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Systems dynamics applied to reconstruct the dispersal of modern man on Earth and language patterns during the last 120,000 years

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Abstract

Movement of populations and languages in Eurasia has been mathematically modeled. The movements are explained by primarily demographic expansion caused by climatic change in the historic past, ecological factors and the introduction of agriculture from the Near East and Southeast Asia into the neighboring territories. This study use model outputs for the time period 120,000 BC-1,500 BC to investigate the relation between language families such as Nostratic, Austric and Dene-Sino-Caucasian, the approximate date of splitting into member languages, assuming that language follow etnicity. The model is capable of reproducing the archaeological dates available for initial settlement during the paleolithic period and the archaeological dates for the neolithic transition in Europe, Middle East, India, Indochina and Far East simultaneously within approximately +/-20%. The calculations supports the existence of Nostratic, Austric and Dene-Sino-Caucasian, and the date of initial settlement of Eurasia and the spread of different types of agriculture economies provide important clues to the dating of the splitting of language families. The calculations suggest that it is not probable that the forst humans arrived in America earlier than 25,000 years ago. The integrated interpretation of the modeling study that the origin of language is significantly earlier than 100,000 years ago, in Africa, and that language transfer and diversification has been driven by ecological factors.

1 Introduction

This study arose as a by-product of models for population dynamics and models for forest growth and soil carrying capacity developed by the Biogeochemistry and systems analysis group at the Department of Chemical Engineering at Lund University in Sweden. When doing mathematical modeling and systems analysis of environmental pollution impacts on ecological systems across Asia, we discovered that past climate changes and fossil pollen records could be used to test the predictive capability of mathematical ecological models for the effects of global climate change. Being used to make population models, it was only natural to experiment with modelling of human populations. Once we were able to use ecological factors for population control, the next natural step was to give them a language and study where the different languages would go. The idea of large language families is considered by many linguists to be very controversial to this day. The major argument forewarded is that all resemblance between languages become lost in the noise of random change after approximately 10,000 years. The American linguist Merrit Ruehlen has written several books on that subject and analysed the long discussions pro and contra concerning larger language families. In contrast, several Russian and American scientists have shown such an assumption to be thoroughly wrong and more based in conservatism than scientific analysis. At the same time, the ”out of Africa” theory for modern human origins has gained more and more scientific support among anthropologists and pre-historians.

2 Unifying languages

The idea that all humans must have had one language is not new. In fact it follows as a consequence from the consept of an originally created human couple, as found in most creation myths of the world. Recent advances in comparative linguistics have started to develop a picture of relationships between language families and groups of language families. Using the same methodology, but starting where researchers in comparative linguistics in Indoeuropean, Sino-Tibetan etc. left off, large superfamilies were reconstructed. Several such superfamilies of languages could be identified as a result of recent work (Illich-Svitych 1964, 1967, 1989; Dolgopolsky, 1986, 1988; Greenberg, 1990; Shevoroshkin, 1990). According to the results of the above listed studies as well as our mathematical studies, a majority of the worlds languages can be ordered into 9 major language families that come in three larger language family groups;

- The North Eurasian language family group has three branches;
  - Nostratic-Eurasiatic, Dene-Sino-Caucasian, Amerind
- The South Eurasian language family group has three branches;
  - Austric, Indo-Pacific, Australian
- The African language family group had four branches;
  - Nilo-Saharan, Niger-Congo-Cordofanian, Khoisan, *The extinct Mbuti languages*

Nostratic is more or less overlapping with what is sometimes also called **Eurasiatic**. As we understands the entity Nostratic, it comprises the language groups of Indo-European, Kartvelian, Afro-Asiatic, Finno-Ugric, Yukagir, Dravidian and Altaic including the Korean and Japanese languages, probably also Eskimo-Aleut and Chuckchi-Kamchadal (Pedersen 1933; Illich-Svitych 1964, 1967, 1989; Dolgopolsky, 1986, 1988; Greenberg, 1987; Kaiser and Shevoroshkin, 1986). The language groups listed have different rankings in the development hierarcy within the group.

Dene-Sino-Caucasian , comprises the following larger language groups; Sino-Tibetan languages, the North-Caucasian languages, Burushaski, Yenesseian, the pre-Indoeuropean North Caucasian languages of paleolithic Europe, Basque, Iberian, Pictish, Etruscan, Rätian, Lemnian, Sumerian (Trombetti, 1925; Bouda 1948) and the Na-Dene languages of the American Northwest Coast and East Central Canada (Rhys, 1892; MacAlister 1940; Ruehlen, 1988; Greenberg, 1990; Starostin, 1989, Orel and Starostin, 1990, Sverdrup 1995, 1999). Of these there is a major divide east-west, the eastern group comprising Sino-Tibetan, possibly Yenesseian and Na-Dene.

Austric comprise the larger language groups Austro-Tai languages, the Miao-Yao-She languages and several related extict languages called Man that once covered large tracts of Eastern and Southern China, the Austronesian languages and the Austro-Asiatic languages of India and Indo-China (Bellwood 1991; Peiros 1990).

Amerind comprises all Indian languages of the American Continents, except the Na-Dene languages, a Dene-Sino-Caucasian language group and the Eskimo-Aleutian, distantly related to the Nostratic language group (Ruehlen 1988; Greenberg 1987; Greenberg et al. 1988; Shevoroshkin 1990; Nikolaev and Mudrak 1989).

Niger-Congo, **Nilo-Saharan** and **Khoisan** are the general African language families, **Indo-Pacific** is a language family comprising Andamanese, Papua-New Guinean and Tasmanian.

The research in inter-language grouping comparisons has been brought to the attention of a wider audience after an International Conference on Language and Prehistory at Ann Arbor in 1988, arranged by the Professor of Slavic languages, Vitaly Shevoroshkin, Professor of Slavic languages and literatures at Ann Arbor, and edited a series of publications with material from that conference (Reconstructing Language and Cultures, 1989; Explorations in language macrofamilies, 1989; Proto-languages and proto-cultures, 1990; Dene-Sino-Caucasian languages 1991). The professor of Archaeology at Cambridge, Colin Renfrew, has written several books in European prehistory and initiated a total revision of European prehistory. Renfrew has brought transdisiplinary scientific thinking to a very traditional field of science, and presented inovative results. Renfrew's articles have started a vigorous debate on many aspects of archaeology, and initiated a complete rethinking of what causes evolution of language and cultural change. The phyologenetic trees are used to present the evolution and history of languages. This approach has been criticized in the literature as being too simple and omitting many aspects. The phylogenetic tree is of course nothing but the projection of a multi-dimensional figure onto two-dimensional paper. It implies that several different phylogenetic trees may be all correct because they represents different projections onto paper.

3 Objectives

The objective of this study is to mathematically model the language distribution patterns in Eurasia as a result of major movements of paleolithic and mesolithic peoples in Eurasia during the time period from 100,000 BC to 10,000 BC, and on this overlay the effect of the neolithic transition 10,000 BC to 2,000 BC causing a demographic inflation of the population sizes. The models is much based on ecological mechanisms for driving the population transfer. The calculations are analyzed by using linguistic information, genetic information and archaeological information, in order to obtain an overall view of language and proto-culture origins and dispersal in Eurasia. The model will be used for (1) establish linguistic classifications based on the model alone, and (2) synthesize the results of the model with the earlier language classifications of Ruehlen (1988) to yield a new picture. Several hypothesizes have been formulated, and which will be tested with the model. These are

1. The pre-colonial genetic pattern of the world's populations can not be explained mainly by demographic processes starting in Africa more than 100,000 tears ago, only if it is modified by the processes started by the invention of agriculture in the Middle East and central China.

2. Language is not the primary identifier of ethnicity and language can not be modelled by a linear dependence on genetic ethnicity.

3. The model results do not support the large language families (Nostratic, Dene-Sino-Caucasian. Austric, Amerind) proposed by comparative linguists.

4. The main driving forces for demographic expansion from the beginning until 1,500 BC are not of ecological nature.

4 Theory

4.1 Principles of change

All processes of change requires per definition a driving force. This is also true for language change. Renfrew (1987, 1989) states that ”without a true mechanism and a driving force, there can be no change”, pertaining to linguistic or cultural change, this is a basic principle very well known in basic natural sciences, indeed, it is the Second Law of thermodynamics, and has universal validity. Language change can always be modeled, as long as the kinetic rules and the boundary conditions can be properly defined. The major problems are finding numerical values for rate coefficients and field data for model verification. The model must always fulfill two conditions in order to be justifiable; It must be both calculable and it must be quantitatively verifiable. Models are especially important in research, not because they produce results of their own right, but because they allow complex and non-linear systems to be investigated and data from such systems to be interpreted. When forced to form laws of change, equations and set values to coefficients, then the formal understanding of the system is tested. There are no ”maybe's” in modeling, as all parameters are assigned quantitative values according to unique and precise rules. It is also important to recognize that some problems are so complex, non-linear and involve so many interconnected processes that no prediction with any certainty can be made without a model. Modeling language change with time and simultaneously modeling ethnic dispersal geographically may be an example of such a complex problem where the use of models are of great help. Just stiffly claiming that two languages are not related, is also a model, even if it is a simple one. Such a model does not live up to the criteria of calculability and verifiability as defined above, and is therefore of no scientific value. There are basically two ways of testing the validity mathematical models. It can be done either by testing against hard data, which means words from written records, or indications from archaeological and genetic data. The model will have to predict that certain populations advance to geographical points in space and time as indicated by archaeology and subsequently arrive at the correct final distribution of populations. Simultaneously it should match the observed pattern of language distribution before the onset of large scale political movements of peoples and fit the observed historical and present genetic pattern. In order to discuss language grouping inter-relations and explain how they can be derive from each other, we have to define the mechanisms by which we hypothesize the dispersal occurred. We will not accept that change just occur with no mechanism at all. When a language has spread to an area

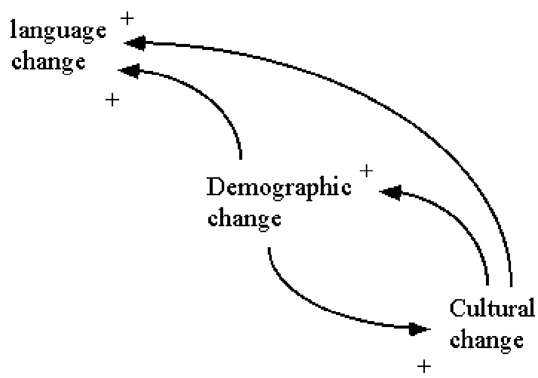

Figure 1: *The connection between language, demography and cultural change.*

or overlays the established language in a region, then this can only happen if there is a valid ecological or political mechanism for the transition. This will also have consequences for the relative relatedness of different languages, and will help us in deciding between different hypothesizes and hierarchies of relatedness which have been forwarded. Renfrew (1990) has stated that the earlier applied equation describing that states are related such as culture to population to language should be abandoned in favor of a differential model stating that the change in one system will induce change in connected systems; language change is proportional to demographic change which is proportional to cultural change. This view forwarded by Renfrew (1990), was utilized to explain the origin of the Indo-Europeans in Europe, combining the modeling of agricultural dispersal by Ammerman and Cavalli-Sforza (1984). This is identical to the statement of Levenspiel (1980), where the first equation represents the descriptive approach to industrial engineering utilized before 1950. Levenspiel illustrated the development of process modeling with time in engineering as the development through three stages:

Qualitative description	$\rightarrow$	Direct quantitative description in terms of observables	$\rightarrow$	Differential rate based on underlying physics and processing conditions

The consequence for language change would be to write language change as a differentuoal equation where the change is driven by those conditions influencing language change in every moment (demography, social order, political order, subsistence conditions, ecological conditions, outside pressure, cultural conditions and state...). Potentially the quantitatively functional dependency on the actual conditions would be more difficult to define in mathematical models for linguistics and archaeology, but the study of Ammerman and Cavalli-Sforza (1984) is an excellent example of the feasibility in this and the large possibilities in such a approach. It is also important to realize that certain problems are so complex, non-linear and multi-dimensional, that quantitative differential models are required for the solution of the problem. In such cases, the solution would simply be beyond the reach of empirical approaches, linear regressions, descriptive efforts and paper-and-pencil-only approach.

4.2 Mechanisms of language change

There are principally three different mechanisms of language change:

1. Initial colonization
2. Replacement:
   - Demography-subsistence mechanisms
   - Political mechanisms
   - System collapse mechanisms
3. Continuous development

Climate and vegetation for very strongly influencing boundary conditions to all mechanisms.

