# Problems in the method and interpretations of the computational phylogenetics based on linguistic data
An example of wishful thinking: Bouckaert et al. 2012

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Results of Bouckaert et al. 2012 were recently (at the end of August 2012) widely reported in the news media concerning their opinion about the Indo-European original homeland. In the ingress of the study they write: *"We found decisive support for an Anatolian origin over a steppe origin."* Instead of being decisive, the study shows wishful thinking, ignoring the numerous possible sources of error innate in the method. In this article I shall present the most important sources of error and weigh the other arguments claimed to support the Neolithic Anatolian homeland (ca. 7000 BC) *contra* the Copper Age steppe homeland in Ukraine (ca. 4000 BC).

Phylogenetic tree from Bouckaert et al. (2012: figure S1)
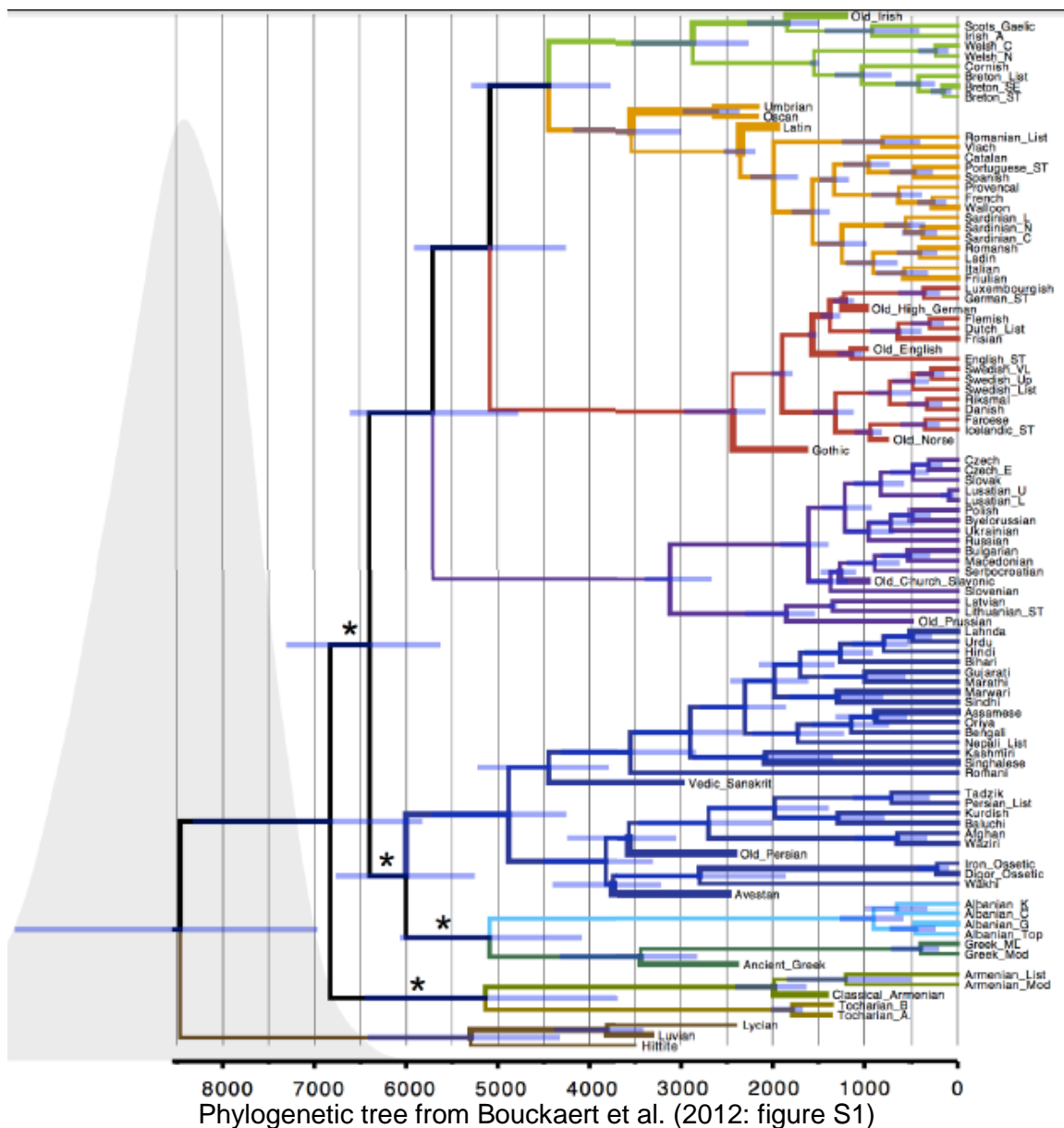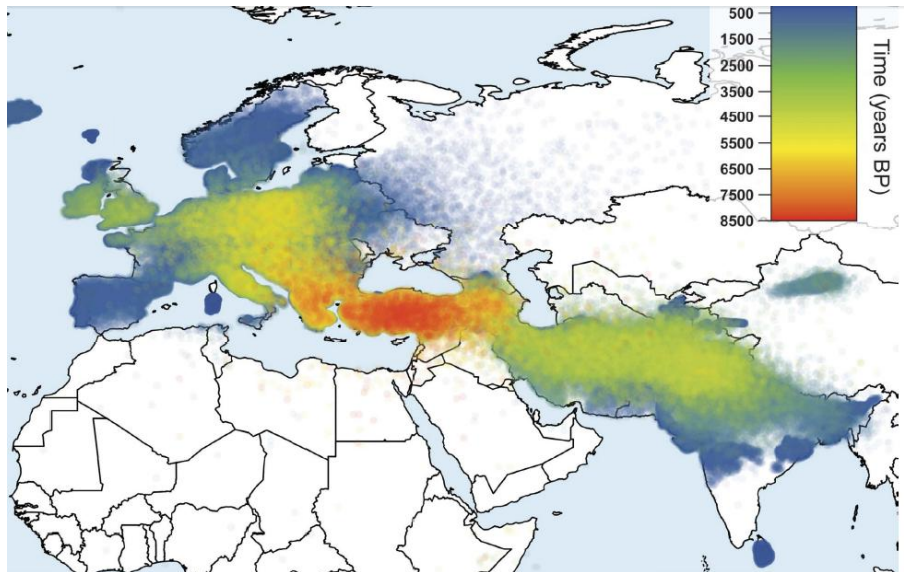
Map from Bouckaert et al. (2012: figure S4)

PART I: Methods

1. How to find out the true divergence?

There are two criteria which must be fulfilled when tracing the true divergence of a language family:
1. Shared innovations between branches
2. The most reliable level of language

1.1. Shared innovations between branches

Lexicostatistics is based on counting the retained words inherited from the common protolanguage (like the Swadesh lists). However, such retentions cannot reliably testify for an intermediary protolanguage, because the highest retention rate can sometimes be found in the opposite ends of a language family. Retentions can thus tell only about conservativeness of a branch, and conservativeness does not always coalesce with true divergence. Only shared innovations can tell whether two branches descend from a common intermediary protolanguage.

1.2. The most reliable level of language

Lexical level alone is not very reliable: a word could equally well be a later loanword than an inherited word. The only way to distinguish which one is in question is to apply the reconstructed sound history of the language family. Only at the phonological level the loanwords can be distinguished from the inherited words.

For example English *wagon* is a Middle Dutch loanword from the 16th century, and the Proto-Germanic word **wagnaz* is regularly represented by English *wain* < Old English ‹*wægn*›. In *wain* we see the regular change **a > æ* in Old English and the weakening of **g* until Middle English (Ringe, presentation). The Germanic word, then, goes regularly back to Proto-Indo-European **wog^{h}nos*, derived from **weǵ^{h}*- 'to carry, to move'. Without the sound history reconstructed by the methods of historical linguistics we could not judge loanwords from the inherited words.

Phonological level is also free of all distorting processes which make the lexical level unreliable: false divergence, invisible convergence, innovativeness and conservativeness (see Chapter 2). The reason is that a sound change can be seen in numerous words, while words are single, separate units. A word appears, disappears or gets replaced independently from all the other words, but sound change affects the whole vocabulary.

