# Making the 'Next Billion' Demand Access

The Effect of Local Content `google.co.za` in Setswana

Bastiaan Quast

## Abstract

This paper shows that an exogenous increase in accessability of local language content leads to a very large increase in demand for internet connectivity among native speakers. Internet connectivity provides enormous improvements in quality of life as well as opportunities for the newly connected, yet recent attempts to connect the 'next billion' in Africa have not met expectations, even in places where infrastructure has come online and prices have gone down. The introduction of the Setswana (Tswana) language in the South-African Google Search website was a spillover of the translation from English to Setswana being done for the Botswanan Google Search website. This exogenous event has resulted in a substantial increase in the number of native Setswana speakers online as well as usage of the Setswana language online, suggesting that connecting the fourth billion will require a greater focus on demand by mean of local content.

# 1 Introduction

Local content will be vital in bringing new internet users online.

Since the term 'Connecting the Next Billion' was introduced in The Economists 2006 'End of Year Report' (Standage, 2006), close to 2 billion people are estimated to have been connected to the internet, up from the just over one billion at the time of the article's publication (Sanou, 2015). Yet, despite increased range and improved affordability, key markets, particularly sub-Saharan Africa are showing stagnation in the growth of internet connections.

This paper shows demostrates how an exogenous increase in accessability of local language content gave rise to a vast increase in the number of local language speakers online as first-time internet users.

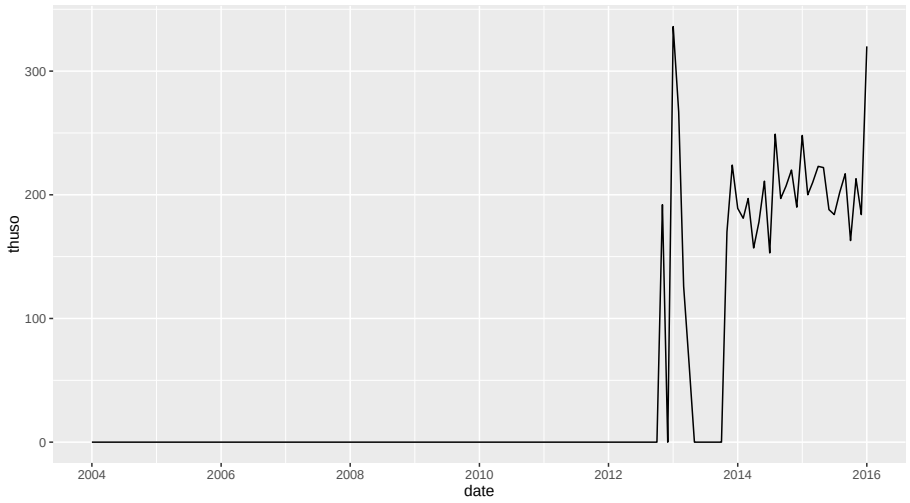
In 2010 Google collaborated with a Botswanan team of linguists(Otlogetswe, 2010) to make its Botswanan website (`google.co.bw`) available in the local language: 'Setswana'. In addition to being spoken in Botswana, there is also a sizable population of Setswana directly across the border in South Africa, where it is also one of the official state languages. This led to the introduction of the Setswana language on the South African Google website (`google.co.za`) as spillover of the translation work performed for Google's Botswanan website. This exogenous led to a large increase in the number of native Setswana speakers reporting to have spent some amount of money in the past 30 days on internet access.

Although it is not required to use a certain interface language in order to search for content in this language, the search page is in many instances the first website viewed by users. Asides from being able to understand the interface, having the interface be in a certain language also encourages usage of this language, which in turn reveales more content in this language.

In short we can identify several major channels which promote further engagement, which together constitute the theory of change. Firstly, the ability to read and understand the words of the interface increases the chance that user continue using it. Secondly, the visibility of local language content increases the likelihood of the user entering search queries in the local language and thereby finding more content in the local language. This last effect is also visible from Figure 1, which illustrates how usage of the Setswana word 'thuso', meaning 'help' was zero prior to the introduction of the Setswana search interface and became widespread thereafter.