Climate change may induce a movement leading to initial colonization, climate change may also change the rate of colonization most significantly. The first and last mechanisms are obvious in their manner of working, whereas the replacement mechanisms need some further explanation. With the development of political states and more complex societies, new mechanisms of language replacement and dispersal evolved such as colonization and forced settlements, variants of the elite dominance mechanism. The introduction of superior war technologies and metal represents a possibility for conquest and political dominance. A special case of the system collapse mechanism is ecological collapse, such as desertification of agricultural land, salination problems from irrigation, rise in sea level, glaciation advances, climate change or epidemic events which cause system collapses, or even outright depopulation. This way ecological events can depopulate geographical areas by extermination or exodus, preparing it for repeated initial settlement. The other possible cause for initiating a population migration, is overpopulation in a case where child mortality is decreased simultaneously with an increase in fertility. Then a relative shortage of land can occur and a migration be initiated.

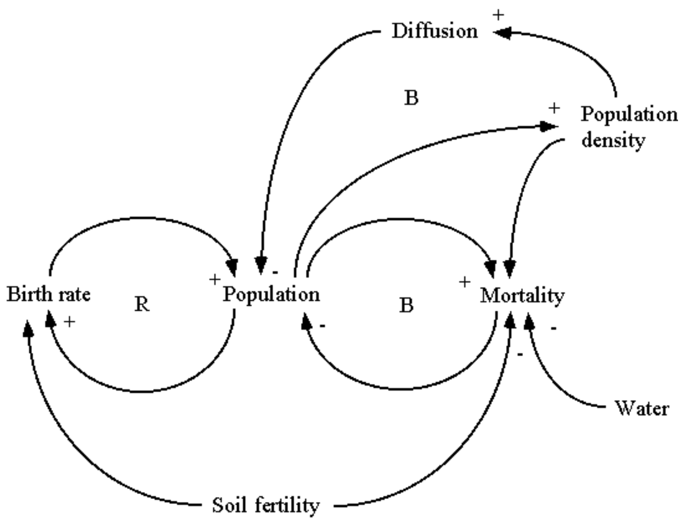

Figure 2: *CLD of the basic population model as it was realized in the LANGUAGE model.*

4.3 Neolithic transition

Dr. A. Ammerman and the Professor of Genetics at Stanford University, Dr. Luigi Lucca Cavalli-Sforza modeled the genetic pattern of Europe, using a demographic diffusion model to simulate the effect of the neolithic transition in Europe as early as in 1984. The prehistoric transfer of people into Europe correlated well with the available dates of first appearance of neolithic farmers. The model was based on a demographic diffusion principle. The present study owes much of its basic principles to that study. Their modeling patterns were used by Renfrew (1990) to draw conclusions on the origin of the Indo-European language. Ammerman and Cavalli-Sforza (1984) found that any type of ecological advantage permitting a higher population density than the aboriginal population, will eventually evolve into wave-of-advance moving over the territory, where the population change occur in the wave front (Fig. 6). Over flat landscapes such as in central Europe, the wave of agriculture advanced on the average 800-1,000 km per millennium. In ecologically less advantageous conditions the rate of advance will be less. The demography-subsistence mechanism imply that the original inhabitants are either outnumbered or assimilated, in principle no violence is necessary. There are no migrating hordes, and no planned colonization as the greeks did much later, but rather the slow diffusion forward by a modest random and local migration activity. This is equivalent to the situation where the son will make his new farm next to his fathers farm in the general direction of available new land. The mesolithic groups pre-occupying the land in much smaller number will simply be massivly outnumbered or assimilated, unless they adapt the more superior food production technology. The archaeological record will not show any trace of catastrophic events or sharp breaks in culture, as the the agriculturalists are introduced into the system as a minority, and simply outgrow the others. The record will accordingly show a continuous change, and a significant increase in population density. In the demographic diffusion of agriculture, we must also consider the potential for herding, implying that the growth of a population coming in, may push a part of the aboriginal population before it, thus increasing the population density of the aboriginal population and later causing a counter-pressure to occur. The idea of agriculture may also diffuse faster than the advance of population increase, which also will have a similar effect of creating a counter-pressure to the advance. Apparently this was what could have happened in the Iberian Peninsula, southern France and Scandinavia. In southern Scandinavia there was possibly an early adaption of partial agriculture by the semi-mesolithic Erteбölle culture.

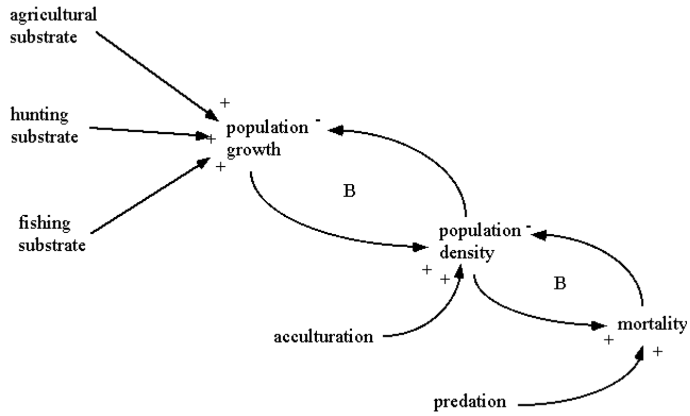

Figure 3: *CLD of the population and population submodel as it was realized in the LANGUAGE model.*

4.3.1 Demographic diffusion

The principle of partly assimilation and partly herding of the aboriginal mesolithic population is illustrated in Figure 6. The basic equation for demographic diffusion into an area such as the neolithic transition in Europe, is the general equation for diffusion and simultaneous reaction of the diffusing substance, called the **equation of continuity**, derived from the principle of mass conservation in a system (Bird et al., 1960; Cranck, 1979; Sverdrup and Bjerle, 1982, Ammerman and Cavalli-Sforza, 1984). It describes the transfer of two substances through a volume element fixed in space, in our case the transfer of two types of population through a land surface element fixed geographically. One basic assumption is that the concentration within the geographical element of infinitesial size is uniform. For each element we have the basic mass balance equation:

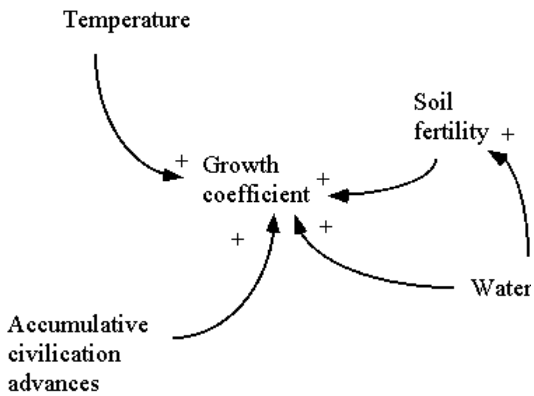

Figure 4: *CLD of the environmental adjustment of the rate coefficient in the population growth submodel.*

$$production + in = ackumulation + out \tag{1}$$

For population change this implies having human individuals as the substance. Organic growth in numbers occur when the humans convert resources within the geographical element to energy and mass in order to give birth to new members, positive production, and when individuals die, negative production. Numbers in the geographical element is also changed when individuals enter the geographical element from another element or when they leave it. Under conditions where a neolithic population is diffusing into the area, the diffusion of mesolithic hunter-gatherers out of the area will be proportional to the total number of people in the area. The diffusion of neolithics into the area will depend on the gradient, that is the difference between the population density behind the wave front and that before it. Mostly the density of mesolithics will be neglible as compared to neolithics, but there are som important exceptions. In cold areas will the fertility of the land decrease, and the saturation population density for neolithics will be lower. At some point it will sink to the level of the local mesolithic population, at which point the diffusion will come to a halt. This ocurred in Scandinavia. There are also locations in the Bay of Bisquay, in Denmark or Scotland where fishing resources or local aboundances of game allowed the density to become higher than normal. In such areas, the diffusion of neolithics will be slower or even halted completely. This is what we believe happened to the Basque speaking population between Spain and France. We assume that the farming population, utilize the landscape for hunting just the way the mesolithic population would do in addition to their farming activities. Thus within a cell, the mesolithic poulation will be subject to both adsorption into the farming population, and a large urge to leave for other hunting-grounds. For any population, this implies a basic transfer equation in traditional algebraic notation:

$$\frac{\partial p}{\partial t} = D \cdot \nabla^2 p + Q \cdot \nabla p + r \qquad (2)$$

where ∇ is the Nabla differential operator (km^{-1}), p is population density (persons km^{-2}), D is the diffusivity of population (persons km^{-2} yr^{-1}), Q is physical flow rate of population unit (persons km^{-1}) and r is the net population growth rate (persons km^{-2} yr^{-1}). Diffusion of the mesolithic population is driven by the total population density during the neolithic period. Values of agricultural diffusivity in Europe has been determined by Ammerman and Cavalli-Sforza, (1971). Mesolithic population densities varied in the range 0.03-0.2 km^{-2} in the past, under neolithic economies this the total population density can rise to 10-15 km^{-2} on fertile land.

4.3.2 Population growth kinetics

All populations exist in predator-prey relationships with the environment. This also implies man, and this relation can be described with simplified equations for the growth rate in a geographically fixed surface unit, for a population in general:

$$r = r_{growth} + r_{acculturation} - r_{mortality} - r_{predation} \qquad (3)$$

where r is the rate (persons km^{-2} yr^{-1}). Acculturation is the assimilation of one identifiable group into another group of the same species. Mesolithic populations are assimilated into neolithic populations, but rarely the opposite. Vegetation cover was estimated using the climate change models reported in the literature. Neolithic societies will tend to reduce the role of prey animals significantly as a source of nutrient, living off agricultural products and farmed animals. For the agricultural population we need parameter values for growth rate coefficient for (a) agricultural subsistence, (b) hunting subsistence, (c) fishing subsistence (persons kg^{-1} yr^{-1}), animal hunting yield, agricultural yield and fishing yield (kg km^{-2}). The first term relates to substrate from agricultural production, the second from hunting of large animals and the third from fishing and gathering. Farmers are assumed to hunt and gather as effectively as a mesolithic population.

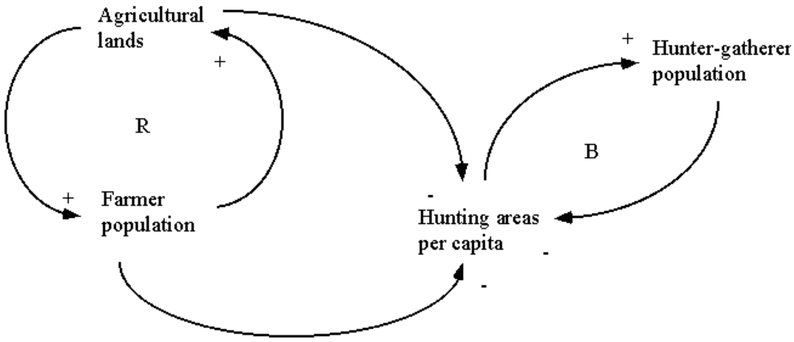

Figure 5: *CLD of the competition between a farming population and a hunter-gatherer population. It can be seen that the hunter-gatherer population has no feedback on the farmers, whereas the farmers have a limiting feedback on the hunter-gatherer. The hunter-gatherer population will be the obvious long term loosers in this game.*

The growth coefficient is adjusted for soil fertility as expressed by the weathering rate and soil carbon content, soil wetness and temperature. Total mortality is assumed to be proportional to population density saturation. For population density above the saturation density, the mortality is infinite. The saturation coefficient would be related to agricultural sustainability depending on such factors as water, temperature, soil fertility and agricultural technology efficiency. The mortlity approach infinity when the population density approach the saturation density. The physical reality of the density saturation coefficient falling below the ambient population density would be the initiation of a hunger catastophe, which would instantly reduce the population density to below the sustainability limit. For low population densities, the mortality stays nearly constant. The civilization development factor is an empirical function derived from the idea that all humans have contributed to the advancement of civilization, the collective accumulated cultural inheritage. The function thus integrates the number of peoples over the whole area in each geographic cell and time to determine the civilization advance in that cell at a particular point in time. The integral is integrated from t=0 to the time after the initial staring point, and thus does not fit calendar years. The mesolithic population is also absorbed and assimilated by the population with higher material standard and higher population density. This is assumed to be proportional to the product of the population density of the absorbing and the absorbed population. The rate of acculturation in relation to the neolithic population is positive, since individuals from the mesolithic population are absorbed. For the paleolithic/mesolithic population we have a similar set of rate expressions for growth, mortality and loss due to assimilation in the agricultural population. The growth rate will depend on hunting gathering and fishing only. The mesolithic population losses individuals due to assimilation in the neolithic population. Kinetics of populations are often modeled using Michaelis-Menten kinetics for growth minus a mortality rate (Chapra and Reckhow, 1983, Sverdrup et al., 1991). For an agricultural population, growth depend on ecological factors and the ability of the population, making growth to a certain degree independent of the population density, below the over-population threshold. Growth on a mesolithic level depend on the density and absolute volume of the resource upon which the mesolithic population live. The coefficients k_a represent acculturation, the shift to food production from hunting and gathering by the mesolithic population. Warfare and spread of contagious dangerous diseases upon contact, have been neglected as insignificant long term processes. The growth of social structure and rise of polity and central government may enhance trade and other contacts between population groups and increase the value of k_A.

