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Chapter 11

Click languages tend to have large consonant inventories: Implications for language evolution and change

Thora Daneyko[a] and Christian Bentz[a,b]

Abstract
Languages with click consonants have been noted to exhibit exceptionally large phoneme inventories. We test this pattern empirically on a sample of 17 click languages compared to 1650 non-click languages obtained from the Phoible database. We find a significant statistical association between having clicks and larger phoneme inventory size, especially consonant inventory size. This association holds also a) when clicks themselves are removed from the consonant inventories, and b) within the Bantu family, some of whose members have adopted clicks from neighboring Khoisan languages. Clicks are sometimes argued to reflect a deep split in the human lineage, being retained in an early divergent population and lost in the rest. However, a possible alternative is that clicks were adopted at a later point in some languages that already had large phoneme inventories. In the case of Southern Bantu languages, it is likely that clicks were borrowed due to sociolinguistic pressures such as language taboos and identity marking.

INTRODUCTION

Click consonants rank among the rarest phonemes of the world's languages (Maddieson 2013), occurring only in a small number of languages in southern Africa and a speech register in Australia (Ladefoged and Maddieson 1996: 246). However, they are not uncommon per se, and occur frequently in language communities all around the world with paralinguistic functions (Gil 2013). As phonemes, they often come in large quantities. While being created with a lingual (or labial) airstream, they can be articulated with various pulmonic and non-pulmonic accompaniments such as nasalization, aspiration, or ejectives (Clements 2000; Ladefoged and Maddieson 1996: 264-265). A small number of basic click articulations can thus quickly explode into a multitude of phonemic consonants.

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It has been observed that the world's largest phoneme inventories occur in click languages, and that click languages of the Khoisan group seem to generally exhibit very large phoneme inventories (e.g., Güldemann 2001: 4). In particular, Fleming (2017: 53) claims that: "Click consonants not only contribute to the extra-large phoneme inventories of these Southern Khoesan languages, but they also are its principal cause," suggesting that without the clicks, these languages would actually have average phoneme inventories.

In this paper, we investigate quantitatively whether these observations hold up to statistical scrutiny. Therefore, in our first analysis, we contrast the global distribution of phoneme inventory sizes in languages without clicks with inventory sizes of languages having clicks. We then specifically investigate Bantu languages in Subsaharan and southern Africa in the second analysis. Finally, we discuss potential repercussions of the statistical results for theories of why certain languages have "marked" phonemes such as clicks.

Geographic distribution of click languages

Except for the speech register Damin of the Australian (Tangkic) language Lardil (Hale and Nash 1997), all known click languages are spoken in eastern and southern Africa. According to Ladefoged and Maddieson (1996: 246), these include all the languages of the Khoisan group, some Bantu languages, as well as the Cushitic language Dahalo.

The so-called Khoisan languages have not (yet) been established as an actual family of related languages by the comparative method, but are rather a group of languages that share certain features – such as clicks. They are commonly divided into the southern African Khoisan languages, which comprise the three families Kx'a (formerly Ju-ǂHoan, also referred to as Northern Khoisan), Khoe-Kwadi (Central Khoisan), and Tuu (Southern Khoisan), as well as the eastern African Khoisan languages: the two isolates Hadza and Sandawe (Güldemann 2014: 25-31). In some analyses, Sandawe might be counted towards the Khoe-Kwadi family (see Güldemann 2014: 35). A feature that all of the Khoisan languages have in common is their phonemic usage of clicks, and that these clicks are inherited, i.e. that there is no evidence for recent borrowing (though the case of Hadza is debatable, see Güldemann 2007). Moreover, for the S. A. Khoisan families, clicks can be traced back to their respective shared ancestors (Güldemann and Vossen 2000).

Cushitic and Bantu languages, on the other hand, did not originally have clicks. The Bantu click languages either acquired their clicks via contact with the Khoisan speakers in surrounding areas, sometimes mediated via other Bantu languages, or through independent innovation (Pakendorf et al. 2017: 7 pp.). In the case of Dahalo, it is unclear where it gained its clicks from. However, it has been argued that clicks can definitely not be reconstructed to Proto-Cushitic, so the most plausible expla-

nation is a contact situation with a click language at some point in its history (Güldemann 2007: 13).

HYPOTHESIS 1: GLOBAL ASSOCIATION BETWEEN CLICKS AND LARGE PHONEME INVENTORIES

In the following analysis we test whether phoneme inventories of click languages are generally larger than phoneme inventories of non-click languages. Importantly, we test whether their size is also above average if we *subtract the click series*. Hence, we test the following hypothesis:

> *Hypothesis 1: Languages using clicks as phonemes have generally larger non-click sound inventories than languages not using clicks.*

Data

To test this hypothesis, we consult the *Phoible* database (Moran, McCloy, and Wright 2014). This database comprises seven smaller phonological databases and contains phoneme inventories of overall 1672 languages. For each inventory, all phonemic segments, i.e. consonants, vowels and tones, are listed separately both as IPA symbols and as feature bundles. Due to disagreement between the individual sources, Phoible does not list one inventory per language, but one inventory per 'doculect', i.e. per language according to a given source. This means that for many languages, there are multiple inventories available, which can differ noticeably in size and content. Overall, there are 2155 inventories in Phoible.