1.2.1. Unreliability of the lexical level

A couple of examples suffice to demonstrate the unreliability of the lexical level. First, different results are achieved with different word sets. With the Swadesh 200 list it seems that Germanic and Italic are together after the split off of Celtic, but with the Swadesh 100 list it seems that Italic and Celtic are together after the split off of Germanic (Atkinson & Gray 2006). Other differences occur, too: with the Swadesh 200 list Greek and Armeni-

an form a branch, but with the Swadesh 100 list they do not; with the Swadesh 200 list Albanian and Aryan form a branch, but with the Swadesh 100 list Aryan and Balto-Slavic form a branch.

Second, when the shared phonological and morphological innovations are included, the Indo-European taxonomy changes again: Italo-Celtic and Graeco-Armenian are consistent branches (Ringe, Warnow & Taylor 2002; Nakhleh, Ringe & Warnow 2005).

Atkinson and Gray (2006) explain the difference between the word sets by stating that Swadesh 100 list is less prone to contain borrowable words. But still, the Swadesh 100 list catches correctly the Italo-Celtic branch, while the Swadesh 200 list catches the Graeco-Armenian branch. The Swadesh 100 list does not seem to be any more precise than the Swadesh 200 list, even though they lead to contradicting results. Neither of them fully agrees with the data which includes phonological and morphological innovations.

1.2.2. Reliability of the phonological level

In theory sound changes can spread secondarily, just like words, but it is very improbable that
1) several sound changes would spread secondarily at the same time;
2) they all would have identical distribution;
3) in all cases the borrowed sound would have managed to replace precisely the same original sound.

An important difference is, that a sound change is a *continuous process*, while borrowing is a *momentaneous incident*. Therefore when a sound is borrowed, it is a matter of borrowing a certain point of the phonological development: there is no relationship between P_1 (original sound) and P_2

(result sound) in the borrowing language, only in the donour language. Due to this difference, the sound change affects all the words containing a certain sound in the donour language, while the borrowed sound replaces the original sound only in one word at the time in the target language, which can be seen in the fact that the borrowed sound is present in different words in different dialects.

For example Forest Nenets has borrowed the sound *L* (voiceless fricolateral, IPA *ɬ*) from Khanty. In this case it is very easy to recognize the borrowing, because the Khanty *L* is derived from the Proto-Uralic **s*, while the regular cognate of the Proto-Uralic **s* in Forest Nenets is *t*, and the *L* has replaced only *l* and *r* in the Forest Nenets. Still, even if the borrowed sound replaced the very same sound from which the original sound was developed in the other language, the borrowing of the sound would be easily recognizable from the distribution both in the vocabulary level and in the dialectal level (picked from Lehtisalo 1956):

Lj. S Nj. *korra* ~ P *koLLa* 'male'
Nj. *kŭŕŕa-* ~ Lj. P *kŭĹĹa-* 'to fasten'
Kis. Nj. Lj. *kŭr-* ~ P *kŭL-* 'to rage'
Lj. *koråcyena* ~ Kis. *koLåtyena* 'being open'

In other words: a sound P_2, which represents the result of an *ancient sound change* $P_1 > P_2$, is seen in all the words which contained P_1, and in all the dialects. A sound P_2, which represents the result of a *recent sound borrowing*, is seen in only some words which contained P_0 (a sound which became replaced by the borrowed P_2; P_0 in the target language may or may not be the same sound as P_1 in the donour language), and different words have an individual distribution pattern in the dialects.

Result of an ancient sound change — **Result of a recent sound borrowing**

WORDS

Words containing certain sound

DIALECTS
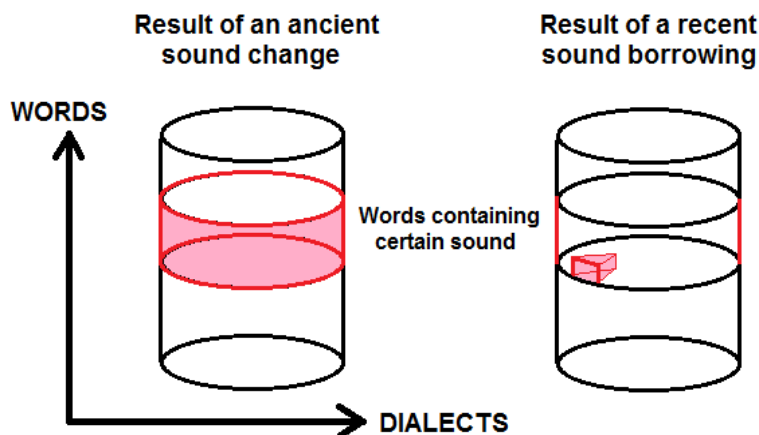
A somewhat fuzzier is the case of etymological nativization, where the speakers of one language are aware of the old regular sound correspondences between their own language and another language; the awareness may be due to the words inherited from the common protolanguage, or due to the ancient contacts. When borrowing words from the other language, the speakers of the first language change the form of a loanword to resemble the form of the old cognates. (Aikio 2007.)

However, there are many ways to detect a word which has been etymologically nativized (Aikio 2007: 29):

1. Consonant correspondence may reveal the borrowing
2. Syllable structure may reveal the borrowing
3. Meaning of the word may reveal the borrowing
4. Parallel loan from the same word may reveal the borrowing
5. Existence of an inherited cognate may reveal the borrowing
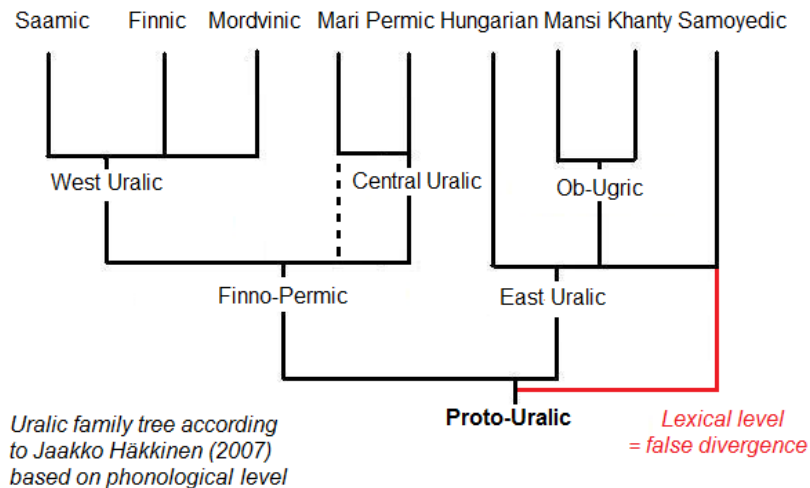6. Loan etymology of the word may reveal the borrowing

7. Distribution in the dialects may reveal the borrowing

It is important to notice that etymological nativization requires dense contacts: it does not occur between languages which are not spoken in adjacency and which do not have a mass of mutual loanwords (to one or another direction). And even if some borrowings which have applied the etymological nativization remained undetected, it would still be only a case of individual loanwords – it could not change the whole picture based on the phonological level, because a sound change is visible in *tens or hundreds of old words*.

