

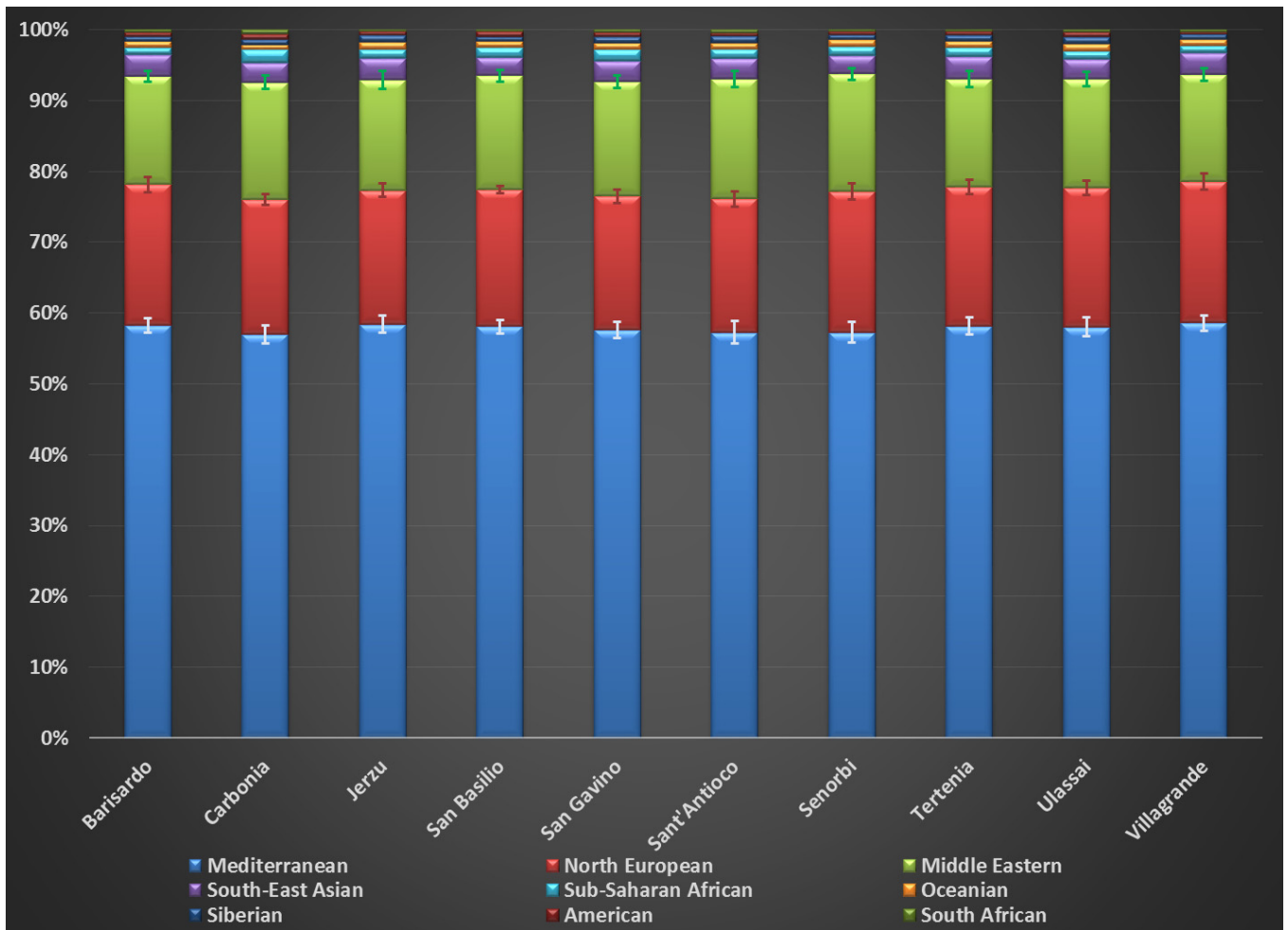
## Supplemental information

Pavel Flegontov, Alexei Kassian, Mark G. Thomas, Valentina Fedchenko, Piya Changmai, George Starostin. 2016. Pitfalls of the geographic population structure (GPS) approach applied to human genetic history: A case study of Ashkenazi Jews.