4.4 Paleolithic diffusion

In the paleolithic and mesolithic stage, modeling of movements is more difficult. In this study, we have modeled the initial settlement of Europe as a function of temperature and substrate (Game for hunting). This would tend to take into account the effect of disappearance of big game, as well as climatic variations affecting the ecological conditions. Paleolithic and mesolithic mans wanderings was governed by temperature and availability of prey animals, and limited by competing groups and scarcity of prey. Accordingly, they would move along gradients in population density, prey density and temperature gradients in the absence of farming populations. The net population production depend on the amount of substrate and ecological factors, but the acculturation term is zero. The invasion of biomass is assumed to follow clearance of land from ice by instant seeding of grass. In large part of Eurasia, another species of man lived, *Homo erectus*, and in Europe also *Homo neanderthaliensis*. How the advancing modern man interacted with the populations of these other species was in principle ignored but for one exception. Modern man was not allowed to advance into Europe neither from Anatolia nor from North Africa, before 50,000 BC, and then from central Asia. This represent a forcing of the model, and generate significant uncertainty in the calculations. Without this restriction, the present genetic pattern cannot be recreated from any initial starting position. The wild vegetation invasion diffusivity in previously unvegetated landscape is similar or slightly larger than the diffusivity of agricultural advance in Europe (Ammerman and Cavalli-Sforza, 1984). The rate has been measured for post-glacial conditions at several locations (Ugolini, 1986). The ecological factors enter the calculations by the growth rate coefficients and the mortality coefficients. The factors are affected by temperature and annual rainfall, the transfer coefficient and diffusivity, are also affected by the roughness of the landscape. For the establishment of a functioning vegetation and fauna, the temperature dependence of growing trees and shrubs was used, and accordingly the temperature dependence of the lowest trophic level of the mesolithic ecological system. However, for the human population a stronger dependence was used due to the fact that humans are more mobile and thus more adaptive in terms of changing his environment. The temperature dependence of neolithic population density was set at a value derived from data of population density gradient going from

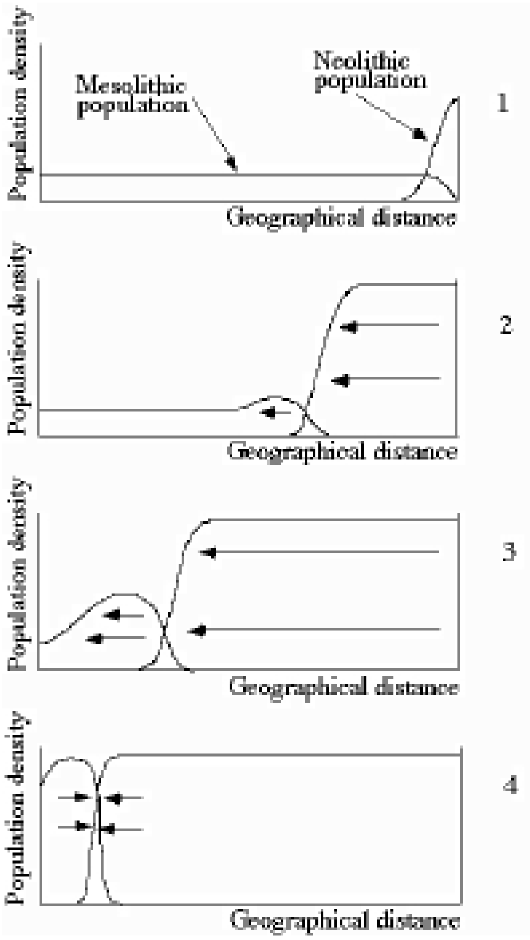

Figure 6: *The evolution of demographic diffusion over time. The wave of advance of the population density for farmers move in a front at constant speed. A part of the hunter-gatherer population is assimilated, the rest is displaced. Over time, the displaced population builds up a counterpressure to the advancing wave, if they can maintain the population density with modified food supply methods.*

southern Europe to middle Scandinavia, where the population saturation density for farmers were assumed to go from saturation in Northern Italy to approach hunter-gatherer population densities in the north. For the hunter-gatherer populations, the saturation density is dependent on the production of prey, depending on the production of grazing. Accordingly the temperature dependency observed for boreal forests were used.

Within a short time the gradient at the wave front will reach a pseudo-steady state, and the wave propagation velocity will depend only on the difference between the population density before the front and after it, however modulated regionally by landscape diffusivity and ambient temperature. The wave propagation velocity can be approximated when it is assumed that the diffusivity is constant in time and space, or alternatively, changes in D occur over timeperiods one order of magnitude faster than the adjustment of the gradient from one steady state to another. The rate of transfer at steady state in the wave front for the neolithic population can then be approximated with:

$$v_N = k_T \cdot (p_{NS} - p_{MS}) \tag{4}$$

where v_N is the neolithic population density wave velocity (km yr^{-1}), k_T is the transfer coefficient (km^3 yr^{-1}), p_{NS} is the neolithic population saturation density, 3-12 km^{-2} and p_{MS} is the mesolithic population saturation density, 0.02-0.05 km^{-2}. For the time period before agriculture, mesolithic transfer occur according to:

$$v_M = k_T \cdot p_{MS} \tag{5}$$

where v_M is the mesolithic population density wave velocity (km yr^{-1}). The transfer coefficient is adjusted for surface roughness:

$$k_T = k_0 \cdot f(\ \ ) \tag{6}$$

where k_0 is the reference transfer coefficient (km^3 yr^{-1}) and $f(\ \ )$ the landscape roughness response function (0-1). Roughness affects transfer in the same way as surface diffusion is affected on an adsorbing surface:

$$f(\ \ ) = (\frac{1}{\ \ })^n \tag{7}$$

where   is landscape slope (m km^{-1}) and n roughness order. The steady state population density is adjusted for temperature and water availability changes over time:

$$p = p_0 \cdot V(w) \cdot g(T) \cdot f(F) \cdot C(civ) \tag{8}$$

where p_0 is the reference steady state population density (km^{-1}), p the steady state population density (km^{-1}), $f(F)$ is a fertility index function, $g(T)$ the temperature dependence, $V(w)$ the water availability dependence and $C(civ)$ theumulative cultural inheritance. In general terms the water availability function is expressed with a function analogous to water absorption to soil particles:

$$V(w) = \frac{1.25 \cdot FC^{1.8}}{FC^{1.8} + 42.6 \cdot w^{1.8}} \tag{9}$$

where FC is the field capacity (m^3 m^{-3}) and w the soil water content m^3 m^{-3}). Soil fertility is a function of many factors such as nutrient availability, soil carbon content, clay content, expressed as:

$$f(F) = \ _1 \cdot \ _2 \cdot \ _3 \tag{10}$$

Transfer mechanism	Transfer rate	k_T	K_p
Neolithic diffusion	0.8 km yr^{-1}	0.3 $km^3 yr^{-1}$	5 km^{-2}
Mesolithic diffusion	0.3-1.5 km yr^{-1}	0.3 $km^3 yr^{-1}$	0.02 km^{-2}

Table 1: *The transfer rates, transfer coefficients and intrisic saturation population densities used in the calculations with the LANGUAGE model. The values were derived from archaeological data before the calculation were initiated.*

where the fertility index dependent on nutrients like Ca, Mg, K, P is:

$$ {}_1 = \frac{\min_i \left(\frac{W_i + D_i - L_i}{x_{N:i}} \right)}{\psi_{Max}} \tag{11} $$

the dependence on carbon substrate is given by the amount of carbon in the soil:

$$ {}_2 = \frac{x_{LOI}}{x_{LOI} + K_{LOI}} \tag{12} $$

and the nutrient holding capacity is dependent on the amount of clay:

$$ {}_3 = {}_1 \cdot x_{Clay} \cdot (1 - {}_2 \cdot x_{Clay}) \tag{13} $$

the symbols are ψ is flux of nutrient i, $x_{N:i}$ is the restiction ratio, i is the nutrients Ca, Mg, K, P, C, x_{LOI} is the soil clay content, %/100, x_{LOI} is the soil organic matter content, %/100, W is weathering, D is deposition, L is leaching and a coefficient. N content in the soil and long term avaliability is a dependent variable with respect to soil fertility and vegetation type. The temperature dependence is assumed to follow the Arrhenius function:

$$ g(T) = 10^{(E_a/R)\cdot(\frac{1}{T_0} - \frac{1}{T})} \tag{14} $$

where T_0 is the reference temperature (degrees Kelvin), E_a is the energy of activation (kJ mol^{-1}), R is the universal gas constant, 8.31 kJ $mol^{-1\,o}K^{-1}$ and T is the temperature (degrees Kelvin). The temperature and soil moisture saturation dependence is set at the same as that for forest vegetation, as the temperature and moisture sensitivity is related to the complete ecosystem as an entity and not the single species. We have used the Arrhenius relationship here for its simplicity of use and the easy access to annual average temperatures for Eurasia. An alternative would have been to use the temperature sum, summing up the effective temperature-growth-days during a year. The temperature dependencies used in the calculations are for demographic agricultural diffusion rate E_a=56 kJ/mol, for the Paleolithic/Mesolithic diffusion rate, E_a=22 kJ/mol, for natural vegetation growth, E_a=56 kJ/mol, and for organic matter decomposition, E_a=48 kJ/mol.

5 Input data, boundary conditions, test data

Our model of language dispersal should from the chosen starting point, arrive at the known genetic pattern observed, as compared with language dispersal in historical times. There are a number of dated events that can be used to constrain the model. The paleolithic expansion was prevented from entering Europe through Anatolia until 40,000

Event	Date
African migration to Near East	105,000-95,000 BC
Migration from Central Asia to Northern East Asia	50,000 BC
Migration from Central Asia to Southern East Asia	60,000 BC
Modern man replace neandertals in Europe	45,000-35,000 BC
Migration into Australia	40,000-30,000 BC
Amerindian migration to America	25,000-15,000 BC
Eskimo-Aleut migration to America	15,000-12,000 BC
Na-Dene migration to America	11,000-9,000 BC

Table 2: *Archaeological dates can be used to date some of the nodes in the genetic tree derived by Cavalli-Sforza et al., (1988), Cavalli-Sforza, (1991) and possibly some of the nodes in the language tree (Clark and Piggott 1985). Such data has also been used to check the performance of the model.*

BC. The calculations, rest partly upon soil data sampled throughout Far East Asia on a 0.5^o by 0.5^o grid, in Russia on a 150 km by 150 km grid, in Europe on a 50 km by 50 km grid and in Africa and America on a polygon basis approximately comparable to a 2^o by 2^o grid. The temperature is of large importance in the model, and temperature distribution patterns over Asia were utilized to distribute the effects of global change on the local climate in Eurasia. The global temperature variations over the last 170,000 years and since the last glaciation has been shown in Fig. 7, together with the average summer temperature in Southern Scandinavia for the period 12,000 BC-present. Initial settlement of Europe occurred approximately 50,000 BC from the East. In 32,000 BC, a period of very cold climate started which lasted till 23,000 BC, the Wurm-Weichsel glacial maximum. This maximum transformed the Central European fringe to the icesheet to a very cold polar desert. The paleolithic resettlement of Europe after the retreat of ice approximately started maybe as early as 23,000 BC, but gained momentum 15,000-17,000 BC due to significant warming of the climate, when the polar desert disappeared. It represents an ecological event which can have carried a new population into a virtually empty region. The change from paleolithic to mesolithic also represents a large cultural change with possibly ecological causes, capable of changing the population density and hence population. The upper paleolithic had been based on reindeer and its hunting grounds on the tundra relatively close to the continental icecap. The period called Younger Dryas, a cold period lasting from 8,800-8,300 BC, had a particularly profound effect on the conditions. It caused the already established northern boreal forest zone in Europe to revert to cold tundra and arctic desert. This reduced the population density to a very low level. The end of the Younger Dryas period saw the settlement of culture bearers throughout Europe from central Asia and the Near East speaking a North Caucasian language, filling the empty ecological space left as the reindeer hunters of the glacial period pulled north with the ice and prey. This changed during transition to the mesolithic, about 10,200-8,800 BC or after 8,300 BC, when the climate improved over larger parts of Europe (the Alleröd oscillation or more probably at the end of the Younger Dryas cold period), and the reindeer economy only survived for a period in the Alleröd-Lyngby culture in Denmark. The mesolithic culture involved a more sedentary lifestyle relative to the reindeer cultures of the tundra. Research has established connections and relationships between languages on pure linguistic data. These linguistic reconstructions are based on