Therefore the dialects based on the phonological level are real. For example, Samoyed has almost for a century seen to have been the first branch to split off from Proto-Uralic, because it shares least inherited words with other Uralic branches. However, Samoyed shares many phonological innovations with the Ugric branches Hungarian, Mansi and Khanty (Häkkinen 2007):

From Proto-Uralic to East Uralic:
1. *s > *š (coalescence with original *š)
2. *š > *L (both original *š and *s change to voiceless fricolateral, IPA ɬ)
   Hungarian Ø (loss) ~ Mansi *t ~ Khanty *L ~ Samoyed *t
3. *ś > *s (secondary *s appears)
   Hungarian sz ~ Mansi *s ~ Khanty *s ~ Samoyed *s
4. *e̮ > *e̮, *i̮ (split; conditions not known)
   Hungarian a/i ~ Mansi *ii̮ ~ Khanty *aa, *ee ~ Samoyed *e̮, *i̮
5. *k, *w, *γ > *γ (coalescence with original *γ < *x between vowels)
   Hungarian v/Ø ~ Mansi *γ ~ Khanty *γ ~ Samoyed Ø
6. *kS, *Sk > *γS (sibilant metathesis in some obstruent clusters and the weakening of *k)
   Hungarian S (= sz/Ø) ~ Mansi *γəS (= *s/*t) ~ Khanty *γəS (= *s/*L)~ Samoyed S (*s/*t)

These changes are neither simple losses nor typologically very expectable, so they can hardly be due to independent parallel developments. Indo-European loanwords prove the East Uralic features innovative, while West Uralic Mordvin has preserved the original quality:

Evidence from Proto-Aryan loanwords:
1. Hungarian *száz* ~ Mansi KM *se̮e̮t* ~ Khanty V *sàt* '100'
   < East Uralic *se̮ta
   < Proto-Uralic *śe̮ta (> Mordvin E *śado*)
   ←Proto-Aryan *ćata- / Proto-Indic *śata- '100'

2. Mansi KM *uutər* 'lord, prince; hero'
   < East Uralic *aLəra
   < Proto-Uralic *asira (> Mordvin E *azoro*)
   ←Proto-Aryan *asura > Iranian *ahura* 'lord'

We now have a serious contradiction between the testimonies of the phonological level and the lexical level. The phonological level is far more reliable, while the lexical level is vulnerable to many distorting processes (see Chapter 2), so the correct taxonomy of the Uralic language family is achieved through the phonological level:

Uralic family tree according to Jaakko Häkkinen (2007) based on phonological level

Proto-Uralic

Lexical level = false divergence

2. Processes distorting the true divergence

### 2.1. Innovativeness vs. conservativeness

Conservativeness of branches leaves them more similar to each other than expected. This is especially the case with Baltic, which in the supplementary materials of Bouckaert et al. (2012: figure S1) has divided only ca. 200 AD, and East Baltic only ca. 700 AD. These seem clearly too late dates, because we have dialectal Baltic loanwords already in Middle Proto-Finnic before the Common Era (Kallio 2007; 2008). Baltic is well-known for its conservativeness, which explains the erroneously late dating for the Baltic splits.

Conversely, **innovativeness** of branches makes them more different from each other than expected. An example from Bouckaert et al. (2012) comes from Romani, which in their tree has split off from the rest of the Indic languages around 1600 BC. This seems too early a date according to what we know about the Indic languages – at that date the Aryan branches Indic and Iranian themselves were only recently separated (Carpelan & Parpola 2001). We know that Romani language has during its long journey become strongly influenced by many prestigious languages, which exposed it to massive lexical borrowing. This lexical innovativeness explains the erroneously early dating for the split off of Romani.

2.2. False divergence vs. invisible convergence

On another axle are processes I call false divergence and invisible convergence (Häkkinen 2012c). These affect parallel to the conservativeness vs. innovativeness -axle: invisible convergence makes two branches look more similar than they would be based on the true divergence, and false divergence makes one branch to look more distant from the others than expected on the basis of the true divergence.
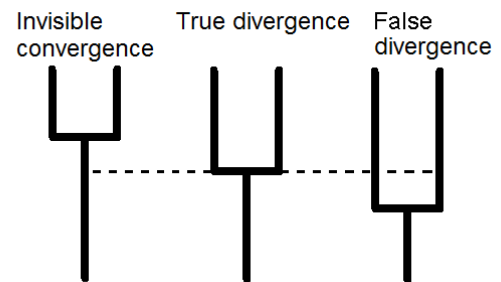
Invisible convergence means a situation where two branches are separated as speech communities but still remain in the vicinity of each other long before they become distinguished phonologically. For example Germanic loanwords of different age show that Finnic and Saami were already separated during the Palaeo-Germanic stage (as seen from different derivatives), but their loanwords became phonologically distinguishable mainly not earlier than during the Late Proto-Germanic and Northwest Germanic stage (Koivulehto 2002; Häkkinen 2010).

It is therefore a true possibility that Anatolian resembles Samoyedic in this respect. It may not be as radical a situation, but at least it is possible that there are other reasons than true divergence behind the fact that Anatolian shares the least words with other Indo-European branches.

Fi. *kavio* 'hoof of a horse' < LPF **kapja* < EPF
  *kapa-ja
~ SaaS *guehpere* 'hoof, claw' < LPS **kuopērē* <
  EPS **kapa-ra*
← Palaeo-G **kāpa-s* 'hoof' > LPG **χōfa-z* > Engl.
  hoof
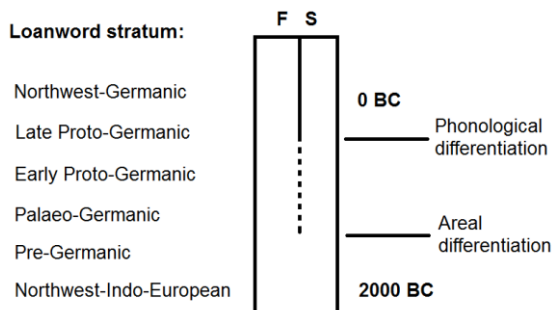
Therefore it seems very probable that also some part of the common Finno-Saamic vocabulary may actually be invisible loanwords from one branch to another. Considering the inherited Proto-Uralic vocabulary, some words might already have disappeared from either branch, only to become soon again invisibly borrowed from the other branch. Even more common phenomenon might be, that the preservation of a word in one branch may have been supported by the same word existing in the other branch, because the dialectal difference did not yet prevent mutual comprehension. Indeed, both Finnic and Saami seem to be lexically conservative branches, sharing a lot of inherited words with even very remote Uralic branches (Michalove 2002), which may be caused by the invisible convergence.

In the Indo-European side for example the appearance of the Graeco-Albanian branch in Bouckaert et al. (2012) might be caused by invisible convergence; the two branches have, after all, been spoken in the adjacent areas since the "beginning". When phonological and morphological innovations are included, Albanian seems rather to group together with Germanic, and Greek with Armenian (Ringe, Warnow & Taylor 2002; Bouckaert et al. 2012: Supplementary Materials, figure S12).

False divergence means a situation where a branch shares less inherited words with the other branches than it should do, making it look like the first branch to split off from the common proto-language. False divergence can be unveiled by comparing to the results of the phonological level. For example Samoyed branch was for nearly a century seen as the first entity to split off from Proto-Uralic, because it shares the least words with other Uralic branches. However, I have re-

cently shown that Samoyed has participated in the very same sound changes than the Ugric branches (Hungarian, Mansi and Khanty), so it could not have been split off until after the East Uralic dialect (Häkkinen 2007; see Chapter 1.2.2).

The phonological level is not vulnerable to the distorting processes like the lexical level, because sound changes can be seen in numerous words, while a single word may disappear or appear without affecting any other words. Therefore when a contradiction appears, the phonological level tells the true divergence and the lexical level shows the false divergence (Häkkinen 2012c).

The reason behind the false divergence seems to be connected to a strong foreign influence on languages, which have spread far from their relatives; at least both Samoyedic and Hungarian (the clearest false divergence cases within the Uralic family) fulfill this criteria. In the Indo-European side examples fulfilling the criteria might be the Anatolian and Tocharian branches.
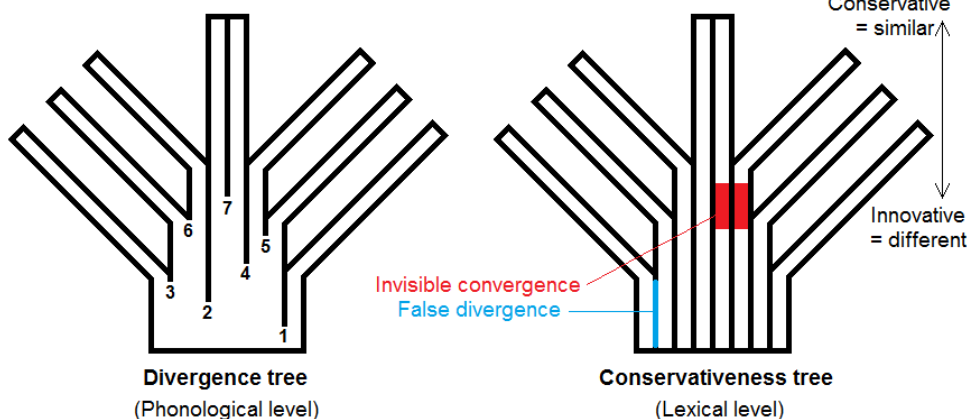
Anatolian still may have been truly the first branch to split off from Proto-Indo-European as argued by Kloekhorst (2007: 22–26; cf. Melchert, forthcoming), but perhaps it is not as ancient as it seems from the lexical viewpoint. It is interesting to note that Anatolian shares ancient features with East Greek (Garrett 2006; see Chapter 8). Anatolian also has words related to the animal traction (Darden 2001; see Chapter 7), so at least we may speak about *exaggerated divergence*, if not false divergence.