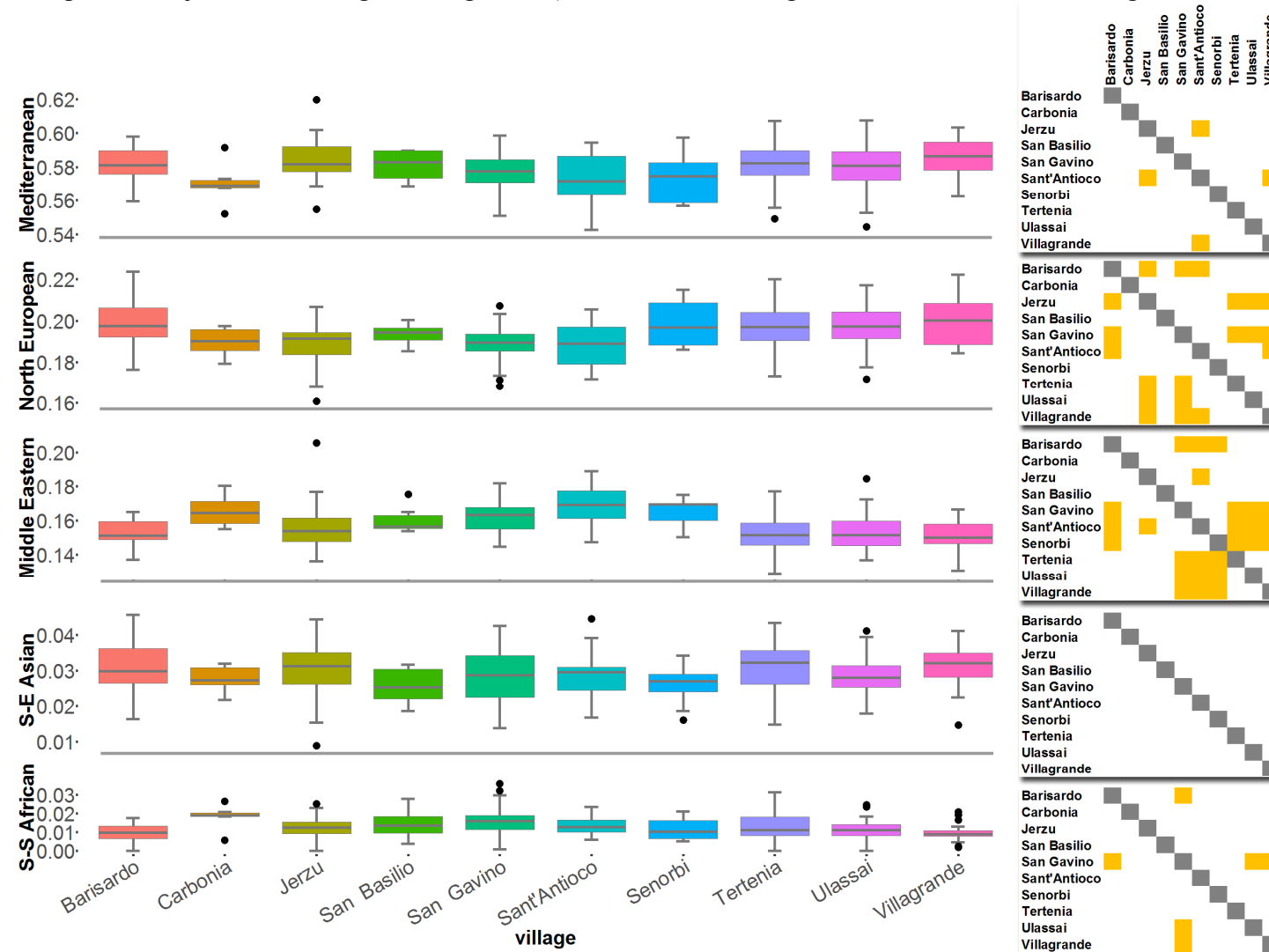
**Suppl. Table 1.** Average admixture coefficients and their standard deviations of the sample for ten Sardinian villages (data from Elhaik et al. 2014).