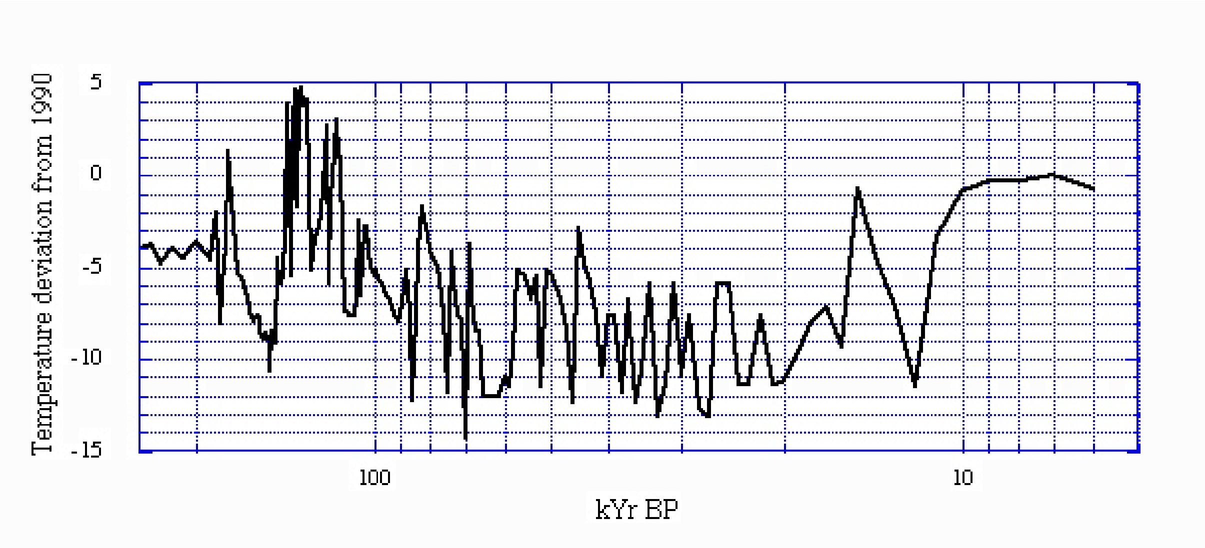

Figure 7: *Example of temperature data used. Average temperature in Greenland during the last 250,000 years. The data was digitized from the published work of Dansgaard et al., 1990 given as a diagram in Calvin (1994). A number of rapid changes can be seen. The changes are especially large and rapid in the time periods of 145,000-115,000 BP, 13,000-12,000 BC and 11,000-9,900 BC. These time intervals are very important in the history of man.*

rules which are basically the same language change laws which have been brought to play between languages within establishedlanguage families. Especially the Indo-European languages and the languages of the Pacific Ocean have been thoroughly studied, and many of the proto-languages constructed. The same rules can also be applied when starting from proto-languages in order to study the relationship between language families. The fact that the rules must work both ways, constrain the model of language change over time considerably more than just using the model for bilingual comparison or comparisons from within a language family. The model is not correct unless the derived proto-language from several languages and the derived proto-language from the proto-proto-language are identical. This has changed some of the rules for language change (Greenberg, 1990; Kaiser and Shevoroshkin, 1989). The strength of the outside-inside approach is of course that the information inside the language group is independent of the information used from the outside of the language group, i.e. the information from other languages in the same supergroup. In this study the the diagrams over language family structure is generally based on the model calculations, and not the structure of the group as it has been derived from linguistic data. One aim has been to test the hypothesis that the language phylæ Nostratic, Austric, Dene-Sino-Caucasian etc., are valid genetic language nodes that would be supported by the model calculations. We cannot prove this, but we can show that it is possible, and maybe very plausible. Thus, our phylogenetic trees should best be compared with language classifications such as that of Ruehlen (1988, 1994). The language relationships are presented as phylogenic trees.

Archaeology and history forms the ultimate data backdrop for checking the theories. Archeological artifacts do not carry any indication of the language of their makers, unless inscribed in written language, but still can give indications of when a certain type of cultural change took place as well as indications about the relation of individual cultures to other cultures. The first appearance of man in a region is valuable information. Recording

Event	Dating method	Date	Reference	Model prediction
Proto-Dene-Sino-Caucasian	G	8,000-7,000 BC	Starostin 1989	20-50,000 BC
Proto-Dene-Sino-Caucasian	G	8,000-7,000 BC	Peiros 1990	20-50,000 BC
Proto-Sino-Tibetan	G	6,000-5,000 BC	Peiros 1990	7,000 BC
Proto-Sino-Tibetan	G	7,000 BC	Yakhonotov 1977	7,000 BC
Proto-Sino-Tibetan	A	7,100 BC	Chang 1990	7,000 BC
Proto-Austric				7,000 BC
Proto-Austro-Tai	G	6,000 BC	Reid 1989	6,000 BC
Proto-Austro-Tai	G	6,000-5,000 BC	Peiros 1990	
Proto-Austronesian	G	5,000-4,000 BC	Peiros 1990	
Proto-Austronesian	A	5,000 BC	Tryon 1985	5,500 BC
Proto-Nostratic	G	11,000-10,000 BC	Starostin 1989	12,000 BC
Proto-Afro-Asiatic	G	11,000-9,000 BC	Militarev 1989	12,000 BC
Proto-Afro-Asiatic	G	10,000-9,000 BC	Starostin 1989	12,000 BC
Proto-Akkadian-Semitic	G	2,300 BC	Starostin 1989	5,000 BC
Proto-South Semitic	G	2,000 BC	Starostin 1989	4,000 BC
Proto-Altaic	G	4,500 BC	Starostin 1989	4,500 BC
Proto-Dravidian	G	3,000 BC	Peiros and Shnirelman 1989	3,700 BC
Proto-PIE-Kartvelian	G	9,000 BC	Diakonov 1985	9,000 BC
Proto-Indo-European	G	6,500 BC	Diakonov 1989	7,000 BC
Proto-Indo-European	A	7,000 BC	Renfrew 1989	7,000 BC
Proto-Indo-European	G	4,200 BC	Swadesh 1972	7,000 BC
Proto-Italic-Celtic	G	3,900 BC	Swadesh 1972	6,000 BC
Proto-Italic-Slavic	G	3,000 BC	Swadesh 1972	6,500 BC
Proto-Germanic-Slavic	G	2,500 BC	Swadesh 1972	5,000 BC

Table 3: *Approximate dates of separation of some language groups as estimated using glottochronology (G) or archaeology (A). The dates were taken from the authors indicated.*

the time for major cultural changes may also be helpful. A set of dates for the first arrival of modern man throughout Eurasia are available. The model must be able to reproduce calculated values reasonably close to these values. Archeological dates can be used to date some of the nodes in the genetic tree derived by Cavalli-Sforza et al., (1988), Cavalli-Sforza, (1991) and possibly some of the nodes in the language tree (Clark and Piggott 1985). Data on first date of arrival has been listed in Tab. 2. Agriculture arose independently certainly in two, maybe three locations in Eurasia, (1) in the fertile crescent, (2) in South-Central China and (3) probably in Northern China. Approximately 12,000 BC, wheat was harvested systematically in the Natufian culture in southern Palestine. The plants harvested, were wild and the full domestication process took perhaps a millennium. At a single habitation site, domestication can take considerably shorter time (50-100 years), but since the process has elements of randomness, it probably took longer for a whole region to systematically adopt cultivation as the major source of food production. Wheat is cultivated on a larger systematical scale in the Levant and in the Northern part of the Fertile Crescent around 8,000 BC. During the initial phase when the domestication is taking place and cultivation technics are developed, the efficiency of cultivation steadily increase. When a critical yield is reached, farming becomes the dominant source of food, and the spread outward through demographic diffusion starts. Around 8,000-7,000 BC, initializing agricultural nuclei was established around Catal Hüyük in the Conya plain in present Turkey (Proto-Indoeuropean), the Natufian culture centered on Jeriko and Wadi Arabi (Proto-Afroasiatic), maybe at Cayonu in eastern Turkey (Proto-North Caucasian, Hatti), around Ali Kosh in the Southern Zagros Mountains (Proto-Elamo-Dravidian) and maybe also at Jeitun in Transoxania (Proto-Ugric-Altaic). We hypothesize that this initial phase concluded the division of the language group called Nostratic, a process that must have started earlier with the retreat of the ice-sheets over central Europe. Agriculture based on millet and later wheat started as an independent invention in Northern China occurred before 6,500 BC. At the same time, wet rice cultivation was initiated in the central Yang Tze River region of China. This was perhaps a development initiated from the Fukien-Tonkin area in Southern China around 8,000-7,500 BC, where horticulture was the initial form of agriculture. The introduction of agriculture into the Indian subcontinent probably occurred from Anatolia (Renfrew, 1989), entering India around 4,500 BC moving into central and east central india by 3,000 BC (Peiros 1990). Similarly, rice agriculture penetrate from the east into central India around the same time. The settlement of America by Amerindians is hypothesized from Eastern Asia and the settlement by Na-Dene Indians is hypothesized to have originated from the Mongolia-Amur region, as indicated by fossil dental genetic data (Turner, 1989). The settlement of America by Eskimos and Aleutians is also inferred to have occurred from the Amur region. The settlement of Japan by Jomon and Southern China occurred from the Sundaland region and the much later migration of Japanese to Japan from Korea and Northeastern China. The dates derive from archaeological dating at specific sites, possible languages affected by the change have been suggested. The different dates were taken from McEvedy, (1985); Renfrew (1987,1989); Renfrew (1989); Benedict, (1975); Bellwood, (1991); McAlpin, 1981; Zvelebil and Zvelebil, 1990; Turner, (1989), Greenberg, Turner and Zegura (1988) and Cavalli-Sforza (1992). Important corroborative data has come from different types of genetic research on the populations of the world. One approach use present populations, and analyses a different number of genetic markers. The relatedness of the investigated populations can then be assessed and approximately dated. Assimilations and admixtures are the major source of uncertainty, even if the most evident melting pots for populations have been avoided in the investigations. The distribution of principal components of different genetic markers as revealed by a synthesis of different genetic markers not sensitive to climatic adaption in Eurasia. It is interesting to study the genetic relations measured by Cavalli-Sforza et al., (1988) and Cavalli-Sforza (1991) on different human populations. The relative relatedness of different populations was quantified using a number of different genetic markers, and avoiding such genetic traits which are believed to be affected by climatic adaption (Menozzi et al., 1987). The genetic tree as revealed in two different studies are shown in Fig. 15. Whereas political mechanisms and elite dominance can change language, only quantitatively significant population migrations and demographic expansions show up in the genetic information. To Fig. 15 some footnote remarks can be made: The Ethiopian people is known to have acquired a Semitic language in historic times. Tamil and Lapp peoples are closer related to the Altaic and the Ugrian peoples, but both have been exposed to heavy admixture of Scandinavians and Indo-Aryans, respectively. The Tibetan people was a Mongolic tribe which acquired Sino-Tibetan language in historical times. The Ainu people is very heavily admixed with Japanese, and the genetic signature may be totally muddled. The Siberian Turkic peoples may have experienced admixture from Paleo-Sibirian groups. A similar genetic tree was constructed based on nuclear DNA, indicating an African branch, a West Eurasian branch and an East Asian branch (Stringer, 1990). Cavalli-Sforza et al., (1988) had unfortunately not sufficient data on the Basque, Caucasian and Northern Chinese populations to assess their proper place in the phylogenetic tree, their mutual connection as indicated by linguistic comparison, and the linguistically indicated affiliation with Proto-Nostratic. The Basque sample was pooled with the European, but other studies show the Basque population group to be genetically very different from the present European population. It is generally accepted that the Basque are a remnant of the Pre-Indo-European population of Europe (Bodmer and Cavalli-Sforza 1976, Nei and Roychoudhury 1982). In the study of Cavalli-Sforza et al., (1988) Sino-Tibetan was by mistake assigned to the Southern Chinese population group, but this is more correctly placed within Austric. Chinese linguists are well aware of the fact that the population of southern China (Chang 1990) spoke an Austric language distantly related to Miao-Yao. Miao and Yao are the relict languages of Southern China, and was earlier spoken over most of the Southern Chinese territory (the Chinese called it "Man"). Through political mechanisms and events, recorded in old texts, in the distant historic past (Han dynasty), Miao, Yao and similar languages of central China were replaced with Old Chinese. This is supported by data from Turner (1985) which also shows a genetic difference between the Northern Chinese population and the Southern Chinese population, "sundadontry" of Southern China versus "sinodontry" of Northern China. The Southern Chinese population tend to cluster with the Japanese and the Indo-Chinese. The affiliation of Japanese with Southern China may come from the fact that the Austric agricultural diaspora started here sometime during 8,000-7,000 BC. Turner (1985) showed using fossil dentition that the origin of Jomon may be in Southern China. The connection of the Ainu with Southern China is also supported by fossil dental data. Whereas different political mechanisms migrations, demographic diffusion and expansion and elite dominance all can change language, only quantitatively significant population migrations and demographic expansions show up in the genetic information. Some of the nodes in the genetic tree can be dated on archaeological data, but models for genetic change over time share some of the same uncertainties as the glottochronological model. The rate of evolution is not necessarily constant, especially in the view of the the very large climatic and ecological changes seen in the paleolithic. The calculations are carried out in two steps. Phase 1 comprise the initial peopling of Eurasia by modern man and spans the time period 100,000 BC to 8,000 BC. It is initialized with 10,000 individuals in Northeast Africa in the location of present day Cairo, an equal number stand ready at present day Djibouti on the coast of Ethiopia, on January 1., 100,000 BC, all having uniform language, new brains and full of initiative. The known initiation locations for the introduction of agriculture in the old world can be summarized as follows. The main loci for demographic expansion, initiated by the invention of agriculture are (1) in the fertile cresent connected to the Nostratic languages Afroasiatic, Indoeuropean, Kartvelian, North Caucasian and Elamo-Dravidian, (2) Anyang, Northern China connected to Sino-Tibetan and (3) Fukien connected with the Austric languages. Additional secondary loci of lesser importance for the final global result may be Southcentral Sahara (4), connected to the Nilo-Saharan languages, and Transoxania for Altaic languages (5). Phase 2 comprise the neolithic transition in Eurasia during 8,000 BC to 1,500 BC. The demographic diffusion due to neolithic transition is started in the Far East in the Chinese Central Yellow River Vally approximately 7,500 BC, at the same time in southern Chine in Fukien. It is also started in the Jerico 8,800 BC, creating secondary initiation centres by 6,800 BC in different parts of the Fertile Crescent and Anatolia.