It is thus possible that such an exaggerated divergence does to the Anatolian branch the same which the innovativeness does to the Romani language: it looks too old a split. Difference between innovativeness and false divergence is not that much difference in a content, but difference in a view point: innovativeness is a quality of a language, while false divergence is a result caused by lexical innovativeness due to foreign influence and leading to premature aging.

2.3. Divergence tree or something else?

So, what can we say about the trees of Bouckaert et al. (2012) and the trees of the Gray School in general? The trees show the Anatolian branch to split off first, but what that split in the tree actually describes? As I have argued in this presentation, the lexical level is vulnerable to many distorting processes, which make it impossible to know for certain whether or not a case represents true divergence. It is possible that the tree shows Anatolian to split off first only because it is so

innovative, or because it shows false divergence. Therefore we should interpret the trees differently, depending on how reliable method they are based on.

Divergence tree
(Phonological level)

Conservativeness tree
(Lexical level)

Conservative = similar
Innovative = different

Invisible convergence
False divergence

A tree can be interpreted as a divergence tree only when we know for certain that the splits off the trunk are based on the true divergence: only the phonological level can reliably tell that the first split truly occurred first, and that it occurred as early as it looks (related to the other branches). The splits based on the lexical level may also be true, but they may equally well be totally erroneous like in the case of Samoyed, or at least they may be temporally exaggerated (false divergence) or underrated (invisible convergence). Therefore only a tree based on the phonological level can be taken as the divergence tree for certain, but a tree based on the lexical level is far more uncertain and thus should be taken as the conservativeness tree only. Lexical data alone cannot reliably tell the true divergence: the many uncertainties of the method leave too much room for different interpretations.

The trees achieved by the method of the Gray School so far should not be seen as divergence trees, as long as they lack the means to distinguish and neutralize the effect of the distorting processes presented afore. The trees in Bouckaert et al. (2012) are thus conservativeness trees, which might or might not match with the true divergence tree of the Indo-European language family. The trees which include also phonological features (Ringe, Warnow & Taylor 2002; Bouckaert et al. 2012: Supplementary Material, figure S12) have much higher probability for representing the true divergence than the trees based on the lexical data alone.

3. Locating the homeland

Bouckaert et al. (2012) have applied a new method to find out the most parsimonious way to explain the locations of the Indo-European languages. They write that their method does not just return the center of mass, because the geographic centroid would hit the steppe region (page 958). However, geographic center is not the same as the center of mass. The map of the included languages (Supplementary Materials, figure S6) shows clear axle of gravity from Britain to India, Anatolia being exactly on this axle. Only few languages are outside this axle. However, this probably won't cause any problems, because the densest area language-wise is Europe, and therefore the center of mass would hit around Balkan and not Anatolia.

They have also tested that the presence of the three ancient Anatolian languages will not affect the result, which is promising. The result that the homeland of the Romance languages is located near Rome is also very promising. It would be very interesting to see how the method will manage with a language family with unexpected, uneven and recurring waves of spread from the homeland, like Turkic.

3.1. Possible problems in the method

However, there are also some possible sources of error. The first possible problem concerns the method itself. I say here "possible problem", because I admit that I'm not sure if I understood right the role of all the factors used in their formulas:

"We connect the cognate evolution model with stochastic processes of spatial diffusion in a joint inference framework. To do this, we apply the same approach as for cognate evolution to infer internal node locations from the language ranges at the tips of the tree (see Figure S6)." (Bouckaert et al. 2012: Supplementary Materials, p. 9.)

If I understood right this and what they wrote on the previous pages and what is said about the method in Gray, Atkinson & Greenhill (2011), this might mean that the branch length, which is produced by the amount of changes (more changes ≈ more time), may affect the location. If so, does this mean that the ancestral location of a branch becomes located closer to the location of the more conservative language?

If so, this is a possible source of error in the method, because there is no rule that the most conservative language is the one closest to the homeland. Actually the opposite may often be true: there is a principle of lateral areas, according to which the most conservative languages are to be found on the fringes of a language family. For example the most conservative Uralic languages are the westernmost (Saami, Finnic, Mordvin) and the easternmost branches (Samoyed), while the central languages are more innovative.

The second possible problem is, that geography alone does not explain the spread of a language, but also factors related to subsistence strategies connected to certain ecological zone may determine the direction and speed of expansion. Also political powers vs. voids in the adjacency may affect the spread of a language by pushing or pulling force. However, these are complicated questions in which I will not go deeper here.

3.2. Problem concerning the location of the ancient languages

A real problem – and a big one – is the location of the ancient Aryan (Indo-Iranian) languages. As can be seen, all the ancient Aryan languages are located in the very southern latitudes (Bouckaert et al. 2012: Supplementary Materials, figure S6). The Aryan languages are the most southern of all the Indo-European languages, and the only branch more southern than Anatolia. The model presented by Bouckaert et al. (2012) allows the Aryan languages spread right to the east from Anatolia, which is a grave mistake. There are plenty of Aryan loanwords of different age in the Uralic languages, and I have recently updated their stratification to match the new Uralic chronology (Häkkinen 2012a):

Early Proto-Aryan *ǵuǵhew-* → Early Proto-Uralic *juxi-/jôwxi-* 'to drink'
  < IE *ǵhew-*
Middle Proto-Aryan (Pre-Iranian dialect) *dzen-* → Middle Proto-Uralic *sen-ti-* 'to born'
  < IE *ǵenh-*
Late Proto-Aryan *ćatam* → Late Proto-Uralic *śęta* '100'
  < IE *ḱm̥tóm*
Early Iranian *zaranya* → Late Proto-Uralic *sęrńa* 'gold'
  < Late Proto-Aryan *źhar-* < IE *ǵh(o)l(H)-*

Based on all the relevant arguments Proto-Uralic is located in the taiga zone in the Volga-Ural region, from where its expansion began only ca. 2000 BC (Kallio 2006; Häkkinen 2009), but Pre-Proto-Uralic seems to have been spoken in Southern Siberia, north from the Sayan Mountains, where it shared typological developments with the protolanguages of the Altaic type (Janhunen 2001; 2007) and donated loanwords to Pre-Proto-Yukaghir (Häkkinen 2012b). The Aryan developments must have taken place in the vicinity of Proto-Uralic, that is in the North Caspian Steppes, as extensively argued by Carpelan & Parpola (2001).

It follows that the earliest location of a distinctively Aryan language was much more northern than the location of the later Aryan languages – even the earliest written ones. This result is indisputable, and it disproves the direct expansion route of Aryan from Anatolia to Iranian Plateau and South Asia. Even if Anatolia could be proven to be the original Indo-European homeland, the Aryan language must have spread *first to the north*.

Taken the fact that the Aryan languages are the only Indo-European languages more southern than Anatolia, the replacement of the Aryan homeland to the North Caspian Steppes should affect the location of the Indo-European homeland – most probably it would not be located in Anatolia anymore even by the method of Bouckaert et al. (2012), because all the basal branches (excluding Anatolian) would draw the location to the north. It seems that the Anatolian homeland is supported only because the common ancestral branch of Aryan and Northwest Indo-European is located in Anatolia, and this is only due to the mistake that they allow the Aryan languages to spread directly to the east.