Phoible mostly adopts a so-called *unit analysis* of complex segments, meaning that these are represented as single units rather than teased apart into sequences of segments (Moran 2012). In Khoisan linguistics, on the other hand, it has been suggested to rather analyze some complex clicks (as well as other complex consonants) as sequences of segments in a so-called *cluster analysis* (Güldemann 2001; Nakagawa 2006). For example, Güldemann (2001: 23, Table 4) analyzes a voiced alveolar click accompanied by a velar fricative [g!x] (in the language !Xõo, more recently renamed to Taa) as a cluster of two separate segments /g!/+/x/, whereas Phoible represents this as a single unit. Clearly, such differences in the analysis result in differences in the overall segment count. Since we here use Phoible, we follow its respective analysis for any given inventory.

In order to get a global comparison between inventory sizes, we extract the data for all languages listed in Phoible. In addition to the individual inventory sizes, we also download genealogical (genus and family) and geographical information (latitude, longitude and country), as well as the click segments for the click languages.

Table 1 shows the click languages contained in Phoible and how they are classified there. Note that while Sandawe is grouped with the Khoisan languages, Hadza is counted as an isolate. Also, Phoible lists the

Nilo-Saharan language Masalit as having two clicks according to Edgar (1989). However, Edgar (1989) notes that "these occur very rarely indeed (in [his] data): e.g., *ndo†* (sucking noise made by infant at the mother's breast)," which suggests that they might only surface as onomatopoetic sounds, and not as regular consonants. Since Masalit is also not mentioned as a click language in other works, we decided to mark it as a non-click language.

The Bantu click languages in this sample further differ by the "functional load" of clicks, i.e. the proportion of click words in dictionaries. For example, Pakendorf et al. (2017: 10) estimate that in the Southeastern Bantu (SEB) languages Xhosa and Zulu the functional load is at 26.8% and 22% respectively, while for the Southwestern Bantu (SWB) language Yeyi it is at 10-15%, and for Fwe it is only at around 1%. In fact, some of the Bantu languages in this sample (e.g. Chopi, Kgalagadi, and Ronga) are only considered "marginal" click languages by Pakendorf et al. (2017: 6) due to their very low functional load. We do here not distinguish between Bantu click languages according to functional load, though this might be considered in further research.

Finally, five non-click languages have to be removed from the sample due to missing geographical data (Akuntsu, Larantuka Malay, Kisa, Saamia and Tsotso). For the remaining languages, we calculate the mean sizes of their inventories across different doculects to obtain a single value for each language. Thus, the final sample containes 17 click and 1650 non-click languages.

Table 1.
Number of click languages (n) listed in Phoible with their classification, their Phoible name, and common alternative names in parentheses.

n	Classification	Phoible names, and alternative names in parentheses
6	Khoisan	Hai//om, Ju/'hoan, Nama (Khoekhoe), Kxoe (Khwe), Sandawe, !Xoo (Taa)
9	Niger-Congo (Bantoid)	Chopi, Fwe, Kgalagadi, North Ndebele[1], Ronga, "Sissano" (Sesotho, i.e. Southern Sotho)[2], Xhosa, Yeyi, Zulu
1	Afro-Asiatic	Dahalo
1	Nilo-Saharan	Nuclear Masalit
1	Hadza	Hadza

[1] This inventory likely derives from Zimbabwean Ndebele, since Northern Ndebele has lost all clicks according to Pakendorf et al. (2017: 10).
[2] The Sesotho (Southern Sotho) inventory is erroneously attributed to the Austronesian language Sissano in Phoible.

Methods

We use the statistical software R (R Core Team 2017), in particular the package *ggplot2* (Wickham 2016) for plotting, and the package *ggmap* (Kahle and Wickham 2013) with map data from google for the background in Figure 4. To compare click and non-click languages, we conduct Wilcoxon rank sum tests via the function *wilcox.test( )*. This is a non-parametric alternative to the student t-test, applied when the data distributions deviate from normality. To check for correlations between numeric variables, we employed Pearson's product-moment correlation tests as implemented in R.