village	Mediterranean	North European	Middle Eastern	South-East Asian	Sub-Saharan African	Oceanian	Siberian	American	South African
<b>Barisardo</b>	58%	20%	15%	3%	1%	1%	1%	1%	0%
SD	1.0%	1.1%	0.7%	0.8%	0.5%	0.6%	0.5%	0.6%	0.4%
<b>Carbonia</b>	57%	19%	17%	3%	2%	1%	1%	1%	1%
SD	1.3%	0.7%	1.0%	0.4%	0.7%	0.6%	0.5%	0.7%	0.5%
<b>Jerzu</b>	58%	19%	16%	3%	1%	1%	1%	1%	0%
SD	1.2%	1.0%	1.3%	0.7%	0.6%	0.6%	0.6%	0.5%	0.3%
<b>San Basilio</b>	58%	19%	16%	3%	1%	1%	1%	1%	0%
SD	1.0%	0.5%	0.8%	0.5%	0.9%	0.5%	0.4%	0.7%	0.3%
<b>San Gavino</b>	58%	19%	16%	3%	2%	1%	1%	1%	0%
SD	1.1%	0.9%	0.9%	0.7%	0.8%	0.7%	0.5%	0.4%	0.3%
<b>Sant'Antioco</b>	57%	19%	17%	3%	1%	1%	1%	0%	0%
SD	1.6%	1.1%	1.1%	0.7%	0.5%	0.7%	0.5%	0.5%	0.4%
<b>Senorbi</b>	57%	20%	17%	3%	1%	1%	1%	0%	0%
SD	1.5%	1.1%	0.8%	0.6%	0.7%	0.9%	0.3%	0.3%	0.4%
<b>Tertenia</b>	58%	20%	15%	3%	1%	1%	1%	1%	0%
SD	1.2%	1.0%	1.1%	0.7%	0.8%	0.6%	0.5%	0.4%	0.4%
<b>Ulassai</b>	58%	20%	15%	3%	1%	1%	1%	1%	0%
SD	1.3%	1.0%	1.0%	0.6%	0.6%	0.5%	0.6%	0.5%	0.3%
<b>Villagrande</b>	59%	20%	15%	3%	1%	1%	1%	0%	0%
SD	1.1%	1.1%	0.9%	0.6%	0.5%	0.8%	0.5%	0.5%	0.4%

**Suppl. Fig. 1.** Average admixture profiles of ten Sardinian villages (data from Elhaik et al. 2014). The error bars show standard deviations of the sample for three major admixture components.



**Suppl. Fig. 2.** Box plots illustrating distributions of five admixture components in each village (data from Elhaik et al. 2014). The components that reach >1% in the whole Sardinian dataset are Mediterranean, North European, Middle Eastern, South-East Asian, and Sub-Saharan African. The box plot shows the median (crossbar), the first and third quartiles (hinges) and values within 1.5 inter-quartile range from the hinge (whiskers). Outliers are shown with black circles. Pairs formed by villages that are significantly different according to ANOVA combined with Tukey's honest significance test ( $p$ -value adjusted for multiple testing < 0.05) are marked in orange in the matrices beside each panel.



## Suppl. Text 1: Genetic affiliation of the Yiddish language

by Alexei Kassian, Valentina Fedchenko, George Starostin

According to a general consensus in modern linguistics (see, e.g., Jacobs et al. 1994; Jacobs 2005; Rothstein 2006; Harbert 2007; Weinreich 2008; Roberge 2010, etc.), Yiddish is a language of the Germanic group of the Indo-European language family; even more precisely, it belongs to the High German cluster of Germanic (thus Yiddish's close relative is Modern German). Yiddish originates from a High German dialect, or rather an *ethnolect*, spoken by the Ashkenazi Jews of Central and East Europe in the Middle Ages (which naturally implies that the Yiddish ethnolect arose after the Ashkenazi Jews shifted from their original language(s) to Old or Middle High German).

