on this problem. If they assert the Neogrammarian regularity hypothesis, do they consider that language change always taking place in the present can only be found in analogical change and borrowings?

Actually most of Joseph’s (1992) examples are from analogical change. But their statements are factually incorrect. We maintain that lexical diffusion is the fundamental mechanism of language change. We can observe the processes not only in phonological change (Ogura 1987, 1990, 1995), but also in morphological change (Ogura / Wang 1996), syntactic change (Ogura 1993), and semantic change (Ogura / Wang 1995). Lexical diffusion can be described based on the relative ratios of W-diffusion and S-diffusion as shown in Figure 4. It 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 ($W = S$). When W-diffusion is slower than S-diffusion, the difference is greater between words, and when W-diffusion is faster than S-diffusion, the difference is greater between speakers.

What is especially interesting to us is the latter case, especially when W-diffusion proceeds fast. Labov (1994) considers that the chain shifts and many of the mergers discussed in his Parts B and C

show the regularity of sound changes and phonetic conditioning. The lexical diffusion model assumes that in these cases W-diffusion proceeds so fast that it is difficult to observe it within each individual, but there are great variations among individuals. Actually Labov's instrumental measurements of spontaneous speech show that 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, and 6.20. Our 2-dimensional model can uniformly explain the Neogrammarian regularity of sound change. Ogura / Wang (1998) discuss this in greater detail.

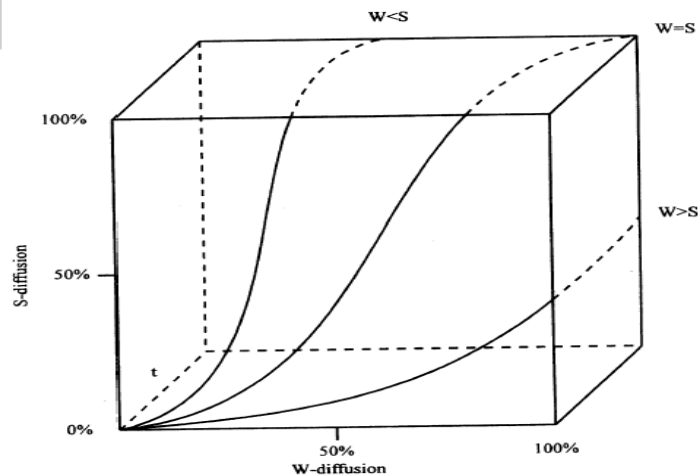


Figure 4. S-curve progress of 2-dimensional diffusion through time
(from Ogura / Wang 1998).

5. Conclusion

We have shown that both linguistic selection and language games are important mechanisms in language evolution. Linguistic selection is unconscious functional selection between available variants by learners. Languages become adapted to the productive, perceptual and

cognitive abilities of human beings in the transmission across generations. Changes arising from random variation or social factors spread by cooperation in repeated pairwise interactions between individuals.

We have synthesized linguistic selection and language games in the complex adaptive system of dynamic dialectology. Our discussion is based on simulation and historical data from English: GVS based on the SED data, word order change from OV to VO, simplification of inflectional endings of nouns and verbs, and development of the *-ing*-form in the present participle for linguistic selection; and vocabulary emergence, development of *-s* in the third person singular present indicative, and the development of West Germanic <*a> before nasals in the Mercian speech community for language games.

We have shown that dialect differences emerge in both types of language evolution. A change may start in a particular location and spread out from there to cover neighboring areas. Some changes may spread so much that they eventually cover the whole country. Others will only spread locally. In a linguistic selection type of evolution, languages tend towards uniformity rather than diversity. In a language game type of evolution, the size of the neighborhood determines the number of individuals that interact, and socially influential people have an increased probability of being imitated by their neighbors. Hence, successful changes spread locally. Even rare variants are adopted and spread through entire communities by means of a functionally biased learning strategy and socially influential people. Without such functional and social bias, a considerable number of changed variants are necessary for the change to spread.

Finally, we have explained why the change that started slowly in a few words spread through more and more words in a rising S-curve from Kolmogorov Complexity. We have also claimed that the lexical diffusion model synthesizes the Neogrammarian conception of the regularity of sound change and the dialectologist's conception that each word has its own history. Dialect differences are closely related in the complex adaptive system of dynamic dialectology, or more generally, of language evolution.