However, if their method still produced the Anatolian homeland after relocating the Aryan

branch to the North Caspian Steppes, then there is a severe innate bias in the method. In that case only the Anatolian branch could pull the homeland in Anatolia, and there is no scientific basis to locate the homeland in the area of the first separated branch, because it could equally well be located in the area of the other branch, or in the area between the two branches.

3.3. Parsimonious ≠ true

What the method actually seems to find out, is the most parsimonious explanation for the expansion of all the Indo-European branches – in other words: the *movement center* of the language family. However, the most parsimonious route does not equal the true route. An example is the Ukrainian language, which even in the steppe homeland framework has not remained in its original place, but the subsequent linguistic expansions have moved in a circle:

1. Proto-Indo-European from Ukraine to Eastern Central Europe
2. Northwest Indo-European from Eastern Central Europe to Eastern Europe
3. Proto-Balto-Slavic in Eastern Europe
4. Proto-Slavic in Middle Dnieper region
5. East Slavic from Middle Dnieper to Ukraine

Languages do circulate, and the most parsimonious route is not always the right one.

3.4. Central ≠ original

The movement center of the language family is not necessarily the location of the original homeland. This is also true when the taxonomic relations are taken into account – that is, when the homeland is located in the area of the deepest diversity. For example the Turkic homeland was neither in the geographic center of the language family (around Northern Kazakhstan) nor in the area of the deepest diversity (in the Middle Volga region), but in the southeasternmost corner, nowadays totally outside the distribution of the language family: in Mongolia (Janhunen 1996).

This suffices to point out, that no computational method can decisively locate the original homeland on the basis of the known (both the modern and the ancient) languages alone – also the results of historical linguistics should be taken into account.

PART II: Linguistic results supporting the Neolithic Anatolian homeland

4. Results of the computational phylogenetics

As I have presented afore, there are many possible sources of error in the method of computational phylogenetics, so the results gained by the method are far from decisive. So far the method is too unreliable to challenge the traditional methods of historical linguistics.

5. Evidence from the Kartvelian and Semitic contacts

There are shared words between Indo-European languages on the one hand, and Kartvelian and Semitic languages on the other hand. What can they tell in the battle between the steppe and the Anatolian homelands? Not much. First, Indo-European loanwords in Semitic and Kartvelian cannot testify about the Indo-European homeland – they can only tell that there was some archaic Indo-European language in contact with the two language families. Only the Semitic and Kartvelian loanwords in Proto-Indo-European can tell something about the Indo-European homeland.

Second, even the Semitic and Kartvelian loanwords in Proto-Indo-European cannot help to decide between the two possible homelands, because the steppe homeland is located immediately north from Caucasus. Both homelands are close enough to the areas of Kartvelian and Semitic to count for the loanwords. More telling in the geographic respect are the contacts with Uralic (see Chapter 9).

6. Evidence from the deepest taxonomic gap

Even though it looks probable that Anatolian truly was the first branch to split off, as argued by Alvin Kloekhorst (2007: 22–26), it does not make Anatolia the homeland. The homeland could equally well have been in the area of the other branch (Proto-Indo-European proper or Nuclear Indo-European), or in between the branches.

PART III: Linguistic results supporting the Copper Age steppe homeland

7. Evidence from linguistic paleontology

Here it is obligatory to be very precise and objective and avoid generalizations. I will consider also the possibility of the two-step model supported by Bouckaert et al. (2012), which suggests the Anatolian homeland for Proto-Indo-Hittite but possible steppe homeland for Proto-Indo-European proper (Nuclear Indo-European).

The widely known support for the Copper Age steppe homeland comes from linguistic paleontology. Words connected to wheeled vehicle (wheel, convey, axle, thill), secondary products (milk, butter, wool), animal traction (yoke, harness, harness pole), and metals (copper, gold, silver) have been reconstructed in Proto-Indo-European, and they give the upper limit (*terminus post quem*) for the dispersal of Proto-Indo-European: the language cannot have dispersed before the cultural development had reached the certain level seen in the meanings. (Mallory 1989; Mallory & Adams 2006.)

However, although the words themselves can be regularly reconstructed (in most cases), the meanings leave more room for different interpretations, as stressed by Paul Heggarty (presentation). I must agree with Heggarty to certain extent – in some cases it seems to be a case of wishful thinking instead of consistent, objective assessment of different options. There are three kinds of problems: (1) words either are not reliably attested in the Anatolian languages or their cognacy is uncertain (like with Hittite *hurki* 'wheel'), (2) their meanings don't match (for example, the word which widely has the meaning 'milk', denotes only 'fluid of plants' in Anatolian), or (3) the meaning has been modernized in all the languages.

Heggarty considers the last point as a true weakness of the method which cannot be counted out: the Proto-Indo-European word *$h_2rēǵ$-s* should have the reconstructed meaning 'king', which in his opinion is far too modern a concept for Proto-Indo-European. He equates the words denoting 'plough' and 'wheel' just as vague.

However, there is a clear difference between the three meanings: there have always been people who command and people who obey, and it is only a matter of the direction of the cultural development whether the meaning is 'chief', 'maharaja' or 'king'. On the contrary, there have not always been wheels and ploughs, but they became existing only at the certain point of the cultural development. Admittedly, there have been circular objects, but nothing which would have been motivated by 'turning' or 'rolling' (from which the words for 'wheel' are derived) until the invention of the wheel and its immediate predecessors (the rolling log), as stressed by David W. Anthony (2007).

When the criteria are strict enough and when the analysis is objective, the method of linguistic paleontology is still valid. The most certain candidates with some value for dating the homeland, which have a cognate in Anatolian and which are semantically coherent, are the following words: Hit. *hiss(a)* 'harness pole', Hit. *jukan* 'yoke', HLuv. *á-zú* 'horse' and Hit. *hulana* 'wool'. It is remarkable that the first, third and fourth word cannot be later loanwords in Anatolian due to the phonological reasons: 'harness pole' and 'wool' have preserved the reflex of a laryngeal, and 'horse' has developed very differently from the adjacent Indo-European languages (cf. Greek *hippos*). Only 'yoke' is so similar in many languages that it could in theory be a later loanword from some other Indo-European language.

Both animal traction and horse appear in Anatolia only around 4000 BC; only wool would allow an earlier dating (Darden 2001). Thus, even though the evidence for the wheel in Anatolian has been disputed (Hittite *hurki* ~ Tocharian A *wärkänt* being different derivatives), there are still solid evidence against the Neolithic dispersal of Indo-Hittite. There are three words ('yoke' excluded) which fulfill even the strictest criteria:

1) the word has phonologically regular cognates in Anatolian and other branches
2) the word has phonological characteristics which make later borrowing very improbable
3) the word is not derived from any such Indo-European root from which it would be possible to derive the word independently at some later stage
4) the word has an identical meaning in Anatolian and other branches
5) the word has a specific meaning which requires certain technological level or chronological stage which can be verified in the extra-linguistic world

Consequently, because these words can be neither loanwords nor later independent development in Anatolian, they must be inherited from Proto-Indo-Hittite; and because two of the objects to which the words denote were not present in Anatolia before ca. 4000 BC, the dispersal of Proto-Indo-Hittite could not have began before the 4th millennium BC.

There are (following the strictest criteria above) at least two water-proof words which indisputably disprove the Neolithic time-depth, but these two words *cannot be explained away*. Quality beats quantity.

8. Evidence from the ancient dialect boundaries

There are two important things which can help us to date the spread of ancient Indo-European dialects. First, Andrew Garrett (2006) has argued that Proto-Greek, when Mycenean included, is actually nearly identical to Late Proto-Indo-European. Second, J.P. Mallory (2001) and Petri Kallio (2006) have argued that Northwest Indo-European (> Celtic, Italic, Germanic, Balto-Slavic etc.) seems to have remained very archaic until the 2nd millennium BC. Indeed, there are Indo-European loanwords in Uralic, which seem to be contemporary with Late Proto-Aryan loanwords – or even younger, based on the areal distribution of some loanwords.