6 Results

6.1 Units

The model is used to calculate the results in terms of:

- First date of arrival of wave of advance
- Geographical area covered as a function of time for
  - huntergatherer population (km^2)
  - neolithic population (km^2)

  For the neolithic population, the area of expansion and number of speakers can be integrated per language group as seen expanding from each initial nucleus.
- Population density in each grid
- Total integrated population number for
  - huntergatherer population (persons km^{-2})
  - neolithic population (persons km^{-2})
- Fraction of original language remaining, using the calculated variable isogloss rate over time

Soil fertility is calculated as a function of soil moisture and chemical weathering rate (Hettelingh et al., 1995), climate is expressed in terms of temperature, annual rainfall and annual precipitation surplus (Kuylenstierna et al., 1995). Language isogloss retention is calculated, assuming a simple linear glottochronological model, but applying different loss coefficients for paleolithic, mesolithic and neolithic times.

6.2 Paleolithic Eurasia

The calculated situation in Eurasia during the paleolithic timeperiod from 100,000 BC to 20,000 BC is shown in Figure 8. The map show the position of the front of the wave of advance at different times. The lines are isochrons for the first appearance of modern man throughout Eurasia. The black shaded areas indicate mountains, and due to a lower sea level, much land in the Sunda region was dry in the paleolithic. The hatched areas represents areas under ice. The glaciation situation has been simplified here in order to allow to show the whole movement in the period from 100,000 BC to 10,000 BC. The map indicate how modern man initially populated Eurasia. The dates are calculated dates. The first divide between those moving southeast of Himalaya and the other moving north and west create the divide between Austic-Indp-Pacific and Australian languages on one side and Nostratic, Amerind and Dene-Sino-Caucasian languages. This divide ocurred 60-70,000 years ago according to the model. The isoglosses found between these language groups must be this old. Isoglosses that are also found in African languages must be older than 100,000 years old. Such glosses have been found, and confirm that human language is at least 100,000 years old. Nostratic and Dene-Sino-Caucasian divided as separate languages from their common Eurasian ancestor in central Asia 40-50,000 years ago. The period from 67,000 to 58,000 BC was among the coldes during the glacial period, and at this time Central Europe south of the ice was probably a rather sterile polar desert.

This changed after 45,000 BC when a short period of somewhat warmer weather followed. The northern part will eventually develop into a Dene-Sino-Caucasian group in the West and North and and Nostratic languages in the south and northeast, the southern movement contiues south to become Austric, Indo-Pacific and Australian languages. The transit through Siberia come in the time period 50,000-30,000 BC. After 40,000 BC this region was very cold, and only a small number of people may have passed through. The number indicated by the model for the population density in this area is small, and suggests that this is a narrow section. The implication is that only a part of the genetic signal may have passed this constriction, making the Far Norytheast Asian population genetically distinct from the western far east Asian population. Linguistic and genetic data indicate that Amerind and Eskimo-Aleut must have taken separate paths in North-Eastern Asia, and that they must have taken separate paths to America. The model does not have the required resolution in this area to explain any of that. Eastern Eurasian languages splits in at two or three branches in Siberia in the time period 40,000-30,000 BC. One northern branch continues eastward to become divided into Amerind, Eskimo and Chuckchi-Kamchadal. One branch may move into the Amur-Korea area and form Gilyak and maybe a part of what later was to make one of the elements in Ainu. Dene-Sino-Caucasian is originally a language of the western Eurasian reindeer hunters, which at the end of the glaciation after 30,000 BC spread eastward across Russia and Siberia. The initial internal split in this group may have been as early as 50,000 BC into an eastern and western branch. This is represented by the Macro-Caucasian group (Bengtson 1991a,b,c; Sverdrup 1995, 1997), containing at least the ancestors of a western group of Basque, Pictish, Iberian, a central group consisting of Rätian and Etruscan,

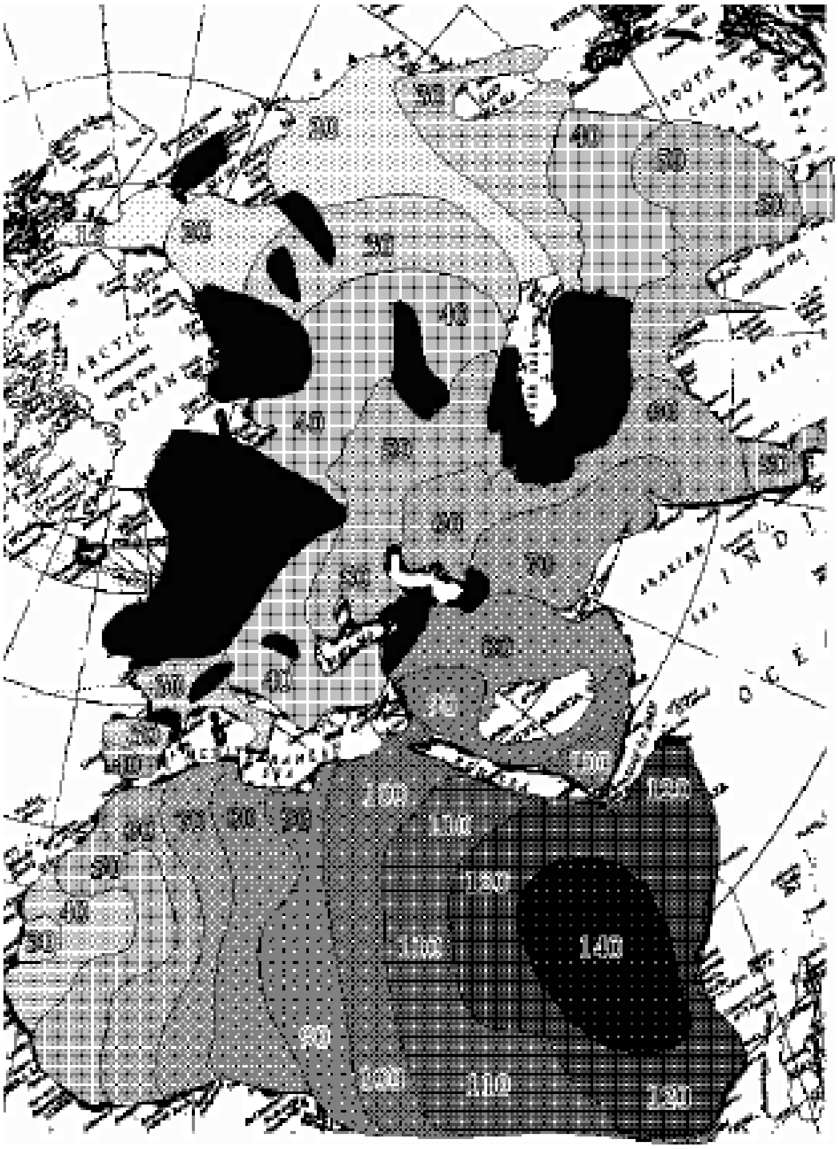

Figure 8: *The calculated situation in the timeperiod 100,000-20,000 BC. The map show the calculated first appearance of mesolithic cultures in Eurasia.*

North Caucasian and another central group with Sumerian and Burushaski languages. The eastern group, is what later became Sino-Tibetan, Yenesseian and Na Dene. During the last cold period of the early post-glacial 25,000-19,000 BC, these populations were shifted southward, thus establishing themselves in Northern China. This implies that the model suggests that the ancestors of the Sino-Tibetan speaking Chinese came to China from the very cold north approximately 12,000 BC. Any earlier Proto-Nostratic population in the area would have disappeared. The very cold period of the third Weichsel-Wurm glacial maximum 26,000-15,000 BC moved the tundra border south, and possibly pressed population groups in Europe and Central Asia farther south. Something similar but less severe occurred during the more recent Older Dryas and Younger Dryas cold periods. In Europe, this implied that the population density fell to very low level, and large regions being polar desert would have been inhabitable. As the temperature rose after 21,000-15,000 BC, there would have been a reflux of Caucasian languages northward into Europe. There was a reflux from Iberia and Northern Africa along the Atlantic border towards the north, and another reflux started from Anatolia going northwest. According to this scenario, the Eastern European branch of North Caucasian represented by Lemnian, Rätian, Elymian and Etruscan divided from Proto-North Caucasian in Northern Anatolia approximately 12,000-15,000 BC. The western branches that originally split from Proto-North Caucasian 30,000-40,000 years ago, divided internally into Proto-Basque, Proto-Iberian, Proto-Pictish after 15,000 BC. This deduction is supported by the pattern of Gravettian statues. Throughout Europe and Western Asia, small stone statuettes of similar shape and basic design have been found (Renfrew 1994; Powell 1977). They all originate from the time period 32,000-20,000 BC. The great consistency in form suggest some form of information exchange over the area covered by the finds. The area covered by all these finds represents an area with some type of cultural or maybe linguistic unity. The information exchange required to create such an uniformness, must have been occuring at a transfer rate at least at a rate where the whole area involved could be traversed in one third to one fourth of the span of the time period. Thus the information signal velocity must have been at least 1,000 km per millenium. It is suggested that the language in this area was Proto-western-Sino-Caucasian. It eventually split up into the Western branch which later became Basque, Pict and may be Iberian, a central European branch later developing into languages like Etruscan, Rätian, Elymian, Lemnian and the non-Indoeuropean substrate language found in southern Italy, Balkan and Greece, and the Caucasian branch developing into Hatti, Urarti, Hurri, present day Northwest Caucasian, Northeastern Caucasian and the rather distinct Sumerian. The cultures in this area have been called Capsien in the Western part and Tardenosian in the central part, and the overlap with the Gravettian statuettes is almost complete in the western and central parts. But the Capsien culture may also be one with a different genetic heritage and language. It may be remnant of the initial peopling of North Africa. In that case, Iberian or Tartessian may be remnants of this language. Bone remains would tend to suggest that the population north and south of the strait of Gibraltar was the same at this time, favoring an earliy Dene-Sino-Caucasian population. For the period 30,000-16,000 BC, cave art occur throughout large the same area. The cave art of northern Spain and southwestern France is famous, but very similar cave art has also been found in Sicily and in the Ural mountains. No cave art is known from central Europe, but animal figures in stone occur over the same area as the female figurines for approximately the same timeperiod. It is suggested that all this art arose within the same cultural area and mass of cultural inheritance. The uniformity seen in art and sculpture suggests that the different groups communicated culturally enough for the language with in the area to diverge at a lower rate and stay understadable between groups.

