

Diffusion and Inheritance of Language and Culture: A Comparative Perspective

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Abstract. Data from three published worldwide compilations are used to express the average similarity between pairs of languages and cultures as joint functions of geographic distance and recency of common ancestry. Even for languages and cultures with no known common ancestor, similarity decreases as distance increases out to several thousand kilometers, suggesting widespread diffusion or possibly adaptation. At any given geographic distance, languages in the earliest branches of the same family are more similar than unrelated languages, but cultures in different branches are more similar than unrelated cultures only if the branches diverged later, suggesting that language changes more slowly than culture.

1. Introduction. In general, the further apart languages or cultures are located geographically, the fewer traits they have in common and, hence, the less similar they are to each other. This empirical relationship has been confirmed in a wide range of contexts: cultural similarity among indigenous communities in Brazil, Melanesia, and California (Milke 1949); cultural and linguistic (lexical) similarity among Salishan tribes in western North America (Jorgensen 1969); lexical similarity among dialects in France (Séguy 1971), dialects in the Alps (Goebel 2001), dialects and closely related languages in Micronesia (Cavalli-Sforza and Wang 1986), and languages worldwide (Holman et al. 2008); phonological, lexical, and syntactic similarity among dialects in the Netherlands (Spruit et al. 2009); phonological similarity among dialects in Gabon, Bulgaria, Germany, the U.S.A., the Netherlands, and Norway (Nerbonne 2010); and grammatical similarity among languages worldwide (Holman et al. 2007). Milke, Séguy, Cavalli-Sforza and Wang, and Nerbonne all fit different mathematical functions to their data, and

Nerbonne observed that whatever the specific function, the relationship is generally sublinear in the sense that a given change in distance has less effect on similarity at longer distances than at shorter ones.

There are three principal processes that may contribute to the observed relation between distance and similarity. One is borrowing or diffusion between languages or cultures in contact, through a process of horizontal transmission in which people of different languages or cultures acquire information from each other. Since people are most likely to interact with others who live nearby, diffusion and thus similarity will be negatively related to distance. Another process is inheritance of attributes from a common ancestral language or culture through a process of vertical transmission in which people of earlier generations pass on information to people of later ones. To show how inheritance is related to distance, Cavalli-Sforza and Wang (1986) pointed out that after two linguistic or cultural groups diverge from a common ancestor, they become less similar to each other with the passage of time and also more likely to have migrated away from each other. A third process, also indirectly related to distance, is adaptation to the local environment, which causes similarity between cultures located in similar environments, which in turn are likely to be near each other geographically. Although adaptation has traditionally been considered relevant to cultural but not linguistic features, evidence for an effect of adaptation on linguistic phonology has recently been accumulated by Munroe et al. (1996), Fought et al. (2004), Ember and Ember (2007a, 2007b), Munroe and Fought (2007), and Munroe et al. (2009). Moreover, as Borgerhoff Mulder et al. (2006) mentioned, adaptation can influence both diffusion and inheritance, because well-adapted traits are more likely to be borrowed or inherited.

The next step is to estimate the relative contributions of these three causal factors to the relation between distance and similarity. Most research on this question has applied correlational methods to cultural data. A contentious series of studies analyzed the material culture of villages located on the north coast of New Guinea that are inhabited by speakers of languages in several unrelated families; the data were originally analyzed by Welsch et al. (1992) and subsequently reanalyzed by Moore and Romney (1994, 1996), Roberts et al. (1995), Welsch (1996), and Shennan and Collard (2005). All the studies showed an effect of geographic proximity with language held constant, which was attributed to diffusion. Depending on how cultural similarity was defined, most of the studies also found an effect of language with geographic proximity held constant, which was attributed to inheritance. Other studies by Guglielmino et al. (1995) and Hewlett et al. (2002) analyzed the cultural data from sub-Saharan Africa in Murdock's (1967a) *Ethnographic Atlas*. As in the New Guinea studies, spatial proximity was used as a measure of diffusion and phylogenetic proximity in language classifications was used as a measure of inheritance; in addition, environmental similarity as inferred from vegetation maps was used as a measure of local adaptation. Each of these measures was correlated with the similarity between pairs of African societies with respect to each cultural trait. Differences among the correlations suggested differences among cultural traits in the relative importance of inheritance, diffusion, and adaptation.