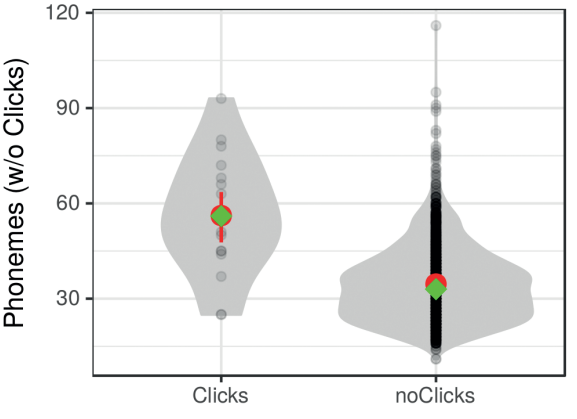


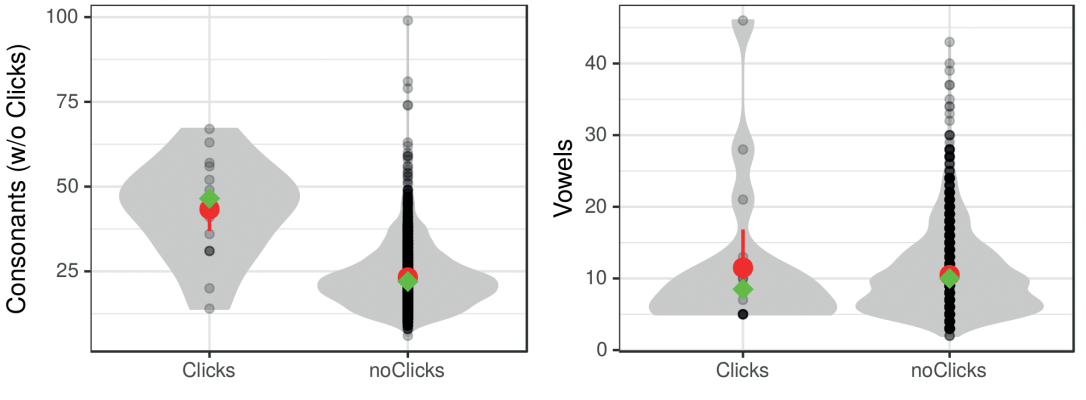
Fig. 1.
The number of phonemes (excluding clicks) in languages with and without clicks ("Clicks" and "noClicks"). The black transparent dots represent inventory sizes of individual languages. Grey areas indicate the density of data points in a so-called "violin" plot. The red dots indicate mean values with confidence intervals. Green diamonds indicate median values.

Results

As Figure 1 illustrates, there is a clear difference in mean and median phoneme inventory sizes between click (mean = 56.2, median = 56, SD = 18.3) and non-click languages (mean = 34.6, median = 33, SD = 11.8). Namely, languages featuring clicks in their phoneme inventories have on average *21 phonemes more* than languages not featuring clicks. Note, again, that this is *after* clicks themselves are removed from the inventories. A Wilcoxon rank sum test reveals that this difference is highly significant ($p < 0.0001$).

If we split the inventories into consonants and vowels, as shown in Figure 2, we get a very similar picture for consonant inventories but not for vowel inventories. Click languages tend to have more consonants (mean = 43.3, median = 46.5, SD = 14.1) than non-click languages (mean = 23.2, median = 22, SD = 9.2). This is again a

Fig. 2. below
The number of consonants (left panel) and vowels (right panel) in languages with and without clicks ("Clicks" and "noClicks"). The black transparent dots represent inventory sizes of individual languages. Grey areas indicate the density of data points in a so-called "violin" plot. The red dots indicate mean values with confidence intervals. Green diamonds indicate median values.



highly significant difference ($p < 0.0001$). However, the mean and median number of vowels is very similar for click (mean = 11.5, median = 8.5, SD = 10.6) and non-click languages (mean = 10.5, median =10, SD = 5.6), with no statistically significant difference ($p = 0.36$). Henceforth, we therefore only investigate *consonant inventory sizes*, not the overall number of phonemes.

HYPOTHESIS 2: CONSONANT INVENTORIES AND CLICKS WITHIN BANTU

As pointed out above, all click languages investigated here are spoken in a fairly restricted geographical area (on a global scale). Except for two (Hadza and Dahalo), they all belong to the Khoisan group or Bantu family. It is thus possible that the connection we see between large consonant inventory sizes and clicks is a property of southern and eastern Africa as a geographic area.

To further disentangle phylogenetic from geographic patterns, we should test for the link between consonant inventories and clicks within an established family. Our possibilities for this are very limited: the different languages of families grouped under Khoisan constitute examples that can be shown to have inherited clicks. However, these languages all have clicks, and there are hence no non-click Khoisan languages which we could compare consonant inventory sizes against. Hadza, if not counted towards Khoisan, is an isolate and has no relatives to test against. Dahalo is the only click language in the Cushitic (Afro-Asiatic) family. Testing a single data point against all other Afro-Asiatic languages is not very telling. We are left with the Bantu subfamily, which provides us with multiple click and a large number of non-click languages. We thus postulate a second hypothesis:

> *Hypothesis 2: Bantu languages using clicks as phonemes have generally larger non-click consonant inventories than Bantu languages not using clicks.*

Data

Phoible contains 201 languages from the Bantoid genus, nine of which use click consonants. Bantoid is not to be confused with Bantu, rather, it is a group containing the Bantu languages (Narrow Bantu) as well as languages closely related to Bantu. The exact division between Narrow Bantu and the other Bantoid languages is contested, but all clearly non-Bantu and controversial cases are spoken exclusively in Nigeria and Cameroon (Williamson and Blench 2000). We remove the Phoible Bantoid languages spoken in these countries from the sample, which reduces it by almost half to 102 Narrow Bantu languages (including the nine click languages).

Results

The statistical association between having clicks and large consonant inventories also holds within the Bantu family, as shown in Figure 3. The effect even seems to be stronger: Bantu languages with clicks have on average approximately 25 *consonants more* (mean = 50, median = 49, SD = 12.2) than Bantu languages without clicks (mean = 25.4, median = 22, SD = 9.6). Again, this difference is highly significant ($p < 0.0001$).