Figure 1: Usage of Setswana Words on Google.co.za

```
ggplot(thuso) + geom_line(aes(x = date, y = thuso))
```




The vast majority of internet access is developing countries is through handheld devices such as smartphones. However, due to the limited 'real estate' (surface area of the screen) on a mobile website, the link to changing the interface language is replace with a dropdown menu that reveales the additional language options. Generally, the website will default the the operating system (Android / iOS) language, however, since many local African languages are not available as a system language, this is not possible there. The fact that the introduction seems to benefit deskop usage but not mobile usage is further substantiated by our results that isolate an increase in computer ownership, but no increase in cell phone ownership.

In addition to the increase in the number of individuals spending on an internet connection, we also find a positive effect on the number of individuals living in households with a computer.

The data used for this study comes from the South African National Income Dynamics Survey, provided by Southern Africa Labour and Development Research Unit (2008, 2012, 2013), the data is futher discussed in section 2. After whichsection 3 discusses the methods employed in this study, specifically, the discussion of the identification strategy can be found is subsection 3.1 and the use of the Difference-in-Difference estimator in subsection 3.2.

# 2 Data

- descriptive stats:

- number of adults
- Setswana speakers
- people using internet / cell phone etc.
- male / female
- linguistic skills
- income distribution

---

South Africa's National Income Dynamics Survey collect data on a representative set of around 10,000 households over time. The first survey took place in 2008, the second one in late 2010 and early 2011, and third one took place in 2012 (Southern Africa Labour and Development Research Unit, 2008, 2012, 2013).

It contains an extensive household questionaire, which breaks expenditure down into many forms of food and non-food expenditure. In addition to this, the household income is calculated and imputed with other income such as home ownership.

The individual (adult) questionnaires also contain information on linquistic skill and Englis and in the native language, as well as a series of variables relating to communication technology ownership and utilisation.

# 3 Methods

This section beings with a discussion of the identification strategy employed, followed by a explanation of the estimator used to operationalise this, and concludes with a description of the software used for this estimation.

## 3.1 Identification Strategy

This paper exploits the introduction of the Setswana interface language to Google Search in South Africa as a spillover of the development of that interface for the Botswanan Google Search website. By comparing the number of native Setswana speakers in South Africa being internet users, with the number of South Africans with a different native language around the same time, we isolate the effect of this introduction.

The Setswana language was first developed for the Botswanan Google Search website (`google.co.bw`). As such, the introduction of Setswana to the South African Google Search (`google.co.za`) was a spillover effect of that development. This allow us the rule out any possible endogeity issues that might otherwise arise in context such as these. For instance, the Afrikaans language is almost solely spoken in South Africa. When we observe that the introduction of the Afrikaans Google Search interface occurs around the same time as a growth in the number of native Afrikaans internet users, it will be hard to isolate the

effect from the introduction from its cause (since an increase in native Afrikaans internet users would be a good reason to introduce it as an interface language).

Substantial numbers of Setswana speakers exist in Botswana, South Africa, Zimbabwe, and to some extend Namibia. However the language is most important in Botswana, where it is spoken by approximately 80% of all people, and where it is the only official language other than English. As such, it is also the place where most linguistic work on the Setswana language takes place. The Setswana Google Search interface was also developed at the University of Botswana by prof. Otlogetswe.

It is worth noting that it is very common not to personally own a computer and 'paying for internet access' therefore also includes a lot of people who use the internet in other locations such as internet cafe's.

In addition to using the propensity to spend on internet (in the last thirty days), we also use the propensity to own a computer as a dependent variable.

## 3.2 Estimation

As mentioned in the above section, we compare the change in the level of internet users among native Setswana speakers in South Africa, with that of native speakers of other language in South Africa around the introduction of the Setswana interface to the South-African Google Search. For this we use a Difference-in-Difference estimator using a native-Setswana speaker dummy variable, interacted with a event dummy variable on the introduction of the Setswana interface on `google.co.za`.

In addition to this estimation, we use an alternative specification whereby a factor variable of native language is interacted with the event dummy variable. In a linear regression context, factor variables are estimated as dummy variables for all levels (here: all languages) except for once 'base' level, which is where all language dummies are `FALSE` (i.e. `0`) and the level (native language) thus has to be the nth one (here `IsiNdebele`).

The dependent variable here is also a dummy variable, which would normally allow for the usage of a estimator such as logit. However, since we are employing the Difference-in-Difference methodology ....