Thus branching to dialect level is assumed, but not to single language status. The model calculations show that Sino-Caucasian groups in the fertile crescent, forebearers of the Hurrians, Urartians and Sumerians are completely confined by Nostratic languages to the West, South and Southeast, In the north, the Caucasus mountains form a slowly penetrable barrier, after which the steppe begins. Hence an expansion of Caucasian has no outlet to any significant amount of territory fit for agriculture. The implication of this is that the western Caucasian languages did not really start to diverge until the cultural changes that occured with the advent of the mesolithic around 13,000-12,000 BC. Then the population densities rose somewhat, and there was a change in economic base and probably as a result also in religion. The calculated initial situation in 12,000 BC, before the advent of agriculture is shown in Fig 8. The population density in each grid depend on several ecological parameters, where water, soil fertility and temperature play the major role. As climate change, diffusion population transfer and saturation population densities will change.

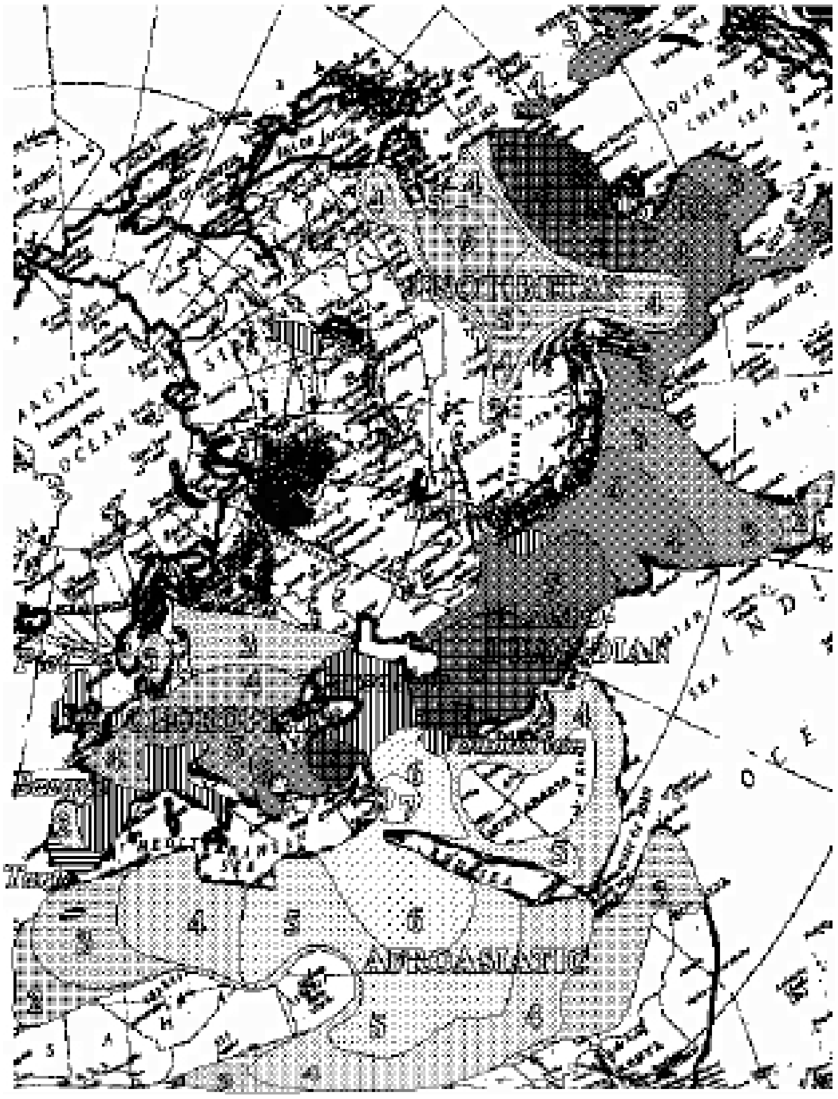

Figure 9: *Calculated expansion due to demographic diffusion driven by agriculture for Indo-European, Afro-Asiatic, Ugrian-Altaic, Elamo-Dravidian, Austric and Sino-Tibetan for the time period 7,000-2,000 BC.*

6.3 Neolithic Europe and Africa

The known initiation locations for the introduction of agriculture are (1) in the fertile cresent connected to the Nostratic languages, Eastern Afroasiatic, Indoeuropean, Kartvelian and Elamo-Dravidian, and the non-Nostratic North Caucasian, (2) Northern China connected to Sino-Tibetan and (3) Fukien connected with the Austric languages. Wheat is assumed to have been domesticated just after 9,000 BC, but the lag-phase when the practice takes root and expands rather passively in the fertile crescent takes place 9,000-

7,000 BC. During this time the practice spreads as an idea faster than the population increase, causing agricultural practices to cross several language borders at this stage. This implies that groups speaking Nostratic languages and North Caucasian get inoculated with agricultural practices. By 7,000-6,500 all nucleus sites reach saturation population density and start expanding outward. The neolithic revolution has just started. Initial language positions in Central Asia at the inception of agriculture is based partly on guesses and partly on modeling for the period 120,000 BC to 7,000 BC using the model. The calculated situation for the time period from 7,000 BC to 2,000 BC is shown in in Fig. 9. Nostratic has completed the process of crystallizing into Afro-Asiatic, West-Nostratic comprising Indo-European and Kartvelian, and East Nostratic comprised of Elamo-Dravid, Ugric and Altaic. The transition to agriculture creates a wave of advance traveling out radially from the fertile crescent. In 3,000 BC, Nostratic has reached the Atlantic Ocean and the Northern border of agriculture. Etruscan gets confined in the mountain valleys of the Central and North Appeninne Mountains in Italy. Basque, Pict and Etruscan occupy confined enclaves. Iberian may also be such an enclave, but the model cannot distinguish between this alternative and Iberian being an Afro-Asiatic language. Fig. 16 show the relation between the languages included in the Nostratic group. The northern branch of eastern Nostratic (Altaic, Ugrian) adapted agriculture in Northern Persia/Southern Turkmenistan (Jeitun) and moved north into central Asia. Ugric-Yukagir-Altaic expanded straight north confined by the Caspian Sea and the Hindu Kush, Finno-Ugrian expand into the area between Volga and Ural rivers. Altaic languages occupy the territory east of the Ural river towards the mountains. Further up Volga, this wave of Finno-Ugrian meets Slavic languages. Finno-Ugrian can reach Finland and Northern Norway approximately 2,000-1,500 BC. Proto-Elamo-Dravidian diffuses out from the inner eastern shore of the Persian Gulf together with agriculture starting at at the same time as the other Nostratic languages. The languages that moved north and east will develop into Dravidian. It has been acertained that Elamitic languages were once spoken over most of the Iranian plateau in early historic times, 3,000 BC (Lamberg-Karlovsky, 1978). Approximately 3,500 BC, the wave of agriculturalists speaking Proto-Dravidian language meets a comparable wave

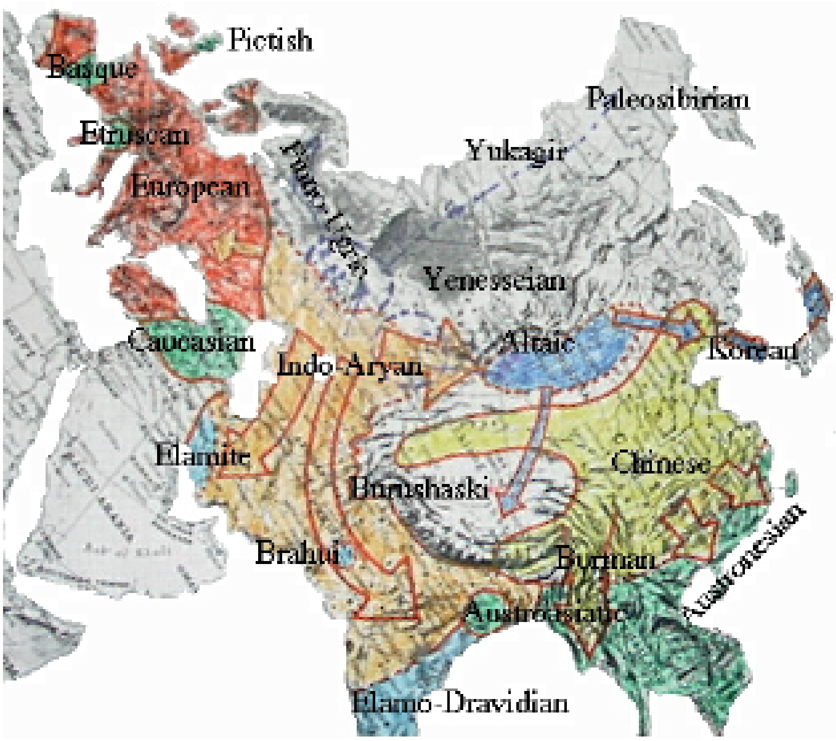

Figure 10: *Population movements 4,000-1,000 BC, driven by political factors. The shown movements were not calculated with the LANGUAGE model, but inferred from published literature.*

of advance of peoples speaking Proto-Austroasiatic in the middle of India. Fig. 12 and 13 show the development of population numbers in millions in the areas going through the neolithic transition, and show the accumulated population number in millions in China highlighted. It can be seen how the huntergatherer population is replaced by a neolithic population, but that the hunter-gatherer population remain as not all land is suitable to agriculture. The points represents the historical population counts available for China. During Han times, the first population count was held in China and number of 52 million was obtained. This did not comprise whole China as we understand it today, and the population for the whole area may have been 65-75 million. Fig. 12 show the integrated number of people of the world during the period 9,000 BC-2,500 BC as calculated by the LANGUAGE model. It is evident that the hunter-gatherer population is relaced by the neolithic population. The model estimate that the world had 400 million inhabitants in 200 BC, excluding America. The standard deviation of the calculation from observed archaeological data was calculated using:

$$= \sqrt{\sum_i^n \frac{T(obs)_i - T(calc)_i}{n-1}} \tag{15}$$

The archaeological data was taken from Cavalli-Sforza (1988); Larichev et al., (1988); Howells (1988); Chang (1988). The coefficient of correlation between observed and calculated was r^2=0.91 and the standard deviation =5,100 years, roughly equivalent to an accuracy of +/-18% on the calculated value. Several inherent uncertainties of the model, model geographical resolution and uncertainties in input data may theoretically be added to the observed uncertainty in the test. The accuracy observed in the test is surprisingly good. This is surprisng since large simplifications have been made in the model. It may be a sign that the model despite the simplificatiosn do incorporate the most important driving factors.the present accuracy of the LANGUAGE model for the paleolithic period. There is one anomaly that creates problems for the assumptions behind one of the languages.