Interestingly, we can also see a correlation between the actual number of clicks in any given Bantu language and its consonant inventory size. This is reflected in a Pearson correlation coefficient of $r = 0.63$ ($p < 0.0001$). In other words, Bantu languages with more clicks also tend to have more consonants than Bantu languages with fewer or no clicks. However, it needs to be kept in mind that the sample of Bantu click languages is very small here ($n = 9$).

In the cases where clicks were copied into Bantu languages from Khoisan languages, the question arises whether they were the only consonants copied, or whether both clicks and larger inventory sizes are an effect of proximity to Khoisan. As a preliminary test, we calculate the distance to the closest Khoisan language for each Bantu language. We then investigate whether the resulting minimum distances predict either number of consonants, or clicks, or both. In this analysis, we count Hadza towards the Khoisan group, since it also possibly inherited its clicks and therefore might have been a potential source of clicks and other consonants for the neighboring Bantu languages in the past.

It turns out that minimum distance to Khoisan is not associated with neither consonant inventory size ($r = -0.03$, $p = 0.73$) nor number of clicks ($r = 0.01$, $p = 0.93$). A look at the map in Figure 4, however, reveals that Bantu click languages are indeed spoken close to the southern African Khoisan area. Still, there are many Bantu languages also close to this area that do not have clicks. Incidentally, these also have relatively

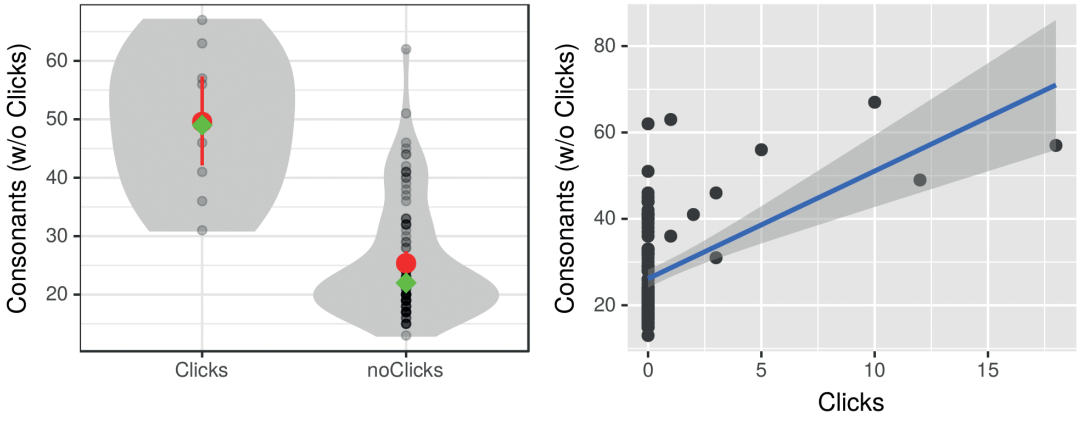


Fig. 3.
The number of consonants (excluding clicks) in Bantu languages with and without clicks (left panel), and in relation to the number of clicks in Bantu languages (right panel). The blue line represents a linear regression model with gray confidence intervals.