## 3.3 Software

In order to make the result as easily reproducible as possible, this research and writing in the article has been done exclusively using open-source software such as R (R Core Team, 2016). This document is written and LyX (LyX Team, 2016) in the LaTeX(Lamport, 1985) language and compiled using the LuaTeX implementation(Hoekwater et al., 2016). The integration of R code in the document is performed using the knitr implemenation (Xie, 2015) of the Sweave framework (Leisch, 2002).

All changes are logged using the version control system Git (Git Team, 2016) and publicly available on GitHub at https://github.com/bquast/Making-Next-

Billion-Demand-Access/[1]

# 4 Results

In the base model, we use an interaction of the `post_event` dummy and `setswana` dummy in order to isolate the effect on the explanandum, a dummy variable describing household expenditure on internet in the last thirty days or not (`h_nfnet`, household non-food internet). The results of this estimation are presented in Table 1.

We find that the the interaction term of the event dummy (`post_event`) and the native Setswana speaker dummy (`setswana`) is positive and highly significant, with a p-value around `0.0018`. Both the individual dummy variables (`post_eventTRUE` and setswanaTRUE) yield significant but negative parameter estimates. In addition to this, the covariates included in the estimation are also highly significant. The highest education level of the individual (`best_edu`) and the household income (`hhincome`) are both positive and significant. The parameter estimate of `a_womanTRUE` here is negative but not at all significant, this is unsurprising as we use internet expenditure at a household level. Most women live in a household which includes men and visa versa, suggesting that this effect cannot be isolated in this estimation. We further investigate this issue in a seperate estimation discussed below. The variables describing linguistic skills in reading and writing in both English and the native language do yield many significant results, though lower levels of English writing skill seems to be correlated with a lower propensity to use the internet (`a_edlitwrten` for levels `2` and `3`, but not the very lowest: `4`).

In an alternative formulation, we include the native language variable as a categorical variable (`factor(a_lng)`), interacted with the `post_event` dummy. In this estimation we only find significantly positive results for `setswana` and `venda` (as small language from the north-eastern region), and a significantly negative effect for the language `afrikaans`.

[1]The repository can by cloned to a local computer by entering in following command in a terminal with Git:
`git clone https://github.com/bquast/Making-Next-Billion-Demand-Access.git`

Table 1: Propensity to live in Household that Spent on Internet in Last 30 Days

```
lm(h_nfnet ~  interface_intro*setswana_logical +
              factor(a_edlitrden)                          +
              factor(a_edlitwrten)                         +
              factor(a_edlitrdhm)                          +
              factor(a_edlitwrthm)                         +
              a_woman                                      +
              hhincome                                     +
              best_edu)
```

| | Estimate | Std. Error | t value | Pr(>\|t\|) |
|---|---|---|---|---|
| (Intercept) | -0.0008565 | 0.0018351 | -0.4667340 | 0.6406924 |
| interface_introTRUE | -0.0117376 | 0.0012170 | -9.6449716 | 0.0000000 |
| setswana_logicalTRUE | -0.0135286 | 0.0024255 | -5.5777454 | 0.0000000 |
| factor(a_edlitrden)2 | 0.0015879 | 0.0040272 | 0.3942904 | 0.6933684 |
| factor(a_edlitrden)3 | 0.0002543 | 0.0052755 | 0.0481963 | 0.9615600 |
| factor(a_edlitrden)4 | -0.0036574 | 0.0068160 | -0.5365861 | 0.5915561 |
| factor(a_edlitwrten)2 | -0.0101933 | 0.0040178 | -2.5369998 | 0.0111839 |
| factor(a_edlitwrten)3 | -0.0107676 | 0.0052214 | -2.0621916 | 0.0391951 |
| factor(a_edlitwrten)4 | -0.0071685 | 0.0066937 | -1.0709421 | 0.2842010 |
| factor(a_edlitrdhm)2 | -0.0025418 | 0.0036848 | -0.6898084 | 0.4903181 |
| factor(a_edlitrdhm)3 | -0.0028899 | 0.0051291 | -0.5634293 | 0.5731453 |
| factor(a_edlitrdhm)4 | -0.0079926 | 0.0069070 | -1.1571655 | 0.2472107 |
| factor(a_edlitwrthm)2 | 0.0008117 | 0.0037229 | 0.2180373 | 0.8274010 |
| factor(a_edlitwrthm)3 | 0.0013993 | 0.0051372 | 0.2723915 | 0.7853222 |
| factor(a_edlitwrthm)4 | -0.0069174 | 0.0069137 | -1.0005354 | 0.3170567 |
| a_womanTRUE | -0.0013881 | 0.0011452 | -1.2121278 | 0.2254696 |
| hhincome | 0.0000027 | 0.0000001 | 46.2987087 | 0.0000000 |
| best_edu | 0.0013582 | 0.0001164 | 11.6710813 | 0.0000000 |
| interface_introTRUE:setswana_logicalTRUE | 0.0119717 | 0.0038666 | 3.0961443 | 0.0019617 |