Modern linguistics generally postulates that two languages can be considered genetically related if there exists (1) a significant number of etymological matches between their basic vocabularies, and (2) a significant number of etymological matches between their main grammatical exponents (number, case, person), see, e.g., Campbell & Poser 2008; Burlak & Starostin 2005; Rankin 2003.

The Germanic (or narrowly High German) affiliation of Yiddish is thus firmly based on two facts: (1) the Yiddish basic vocabulary (including the Swadesh wordlist) is predominantly Germanic, (2) the majority of grammatical exponents, including the main ones, are Germanic.

A good illustration of the Germanic nature of the non-cultural vocabulary in Yiddish would be the Swadesh 200-item wordlist representing the core basic vocabulary of human language. The overwhelming majority of Yiddish Swadesh items are of Germanic origin, cf., e.g., body part terms: *kop* 'head', *ojər* 'ear', *ojg* 'eye', *noz* 'nose', *fus* 'foot', *hant* 'hand' and so on; or the personal pronoun paradigms: *ix*, *mix*, *mir* 'I' (nominative, accusative, dative), *du*, *dix*, *dir* 'you (sg.)', *mir*, *unʒ* 'we'. Only a couple of Swadesh items are of Hebrew (such as *levonə* 'moon', *xajə* 'animal') or Slavic origin (such as *korə* 'bark of tree', *ozərə* 'lake'), which means that, formally, they have to be treated as borrowings.

The same concerns a larger sample of basic vocabulary: Kaufman's 700-item list (Kaufman 1973) which is also mostly Germanic. Only *ca.* 10% of Kaufman's list are Slavic and *ca.* 5% are Hebrew.

The majority of Yiddish grammatical exponents are also transparently Germanic (Jacobs et al. 1994; Jacobs 2005). For instance, the nominal plural exponents are *-ər* or *-(ə)n* with or without Umlaut: *lid* – *lidər* 'song, songs', *sod* – *sedər* 'orchard, orchards' (a Slavic loanword), *jor* – *jorn* 'year, years' (although besides German *-ər*, *-(ə)n*, the Hebrew plural suffix *-əs* is widely used). The case suffixes are: accusative-dative *-(ə)n*, genitive *-(ə)s*. The present tense endings: 1 sg. *-Ø*, 2 sg.

-st, 3 sg. -t, cf. *ix šrajb, du šrajb-st, er šrajb-t* ‘I, you, he write(s)’, *ix čepə, du čepə-st, er čepə-t* ‘I, you, he bother(s)’ (a Slavic loanword). Note that all these exponents are applicable to both indigenous Germanic and borrowed Slavic words (as well as Hebrew words in at least some cases).

In 1991, the Israeli linguist Paul Wexler came up with the idea that Yiddish is actually a language of the Slavic group (‘fifteenth Slavic language’), heavily saturated with High German loanwords. Although Wexler was able to publish his radical views in some authoritative journals and publishing houses (Wexler 1991; 2002; and finally Das et al. 2016), he did not manage to gain any converts among linguists. Das et al. (2016) claim that ‘the opposing view posits a Slavic origin [of the Yiddish language]’, but the references mentioned by Das et al. in support of this ‘opposite view’ are predictably limited to Wexler’s works. Negative reaction by linguists was also scarce (although cf. the critical notes by Bernard Comrie, Neil Jacobs, and other invited referees in the same issue of the *International Journal of the Sociology of Language* 91, 1991), which is naturally explained by the fact that Wexler’s scenario implies such strong methodological flaws and so blatantly violates empirically known mechanisms of language contacts that it is rarely considered worthy of a serious response.