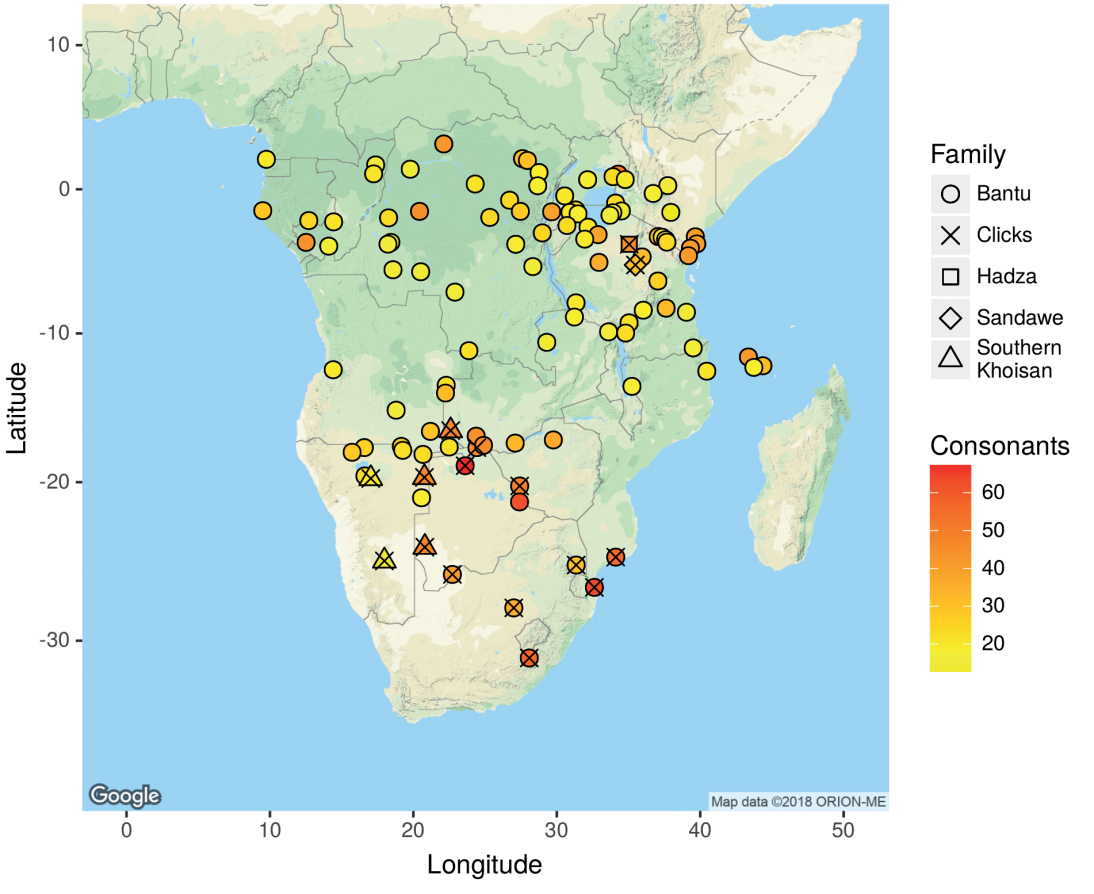


Fig. 4.
The location of Bantu languages (circles), Hadza (square), Sandawe (diamond), and Southern Khoisan languages (triangles) in eastern and southern Africa. The consonant inventory size of languages is indicated by color (yellow = small, red = large). Click languages are marked by a cross.

few consonants, while the click languages have some of the largest consonant inventories of all Bantu languages. Hadza and Sandawe in the east do not seem to have any effect at all on the surrounding Bantu languages.

Of course, we need to take into account that we measure minimum distance to Khoisan languages *as of today*. A possible explanation for the lack of a correlation between geographic proximity to Khoisan and the number of clicks and consonants in any given Bantu language is that the latter have changed their geographic locations in the course of the Bantu expansion. Some Bantu languages such as Xhosa, Zulu, and Southern Sotho might have borrowed their clicks further up north before migrating to the south.

DISCUSSION

Our statistical analyses have revealed a clear association between phoneme—especially consonant—inventory size and the presence of clicks. This trend is also apparent within the Bantu family. Hence, large

inventory sizes are not necessarily lineage-specific, but possibly in some relation with the development of clicks. However, it is yet unclear what exactly this relation is. Why do languages with clicks tend to have many consonants in general?

Clicks as remnants of Proto-Human?

Clicks have sometimes been regarded as archaic sounds, that might potentially be attributed to an ancient Proto-Human language from which all modern languages originated. Fleming (2016, 2017) gives an overview of the literature on this topic going back to the mid 19th century. For a critical discussion see also Sands and Güldemann (2009). The ancient-clicks hypothesis is intriguing and has been rekindled by a genetic survey of different African populations, including southern African Khoisan and Hadza speaking populations, by Knight et al. (2003), who argue that their results imply an ancient status of click consonants:

> *"Indeed, the molecular data are consistent with the most recent shared ancestry of these two populations coinciding with the earliest divergence among extant human populations. [...] If, in fact, San-Hadzabe separation dates back to a time prior to out-of-Africa expansions of modern humans, clicks may be more than 40,000 years old. Under that scenario, clicks would have been lost subsequently in most other populations"* (Knight et al. 2003).

While an interesting hypothesis, there is so far no convincing *linguistic* evidence for clicks being inherited over 40,000 years (Güldemann 2007; Sands and Güldemann 2009). In fact, it is questionable whether there can ever be such evidence, since this time depth by far exceeds the comparative horizon of approximately 10,000 years at most (Nichols 1997). It is possible that the Khoisan languages, a diverse and not necessarily related group of lineages, did not inherit their clicks from an ancestor shared by all members, but rather acquired them later, either by developing them independently, or copying them from other languages long extinct. At least the case of Bantu click languages (which definitely did not inherit their clicks from a Proto-Human language) illustrates that there can be further pressures at play in the adoption of clicks beyond phylogenetic inheritance.

Clicks as last resort consonants?

It appears that there are some sounds that are more "marked" than others (Greenberg 2005), and that there is a hierarchy in which languages tend to develop and lose certain kinds of phonemes (Greenberg, Ferguson, and Moravcsik 1978). Assuming that clicks are among the more marked sounds, it is possible that they are adopted only under "extreme" circumstances, namely when a language already has many "less marked" con-

sonants but there is still pressure to develop additional consonants. Thus, Bantu click languages might have started borrowing clicks because they had already developed most of the available "less marked" consonants.

However, the concept of click "markedness" is hard to grasp in empirical terms. While clicks are rare phonemes, they are not necessarily rare as paralinguistic sounds: language communities around the world employ at least some types of clicks to convey affective or logical meanings. English speakers may utter '*tsk tsk*' (i.e., dental clicks) to express disappointment (Gil 2013). There is evidence that children learn clicks just as early and easily as they learn other sounds (Gxilishe 2004), while adults with clickless native languages are reported to face difficulties learning certain click types and accompaniments (see references in Pakendorf et al. 2017).