References

- Bailey, C.-J. N. / Maroldt, K. 1977. The French Lineage of English. In Meisel, J. M. (ed.) *Langues en Contact*. Tübingen: Narr, 21-53.
- Batali, John 1998. Computational Simulations of the Emergence of Grammar. In Hurford, James R. *et al.* (eds), 405-426.
- Berndt, Rolf 1969. The Linguistic Situation in England from the Norman Conquest to the Loss of Normandy (1066-1204). In Lass, Roger (ed.) *Approaches to English Historical Linguistics*. New York: Holt, Rinehart & Winston, 369-391.
- Bever, Thomas / Montalbetti, Mario 2002. Noam's Ark. *Science* 298, 1565-1566.
- Cangelosi, Angelo / Parisi, Domenico 2002. Computer Simulation: A New Scientific Approach. In Cangelosi / Parisi, (eds), 3-28.
- Cangelosi, Angelo / Parisi, Domenico (eds) 2002. *Simulating the Evolution of Language*. London: Springer.
- Carlton, Charles 1970. *Descriptive Syntax of the Old English Charters*. The Hague: Mouton.
- Cavalli-Sforza, L. L. / Feldman, M. W. 1981. *Cultural Transmission and Evolution: A Quantitative Approach*. Princeton: Princeton University Press.
- Darby, H. C. (ed.) 1936. *An Historical Geography of England before A.D. 1800*. Cambridge: Cambridge University Press.
- Darwin, Charles 1859. *On the Origin of Species*. London: Murray.
- de Boer, Bart 2000a. Emergence of Sound Systems through Self-Organisation. In Knight, Chris *et al.* (eds.), *The Evolutionary Emergence of Language: Social Function and the Origins of Linguistic Form*. Cambridge: Cambridge Univ. Press, 177-198.
- de Boer, Bart 2000b. Self-Organization in Vowel Systems. *Journal of Phonetics* 28, 441-465.
- de Boer, Bart 2001. *The Origins of Vowel Systems*. Oxford: Oxford University Press.
- de Boer, Bart 2002. Evolving Sound Systems. In Cangelosi, Angelo / Parisi, Domenico (eds), 79-97.
- Dobson, E[ric] J. 1957, ²1968. *English Pronunciation 1500-1700*. Oxford: Clarendon.

- Ekwall, E. 1951. *Two Early London Subsidy Rolls*. Lund: Gleerup.
- Gell-Mann, Murray 1992. Complexity and Complex Adaptive Systems. In Hawkins, John A. / Gell-Mann, Murray (eds.) *The Evolution of Human Languages*. Redwood City, Ca.: Addison-Wesley, 3-18.
- Gordon, E. V. 1927, ²1956. *An Introduction to Old Norse*. rev. by A. R. Taylor. Oxford: At the Clarendon Press.
- Hauser, D. Marc / Chomsky, Noam / Fitch, W. Tecumseh 2002. The Faculty of Language: What is it, who has it, and how did it evolve? *Science* 298, 1569-1579.
- Holmqvist, Erik 1922. *On the History of the English Present Inflections Particularly -th and -s*. Heidelberg: Winter.
- Hurford, James R. 1989. Biological Evolution of the Saussurean Sign as a Component of the Language Acquisition Device. *Lingua* 77, 187-222.
- Hurford, James R. et al. (eds) 1998. *Approaches to the Evolution of Language*. Cambridge: Cambridge University Press.
- Jakobson, Roman 1941. *Kindersprache, Aphasie und allgemeine Lautgesetze*. Uppsala. Transl. by Keiler, Allan R., *Child Language, Aphasia and Phonological Universals*. The Hague: Mouton, 1968.
- Jakobson, Roman 1956. Two Aspects of Language and Two Types of Aphasic Disturbances. Rep. in Waugh, L. / Monville-Burston, M. (eds.) *On Language*, Cambridge, MA: Harvard University Press, 1990, 115-133.
- Janda, Richard D. / Joseph, Brian D. 2003. On Language, Change, and Language Change – Or, Of History, Linguistics, and Historical Linguistics. In Joseph, Brian D. / Janda, Richard D. (eds) *The Handbook of Historical Linguistics*. Oxford: Blackwell, 3-180.
- Jespersen, Otto 1942. *A Modern English Grammar*, Part VI. London: George Allen & Unwin.
- Joseph, Brian D. 1992. Diachronic Explanation: Putting Speakers Back into the Picture. In Davis, Garry W. / Iverson, Gregory K. (eds) *Explanation in Historical Linguistics*. Amsterdam: Benjamins, 123-144.
- Kauffman, Stuart 1995. *At Home in the Universe*. Oxford: Oxford University Press.