Although there is indeed a sizeable amount of Slavic words in Yiddish, Slavic languages are not the main lexifier of modern Yiddish. According to various experts, the bulk of Yiddish vocabulary is of High German origin; Hebrew and Aramaic come in second (hereafter the Semitic portion will be labeled simply Hebrew for the sake of brevity), and Slavic occupies the third place. The percentage of German–Hebrew–Slavic items in Yiddish vocabulary is estimated from 70–20–10 to 85–12–3 in Jacobs et al. 1994: 417, as 80–15–5 in King 2001: 216, as from 80–7–7 to 82–8–9 in Joffe 1927/1928 (Wexler (1991; 2010) himself agrees with this kind of ranking, although in Das et al. 2016 he takes the opposite position, claiming that Slavisms allegedly occupy 43% and Germanisms – only 35% of Yiddish lexicon). The exact quotas depend, among other things, on specific dialects: being adjacent to Slavic languages, such as Polish, implies a higher number of Slavic words in vocabulary and *vice versa*, although such variation mostly affects the cultural part of Yiddish vocabulary.

Even more important is that Yiddish basic and non-cultural vocabulary is predominantly German, whereas Slavic elements are characteristic of cultural vocabulary. Cf. some typical semantic fields where Slavic words occur: plant foods: *kašə* ‘porridge’, *malinə* ‘rasberry’, *truskafkə* ‘strawberry’; animals and animal foods: *kačkə* ‘duck’, *prežənicə* ‘omelet’; household objects: *pripəčik* ‘stove’; climate: *vixər* ‘whirlwind’; emotions: *pikrə* ‘unpleasant’; specialized anatomic terminology: *plix* ‘bald pate’, *belmə* ‘cataract’ etc. (the Hebrew portion is mostly cultural as well, normally including religious and legal spheres, abstract concepts, but also comprising several adverbs and prepositions, Katz 1985). Such a distribution unambiguously speaks in favor of the

traditional scenario with the Ashkenazim as a German-speaking religious group influenced by contacting Slavic languages.

It is well established that cultural vocabulary is always borrowed first, whereas basic vocabulary is generally more resistant to borrowing (Thomason & Kaufman 1988; van Coetsem 2000; Thomason 2001; Winford 2003). E.g., the number of French loanwords in Modern English is substantial, but only one French item has managed to penetrate into the Swadesh 100-item wordlist of Modern English (*mountain*). At the penultimate stage of language shift, only a few basic terms are retained as remnants of the original language of the population, the rest of lexicon is borrowed (see Kassian 2014 for such sociolinguistic cases as Malol and Niuafu'ou).

If the Ashkenazim were, as Wexler supposes, an originally Slavic-speaking population influenced by High German dialects, we would expect the reverse situation for modern Yiddish: Slavic basic vocabulary (in particular, predominantly Slavic items in the Swadesh wordlist, since imposition typically implies that more stable components get retained, Coetsem 2000) and German cultural loanwords.

A separate issue is that Yiddish has some words and grammar features that were recently borrowed from Modern German (Weinreich 2008), cf., e.g., inherited *kort* 'playing card' vs. recently borrowed *kartə* 'map' (< German *Karte* 'map; playing card'). Such Germanization is especially typical of Literary Yiddish (Schaechter 1969), e.g., the inherited pronoun *em* ~ *ejm* 'him' is used in the majority of dialects, but Literary Yiddish prefers the variant *im*, borrowed from or influenced by Modern German *ihm* [i:m] 'him'. This is a very common situation when dialects gradually give up their specific traits under the pressure of an official literary language, cf. the same process in the dialects of English, French, Russian, etc.

Wexler's (1991, 2002) evidence for the alleged Slavic (specifically Sorbian – sic!) origin of Yiddish consists of two points:

1) Slavic words in Yiddish vocabulary, which are mostly of cultural origin and therefore not diagnostic for genetic relationship. Such late East Yiddish Slavisms as *pop* 'Orthodox priest', *cerkvə* 'Orthodox church' seem especially suspicious to Wexler (1991), who claims that there were no reasons for German-speaking Jews to borrow such terms. However, *pace* Wexler, local religious terminology is typologically very prone to borrowing, e.g., Slavic-speaking Orthodox immigrants in Germany can use the recent loanword *kirxə* for 'Lutheran/Catholic church' < German *Kirche* 'church in general', etc. (Wexler (1991) also implausibly proposes an Upper Sorbian source for Yiddish *pop*, *cerkvə*, citing a non-existing Upper Sorbian form, although Belarusian is a more likely donor language from the phonetic point of view (on the whole, inaccuracies in Wexler's Slavic data seem quite substantial).