Following Mace and Pagel (1994), a large number of studies have accumulated which trace the histories of cultural features by mapping their evolution onto linguistic trees, mainly in order to test for correlated evolution (Pagel 1994) between cultural features. In particular, the relationships among systems of kinship, marriage, inheritance,

and residence have drawn much attention (Cowlshaw and Mace 1996, Borgerhoff Mulder et al. 2001, Fortunato et al. 2005, Jordan et al. 2009, Fortunato and Jordan 2010, Jordan 2011). Mace and Jordan (2011) provide a review of this literature. Other studies have constructed trees based on aspects of material culture, such as basketry in native societies of California (Jordan and Shennan 2003) or textiles in Iran (Matthews et al. 2011). Collard et al. (2006) compared phylogenetic trees constructed with the same methods for cultures and for animal species. The trees fit the data about as well for cultures as for species, suggesting that inheritance plays about as strong a role in cultural evolution as in organic evolution.

Concern has been raised that the speed of cultural change and the effects of horizontal transmission may pose problems for cultural phylogenies (Boyd et al. 1997, Nunn et al. 2006, Nunn et al. 2010). The latter problem has been addressed in an optimistic fashion by Gray et al. (2007), Greenhill et al. (2009), and Currie et al. (2010), who point to the availability of appropriate phylogenetic methods that into account reticulation, to methods of error estimation, and to the relative robustness of Bayesian phylogenetic methods against horizontal transmission. Less discussion has been devoted to the speed of cultural change. Gray et al. describe several theoretical reasons to expect less stability in culture than in language, but they note a lack of sufficient empirical data to test this expectation. One purpose of the present study is to provide additional data on the issue.

Our study combines aspects of previous lines of research. Like Milke (1949) and others, we construct empirical functions relating similarity in linguistic and cultural traits to spatial distance; like the correlational studies, we infer inheritance from linguistic

classifications; and like Collard et al. (2006), we conduct parallel analyses in two different domains, in this case language and culture. The recent availability of two large linguistic databases allows worldwide comparisons with an older ethnographic database. To distinguish between causal factors, separate functions relating similarity to distance are constructed at different taxonomic levels of linguistic relationship. A difference between taxonomic levels at the same spatial distance can then be attributed to inheritance or adaptation but not diffusion. Since the highest taxonomic level corresponds to languages with no known inherited relationship, an effect of spatial distance at this level can be attributed to diffusion or adaptation but not inheritance. Given that adaptation can influence both inheritance and diffusion, our methods do not distinguish adaptation from either alternative, and we will therefore not attempt to draw inferences about adaptation.

2. Data and Methods. The linguistic data are from two different sources. One is the Automatic Similarity Judgment Program (Wichmann et al. 2011, henceforth ASJP), which provides lexical information. The ASJP database consists of 40-item word lists transcribed into the standard notation described by Brown et al. (2008). The 40 items are those estimated by Holman et al (2008) to be the most stable items in Swadesh's (1955) 100-item list. The present study excludes pidgins, creoles, protolanguages, constructed languages (such as Esperanto), lists based on materials earlier than 1700 CE, and lists with fewer than 28 of the 40 items attested, leaving lists for 5088 languages and dialects, which represent 3581 distinct languages with different ISO639-3 designations in the 16th edition of *Ethnologue* (Lewis 2009).

The other linguistic database is the *World Atlas of Language Structures* (Dryer and Haspelmath 2011, henceforth *WALS*), which provides structural information on living languages. *WALS* contains 138 maps showing the distribution of different phonological, grammatical, and lexical features. Each feature has anywhere from two to nine discrete values or traits. For example, Map 75 refers to the feature ‘epistemic possibility,’ which has three values, ‘verbal constructions,’ ‘affixes on verbs,’ and ‘other.’ The present study draws on 134 of the 138 features, excluding those with redundant data. This study also excludes pidgins, creoles, and sign languages, leaving 2445 languages attested for at least one of the 134 features. Languages are extremely variable in their degree of attestation: 219 languages are attested for only a single feature, one (English) is attested for all 134, and the rest are scattered across the interval between these extremes. Features are less variable, ranging from 111 to 1369 in the number of languages attested.