Furthermore, we also use a variant of the base model, in which the propensity of adults (`a_owncom`) to own a computer is used as an explanandum. This is of particular relevance, as the explanandum here (`a_owncom`) differs from the base model's explanandum in two ways. Firstly, it does not include expenditure on internet in ways such as internet cafes, focusses on actual ownership, signaling a more long-term investment and interest. Secondly, the `h_nfnet` variable is at a household level, whereas the `a_owncom` variable is at the level of an individual adult. The results from this estimation are included in Table 2. This form of the estimation yields similar results to those estimated in the base model. Firstly we find that the variable of interest, the interaction term between the event and the setswana dummy (`post_eventTRUE:setswanaTRUE`) is positive and highly significant, with a p-value smaller than `0.001`. The invidivual dummie variables

(post_eventTRUE and setswanaTRUE) again are significant and negative with for the former's p-value smaller than 0.01 and the later's small than 0.001. In terms of the linguistic skill, we find that the lower levels of English reading as well as English writing are correlated with lower propensities of computer ownership. Similar to internet expenditure model, household income (hhincome) and highest level of education (best_edu) are both positive and highly significant (p-value: ~0). However unlike in the household internet expenditure model, the sex of the individual here is highly significant, specifically, parameter estimate of a_womanTRUE is negative and highly significant (p-value: ~0). As mentioned above, this variable is difficult to interpret when using a household-level variable as an explanandum, however, here, the computer ownership variable is at an individual level, makes the coefficient more interpretable.

Table 2: Computer in Household

```
lm(a_owncom ~ interface_intro*setswana_logical +
              factor(a_edlitrden)                    +
              factor(a_edlitwrten)                   +
              factor(a_edlitrdhm)                    +
              factor(a_edlitwrthm)                   +
              a_woman                                +
              hhincome                               +
              best_edu)
```

| | Estimate | Std. Error | t value | Pr(>\|t\|) |
|---|---|---|---|---|
| (Intercept) | 0.0075393 | 0.0031352 | 2.4047103 | 0.0161891 |
| interface_introTRUE | -0.0053820 | 0.0020917 | -2.5729824 | 0.0100856 |
| setswana_logicalTRUE | -0.0147502 | 0.0041653 | -3.5411916 | 0.0003987 |
| factor(a_edlitrden)2 | -0.0306749 | 0.0069077 | -4.4406931 | 0.0000090 |
| factor(a_edlitrden)3 | -0.0310090 | 0.0090330 | -3.4328617 | 0.0005978 |
| factor(a_edlitrden)4 | -0.0389174 | 0.0116674 | -3.3355679 | 0.0008519 |
| factor(a_edlitwrten)2 | -0.0173238 | 0.0068925 | -2.5134122 | 0.0119602 |
| factor(a_edlitwrten)3 | -0.0210640 | 0.0089384 | -2.3565895 | 0.0184476 |
| factor(a_edlitwrten)4 | -0.0187291 | 0.0114540 | -1.6351572 | 0.1020227 |
| factor(a_edlitrdhm)2 | -0.0017925 | 0.0063219 | -0.2835349 | 0.7767681 |
| factor(a_edlitrdhm)3 | -0.0041655 | 0.0088001 | -0.4733526 | 0.6359638 |
| factor(a_edlitrdhm)4 | -0.0267964 | 0.0118797 | -2.2556443 | 0.0240974 |
| factor(a_edlitwrthm)2 | 0.0010896 | 0.0063817 | 0.1707311 | 0.8644360 |
| factor(a_edlitwrthm)3 | -0.0020020 | 0.0088176 | -0.2270503 | 0.8203856 |
| factor(a_edlitwrthm)4 | -0.0357886 | 0.0118921 | -3.0094517 | 0.0026186 |
| a_womanTRUE | -0.0230335 | 0.0019598 | -11.7530143 | 0.0000000 |
| hhincome | 0.0000058 | 0.0000001 | 56.8794124 | 0.0000000 |
| best_edu | 0.0058419 | 0.0002002 | 29.1761771 | 0.0000000 |
| interface_introTRUE:setswana_logicalTRUE | 0.0238052 | 0.0066799 | 3.5637169 | 0.0003660 |