2) Phonetic and morphosyntactic similarities between Yiddish and Slavic. Despite Wexler's claims that the component 'of the phonotactics, and, I suspect, morphosyntax, is predominantly Slavic' (Wexler 1991), 'Yiddish grammar and phonology are Slavic (with some Irano-Turkic input)' (Das et al. 2016), he offers only a few such cases. We will not dwell upon phenomena which are characteristic specifically of Slavic and/or Hebrew portion of Yiddish vocabulary, since these are irrelevant for our purposes. Typical Yiddish-Slavic matches that apply to the whole vocabulary, according to Wexler (1991, 2002), are:

- phonological distinction between voiceless and voiced obstruents in final position;
- semantic shifting of some German aspectual/spatial verbal prefixes, as well as some nominal derivational suffixes, towards the functions of their Slavic counterparts;
- some German (as well as Hebrew) nouns changed their grammatical gender to match their translational equivalents in Slavic languages;
- presence of some Slavic derivational affixes, e.g., the verbal (imperfective) suffix *-avə-* (which competes with the German suffix *-ir-*);
- and a couple of others.

Although these phenomena do look like Slavic-influenced innovations (rather Ukrainian-Belarusian or Polish, not Sorbian as Wexler suggests), structural changes of such kinds cannot serve as proof of genetic origin. On the contrary, structural divergence as well as borrowing of some derivational affixes is a typical result of heavy linguistic influence on the part of a dominant language (Yiddish dominated by Slavic in our case), sometimes called *metatypy* in modern linguistics (Thomason & Kaufman 1988; Thomason 2001; Winford 2003; Ross 2006). An appropriate mirroring instance is Slovenian, a Slavic language dominated by neighboring German: the functions of Slovenian verbal aspectual/spatial prefixes have been accommodated to the corresponding German prefixes (Reindl 2008). Another mirroring example is the Modern Russian verbal suffix *-ir-*, borrowed from German.

Wexler (2002, 2010 and elsewhere) also claims that there are Iranian and Turkic loanwords in Yiddish – this is a crucial point for Das et al. 2016, where the following wording is used: 'a Slavic origin [of Yiddish] with strong Iranian and weak Turkic substrata'. In fact, however, Wexler (2002; 2010) offers only a couple of Yiddish cultural words which eventually go back to 'Iranian' (*scil.* Persian?) or Turkic forms, but all reliable cases represent areally diffused words spread across Slavic languages. E.g., Yiddish *lokš* 'noodle' which corresponds to Ukrainian *lokš-in-a* (dial. also *lokša*), Czech *lokša*, Tatar dial. *lakša*, etc. < Persian *lākča*, all meaning 'noodle'. The same concerns Yiddish *kaftn* 'caftan', *fistaškə* 'pistachio', *balagan* 'mess, pandemonium' (with the same semantic development), *čugun* 'cast iron' and others, which eventually go back to Persian or Turkic, but have

also penetrated into East Slavic. Thus, Yiddish terms are explainable as Slavic loans, and there is no firm linguistic evidence for positing early Yiddish-Persian or Yiddish-Turkic contacts.

A particular case, which deserves an individual comment, is Yiddish *šabaš* ‘tip given to musicians at a wedding by guests who dance’, quoted in Wexler 2010 as evidence for alleged interference between Yiddish and Persian. The Yiddish word is a rarely used professional term of klezmer argot (Ben-Ezra 1965). Its ultimate source is indeed Persian *ša:ba:š* ‘Bravo! excellent! money thrown about at marriages, or given to singers’ (contraction from the Persian collocation *ša:d ba:š* ‘well done!’). But *šabaš* is currently a Pan-Caucasian word, attested with this specific meaning in various languages of Dagestan and all the way up to Armenian, further in Turkish, etc. The European klezmer community may have obtained this Caucasian-Anatolian *terminus technicus* via minor migrations or via professional musical ties.