The cultural data are from the *Ethnographic Atlas* (henceforth *EA*), originally published by Murdock (1967a) and subsequently augmented by Murdock (1967b, 1968a, 1968b, 1968c, 1971), Barry (1980a, 1980b), Korotayev et al. (2004), and Bondarenko et al. (2005). *EA* summarizes the published literature on 80 cultural features related mainly to subsistence economy, family and kinship, social stratification, division of labor, and house construction. Each feature has from two to fourteen discrete values. For example, the sixth feature is ‘prevailing mode of obtaining a wife,’ which has seven values, ‘bride-price or bride-wealth,’ ‘bride-service,’ ‘token bride-price,’ ‘gift exchange,’ ‘exchange,’ ‘absence of any significant consideration,’ and ‘dowry.’ In order for the linguistic and cultural samples to be comparable, the present study excludes societies dated before 1700

CE, leaving 1271 societies. Degree of attestation ranges from 17 to 80 features across societies, and from 367 to 1271 societies across features.

Both *WALS* and *EA* include language classifications; ASJP uses the same classification as *WALS*, which is also used in the present study because it is more recent than the one in *EA*. The *WALS* classification, described by Dryer (2005), groups languages into genera and genera into families. Genera are defined as the most inclusive groups descended from a common ancestral language spoken within the last 3500 to 4000 years. Families are defined as the most inclusive groups widely considered to be descended from a common ancestor; few if any families are estimated to be more than 10,000 years old. As examples of a family and genera, Dryer offers respectively Indo-European and its major subgroups such as Germanic and Celtic.

The same classification was used both for the languages in ASJP and *WALS* and for those spoken by peoples of the societies in *EA*. The 5088 lists from ASJP are classified into 512 genera and 217 families. The 2445 languages from *WALS* are classified into 458 genera and 205 families. The 1271 societies from *EA* are classified into 276 genera and 117 families.

Geographic distances between languages and between societies are calculated from latitudes and longitudes provided in each database. These distances follow the shortest path on the surface of a sphere, ignoring obstacles such as mountains, deserts, and oceans.

The data were analyzed by calculating the degree of similarity between languages or societies as a joint function of taxonomic level and spatial distance. In some published studies, the results are presented in scatter plots with each point denoting a pair of

languages or societies. This procedure applied to the present data would produce on the order of a million points per scatter plot. The usual solution to this excess, which we adopted from earlier studies such as those of Milke (1949) and Séguy (1971), is to divide distance into intervals and average the points within each interval. We divided distances up to 2500 kilometers into intervals of 100 kilometers, such as 0–100 kilometers, 100–200 kilometers, and so on; and we divided distances above 1000 kilometers into intervals of 500 kilometers, such as 1000–1500 kilometers, and so on. In each interval, pairs were then sorted into one of three taxonomic levels, members of the pair being either (1) in the same genus, (2) in different genera but the same family, or (3) in different families. Only combinations of intervals and levels represented by at least 10 families were analyzed further, in order to avoid unreliable results from unrepresentative samples.

In the ASJP data, the similarity between each pair of lists was calculated as described in Bakker et al. (2009). For any pair of words, the Levenshtein distance (LD) was defined as the minimum total number of additions, deletions, and substitutions of symbols necessary to transform one word into the other. LD was then normalized by dividing it by the length of the longer of the two words. For the pair of lists, normalized LD was averaged across all pairs of words with the same meaning shared by the two lists. To correct for chance similarity, this average was divided by the average normalized LD of all pairs of words on the lists with different meanings. The result was subtracted from 100% to produce the similarity of the pair. Similarity of list pairs was then averaged across taxonomic groups at the given level in the given distance interval, weighted by the square root of the number of pairs in each group. The square-root weighting compensated for the fact that the number of pairs in a group increases approximately as the square of

the size of the group, while the amount of data in a group increases only as the size of the group.