Asides from the effect on the proportion of households with internet expenditure, and the proportion of adults who own a computer, we also estimate any possible effects on the propensity of the household to own spend on a cellphone, and on adults propensity to own a cellphone.

We find no significant effects on the propensity of expenditure on cell phones or the propensity to own one. As discussed in the introduction, we suspect this to be a consequence of the fact that language switching on mobile cannot be automatic, since the Android operating system does not support the Setswana language, combined with the fact that the Setswana interface button is not visible directly on the `google.co.za` homepage, but rather in a dropdown menu (Figure 5).

# 5 Conclusions and Limitations

The vast increase of internet usage among the Setswana speaking population as a result of the newly introduced interface language on `goog.co.za`, suggest that there is a serious lack in the availability of local content in many African languages, which serves as an impediment to further internet adoption here. Additionally, there was also an observedly positive effect on computer ownership amongst adults. This suggest that the effect is unlikely to be emphemeral in nature, since computer ownership constitutes a more long-term investment in internet access.

Finally, the fact that this effect is not observed in cellphone ownership and expenditure, which is possibly a consequence of the fact that the interface cannot automatically switch and that the link 'Setswana' is not directly visible from the landing page, suggests that it is important either make the link directly visible on the landing page.

# References


Git Team

2016 *Git: Software Code Manager*, 137 Montague ST STE 380, Brooklyn, NY 11201-3548, `http://www.git-scm.org/`.

Hoekwater, Taco, Hartmut Henkel, and Hans Hagen

2016 *LuaTeX*, `http://www.luatex.org/`.

Lamport, Leslie

1985 *I1 (\ LaTeX)—A Document*, pub-AW, vol. 410.

Leisch, Friedrich

2002 "Sweave: Dynamic generation of statistical reports using literate data analysis", in *Compstat*, Springer, pp. 575-580.

LyX Team

2016 *LyX*, Free Software Foundation, Inc., 51 Franklin Street, Fifth Floor, Boston, MA 02110-1301, USA, http://www.lyx.org/.

Otlogetswe, Thapelo J.

2010 "Setswana Google is here!", *T.J. Otlogetswe Blog*, http://otlogetswe.com/2010/08/13/setswana-google-here/.

R Core Team

2016 *R: A Language and Environment for Statistical Computing*, R Foundation for Statistical Computing, Vienna, Austria, http://www.R-project.org/.

Sanou, Brahima

2015 "The World in 2015: ICT facts and figures", *International Telecommunications Union*.

Southern Africa Labour and Development Research Unit

2008 *National Income Dynamics Study, Wave 1*, version 5.3, http://www.nids.uct.ac.za/home/.

2012 *National Income Dynamics Study, Wave 2*, version 2.3, http://www.nids.uct.ac.za/home/.

2013 *National Income Dynamics Study, Wave 3*, version 1.3, http://www.nids.uct.ac.za/home/.

Standage, Tom

2006 "Connecting the next billion", *The Economist-The World in 2006*, p. 117, http://www.economist.com/node/5134746.

Xie, Yihui

2015 *Dynamic Documents with R and knitr*, Chapman and Hall/CRC, vol. 29, ISBN: 978-1498716963, http://yihui.name/knitr/.

# A Factor vs. Dummy

In addition to estimating our model using a dummy variable for native Setswana speakers, we also estimate the model using a factor variable of the categorical variable describing language. In a linear model this is operationalised as a dummy variable for each level except for the base level (here `IsiNdebele`). The results of this estimation are similar to the base model, suggesting that the results are robust to specification idiosyncrasies.