It follows from these two points, that we have evidence that only Aryan and Anatolian branches had gone through distinct phonological changes during the 3rd millennium BC, while some other quite basal branches (like Greek and Northwest Indo-European) were certainly still quite archaic at the change of the 2nd millennium BC. Phonological differentiation follows areal differentiation, but the difference between the two phases cannot last for many millennia: even Finnic and Saami, which have "always" been spoken adjacent to each other (as proven by both mutual loanwords and shared Germanic loanwords of different ages; Koivulehto 2002; Aikio 2006; Kallio 2009; Häkkinen 2010; Heikkilä 2011) and which are considered phonologically among the most archaic Uralic branches, became phonologically clearly distinguishable within a millennium following the areal separation of the speech communities (Häkkinen 2012c). There are no languages which would have remained unchanged for millennia.

It seems utterly impossible that the mentioned situation could follow from the Neolithic dispersal of Proto-Indo-European, because it would require that many branches remained unchanged for several millennia. Now, the Gray School of computational phylogenetics tries to bypass this problem by proposing that only the dispersal of Proto-Indo-Anatolian (or Early Proto-Indo-European) seems to be a Neolithic phenomenon, while the dispersal of Proto-Indo-European (or Late Proto-Indo-European) could still be connected to the Copper Age expansion from the Pontic Steppes (Gray & Atkinson 2003; Bouckaert et al. 2012).

There are traces of ancient boundary shift: according to Andrew Garrett East Greek shares some old developments with Anatolian, while West Greek shares some with Italic (Garrett 2006). The dialect boundary between the two Nuclear (or Archaic) Indo-European dialects seems originally to have run through Greece, and only later areal convergence lead to the cohesion, outcome of which is the Greek language; but the original differences (which do not prevent mutual understanding) are still visible. I have recently presented a similar possible boundary shift case in the Uralic side (Häkkinen 2012c).

Now, it is interesting that East Greek shares an ancient morphological feature with the Anatolian branch. This must precede the phonological developments of the individual branches, because the sound correspondences look regular enough and borrowing seems a problematic explanation in this case, but as I argued afore, it is implausible to assume the differentiation to take much over a millennium. If the common Greek developments began only at the post-Mycenean era, that is at the 2nd millennium BC, then we would achieve a timing that around 3000 BC the Bosporic dialect of Nuclear Indo-European (> East Greek, Anatolian) was dispersing, probably caused by the crossing over Bosporus by some of its speakers.

The presented draft agrees with the estimated time-depth of the Anatolian branch: its dispersal has been dated to ca. 3000 BC based on the differences between the Anatolian languages (Melchert 1998: 11–12). The situation is also clearly an argument against the Neolithic dispersal of Proto-Indo-Hittite. But is it an argument against the Anatolian homeland, as well? At least we can observe that in Anatolia we meet only one ancient dialect, the Bosporic dialect with first person plural ending *-men*, while in Greece we meet two dialects: the Bosporic dialect with *-men* and the Nuclear Indo-European (proper) dialect with *-mes*. The situation seems to fit better with the non-

Anatolian homeland, because it would require only one early spread over Bosporus, while the Anatolian homeland would require two early spreads over Bosporus.

If we trace the Proto-Indo-European back in time, we can see the following steps:

1) Proto-Anatolian is dated around 3000 BC (Melchert 1998; Kloekhorst 2007)
2) The Bosporic dialect (*-men) in the both sides of Bosporus can hardly have been dispersed more than a millennium earlier, around 4000 BC.
3) Even though we would assume another 1000 years from the Bosporic dialect back to Proto-Indo-Hittite (which is an exaggeration taken the very few differences between the language stages), we would still be only around 5000 BC.

The ancient dialects and the rate of linguistic change strongly disagree with the dating of the dispersal of Proto-Indo-Hittite around 7000 BC.

9. Evidence from the Uralic contacts

Since the 1980's it has been generally accepted that there are borrowings from archaic Indo-European to Finno-Permic (Koivulehto 1983) and from Proto-Indo-European to Proto-Uralic (Rédei 1986; Koivulehto 1991). However, the recent results concerning the dating of dispersal of Proto-Uralic around 2000 BC (Kallio 2006; Häkkinen 2009) force us to update the situation: Proto-Uralic is no more contemporaneous with Proto-Indo-European but much younger.

I have recently proposed the layering of the known archaic Indo-European and Aryan loanwords based on the Uralic reflex of the laryngeals and similar sounds (Häkkinen 2007; 2012a):

I stage (*x) 2800 BC–	Early Archaic (Proto- or Northwest?) IE borrowings to Early Proto-Uralic: IE *b^heh_1-(ye/o-) → EPU *pexi- 'to cook'	Early Proto-Aryan borrowings to Early Proto-Uralic: EPA *$ǵug^hew$- → EPU *juxi- 'to drink'
II stage (no *x) 2300 BC–	Late Archaic (Northwest) IE borrowings to Late Proto-Uralic: IE *b^heh_1-(ye/o-) → LPU *peša- 'to cook'	Late Proto-Aryan borrowings to Late Proto-Uralic: LPA *argha- → LPU *arwa 'value, price'
III stage (no *x) 1800 BC–	Northwest IE borrowings to Uralic dialects: NwIE *b^hleh_1-tó- → WU *lešti 'leaf, blade'	Proto-Iranian borrowings to Uralic dialects: (No examples of similar source consonants)

Proto-Uralic substitutes for the Indo-European laryngeal and velar aspirate: x-strata (Early Archaic Indo-European and Early Proto-Aryan), š-stratum (Late Archaic Indo-European) and w-stratum (Late Proto-Aryan).

The strongest arguments locate the Uralic homeland in the Middle Volga–Kama region, and the developing Aryan branch can be connected to the Poltavka Culture and later also to the Abashevo Culture, while the Archaic Indo-European (Northwest Indo-European) can be connected to the eastern Corded Ware Fatyanovo–Balanovo Cultures. At the late 3rd millennium BC the Balanovo and Abashevo Cultures got in conflict over the rich copper deposits in the Kama region, so there seem to be both temporally and spatially precise archaeological correspondents for the Northwest Indo-European and Aryan contacts of Proto-Uralic. (Carpelan & Parpola 2001.)

Only one uncertain Early Proto-Indo-European loanword has been proposed so far (U *pata '(ceramic) pot'; Kallio 2006: 5–6); all the other Archaic Indo-European loanwords represent the level of Late Proto-Indo-European, and may thus be also later but not earlier. Besides, I have recently argued that based on the Archaic Uralic loanword layers in Yukaghir, Pre-Proto-Uralic

must have been spoken in Asia, somewhere near the watershed area between the rivers Yenisei and Lena (Häkkinen 2012b). This result agrees well with the relative lateness of the Indo-European loanwords in Uralic: the language families only engaged in contacts after Early Proto-Uralic appeared in the Volga–Ural taiga, north and east from the Indo-Europeans.

Admittedly, it would be a stronger argument supporting the steppe homeland for Indo-European, if we still could claim that Proto-Indo-European itself was in contact with Proto-Uralic. Now the evidence is not so decisive anymore. However, the Copper Age steppe homeland still is more credible candidate than the Neolithic Anatolian homeland, because the further in time and place we go from Middle Volga and 2000 BC, the more difficult it becomes to explain the presence of the two early Indo-European dialects in the area.

Spatially thinking, if the Northwest Indo-European and Aryan branches spread all the way

from Anatolia through Balkan to Middle Volga side by side, they should share many common (inherited or areal) innovations. The clear difference between the branches can be explained much better by assuming them to have spread to the opposite directions. That makes the steppe homeland much better candidate, because looking from there, the Northwest Indo-European spread to the west and the Aryan branch to the east.