As for Wexler’s methodological flaws, we agree with Comrie (1991) who points out that Wexler (1) takes the Slavic origin of Yiddish as an already established fact and simply seeks additional proof for it; (2) believes that a dozen pieces of weak evidence can be equivalent to one piece of strong evidence (Comrie addresses this to Wexler 1991, but it can be fully applied to Wexler 2002, 2010 as well). These two well-known methodological traps allow to ‘prove’ almost any idea and hypothesis.

Moreover, the discussion of Jewish history in Das et al. (2016) contains a substantial number of statements which are speculative and unsupported by positive evidence. One of the most crucial concepts for the hypothesis advanced by Das et al. is the alleged Slavic nature of (Ashkenazi) Jews in the Near East of the late 1<sup>st</sup> millennium AD; for example, cf. the following historical passages from Das et al. 2016 and Wexler’s previous works.

In the 9<sup>th</sup> century, a Persian postal official in the Baghdad Caliphate, ibn Khordādhbeh, described the Iranian Jewish traders, who by then may have already become a tribal confederation of Slavic, Iranian, and Turkic converts to Judaism, as conversant in the main components of Yiddish: Slavic, German, Iranian, Hebrew, in addition to several other languages. (Das et al. 2016)

The first part of this sentence is correct, since ibn Khordādhbeh does indeed describe Jewish traders, the so-called Radhanites (Adler 1930, Holo 2009), but the second part — about their mixed “Slavic, Iranian, and Turkic” nature — is nothing but a speculative hypothesis based on ibn Khordādhbeh’s indication that the Radhanites spoke many languages: Arabic, Persian, Roman (i.e., Greek and Latin), “the Frank”, Spanish, and Slav. It is natural that traders whose routes ran from modern France to China were able to speak the languages of their main interactors, but it does not prove the polyethnic nature of Radhanite Jews. Moreover, the relationship between ibn Khordādhbeh’s Radhanites and the historical Ashkenazim is uncertain.



Ashkenazic began with the meaning of ‘Scythian’. In the 10<sup>th</sup> century in Baghdad it meant ‘Slavic’ [...] (Das et al. 2016);

Sa’adya Gaon translated He[brew] *ashkenaz* by Arabic *’aṣ-ṣaqālība* ‘Slavic’ in his Judeo-Arabic translation of the Bible in the early 10th century [...] (Wexler 2010)

Again, the first statement may be correct: the ethnonym *Scythians* is indeed rendered as *iškuzā(ya)*, *ašguzaya* or *asguzaya* in cuneiform Assyrian records of the first half of the 1st millennium BC written in Neo-Assyrian and Neo-Babylonian languages (Starr 1990; Leichty 2011), and it is a likely source of Ancient Hebrew *Ashkenaz*, the name of one of the descendants of Noah according to the Old Testament (Gen 10:3; an Ashkenaz kingdom is also mentioned in Jer 51:27), if it is true that the Hebrew letter for *u* was confused with the similar letter for *n* in the course of manuscript copying (as is usually proposed, e.g., Kriwaczek 2005: 321, although there is a philological problem with this since the cuneiform forms probably rendered the phonetic structure [skutsa(ya)]). However, all of this is apparently irrelevant for the historical Ashkenazim, since their ethnonym goes back to the already dessemanticized Biblical name *Ashkenaz*. More problematic is Wexler’s second claim about the Medieval identity of *Ashkenazic* and *Slavic*. Indeed, the Medieval Arabic term *ṣaqalībī* ~ *ṣiqalībī* (plural *ṣaqālība*) originally meant ‘Slavs’ (normally denoting slaves of the Slavic origin), but early on, the term *ṣaqālība* was extended to other populations of East and Central Europe stretching all the way from modern Germany to Volga Bulgaria (Golden 1995). Thus, Saadia Gaon’s Arabic translation *ṣaqālība* for the Biblical *Ashkenaz* may simply mean that he located the Ashkenazic land in Europe.