Table 3: Factor of Language

```
lm(h_nfnet ~  interface_intro*a_lng)
```

| | Estimate | Std. Error | t value | Pr(>\|t\|) |
|---|---|---|---|---|
| (Intercept) | 0.0153374 | 0.0068968 | 2.2238509 | 0.0261630 |
| interface_introTRUE | -0.0153374 | 0.0115842 | -1.3239954 | 0.1855107 |
| a_lngIsiXhosa | -0.0119771 | 0.0071155 | -1.6832303 | 0.0923369 |
| a_lngIsiZulu | -0.0101387 | 0.0070175 | -1.4447738 | 0.1485278 |
| a_lngSepedi | -0.0118839 | 0.0073155 | -1.6244854 | 0.1042787 |
| a_lngSesotho | -0.0017102 | 0.0073335 | -0.2331986 | 0.8156081 |
| a_lngSetswana | -0.0100812 | 0.0072567 | -1.3892233 | 0.1647711 |
| a_lngSiSwati | -0.0106935 | 0.0084599 | -1.2640221 | 0.2062281 |
| a_lngTshivenda | 0.1182366 | 0.0101757 | 11.6194711 | 0.0000000 |
| a_lngIsiTsonga | 0.0258487 | 0.0085505 | 3.0230556 | 0.0025036 |
| a_lngAfrikaans | 0.0293054 | 0.0071163 | 4.1180475 | 0.0000383 |
| a_lngEnglish | 0.0884438 | 0.0077486 | 11.4141745 | 0.0000000 |
| interface_introTRUE:a_lngIsiXhosa | 0.0139527 | 0.0119317 | 1.1693853 | 0.2422541 |
| interface_introTRUE:a_lngIsiZulu | 0.0146315 | 0.0117708 | 1.2430305 | 0.2138625 |
| interface_introTRUE:a_lngSepedi | 0.0169315 | 0.0122000 | 1.3878269 | 0.1651960 |
| interface_introTRUE:a_lngSesotho | 0.0130134 | 0.0122768 | 1.0600000 | 0.2891498 |
| interface_introTRUE:a_lngSetswana | 0.0207076 | 0.0121639 | 1.7023816 | 0.0886902 |
| interface_introTRUE:a_lngSiSwati | 0.0241705 | 0.0141419 | 1.7091434 | 0.0874307 |
| interface_introTRUE:a_lngTshivenda | -0.1182366 | 0.0154930 | -7.6316105 | 0.0000000 |
| interface_introTRUE:a_lngIsiTsonga | -0.0234958 | 0.0140080 | -1.6773078 | 0.0934887 |
| interface_introTRUE:a_lngAfrikaans | 0.0106404 | 0.0119382 | 0.8912936 | 0.3727760 |
| interface_introTRUE:a_lngEnglish | 0.0139328 | 0.0132294 | 1.0531742 | 0.2922663 |

Lastly, we also estimate the factor model with the inclusion of the linguistic skill variables. These results are again similar to the ones from using simply a dummy variable for native Setswana speakers, suggesting robustness to specification idiosyncrasies.

Table 4: LM4_1: with read / write in eng / native and woman

```
lm(h_nfnet ~  interface_intro*a_lng    +
              a_edlitrden              +
              a_edlitwrten             +
              a_edlitrdhm              +
              a_edlitwrthm             +
              a_woman)
```