Datings of first pottery, domesticated animals and a semi-neolithic type of culture in central Sahara overthrow the simple assumption that all Afroasiatic languages expanded from Jeriko with agriculture (Kuper 1979). The archaeological data suggests an expansion of a pottry culture straight east and west starting 9,000 BC from the Hoggar-Tibesti region. This may have been the original speakers of Nilo-Saharan. The data also suggest that the Mahgreb region was continuously populated with the peoples that were bearers of the Capsien culture, whereas south of the Atlas, the present desert, then steppe was inhabited by peoples of African stock (Nilo-Saharans). The Capsien cultural bearers are with all probability the decendants of the original Cro-Magnon population in this part of the world. The Basque are believed also to be the decendants of

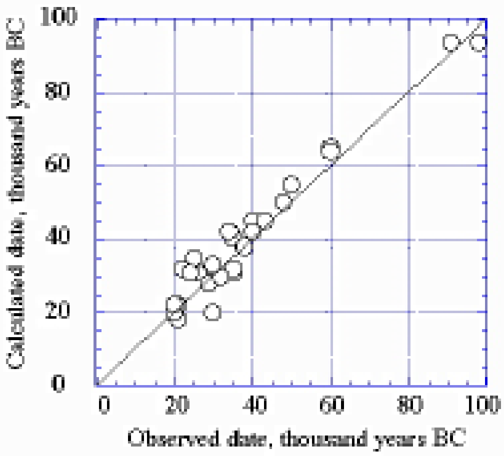

Figure 11: *Date of first arrival in the interval 100,000 BC to 20,000 BC plotted against archaeologically observed dates.*

them as also studies on skelettal remains seem to suggest. The model can be reset and run with this new set of initial conditions, and this yields a sligtly different internal relationship for Afroasiatic languages. It is probable that the initial split of Afroasiatic took place in central Sahara, and expanded outward as Chadic, Kushitic, Beber and Semitic. It must then have been Old Semitic that expanded north-, east- and southward from Jeriko, but the reflux back into North Africa moving over the semi-neolithic culture there brought the Koptic-Berber branch. By the time the expansion would have reached Libya by approximately 4,500 BC, the severe drougt there would have effectively have limited the impact of the demographic expansion to a small coastal band of North Africa. The neolithic culture reached the Canary islands by this process by 4,000 BC. The earlier language in North Africa was according to the model of the same origin as Basque and probably Iberian (Capsien). The Model suggests that a small remnant of the Capsien may have survived as an isolate in the central Atlas mountains. This would also seem to explain what has been called an Euro-Africanian language group to which several sub-Saharan languages, Berber and Basque has been assigned (Mukarowsky 1975; Scharf 1985). In reality, the resemblance with Berber must be from substrate influences, whereas this substrate would have a true genetic affiliation with Basque. Studies on placenames by Roman (1993) may suggest this is correct. The implications of this is that Afroasiatic should be more distantly related to the other Nostratic languages, and not belong to the core group.

6.4 Neolithic East Asia

Fig. 9 show the calculated demographic diffusion initiated by the inception of agriculture. For the calculation two primary focuses were used, and a third secondary was allowed to form in the Central Yang Tze Valley. Austric has expanded with rice agriculture into Indo-China and Eastern India. The western wave of advance meets with the eastern wave in Eastern Central India. The neolithic transition occur in northern China through the cultivation of foxtail millet. North Chinese meets the Austric expansion of rice cultivation coming from the south, north of the Yang-Tse Valley.

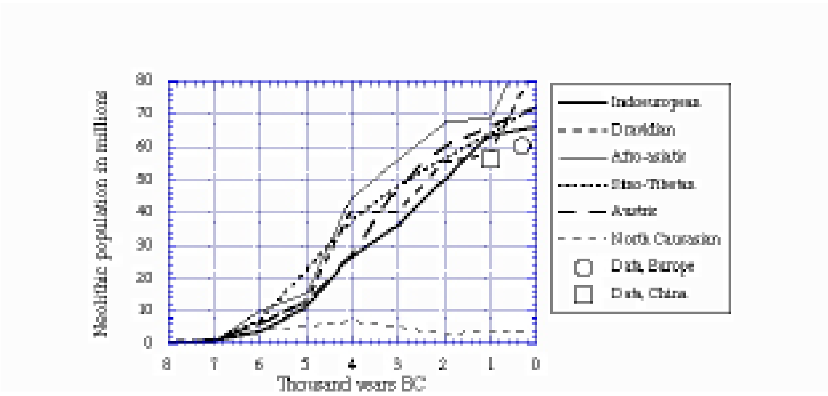

Figure 12: *The development of Eurasian neolithic population numbers with time in the interval 10,000 BC to 1 BC, as calculated with the LANGUAGE model. The points represents historical population estimates.*

This leads to the conclusion that Austric must have had an ancestral home in Southern China and that Chinese language entered China from the north or northwest. A later intrusion of Chinese into the topographically very broken and fragmented region by political mechanisms would also explain why Austric languages like Miao-Yiao and Austroasiatic are very fragmented in the region (Ruehlen 1988). The calculation can be interpreted to suggests that Burushaski gets isolated from other Dene-Sino-Caucasian languages in the Pamir Mountains, close to where it is found today, by Dravidian and Ugrian-Altaic languages around 5,500 BC.

The model suggests that Burushaski is closer to the western Dene-Sino-Caucasian language group, whereas Yenesseian is closer to Sino-Tibetan. Other interpretations of the results are possible within the ranges of uncertainty, and linguistic data must be utilized for choosing a certain interpretation. Bengtsson (1990, 1991) and Ruehlen (1994) has pointed out several similarities between Basque, Sumerian, North Caucasian, Burushaski, Yenesseian and Sino-Tibetan in the core vocabulary. The domestication of hoses in the Central Asian steppe around 4,000 BC lead to development of pastoralism and military superiority by 2,800-2,300 BC. The formation of states starting 2,800 BC and the rise of nomadic pastoralism changes conditions for language dispersal. From now on political factors become more and more important in relation to ecological factors. The LANGUAGE model do not include such processes, and it cannot predict any of the movements of nomadic peoples nor the effect of policies of the large empires.

Later movements as recorded in history and as reconstructed from archaeological remains, has been shown in Fig. 10. Nomads fill the wast grass expanse from Eastern Europe to the Altaic Mountains after the domestication of the horse that started around 4,000 BC. Peoples speaking Indo-Aryan languages expand their numbers due to greater mobility and better economic success at herding animals, and flood the Central Asian steppe, and continue into Iran and India. Dravidian Brahui is isolated in Pakistan, Munda in Western Bengalia. The language of the Indus civilization is in this study uniquely pointed out as speakers of Elamo-Dravidian languages. This is in line with the Finnish results (Parpola et al., 1977; Koskenkenni et al., 1973) Russian results (Knorozov, 1972) and the results of Fairservis (1973), all pointing out Dravidian as the language of the texts from the Indus valley civilization. The Indo-Iranian nomadic movement breaks the language continum, leaving only Elamite in the west, the pocket of Brahui in Pakistan and the numerous Tamils of Eastern India. Recent results (Lambert-Karlovsky 1974) have shown that Elamite or closely related languages were spoken in a larger part of the Iranian area during the neolithic and bronze age. Peoples speaking Ural-Ugric languages may have been pushed North, and groups speaking Altaic languages are pushed east, into Korea and Japan. The Altaic speaking groups aquire the horse in this process, where as the northern part of the Ural-Ugrians that occupy the wet forest zone do not experience the superiority that came with the horse under their forest conditions. The incipient Chinese state expands slowly south during 4,000-1,000 BC, and overlays the Austric language group called Man in old Chinese sources, Miao-Yiao is a remnant of the aboriginal population of southern China (Chang 1987). Within Austro-asiatic and

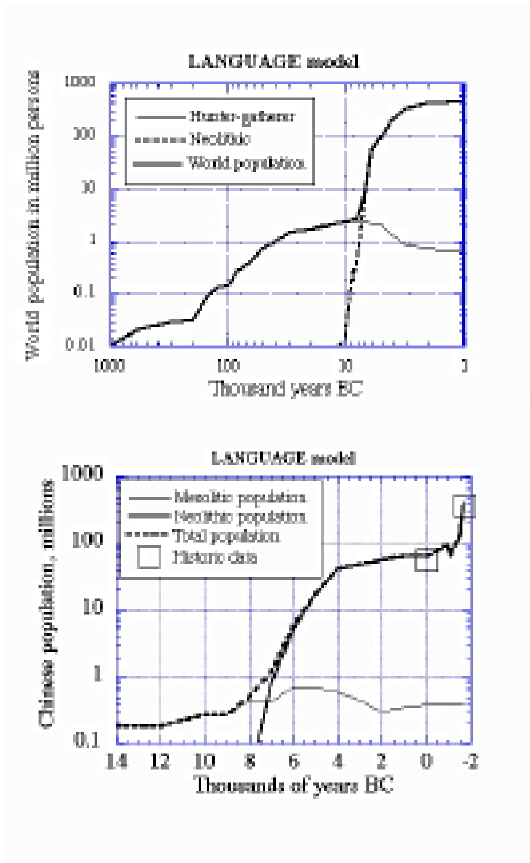

Figure 13: *The development of world and Chinese population numbers as calculated with the LANGUAGE model. The points represents historical population estimates.*

Austronesian languages supposed to belong to Austic similar words are used for tribal name, language name, or word for male and man. The Tibeto-Burmans move into Burma in a process of demographic expansion, and the very special topography in this region creates several isolated pockets of Austric. The relation between the different language groups are based on the model calculations, which agree with the linguistic data down to very detailed levels.

7 Discussion

7.1 Mesolithic movements

The time around 111,000-105,000 BC experienced an interglacial warm period which could have initiated a population diffusion out of Africa into Asia and Southern Europe. The split between Proto-Nostratic and Proto-Sino-Caucasian must have occurred before 17,000 BC, since that is the latest date at which Eskimo-Aleut could have split off from Proto-Nostratic and still made it to America in time.
The time around 45,000 BC and alternatively 55,000-62,000 BC experienced global climatic changes that pushed populations around enough to have initiated such a division. Etruscan and Basque, possibly also Iberian, Aquitanian, Ligurian and Pict (Cæsar 44 BC; Barraclough 1983) seem to originate in the from the same roots as the East-Caucasian languages, supporting the relatedness hypothesized from linguistic data. It must have split from East Caucasian before 12,000-15,000 BC. The movements of Sino-Caucasian languages in central Asia remain uncertain in terms of modeling until 5,000-4,000 BC. Much of the critical movements occurred during mesolithic times 20,000-10,000 BC when the calculations with the model are more sensitive to initial conditions and rate coefficients.

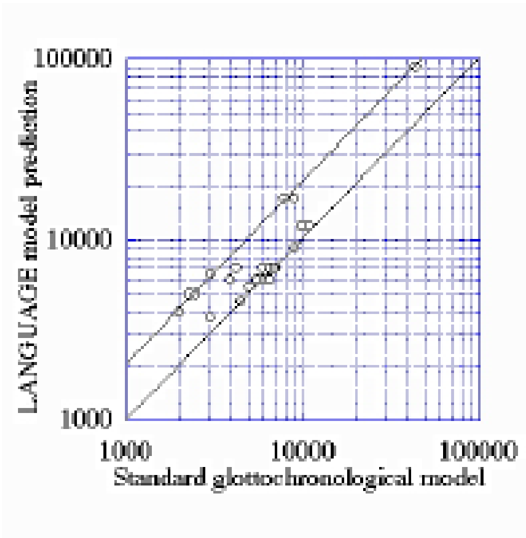

Figure 14: *Test of the model during neolithic times using independent dates from glottochronology.*

7.2 Major phylæ

The calculations correlate well with the superphylæ Nostratic, Sino-Caucasian and Austric. The superphylum Eurasiatic as defined by Greenberg (1987) is only partly supported, this may be explained by the fact that his classification method reveals genetic relationship, but is rather indiscriminate in terms of time depth. Greenberg excludes Dravidian from the Eurasiatic group, something that is difficult to support with the model calculations. Greenberg's method is a method that looks down through several superimposed layers of languages, proto-languages and proto-proto-languages, it collects both recent relationships and distant ones at once, but cannot really estimate the time-depth associated with a certain similarity without help from reconstruction of the proto-layers. It is however, one of the most powerful tools available for detecting distant genetic relationship between languages. The split between Proto-Nostratic and Proto-Sino-Caucasian must have occurred before 17,000 BC, since that is the latest date at which Eskimo-Aleut could have split off from Proto-Nostratic and still made it to America in time. The time around 45,000 BC and alternatively 55,000-62,000 BC experienced global climatic changes that pushed populations around enough to have initiated such a division. The overall relations between the languages of Eurasia as they appear after our integrated interpretation of linguistic data, archaeological data and genetic data, is shown in Fig. 17.