In the *WALS* and *EA* data, the units of analysis were features, which are less variable in attestation than languages or societies. For each feature, the similarity between the pairs in a taxonomic group at a given level was defined as the number of pairs with the same value of the feature, divided by the number of pairs for which the feature is attested in both members. Similarity was then averaged across taxonomic groups at the given level, again weighted by the square root of the number of pairs in each group. These weighted average similarities were finally averaged across all attested features and expressed as a percentage in order to represent the overall similarity of the pairs at a taxonomic level in a distance interval.

3. Results. Figure 1 plots lexical similarity between languages as a function of spatial distance at each taxonomic level. The lower panel repeats the curve for different families on an expanded scale for better visibility. This figure improves on figure 3 of Holman et al. (2008) by applying a better measure of similarity to a much larger version of the ASJP database.

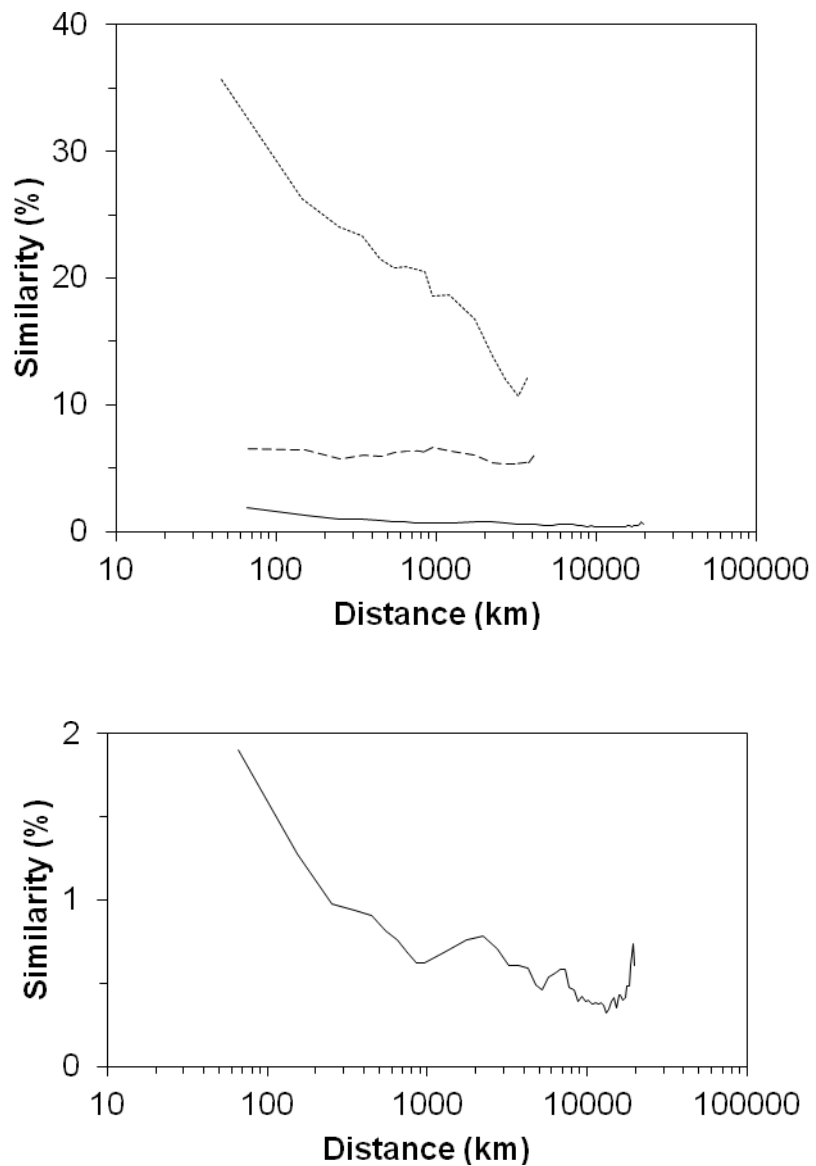


Figure 1. Percentage lexical similarity between languages as a function of the spatial distance between them. Solid line: languages in different families. Dashed line: languages in the same family but different genera. Dotted line: languages in the same genus.