| | Estimate | Std. Error | t value | Pr(>\|t\|) |
|---|---|---|---|---|
| (Intercept) | 0.0317749 | 0.0071775 | 4.4270461 | 0.0000096 |
| interface_introTRUE | -0.0160663 | 0.0115540 | -1.3905423 | 0.1643709 |
| a_lngIsiXhosa | -0.0099180 | 0.0072875 | -1.3609631 | 0.1735320 |
| a_lngIsiZulu | -0.0074551 | 0.0071962 | -1.0359807 | 0.3002165 |
| a_lngSepedi | -0.0117930 | 0.0074983 | -1.5727489 | 0.1157838 |
| a_lngSesotho | -0.0024452 | 0.0074934 | -0.3263203 | 0.7441835 |
| a_lngSetswana | -0.0090956 | 0.0074396 | -1.2225899 | 0.2214908 |
| a_lngSiSwati | -0.0109608 | 0.0086683 | -1.2644745 | 0.2060661 |
| a_lngTshivenda | 0.1112485 | 0.0102479 | 10.8557149 | 0.0000000 |
| a_lngIsiTsonga | 0.0241788 | 0.0088017 | 2.7470744 | 0.0060153 |
| a_lngAfrikaans | 0.0327886 | 0.0072883 | 4.4988214 | 0.0000068 |
| a_lngEnglish | 0.0833091 | 0.0078893 | 10.5597493 | 0.0000000 |
| a_edlitrden | -0.0034523 | 0.0022378 | -1.5427211 | 0.1229053 |
| a_edlitwrten | -0.0067086 | 0.0021968 | -3.0537886 | 0.0022610 |
| a_edlitrdhm | 0.0005400 | 0.0021481 | 0.2513920 | 0.8015121 |
| a_edlitwrthm | 0.0021310 | 0.0021519 | 0.9903130 | 0.3220263 |
| a_womanTRUE | -0.0012363 | 0.0011577 | -1.0678587 | 0.2855898 |
| interface_introTRUE:a_lngIsiXhosa | 0.0132544 | 0.0118983 | 1.1139774 | 0.2652947 |
| interface_introTRUE:a_lngIsiZulu | 0.0145905 | 0.0117427 | 1.2425235 | 0.2140498 |
| interface_introTRUE:a_lngSepedi | 0.0177767 | 0.0121732 | 1.4603215 | 0.1442085 |
| interface_introTRUE:a_lngSesotho | 0.0129867 | 0.0122347 | 1.0614651 | 0.2884841 |
| interface_introTRUE:a_lngSetswana | 0.0200827 | 0.0121370 | 1.6546587 | 0.0980005 |
| interface_introTRUE:a_lngSiSwati | 0.0253579 | 0.0141092 | 1.7972623 | 0.0723005 |
| interface_introTRUE:a_lngTshivenda | -0.1117493 | 0.0153827 | -7.2646212 | 0.0000000 |
| interface_introTRUE:a_lngIsiTsonga | -0.0181667 | 0.0140090 | -1.2967938 | 0.1947086 |
| interface_introTRUE:a_lngAfrikaans | 0.0095960 | 0.0119027 | 0.8062092 | 0.4201264 |

# B Ownership and Expenditure by Native Language

The below table breaks down computer and cellphone ownership as well as internet and cellphone expenditure by linguistic group.

Table 5: Descriptive statistics on Ownership and Expenditure

```
adulthh %>%
  group_by(a_lng, wave) %>%
  summarise(a_owncel    = mean(a_owncel,    na.rm = TRUE),
            a_owncom    = mean(a_owncom,    na.rm = TRUE),
            h_nfcel     = mean(h_nfcel,     na.rm = TRUE),
            h_nfnet     = mean(h_nfnet,     na.rm = TRUE),
            h_nfcelspn  = mean(h_nfcelspn,  na.rm = TRUE),
            h_nfnetspn  = mean(h_nfnetspn,  na.rm = TRUE))
```