- Ke, Jinyun / Ogura, Mieko / Wang, William S-Y. 2003. Optimization Models of Sound Systems Using Genetic Algorithms. *Computational Linguistics*, 29, 1-18.
- Kirby, Simon 1998. Fitness and the Selective Adaptation of Language. In Hurford, James R. *et al.* (eds), 359-383.
- Kirby, Simon 1999. *Function, Selection, and Innateness: The Emergence of Language Universals*. Oxford: Oxford University Press.
- Kirby, Simon 2000. Syntax without Natural Selection: How Compositionality Emerges from Vocabulary in a Population of Learners. In Knight, Chris *et al.* (eds.) *The Evolutionary Emergence of Language: Social function and the origins of linguistic form*. Cambridge: Cambridge Univ. Press, 303-323.
- Kirby, Simon 2002. Learning, Bottlenecks and the Evolution of Recursive Syntax. In Briscoe, Ted (ed.) *Linguistic Evolution through Language Acquisition: Formal and Computational Models*. Cambridge: Cambridge University Press, 173-203.
- Labov, William. 1989. The Child as Linguistic Historian. *Language Variation and Change* 1, 85-97.
- Labov, William 1994. *Principles of Linguistic Change, Vol 1: Internal Factors*. Oxford: Blackwell.
- Labov, William 2001. *Principles of Linguistic Change, Vol. 2: Social ctology*. Oxford: Blackwell.
- Labov, William. 2002. Driving Forces in Linguistic Change. In *Proceedings of the 2002 International Conference on Korean Linguistics*. (in press)
- LALME = McIntosh, Angus / Samuels, Michael L. / Benskin, Michael 1986. *A Linguistic Atlas of Late Medieval English* 1-4. Aberdeen: Aberdeen University Press.
- Lass, Roger. 1988. Vowel Shifts, Great and Otherwise: Remarks on Stockwell and Minkova. In Kastovsky, Dieter / Bauer, Gero (eds.) *Luick Revisited*. Tübingen: Narr, 395-410.
- Lass, Roger 1992a. What, if Anything, was the Great Vowel Shift? In Rissanen, M. / Ihalainen, O. / Nevalainen, T. / Tavitsainen, I. (eds.) *History of Englishes*, Berlin: Mouton, 144-155.
- Lass, Roger. 1992b. Phonology and Morphology. In Blake, Norman (ed.) *The Cambridge History of the English Language*, Vol. II 1066-1476. Cambridge: Cambridge University Press, 23-155.

- Liljencrants, Johan / Lindblom, Bjorn 1972. Numerical Simulation of Vowel Quality Systems: The Role of Perceptual Contrast. *Language*, 48, 839-862.
- Lindblom, Bjorn 1986. Phonetic Universals in Vowel Systems. In Ohala, John J. / Jaeger, Jeri J. (eds.) *Experimental Phonology*. Orlando: Academic, 13-44.
- Lindblom, Bjorn 1998. Systemic Constraints and Adaptive Change in the Formation of Sound Structure. In Hurford, James R. *et al.* (eds.), 242-264.
- Livingstone, Daniel 2002. The Evolution of Dialect Diversity. In Cangelosi, Angelo / Parisi, Domenico (eds.), 99-117.
- Lockwood, W. B. 1975. *Languages of the British Isles Past and Present*. London: Andre Deutsch.
- Lowe, Kathryn A. 2001. On the Plausibility of Old English Dialectology: The Ninth-Century Kentish Charter Material. *Folia Linguistica Historica XXII*, 67-102.
- Maynard-Smith, John 1982. *Evolution and the Theory of Game*. Cambridge: Cambridge University Press.
- Moore, Samuel 1951. *Historical Outlines of English Sounds and Inflections*. rev. by Albert H. Marckwardt. Ann Arbor: Wahr.
- Nevalainen, Terttu 1999. Making the Best Use of 'Bad Data': Evidence for Sociolinguistic Variation in Early Modern English. *Neophilologische Mitteilungen*, 4, 499-533.
- Nowak, Martin A. / Krakauer, David C. 1999. The Evolution of Language. *Proceedings of the National Academy of Sciences*, 96, 8028-8033.
- Nowak, Martin A. / Plotkin, Joshua, B. / Jansen, Vincent, A. A. 2000. The Evolution of Syntactic Communication. *Nature* 404, 495-498.
- Nowak, Martin A. / Komarova, Natalia L. / Niyogi, Partha 2001. Evolution of Universal Grammar. *Science* 291, 114-118.
- Ogura, Mieko 1987. *Historical English Phonology: A Lexical Perspective*. Tokyo: Kenkyusha.
- Ogura, Mieko 1990. *Dynamic Dialectology: A Study of Language in Time and Space*. Tokyo: Kenkyusha.
- Ogura, Mieko 1993. The Development of Periphrastic *Do* in English: A Case of Lexical Diffusion in Syntax. *Diachronica* 10, 51-85.