From the perspective of production, there is some preliminary evidence for anatomical biases that might facilitate or hinder the phonemic usage of clicks (Moisik and Dediu 2017). However, these are very subtle effects that need to be solidified by further studies. The paralinguistic usage of certain click types illustrates that they are in principle widely available as potential speech sounds, though such isolated and spontaneous productions are still different from systematic and rapid production in complex syllable onsets.

From the perspective of perception, it might be argued that clicks are relatively loud, stand out from the acoustic environment, and are hence relatively easy to perceive. However, beyond the clear perceptual distinctiveness of some places of articulation (e.g., labial versus lingual clicks), subtle differences in phonation (e.g., nasalized versus non-nasalized) can also constitute minimal pairs in click languages, and these are certainly harder to keep apart for speakers of clickless languages.

In sum, there is no straightforward answer *why* clicks should be dispreferred as speech sounds. However, purely looking at the distribution of speech sounds across the world they indeed stand out as an unlikely, and hence "marked" option.

Clicks just some of many borrowed consonants?

To further shed light on the relationship between having clicks and large consonant inventories, it is worth taking a closer look at the Bantu languages. They developed clicks recently enough to still show traces of how these entered the language and how the overall phoneme inventory was affected by this.

According to Herbert (2004), the case of Khoisan-Bantu language contact is a curious one. It is striking that the respective Bantu languages almost exclusively borrowed clicks, while "[t]he nasalised vowels and the diphthongs of Khoesan languages, surely less exotic phenomena than clicks, are not borrowed into any Bantu language" (Herbert 2004).

Even more striking than this is the fact that clicks are not restricted to Khoisan loanwords, but can be observed even in Bantu cognates, as in

Zulu *-consa* [ǀonsa] 'fall, drip, leak' vs. *ilithonsi* [ilitʰonsi] 'drop of liquid', where both words are clearly derived from the same (Bantu) root, but one contains a click, while the other does not. Even more often it is the case that the same Bantu word occurs twice in the vocabulary with a slightly different meaning, once with a click and once without, as in Zulu *-chela* [ǀʰela] 'sprinkle' vs. *-thela* [tʰela] 'pour (out)' (examples by Herbert 2004, transcription following Ager 2017).

Herbert (2004) argues that the reason for these unusual outcomes of Bantu-Khoisan contact is a range of avoidance customs grouped under the term *hlonipha* practiced especially by the Southeastern Bantu (SEB) communities. One of the hlonipha customs is a linguistic taboo imposed on married women according to which they are not allowed to pronounce the names of their father-in-law, and certain other male persons, and any syllable contained in these names to show them respect. Finlayson (2004) illustrates this with an example:

> *"Robert and Grace Green have three children – William, Joan and Margaret. William marries Mary and takes her home to his family. [...] [F]rom now on she may never use the syllables occurring in the names of her husband's family, i.e. simplistically* rob*,* ert*,* green*,* will*,* may[1] *and* grace*. Thus for the sentence 'Grace will not eat green yoghurt', Mary would have to say something like: 'The older daughter of Smith refuses to eat grass-coloured yomix'"* (Finlayson 2004: 279).

Since the number of forbidden names and syllables can be quite large, this will considerably reduce the married woman's linguistic options. In order to adhere to the taboo, she will either rephrase her sentences, use synonym words or mutate syllables so that they no longer resemble the offensive ones (Herbert 2004: 306). Clicks are useful for this: Since they are quite different from the native Bantu inventory, replacing the consonant of a forbidden syllable with a click is enough to make the syllable acceptable again. Also, this will not create homophones, as consonant substitution with native sounds could (Herbert 2004: 306). Finlayson (2004) observes that modern hlonipha does not necessarily involve the avoidance of certain syllables anymore, but rather the use of a specific standardized vocabulary. It may be that a similar process led to the incorporation of click-bearing hlonipha words into the regular vocabulary of the affected languages.

Two more recent articles by Gunnink et al. (2015) and Pakendorf et al. (2017) review particular sociolinguistic settings of Khoisan-Bantu contact in the light of the latest linguistic as well as genetic studies. Interestingly, the proportions of "autochthonous genetic lineages," that is,

1 The author probably intended to write *yam* and not *may*.

genetic lineages associated with Khoisan groups, are particularly high in Bantu-speaking populations of southern Africa due to extensive intermarriage between Khoisan women and Bantu men (Pakendorf et al. 2017: 17; Barbieri et al. 2014). This might fit with Herbert's (2004) hypothesis that hlonipha-practicing women of Khoisan origin might have driven the adoption of clicks – at least in the Southeastern Bantu (SEB) communities. In the case of Southwestern Bantu communities (SWB), on the other hand, Gunnink et al. (2015: 218) point out that hlonipha is not in practice, and clicks might instead have served to mark a separate identity.

If this holds true, then clicks were potentially not the only consonants borrowed for sociolinguistic purposes. Did, for instance, the hlonipha-practicing Bantu speakers generally adopt many consonants from neighboring languages, not necessarily only from Khoisan? This could partly explain the striking correlation between having clicks and large consonant inventories.