Figure 2 plots structural similarity between languages as a function of spatial distance at each taxonomic level. This figure improves on figure 1 of Holman et al. (2007) by adding the level of genera and using the latest version of the *WALS* database.

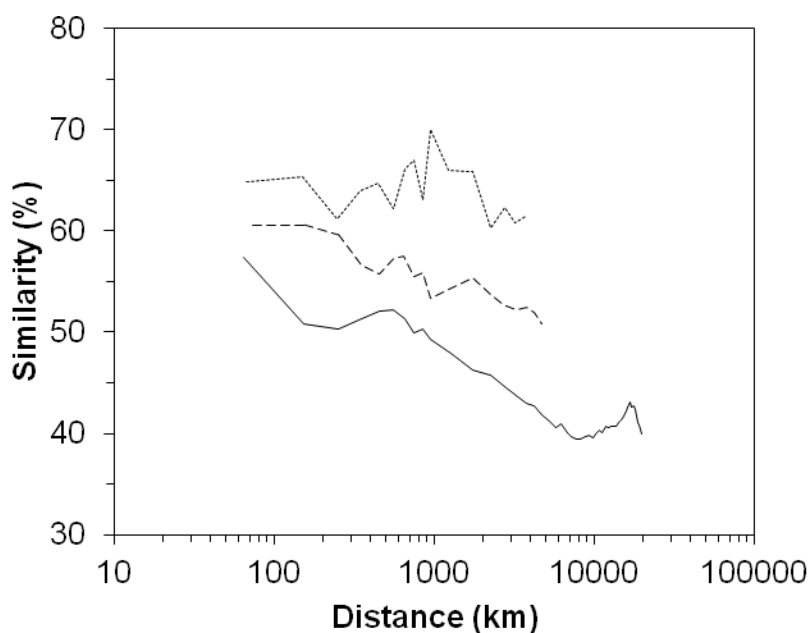


Figure 2. Percentage structural similarity between languages as a function of the spatial distance between them. Solid line: languages in different families. Dashed line: languages in the same family but different genera. Dotted line: languages in the same genus.

Figure 3 plots similarity between societies as a function of spatial distance at each taxonomic level.

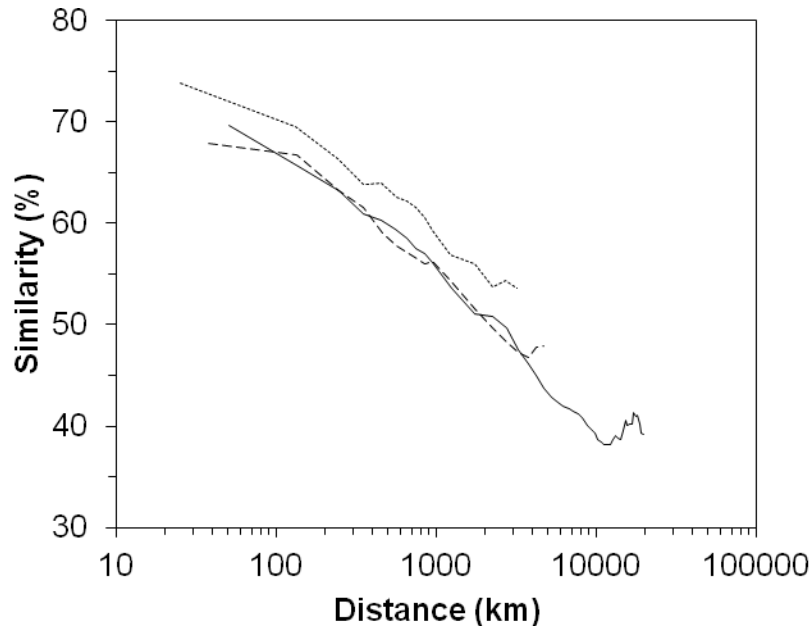


Figure 3. Percentage similarity between societies as a function of the spatial distance between them. Solid line: languages in different families. Dashed line: languages in the same family but different genera. Dotted line: languages in the same genus.