Temporally thinking, the two Indo-European dialects of the 3rd millennium were still quite archaic, and therefore the dispersal of their common protolanguage cannot be more than a millennium behind in time. Spread from Anatolia would have taken much longer time, which should be seen in the increased amount of post-Proto-Indo-European developments. And as I wrote above, a big part of these developments should be shared between Northwest Indo-European and Aryan, were they spread all the way from Anatolia.

We may conclude that the small amount of developments after Proto-Indo-European until the Uralic contacts supports the Copper Age homeland, and the lack of shared developments between Northwest Indo-European and Aryan supports the Pontic Steppe homeland. The Neolithic Anatolian homeland cannot explain the presence of two *different but archaic* Indo-European dialects in the Middle Volga region at the 3rd millennium BC.

PART IV: Conclusions

10. Assembled evidence for my verdict "wishful thinking"

This is how the chain of argumentation goes according to the Bouckaert et al. (2012) and the Gray School in general:
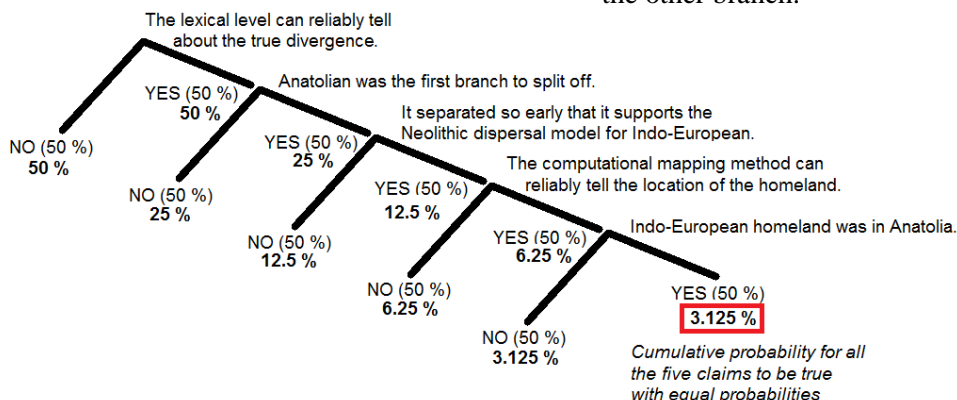
1) The lexical level can reliably tell the true divergence.
2) Anatolian was the first branch to split off.
3) It separated so early that it supports the Neolithic dispersal model for Indo-European.
4) The computational mapping method can reliably tell the location of the homeland.
5) Indo-European homeland was in Anatolia.

This is how it really goes:

1) The lexical level can reliably tell about the true divergence – except it is vulnerable to several distorting processes, unlike the phonological level, thus making the results very uncertain or even erroneous like in the case of Samoyed.
2) Anatolian was the first branch to split off – or maybe it only looks like that because of the false divergence.
3) It separated so early that it supports the Neolithic dispersal model for Indo-European – or maybe it only looks so early because of the lexical innovativeness of Anatolian.
4) The computational mapping method can reliably tell the location of the homeland – or maybe the result is biased towards the more conservative branch or towards the most parsimonious movement center.
5) Indo-European homeland was in Anatolia – or maybe it was somewhere else, because the Aryan languages cannot have spread right to the east from Anatolia; now that all the other branches pull the homeland north from Anatolia, the method should no more produce the Anatolian homeland. If it still does so, it has an innate bias locating the homeland in the area of the first branch to split off, although the homeland could with equal probability be located in the area of the other branch.

The lexical level can reliably tell about the true divergence.

YES (50 %) 50 %

NO (50 %) 50 %

Anatolian was the first branch to split off.

YES (50 %) 25 %

NO (50 %) 25 %

It separated so early that it supports the Neolithic dispersal model for Indo-European.

YES (50 %) 12.5 %

NO (50 %) 12.5 %

The computational mapping method can reliably tell the location of the homeland.

YES (50 %) 6.25 %

NO (50 %) 6.25 %

Indo-European homeland was in Anatolia.

YES (50 %) 3.125 %

NO (50 %) 3.125 %

Cumulative probability for all the five claims to be true with equal probabilities

We can conclude that unlike they state, the Gray School has not *"presented decisive support for an Anatolian origin over a steppe origin"* – their method is far too unreliable for that, and they haven't considered all the possible sources of error. Already from the probabilistic point of view the chance for their hypothesis to be true is very small, even though some "yes"-options may have greater probability than 50 % (at least Anatolian being the first branch to split off) – but some may also have lesser probability.

Thus the results of computational phylogenetics cannot give decisive support for the Neolithic Anatolian homeland. When we take into consideration all the linguistic evidence which can give support to either homeland option (linguistic paleontology, ancient dialect boundaries, and the Uralic contacts), we can see that...

the Copper Age steppe homeland is still the most credible option for the Indo-European homeland.

11. What could be done to make the method more reliable?

1. To trust in the phonological level
2. To find out branches with symptoms of:
   - ◉ Innovativeness
   - ◉ Conservativeness
   - ◉ False divergence
   - ◉ Invisible convergence
3. To take into account all possible results concerning the location of ancient languages

Fortunately it is in favorable circumstances possible to point out languages/branches, which have gone through some of the distorting processes. The false divergence of Samoyed was detected with the help of the phonological level, and the invisible convergence between Finnic and Saami was detected with the help of the Germanic loanwords. Similar help could perhaps be available in the Indo-European side, too.

The results of traditional historical linguistics should not be ignored when assessing the reliability of the computational methods.

Literature

Aikio, Ante 2006: On Germanic-Saami contacts and Saami prehistory.– *Journal de la Société Finno-Ougrienne* 91, p. 9–55. <http://www.sgr.fi/susa/91/aikio.pdf>

Aikio, Ante 2007: Etymological nativization of loanwords: a case study of Saami and Finnish. – Ida Toivonen & Diane Nelson (editors): *Saami Linguistics*, p. 17–52. Amsterdam: John Benjamins. <http://cc.oulu.fi/~anaikio/etym_nativ_preprint.pdf>

Anthony, David W. 2007: *The Horse, the Wheel, and Language: How Bronze-Age Riders from the Eurasian Steppes Shaped the Modern World.* Princeton University Press.

Atkinson, Quentin D. & Gray, Russell D. 2006: Chapter 8: How Old is the Indo-European Language Family? Illumination or More Moths to the Flame? Peter Forster & Colin Renfrew (editors): *Phylogenetic methods and the prehistory of languages*. Cambridge, UK : McDonald Institute for Archaeological Research, University of Cambridge.

Bouckaert Remco, Lemey Philippe, Dunn Michael, Greenhill Simon J., Alekseyenko Alexander V., Drummond Alexei J., Gray Russell D., Suchard Marc A., Atkinson Quentin D. 2012: Mapping the Origins and Expansion of the Indo-European Language Family. – *Science* vol. 337, p. 957–960.

Carpelan, Christian & Parpola, Asko 2001: Emergence, contacts and dispersal of Proto-Indo-European, Proto-Uralic and Proto-Aryan in archaeological perspective. Christian Carpelan, Asko Parpola & Petteri Koskikallio (editors): *Early Contacts between Uralic and Indo-European: Linguistic and Archaeological Considerations*, p. 55–150. Mémoires de la Société Finno-Ougrienne 242. Helsinki: Finno-Ugrian Society.

Darden, Bill J. 2001: On the Question of Anatolian Origin of Indo-Hittite. Drews, Robert (editor): *Greater Anatolia and the Indo-Hittite language family.* Journal of Indo-European Studies Monograph Number 38. The Institute for the Study of Man.

Garrett, Andrew 2006: Convergence in the formation of Indo-European subgroups: Phylogeny and chronology. Forster, Peter & Renfrew, Colin (editors): *Phylogenetic methods and the prehistory of languages*, pp. 139–151. Cambridge, UK : McDonald Institute for Archaeological Research, University of Cambridge. <http://linguistics.berkeley.edu/~garrett/IEConvergence.pdf >

Gray, Russell D. & Atkinson, Quentin D. 2003: Language-tree divergence times support the Anatolian theory of Indo-European origin. – *Nature* vol. 426.