Unfortunately, there is, to our knowledge, no quantifiable information on which languages practice(d) hlonipha. Fandrych (2012) states that it is "common in a number of speech communities in southern Africa belonging to the Southern Bantu language family," whereas Herbert (2004) reduces the number to the Nguni and Southern Sotho subgroups of Southern Bantu. Interestingly, all of the Southern Bantu languages in our sample (as classified in Glottolog; Hammarström, Forkel, and Haspelmath 2017) have clicks, and 7 of the 9 Bantu click languages are Southern Bantu, of which 3 belong to the Nguni and 2 to the Sotho-Tswana group, so there could be a quantifiable link between practicing hlonipha and borrowing clicks in Southeastern Bantu.

Further problems and caveats

While the statistical results of our analyses are strong, they are based on just 17 click languages compared to 1650 non-click languages. There are certainly more Khoisan languages (Güldemann and Vossen 2000 estimate around 30), and also further Southern Bantu languages that might use clicks, but are currently not included in Phoible. In the worst case scenario, these missing languages could have average-sized to small consonant inventories, and hence yield the results non-significant if included in the sample.

Therefore, it would be informative to include other phoneme inventory databases not represented in Phoible, such as the "Ruhlen database" (Creanza et al. 2015), in future analyses. This can help to clarify if our results are robust, or driven by biases in the sample of languages represented. Additionally, the database(s) might be updated by recent contributions on phoneme inventories of click languages, including Nakagawa (2006) for G|ui, Fehn (2014) for Ts'ixa (Khoe-Kwadi), Naumann (2016) for Taa (Tuu family), and Gerlach (2016) for N!aqriaxe (Kx'a family).

Another more general problem with measuring phoneme inventory sizes are inconsistencies and idiosyncrasies of coding. There is some-

times considerable disagreement on phoneme counts between different sources, and the sizes of inventories for a given language can vary according to different 'doculects'. This can be attributed to different criteria established by the sources: Telugu, for example, has 43 phonemes according to one source, but 68 according to another, since the latter counts geminate consonants as separate phonemes while the former does not.

Click languages can be likewise affected by such inconsistencies: One source has only 4 clicks listed for Khoekhoe (Nama), while another lists 20. This is related to the issue of unit analysis versus cluster analysis outlined above. While one inventory only reflects the basic click types by place of articulation (dental, alveolar, palatal, and lateral), the other inventory reflects combinations of click types plus accompaniments. Our strategy here is to not take sides on the "right way" of analyzing clicks, or complex consonants in general, but to represent all the data by averaging across different sources. This yields values which—while somewhat artificial—reflect different concepts of counting phonemes.

CONCLUSION

The results of our analyses presented in this paper statistically support an association between having clicks and (non-click) consonant inventory size, such that on average languages with phonemic clicks have larger consonant inventories than languages without clicks.

However, the cause(s) for this relation remain(s) unclear. It is possible that clicks used to be more widespread, or were present in a very early ancestral language, but were in most instances lost together with other consonants. On the other hand, it seems likely that languages only start incorporating clicks when they already employ many consonants, leaving them with a limited range of phonemic options left to develop. In the case of Bantu click languages, having clicks and large inventory sizes might turn out to be two sides of the same coin, in the sense that Bantu speakers adopted large numbers of consonants, including clicks, from surrounding languages for social purposes. Since we can only trace back the history of languages for a certain amount of time, we cannot exclude that a similar process might have led to the simultaneous development of clicks and large numbers of other consonants in languages of Khoisan lineages.

All of these possible explanations imply that clicks are "marked" sounds that were either lost early in most languages, or adopted late and/or consciously in some few languages. Either way, their relative cross-linguistic rarity is surprising given the widespread paralinguistic usage of click-like sounds. Further research is needed to empirically grasp their perceived "markedness," and how this is interlinked with their evolution and maintenance.

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REFERENCES

Ager, S. 2017. Omniglot - writing systems and languages of the world. Zulu (isiZulu). url: http://www.omniglot.com/writing/zulu.htm (visited on 06/13/2017).

Barbieri, C., T. Güldemann, C. Naumann, L. Gerlach, F. Berthold, H. Nakagawa, S. W. Mpoloka, M. Stoneking, and B. Pakendorf .2014. Unraveling the complex maternal history of Southern African Khoisan populations. *American Journal of Physical Anthropology* 153(3): 435–448.

Clements, G. N. 2000. Phonology. In *African Languages: An Introduction*, ed. by Bernd Heine and Derek Nurse. Cambridge University Press.

Creanza, N., M. Ruhlen, T. J. Pemberton, N. A. Rosenberg, M. W. Feldman, and S. Ramachandran. 2015. A comparison of worldwide phonemic and genetic variation in human populations. *Proceedings of the National Academy of Sciences* 112(5): 1265–1272.

Edgar, J. 1989. *A Masalit grammar: With notes on other languages of Darfur and Wadai*. Reimer.

Fandrych, I. 2012. Between tradition and the requirements of modern life: Hlonipha in southern Bantu societies, with special reference to Lesotho. *Journal of Languages and Culture* 3.4: 67–73.

Fehn, A.-M. 2014. A Grammar of Ts'ixa (Kalahari Khoe). PhD dissertation, University of Cologne.

Finlayson, R. 2004. Women's language of respect: isihlonipho sabafazi. In *Language in South Africa*, ed. by Rajend Mesthrie, pp. 279–296. Cambridge University Press.