In the [Khazar] Empire, Slavic and Iranian had become major *lingua francae* (Wexler 2010). (Das et al. 2016)

This statement is incorrect and the reference to Wexler 2010 is misleading, since Wexler does not analyse any Khazar linguistic material in that paper. The remnants of the extinct Khazar, the main language of the Khazar khanate, are confined to proper names and a couple of appellatives. Despite the scarceness of data, etymological analysis coupled with historical evidence definitely suggests that Khazar belonged to the Turkic language group, most likely to the Bulgar subgroup of Turkic (Golden 1980; Gadzhieva 1996; Golden 2007; Erdal 2007). There is no evidence that Slavic (which form of it?) and/or Iranian (which form of it?) had the functions of *linguae francae* throughout the Khazar khanate.

[...] the small size of the Jewish population in Middle Ages Germany that was on the order of hundreds or thousands, which makes them unlikely to exact a strong cultural influence on the numerous Irano-Turko-Slavic AJs (Polak 1951) [...] (Das et al. 2016)

The most parsimonious explanation for our findings is that Yiddish speaking AJs have originated from Greco-Roman and mixed Irano-Turko-Slavic populations who espoused Judaism in a variety of venues throughout the first millennium A.D. in “Ashkenaz” lands centered between the Black and Caspian Seas (figs. 4 and 5) (Baron 1937). (Das et al. 2016)

Das et al. refer to two authors, Abraham Polak and Salo Wittmayer Baron, who hypothesize that the Ashkenazim are descendants of the Medieval Khazars. This theory is at best controversial (see van Straten 2011: 18–19 for the overview), with only a few proponents among modern scholars (in fact, arguably limited to the authors under review). The main problem with Das et al.’s statements, however, is that they replace *Khazars* with their own enigmatic term “mixed Irano-Turko-Slavic population” that makes the references to Polak and Baron misleading: both Polak and Baron follow the common view that the Khazars were Turks (although it is true that, throughout various periods of its existence in the 7<sup>th</sup>–10<sup>th</sup> centuries AD, the empire-like Khazar khanate controlled territories of many other peoples, among whom were other Turkic tribes, East Slavic tribes, Hungarians, Iranian-speaking Alans, Goths, various Nakh-Dagestanian-speaking tribes and so on).

It is not surprising that suchlike statements and claims are usually left without cited references or are accompanied with references only to Wexler’s works. We have no space to provide further examples of speculative historical statements in Das et al. 2016, but it is necessary to point out that throughout the two sections of the Discussion (Das et al. 2016) focused on history and linguistics, “Evaluating the evidence for the Rhineland hypothesis” and “Reconstructing the origin of AJs and Yiddish”, out of the 32 citations provided, 15 are self-citations by Eran Elhaik or Paul Wexler. The discussion would clearly benefit from a broader overview of the vast amount of literature on Jewish history and linguistics.

Summing up, Yiddish is a language of the High German cluster of the Germanic group with predominantly Germanic basic vocabulary and predominantly Germanic main grammatical exponents.

Numerous Hebrew-Aramaic lexical elements typical of the religious sphere can prove one of two scenarios. (1) Yiddish has borrowed some Hebrew terminology, e.g., during conversion to Judaism. (2) Hebrew words are remnants of the original language of the Ashkenazi community which shifted from Hebrew to High German in the Middle Ages (or in two stages: from Hebrew to some other language and later to High German, but there are no linguistic indications that the intermediate language could have been a Slavic one). Retention of the so-called native cultural vocabulary, implied by the second scenario, is typical of the situation of a language shift unaccompanied by a cultural shift (see Kassian 2014 for the El Molo and Yaka-Baka instances for such retention of the native cultural vocabulary).

The situation with Slavic elements (both lexical and grammatical) is more definite. Slavicization affects the core of Yiddish vocabulary and grammar to a small degree, being characteristic of cultural vocabulary and secondary grammatical features. Thus the available linguistic evidence can only speak in favor of a heavy influence on Yiddish of some Slavic

languages (mostly Polish, Ukrainian and Belarusian; *pace* Wexler, the Sorbian component is very modest) during its usage by the Ashkenazi community. In other words, the typology of language contact definitely suggests that Slavic languages functioned as adstrate and superstrate for Yiddish, rather than an underlying substrate (see also Pereltsvaig 2016, where some more complicated sociolinguistic scenarios are discussed).

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