- Ogura, Mieko 1995. The Development of Middle English *i*: and *u*: : A Reply to Labov (1992, 1994), *Diachronica* 12, 31-53.
- Ogura, Mieko 2001. Perceptual Factors and Word Order Change in English. *Folia Linguistica Historica* XXII, 233-253.
- Ogura, Mieko 2003. Evolution of Word Order. *Folia Linguistica Historica*. (in press)
- Ogura, Mieko / Wang, William S-Y. 1995. Lexical Diffusion in Semantic Change: With Special Reference to Universal Changes. *Folia Linguistica Historica* 16, 29-73.
- Ogura, Mieko / Wang, William S-Y. 1996. Snowball Effect in Lexical Diffusion: The Development of -s in the Third Person Singular Present Indicative in English. In Britton, Derek (ed.) *English Historical Linguistics 1994: Papers from the 8th International Congress on English Historical Linguistics*. Amsterdam: Benjamins, 119-141.
- Ogura, Mieko / Wang, William S-Y. 1998. Evolution Theory and Lexical Diffusion. In Fisiak, Jacek / Krygier, Marcin (eds.) *Advances in English Historical Linguistics* (1996). Berlin: Mouton, 315-344.
- Ogura, Mieko / Wang, William S-Y. / Cavalli-Sforza, Luca 1991. The Development of Middle English *i*: in England: A Study in Dynamic Dialectology. In Eckert, Penelope (ed.) *New Ways of Analyzing Sound Change*. New York: Academic Press, 63-106.
- Pinker, Steven / Bloom, Paul. 1990. Natural Language and Natural Selection. *Behavioral and Brain Sciences* 13, 707-784.
- Steels, Luc 1997. The Synthetic Modeling of Language Origins. *Evolution of Communication* 1, 1-34.
- Steels, Luc 1998. Synthesizing the Origins of Language and Meaning Using Coevolution, Self-Organization and Level Formation. In Hurford, James R. *et al.* (eds.), 384-404.
- Stockwell, Robert P. / Minkova, Donka. 1988a. The English Vowel Shift: Problems of Coherence and Explanation. In Kastovsky, Dieter / Bauer, Gero (eds.), 355-394.
- Stockwell, Robert P. / Minkova, Donka. 1988b. A Rejoinder to Lass. In Kastovsky, Dieter / Bauer, Gero (eds.), 411-417.
- Thomason, G. Sarah / Kaufman, Terrence 1988. *Language Contact, Creolization, and Genetic Linguistics*. Berkeley: University of California Press.

- Tonkes, Bradley / Wiles, Janet. 2002. Methodological Issues in Simulating the Emergence of Language. In Wray, Alison (ed.) *The Transition to Language*. Oxford: Oxford University Press, 226-251.
- Toon, Thomas E. 1983. *The Politics of Early Old English Sound Change*. New York: Academic.
- Trudgill, Peter 1990, ²1999. *The Dialects of England*. Oxford: Blackwell.
- Vicsek, T. 2002. Complexity: The Bigger Picture. *Nature* 418, 131.
- Waldrop, M. Mitchell. 1992. *Complexity*. New York: Simon & Schuster.
- Wyld, Henry Cecil 1920, ³1936. *A History of Modern Colloquial English*. Oxford: Blackwell.