The apparent good fit between language groups and genetically defined populations indicate that initial settlement, demographic diffusion and quantitatively significant migrations have been the major mechanisms of language dispersal in Eurasia, and that the other mechanisms seen as possible have not been of any significant importance, until the development of technological warfare and organized states 3,000-4,000 BC. The results of the calculations also indicate that glottochronology may significantly underestimate the age of language divergences for dates earlier than 5,000-6,000 BC. The principles of glottochronology for preliterate conditions should be reconsidered and analyzed through more research and language change mathematical modeling for factors that would decrease the rate of isogloss losses with time. The split of Nostratic into three initial entities; (1) Afro-Asiatic, (2) Western Nostratic (Indoeuropean, Kartvelian) and (3) Eastern Nostratic languages (Uralic, Altaic, Paleosibirian, Eskimo), must have occurred before the neolithic revolution, in order for the groupings to develop separate linguistic identities. Correlations between population reallocations and diffusion into new territory with climate would indicate a date either around 10,200 BC or 12,000-15,000 BC. The first date correlates well withe glottochronological dates for the separation of Afro-asiatic languages and the splitup of Nostratic into different groups. The different hypothesizes on Indo-European origins and the postulated dates can be plotted in a map (Fig. ??) to show the agreements of the different proposals for a homeland with the demographic diffusion theory. The whole notion of a "homeland" looses all meaning unless it is fixed in time. Since the location has changed perpetually over time, there is not much sense in fixing it in time. Therefore also the apparent confusion in all the available offers for a homeland found in the literature. From the map in Figure ?? with the dates assigned by different authors to the homeland and geographical location offered (Gimbutas 1985; Diakonov 1990; Mallory 1987; Sherratt and Sherratt 1989; Renfrew 1990; Shevoroshkin 1990; Gamkredlize and Ivanov 1990), we tend to get a movement in time out of Anatolia, with a subsequent spread up the Balkans and into Central Europe and the Ukrainian

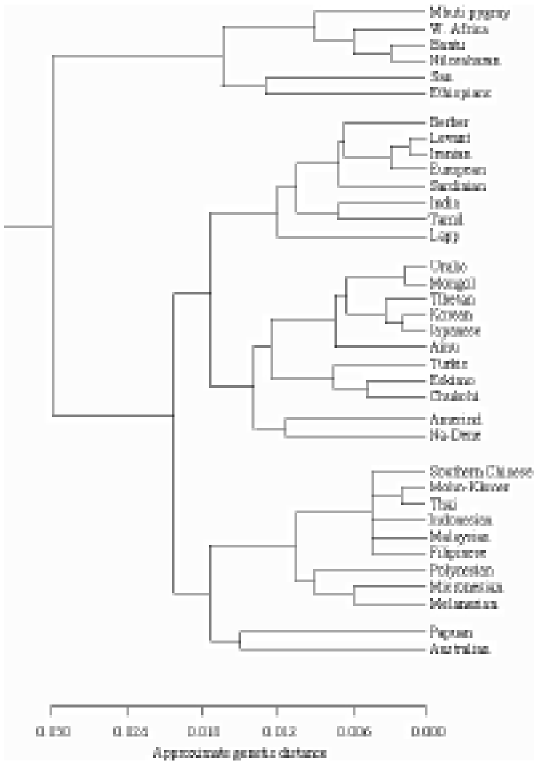

Figure 15: *Genetic relation tree for populations of the world according to Cavalli-Sforza, Piazza, Menozzi and Mountain (1988) and Cavalli-Sforza (1991). The genetic relatedness between different populations as reported by Nei and Roychoudhury (1982). The genetic distances were calculated using different method than those of Cavalli-Sforza and collaborators, still the general pattern of relations stay the same.*

steppe. As it appears, however, the ”homeland” of Gimbutas and others postulated on the steppe of Ukraina, was not the starting point, but rather a secondary center of expansion for a subset of the Indoeuropeans on the way. Any reflux into Europe would have occurred into already Indo-European speaking areas. The modified wave-of-advance model employed here seem to be able to describe the present distribution of languages in Eurasia, also on a detailed level in the European and Indian subcontinents. The isolated positions of Basque, Etruscan, Iberian and Pict in Europe are all predicted. Basque could be a relict of the language of the Cro-Magnon man around 35,000 BC, as suggested by Cavalli-Sforza (1989), but there is also a possibility of it being a product of later language migrations connected to the climatic changes at the end of the glaciation in the Gravettian period of 27,000-15,000 BC. The model favor the earlier date for Basque, but the later date for the general spread of Dene-Sino-Caucasian across Eurasia. Glottochronology in its traditional form the later date. The language of the Cro-Magnon man may still have been something related to the Dene-Sino-Caucasian phylæ, even if Basque came in later. The calculations seem also to give substantially earlier dates for separation between languages than indicated by glottochronology. Comparison of the calculated patterns using the LANGUAGE model with the genetic tree show some very interesting features.

- The populations speaking the languages included in the Austric macro-family form one complete branch of the genetic tree.
- The populations speaking the languages included in Western Nostratic and East Nostratic form two distinct branches in the genetic tree.
- The Asian populations speaking the languages Chukchi-Kamchadal, Eskimo-Aleut and the American Amerind cluster with the same group as the populations speaking East Nostratic languages.

The exceptions are Lapp which cluster with the populations speaking languages of the West Nostratic group, but show admixture of populations speaking East Nostratic languages. Lapp are known archaeologically to belong to the Finno-Ugrian ethnic grouping, but to be heavily admixed with Scandinavians due to the long time of cohabitation. The Afro-asiatic language group overlaps into the African branch in Ethiopia, but this is known to be a later supposition. The Tibetans are also known to be a Mongolic population group which later adopted Sino-Tibetan language. The discovery of a frozen human body in the high mountains above the Ötz Valley on the Italian-Austrian border a few years ago has opened up the possibility for a genetic test. The body has been C14-dated to approximately late neolithic-chalcheolithic, approximately 3,520 BC. Genetic tests have shown the Ötz Valley man to be of central European stock, similar to present central Europeans. The current hypothesis is that he originated in some of the settlements in the Ötz Valley below the mountain on the southern side, in one of the vallies that go down to the Po River plain. This implies that the Kurgan hypothesis prescribing a central Asian origin of the Indoeuropean language, is very likely incorrect.

7.3 Uncertainties

The uncertainties in these calculations remain quite large at the present time. Especially the rate coefficients for population growth and migratory diffusivity in mesolithic time remain problematic to estimate. Further research is needed for this type of transfer. The model use rather large grid cells for Asia at present, and a smaller grid cell would refine resolution as well as precision.

Several points in time are possible for the split between Nostratic, Sino-Caucasian and Amerind. Model calculations cannot be sufficiently confined by independent archaeological data and linguistic clues to decide the issue at present. When modern man expanded into the new world at a rate that implies that there was no population counterpressure. Thus the population density of *Homo Erectus* was either to low to be of consequence, or his competitiveness was so inferior that the actual population density was of no consequence. The models yield the best results if we simply pretend that nobody was there. Something prevented modern man from entering Europe untill 45,000 BC. This could have been the competitiveness of the Neanderthals that was sufficient to prevent modern humans to gain a decisive advantage. Not untill 45,000 BC could such a significant advantage be obtained. The actual mechanism of language transfer of Dene-Sino-Caucasian language into Chinese territory remain unsatisfactory constrained in the model. Independent invention of agriculture in China better fits the absolute dates of arrival for Sino-Tibetan and agriculture throughout Southeast Asia, than agricultural initiation from Anatolia, which tend to have problem to get there on time in the calculations. The model seem to be well confined for several events, however, provided the initial conditions were correctly estimated. As such the unity of Nostratic as concerns the language phylæ Afro-Asiatic, Indo-European and Dravidian are well supported and the only functioning intermediary initial condition leading to their present location is the northwestern part of the fertile crescent. The model is also well confined for the spread of agriculture in south east Asia, supporting the unity of Austric with reasonable accuracy and leading to the present distribution of Austro-asiatic, Austro-Tai, Austronesian and Miao-Yiao with good accuracy. The model calculations within the uncertainty bounds, indicate that the case for Austric appear to as well founded and confined as the case for Nostratic.

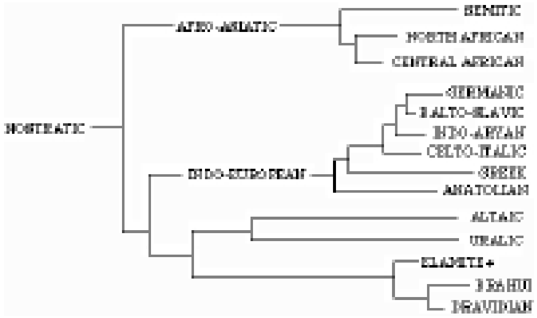

Figure 16: *The relation between the languages included in the Nostratic group according to the LANGUAGE model calculation.The model suggest three basic units; Afroasiatic, Western Nostratic with Indoeuropean and Kartvelian and Eastern Nostratic with Finno-Ugrian, Altaic and Elamo-Dravidian.*

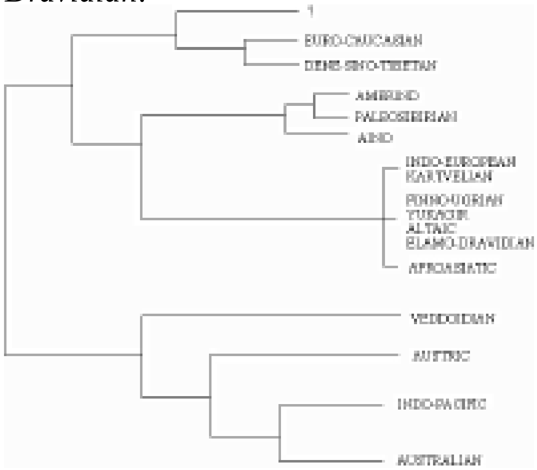

Figure 17: *The calculated interrelation between the major language phylæ of Asia, Europa and America using the LANGUAGE model.*

8 Conclusions

The LANGUAGE model calculations and the data available indicate a number of statements that may be made:

- On Nostratic; Nostratic is strongly supported by the model calculations and the available data for checking the calculations. The spread of the Indo-European, Ugric-Yukagir, Altaic, Dravidian, Kartvelian and Afro-Asiatic languages can be simulated based on ecological factors and the spread of agriculture 9,000-3,000 BC. Nostratic split up into three branches in the area of the fertile crescent 15,000-12,000 BC or 10,200 BC because of ecological factors.

- On Dene-Sino-Caucasian; The Dene-Sino-Caucasian language family is supported by model and data. The Dene-Sino-Caucasian language family was one of the large language families of northern Eurasia before the inception of agriculture. The split between Proto-Nostratic and Proto-Sino-Caucasian must have occurred before 35,000, 43,000 or 55,000 BC caused by ecological changes large enough to have initiated a division. The substrate language underlying Indo-European in Europe and Anatolia must have been of North Caucasian type. The original language from which the European branches of Caucasian developed split in the time period 23,000-17,000 BC, when Europe was repopulated after having been a polar desert in a very cold period.

- On Austric; Austric as a group of genetically related languages is strongly supported by the model calculations. The present distribution of Austric languages can be calculated based on demographic diffusion caused by the introduction of rice agriculture. Proto-Austric was once spoken throughout Southern China. Miao, Yao and She are the only remnants of the Austric substrate language of the region. Austronesian, Austro-Asiatic and Tai-Kadai languages have sprung from the same root as Miao-Yiao around 7,000 BC.

- On Amerindian; Amerindian split of from Proto-Eurasiatic in 22,000, 35,000 or 43,000 BC caused by ecological change. The division of Amerind into many languages cannot have occurred before 25,000 BC, more likely it happened after 15,000 BC.

The genetic distribution pattern observed by Piazza et al,(1978, 1981) was used to check the model calculations. The correlation between model calculation and observed genetic pattern is good, as can be seen from Figures 17 and 15-??. The Nostratic language family is strongly supported by both model and the genetic data. Austric, deduced from linguistic data (Bellwood, 1990, Peiros, 1989), seem to be supported by the synthetic map of genetic markers as well as the genetic and archaeological data presented by Cavalli-Sforza et al. (1989). The pre-colonial genetic pattern of the world's populations can be explained mainly by demographic processes starting in Africa more than 100,000 years ago, including processes started by the invention of agriculture in the Middle East and central China. The human dispersal history as reconstructed by the LANGUAGE model may as a result of this also in broad outline explain the pre-colonial distribution of the world's languages. The worlds languages can be divide into branches, North Eurasian including Dene-Sino-Caucasian, Amerind and Nostratic, South Eurasian including Austric and Indo-Pacific, West African languages including Nilo-Saharan and Niger-Cordofanian and East African including the Khoisan languages. The compilation of data together with the present calculations, indicate that the major language groupings Nostratic, Sino-Caucasian, Austric and Amerind share a common ancestry lying at least 40,000 years back in the past. Genetic data suggests that modern man emerged from Africa about 100,000 BC. The model requires this amount of time to get every man to his modern position when the historical record opens up. This together with the close connection between genetic properties and language actually observed, and the hypothesis that Eurasian and

African humans share a distant common genetic past, seem to indicate that the origin of speech is older than 100,000 years.

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