Gray, Russell D. & Atkinson, Quentin D. & Greenhill, Simon J. 2011: Language evolution and human history: what a difference a date makes. – *Phil. Trans. R. Soc. B* **366**, p. 1090–1100.

Häkkinen, Jaakko 2007: *Kantauralin murteutuminen vokaalivastaavuuksien valossa*. Pro gradu -työ, Helsingin yliopiston Suomalais-ugrilainen laitos. <https://oa.doria.fi/handle/10024/7044>

Häkkinen, Jaakko 2009: Kantauralin ajoitus ja paikannus: perustelut puntarissa. – *Journal de la Société Finno-Ougrienne* 92, p. 9–56. <http://www.sgr.fi/susa/92/hakkinen.pdf>

Häkkinen, Jaakko 2010: Jatkuvuusperustelut ja saamelaisen kielen leviäminen (OSA 2). – *Muinaistutkija* 2 / 2010. <http://www.mv.helsinki.fi/home/jphakkin/Jatkuvuus2.pdf>

Häkkinen, Jaakko 2012a: Uralic evidence for the Indo-European homeland. (Manuscript) <http://www.mv.helsinki.fi/home/jphakkin/UralicEvidence.pdf>

Häkkinen, Jaakko 2012b: Early contacts between Uralic and Yukaghir. Tiina Hyytiäinen**,** Lotta Jalava**,** Janne Saarikivi & Erika Sandman (editors): *Per Urales ad Orientem Iter polyphonicum multilingue Festskrift tillägnad Juha Janhunen på hans sextioårsdag den 12 februari 2012.* Mémoires de la Société Finno-Ougrienne 264, p. 91–101. Helsinki: Finno-Ugrian Society. <http://www.sgr.fi/sust/sust264/sust264_hakkinenj.pdf>

Häkkinen, Jaakko 2012c: After the protolanguage: Invisible convergence, false divergence and boundary shift. – *Finnisch-Ugrische Forschungen* 61.

Heggarty, Paul (presentation): Calling the bluff on linguistic palaeontology – the horse, the wheel and... the king? http://www.arch.cam.ac.uk/~pah1003/loe/Eng/Papers/AbstractsTalks/TalkAbstractHeggarty080514.pdf

Heikkilä, Mikko 2011: Huomioita kantasaamen ajoittamisesta ja paikantamisesta sekä germaanisia etymologioita saamelais-suomalaisille sanoille. – *Virittäjä* 1/2011. <http://ojs.tsv.fi/index.php/virittaja/article/view/4035>

Janhunen, Juha 1996: *Manchuria. An Ethnic History.* Mémoires de la Société Finno-Ougrienne 222. Helsinki: Finno-Ugrian Society.

Janhunen, Juha 2001: Indo-Uralic and Ural-Altaic: On the diachronic implications of areal typology. Christian Carpelan, Asko Parpola & Petteri Koskikallio (editors): *Early Contacts between Uralic and Indo-European: Linguistic and Archaeological Considerations*, p. 207–220. Mémoires de la Société Finno-Ougrienne 242. Helsinki: Finno-Ugrian Society.

Janhunen, Juha 2007: Typological expansion in the Ural-Altaic belt. – *Incontri Linguistici*, vol. 30, s. 71–83. Pisa & Roma: Fabrizio Serra Editore.

Kallio, Petri 2006: Suomen kantakielten absoluuttista kronologiaa. – *Virittäjä* 1 / 2006, p. 2–25. <http://www.kotikielenseura.fi/virittaja/hakemistot/jutut/2006_2.pdf>

Kallio, Petri 2007: Kantasuomen konsonanttihistoriaa. – Jussi Ylikoski ja Ante Aikio (toim.): *Sámit, sánit, sátnehámit. Riepmočála Pekka Sammallahtii miessemánu 21. beaivve 2007*, p. 229–249. Mémoires de la Société Finno-Ougrienne 253. Helsinki: Finno-Ugrian Society. <http://www.sgr.fi/sust/sust253/sust253_kallio.pdf>

Kallio, Petri 2008: On the 'Early Baltic' Loanwords in Common Finnic. Alexander Lubotsky, Jos Schaeken & Jeroen Wiedenhof (editors): *Evidence and Counter-Evidence: Essays in Honour of Frederik Kortlandt 1. Balto-Slavic and Indo-European Linguistics*, p. 265–277. Studies in Slavic and General Linguistics 32. Amsterdam – New York.

Kallio, Petri 2009: Stratigraphy of Indo-European loanwords in Saami. – Tiina Äikäs (editor): *Máttut – máddagat: The Roots of Saami Ethnicities, Societies and Spaces / Places*, p. 30–45. Giellagas-instituutin julkaisut 12. Oulu: Giellagas-instituutti. <http://www.mv.helsinki.fi/home/petkalli/mattut.pdf>

Kloekhorst, Alwin 2007: *The Hittite Inherited Lexicon*. Leiden University Centre for Linguistics, Faculty of Arts, Leiden University. <https://openaccess.leidenuniv.nl/handle/1887/11996>

Koivulehto, Jorma 1983: Suomalaisten maahanmuutto indoeurooppalaisten lainasanojen valossa. – *Journal de la Société Finno-Ougrienne* 78, p. 107–132.

Koivulehto, Jorma 1991: *Uralische Evidenz für die Laryngaltheorie. Österreichische Akademie der Wissenschaften*. Philosophisch-Historische Klasse. Sitzungsberichte, 566. Band. Wien 1991.

Koivulehto, Jorma 2002: Contact with non-Germanic languages II: Relations to the East. – Oskar Bandle et al. (editors): *The Nordic Languages. An International Handbook of the History of the North Germanic Languages*, p. 583–594. Berlin – New York: Walter de Gruyter.

Lehtisalo, Toivo 1956: *Juraksamojedisches Wörterbuch*. Lexica Societatis Fenno-Ugricae XIII. Helsinki: Finno-Ugrian Society.

Mallory, J. P. 1989: *In Search of the Indo-Europeans. Language, Archaeology and Myth*. London: Thames and Hudson.

Mallory, J. P. 2001: Uralics and Indo-Europeans: Problems of time and space. Christian Carpelan, Asko Parpola & Petteri Koskikallio (editors): *Early Contacts between Uralic and Indo-European: Linguistic and Archaeological Considerations*, p. 345–366. Mémoires de la Société Finno-Ougrienne 242. Helsinki: Finno-Ugrian Society.

Mallory, J. P. & Adams, Douglas Q. 2006: *The Oxford Introduction to Proto-Indo-European and the Proto-Indo-European World*. Oxford / New York: Oxford University Press.

Melchert, H. Craig 1998: The Dialectal Position of Anatolian within Indo-European. *Proceedings of the Twenty-Fourth Annual Meeting of the Berkeley Linguistics Society: Special Session on Indo-European Subgrouping and Internal Relations* (1998), pp. 24–31 <http://elanguage.net/journals/bls/article/view/3284/3268>

Melchert, H. Craig (forthcoming): The position of Anatolian. Andrew Garrett & Michael Weiss (editors) forthcoming: *Handbook of Indo-European Studies*. Oxford: Oxford University Press. <http://www.linguistics.ucla.edu/people/Melchert/The%20Position%20of%20Anatolian.pdf>

Michalove, Peter A. 2002: The Classification of the Uralic Languages: Lexical Evidence from Finno-Ugric. – *Finnisch-Ugrische Forschungen* 57, p. 58–67. <https://oa.doria.fi/handle/10024/20282>

Nakhleh, Luay & Ringe, Don & Warnow, Tandy 2005: Perfect phylogenetic networks: a new methodology for reconstructing the evolutionary history of natural languages. – *Language* volume 81, number 2.

Rédei, Károly 1986: *Zu den indogermanisch-uralischen Sprachkontakten*. Manfred Mayrhofer & Volfgang U. Dressler (editors). Veröffentlichungen der Kommission für Linguistik und Kommunikationsforschung, Heft 16. Wien.

Ringe, Don & Warnow, Tandy & Taylor, Ann 2002: Indo-European and computational cladistics. – *Transactions of the Philological Society* volume 100:1, p. 59–129.