Fleming, L. 2017. Phoneme inventory size and the transition from monoplanar to dually patterned speech. *Journal of Language Evolution* 2 (1): 52–66.

Fleming, L. 2016. Phoneme Inventory Size Distributions And The Origins Of The Duality Of Patterning, ed. by S. G. Roberts, C. Cuskley, L. McCrohon, L. Barceló-Coblijn, O. Fehér, and T. Verhoef. url: http: //evolang.org/ neworleans/papers/12.html.

Gerlach, L. 2016. *N!aqriaxe – the phonology of an endangered language of Botswana*. Wiesbaden, Harrassowitz Verlag.

Gil, D. 2013. Para-Linguistic Usages of Clicks. In *The World Atlas of Language Structures Online*, ed. by Matthew S. Dryer and Martin Haspelmath. Leipzig: Max Planck Institute for Evolutionary Anthropology. url: http:// wals.info/chapter/142.

Greenberg, J. H. 2005. *Language universals: With special reference to feature hierarchies*. Walter de Gruyter.

Greenberg, J. H., C. A. Ferguson, and E. A. Moravcsik. 1978. *Universals of human language: Phonology. Vol. 2*. Stanford University Press.

Güldemann, T. 2001. Phonological regularities of consonant systems across Khoisan lineages. *University of Leipzig Papers on Africa, Languages and Literatures* 16. Leipzig: Institut für Afrikanistik, Universität Leipzig.

Güldemann, T. 2007. Clicks, genetics, and "proto-world" from a linguistic perspective. *University of Leipzig Papers on Africa, Languages and Literatures* 29. Leipzig: Institut für Afrikanistik, Universität Leipzig.

Güldemann, T. 2014. 'Khoisan' linguistic classification today. In *Beyond 'Khoisan'. Historical relations in the Kalahari Basin*, ed. by T. Güldemann and A.-M. Fehn, pp. 1–41. John Benjamins.

Güldemann, T. and R. Vossen. 2000. "Khoisan". In *African Languages: An Introduction*, ed. by B. Heine and D. Nurse. Cambridge University Press.

Gxilishe, S. 2004. The acquisition of clicks by Xhosa-speaking children. In *Per Linguam: A Journal of Language Learning* 20.2, pp. 1–12.

Hammarström, H., R. Forkel, and M. Haspelmath, eds. 2017. Glottolog 3.0. url: http://glottolog.org (visited on 06/13/2017).

Herbert, R. K. 2004. The sociohistory of clicks in Southern Bantu. In *Language in South Africa*, ed. by R. Mesthrie, pp. 297–315. Cambridge University Press.

Kahle, D., and H. Wickham. 2013. ggmap: Spatial Visualization with ggplot2. The *R Journal* 5(1), 144–161. URL http://journal.r-project.org/archive/2013-1/kahle-wickham.pdf

Knight, A., P. A. Underhill, H. M. Mortensen, L. A. Zhivotovsky, A. A. Lin, B. M. Henn, D. Louis, M. Ruhlen, and J. L. Mountain. 2003. African Y chromosome and mtDNA divergence provides insight into the history of click languages. *Current Biology* 13.6: 464–473.

Ladefoged, P., and I. Maddieson. 1996. *The Sounds of the World's Languages*. Blackwell.

Ladefoged, P., and A. Traill. n.d. Linguistic Phonetic Description of Clicks. In *Language* 60.1: 1–20.

Maddieson, I. 2013. Presence of Uncommon Consonants. In *The World Atlas of Language Structures Online*, ed. by M. S. Dryer and M. Haspelmath. Leipzig: Max Planck Institute for Evolutionary Anthropology. url: http://wals.info/chapter/19.

Moran, S., D. McCloy, and R. Wright, eds. 2014. *PHOIBLE Online*. Leipzig: Max Planck Institute for Evolutionary Anthropology. url: http: //phoible.org/ (visited on 05/06/2017).

Moisik, S. R., and D. Dediu. 2017. Anatomical biasing and clicks: Evidence from biomechanical modeling. *Journal of Language Evolution* 2(1): 37–51.

Nakagawa, H. 2006. Aspects of the phonetic and phonological structure of the G|ui language. PhD dissertation, University of Witwatersrand.

Naumann, C. 2016. The phoneme inventory of Taa (West !Xoon dialect). In Essays in memory of Anthony Traill, ed. by R. Vossen and W. H. G. Haacke. Köln: Rüdiger Köppe.

Nichols, J. 1997. Modeling ancient population structures and movement in linguistics. *Annual review of anthropology* 26(1): 359–384.

R Core Team. 2017. R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing. Vienna, Austria. url: https://www.R- project.org.

Sands, B., and T. Güldemann. 2009. What click languages can and can't tell us about language origins. In *The Cradle of Language*, ed. by R. Botha and C. Knight. Oxford University Press.

Wickham, H. 2016. *ggplot2: Elegant Graphics for Data Analysis*. New York: Springer Verlag.

Williamson, K., and R. Blench. 2000. Niger-Congo. In *African Languages: An Introduction*, ed. by B. Heine and D. Nurse. Cambridge University Press.