All three figures show distance on a logarithmic scale. Nerbonne (2010) fit his data with logarithmic functions as examples of the sort of sublinear function that he proposed to approximate the effect of distance on similarity. A logarithmic function of distance corresponds to a linear function of the logarithm of distance. Thus, Nerbonne's proposal implies that all the functions in the three figures should be approximately linear. This is indeed an acceptable first approximation to the curves in the figures, but there are some systematic deviations. The curve for lexical similarity between languages in different families is concave-up, and all three curves for similarity between societies are concave-down; these differences indicate that a better approximation will require different functions to describe the effects of distance on lexical, structural, and cultural

similarity. Another deviation from linearity is that all three curves for similarities between different families stop declining as distance increases beyond about 10,000 kilometers.

The effect of distance is easiest to interpret for the similarity between members of different language families, which are generally considered to be unrelated by inheritance. The curves for different families can therefore be interpreted in terms of diffusion and local adaptation. From the shortest to the longest distances, similarity between families drops by less than 2% in figure 1, by about 15% in figure 2, and by about 30% in figure 3. These differences suggest that diffusion and local adaptation are least important for basic vocabulary and most important for culture, with structural properties of language in between.

Similarity also tends to be higher in the curves for lower taxonomic levels, as predicted by inheritance. The effect of taxonomic level is strongest in figure 1, where the lowest point for similarity within genera is above the highest point for similarity between genera within families, and the lowest point on this curve is higher than the highest point for similarity between families. In figure 2, the curves are ordered in the weaker sense that in each distance interval, similarity within genera is highest, similarity between genera within families is next, and similarity between families is lowest. In Figure 3, similarity within genera is again higher than similarity between genera within families in each distance interval, but the curve for genera within families is practically superimposed on the curve for different families, suggesting that cultural inheritance does not extend beyond genera.

4. Discussion. The evidence in figures 1 and 2 for linguistic diffusion out to distances of several thousand kilometers supports Dryer's (1992) suggestion of language areas as large as continents. The even stronger cultural diffusion shown in figure 3 is consistent with the large culture areas inferred from *EA* data by Burton et al. (1996) and further discussed by Korotayev and Kazankov (2000) and Jones (2003). Moreover, the absence of an effect of distance beyond about 10,000 kilometers in all three figures is consistent with size of the proposed language and culture areas.

The present evidence for linguistic inheritance from the time depth of currently accepted families is consistent with the fact that language families are themselves inferred in part from lexical and structural information of the sort contained in the ASJP and *WALS* databases. For cultures, the results in figure 3 confirm, with completely different methods of analysis, the finding of most correlational studies that cultural similarity depends on linguistic affiliation as well as geographic proximity. In particular, there is evidence for inheritance of cultural traits out to the time depth of genera, but little or none thereafter even within families. Inheritance can preserve ancestral features through shorter time spans for culture than for language.

The temporally limited effect of cultural inheritance in figure 3 provides empirical support for the theoretical expectation of Gray et al. (2007) that culture is less stable than language. Figure 3 also suggests that the technique of mapping cultural features onto linguistic trees will be most informative about cultural history within language genera, rather than at greater time depths. Although cultural inheritance is weaker than linguistic inheritance in the present study, it is about as strong as biological inheritance in the study of Collard et al. (2006). Two reasons can be offered for this contrast. First, most of the

cultural data sets analyzed by Collard et al. include representatives of only one or a few genera; cultures this closely related can be expected to show a substantial effect of inheritance according to figure 3. Second, the conventional identification of cultural inheritance with language classifications may be an oversimplification; the cultural phylogenies inferred by Collard et al. may include cases where language and culture are inherited along separate pathways.

In summary, for both languages and cultures similarity decreases as distance increases. This is so even for languages and cultures without known common ancestors, suggesting the influence of widespread diffusion or possibly local adaptation. At any given geographic distance, similarity decreases with increasing remoteness of common ancestry up to the time depth of families for languages, but only up to the time depth of genera for cultures. The present findings, then, suggest that languages are more conservative than cultures.

Notes

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