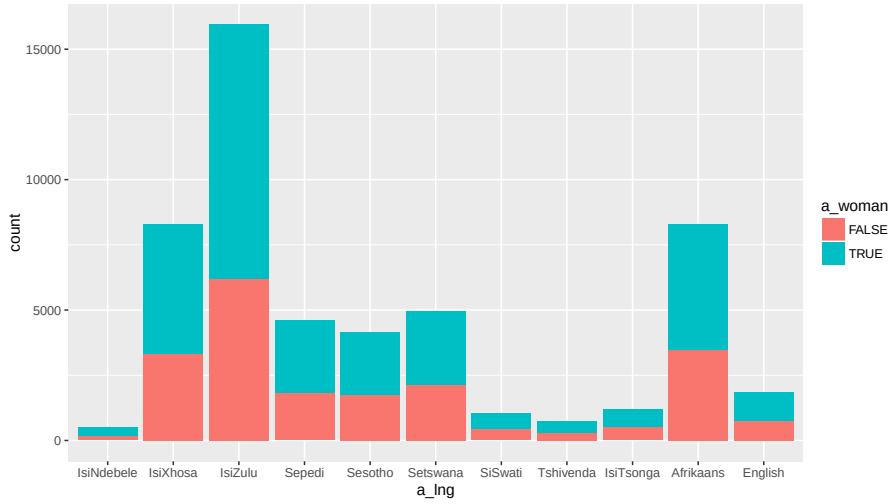
| a_lng | wave | a_owncel | a_owncom | h_nfcel | h_nfnet | h_nfcelspn | h_nfnetspn |
|---|---|---|---|---|---|---|---|
| IsiNdebele | 1 | 0.6026490 | 0.0331126 | 0.6533333 | 0.0000000 | 59.78519 | 0.0000000 |
| IsiNdebele | 2 | 0.6864865 | 0.0270270 | 0.6800000 | 0.0284091 | 84.12571 | 1.4204545 |
| IsiNdebele | 3 | 0.7611111 | 0.0333333 | 0.8722222 | 0.0000000 | 105.46067 | 0.0000000 |
| IsiXhosa | 1 | 0.4631115 | 0.0112269 | 0.4352518 | 0.0012043 | 39.76659 | 0.0574297 |
| IsiXhosa | 2 | 0.6065066 | 0.0186335 | 0.5996664 | 0.0054517 | 54.47248 | 0.2978972 |
| IsiXhosa | 3 | 0.7564988 | 0.0345508 | 0.7041694 | 0.0019756 | 86.33322 | 0.0869279 |
| IsiZulu | 1 | 0.5610984 | 0.0132693 | 0.5756053 | 0.0013730 | 48.21557 | 0.0363844 |
| IsiZulu | 2 | 0.5169004 | 0.0127744 | 0.4721318 | 0.0086366 | 49.00402 | 1.3053671 |
| IsiZulu | 3 | 0.7662405 | 0.0252420 | 0.7247881 | 0.0044928 | 96.59072 | 0.6889696 |
| Sepedi | 1 | 0.6127214 | 0.0265273 | 0.5772947 | 0.0048309 | 40.47351 | 0.3462158 |
| Sepedi | 2 | 0.7029372 | 0.0226818 | 0.5933485 | 0.0021994 | 51.69161 | 0.1583578 |
| Sepedi | 3 | 0.7936063 | 0.0718697 | 0.7863152 | 0.0050477 | 110.64450 | 1.1385306 |
| Sesotho | 1 | 0.6562986 | 0.0366044 | 0.5507812 | 0.0062598 | 49.45647 | 0.4772727 |
| Sesotho | 2 | 0.6973684 | 0.0457010 | 0.5411671 | 0.0213640 | 60.29976 | 3.0657354 |
| Sesotho | 3 | 0.8114210 | 0.0949535 | 0.8147901 | 0.0113032 | 115.52993 | 1.8284574 |
| Setswana | 1 | 0.5796003 | 0.0351724 | 0.5281593 | 0.0068681 | 59.33404 | 0.2886598 |
| Setswana | 2 | 0.6004872 | 0.0359537 | 0.6494778 | 0.0037783 | 86.17885 | 1.0214106 |
| Setswana | 3 | 0.7728036 | 0.0711086 | 0.7684564 | 0.0106264 | 112.96165 | 0.8509804 |
| SiSwati | 1 | 0.6593060 | 0.0441640 | 0.7823344 | 0.0000000 | 59.17647 | 0.0000000 |
| SiSwati | 2 | 0.7598870 | 0.0612813 | 0.6693227 | 0.0091185 | 63.28685 | 0.4589666 |
| SiSwati | 3 | 0.8247978 | 0.0458221 | 0.7816712 | 0.0134771 | 120.19944 | 1.4555256 |
| Tshivenda | 1 | 0.5980861 | 0.0334928 | 0.5645933 | 0.0000000 | 108.45631 | 0.0000000 |
| Tshivenda | 2 | 0.7804878 | 0.0000000 | 0.9621212 | 0.5441176 | 50.85606 | 1.2058824 |
| Tshivenda | 3 | 0.8617363 | 0.0225080 | 0.8456592 | 0.0000000 | 142.95035 | 0.0000000 |
| IsiTsonga | 1 | 0.6411765 | 0.0235294 | 0.4408284 | 0.0000000 | 27.80896 | 0.0000000 |
| IsiTsonga | 2 | 0.7375887 | 0.0118203 | 0.7163636 | 0.0929368 | 55.88364 | 0.9368030 |
| IsiTsonga | 3 | 0.8621495 | 0.0397196 | 0.8691589 | 0.0023529 | 103.93128 | 0.3529412 |
| Afrikaans | 1 | 0.5392884 | 0.1345441 | 0.6227876 | 0.0465116 | 133.43521 | 9.4163569 |
| Afrikaans | 2 | 0.5422477 | 0.0904605 | 0.6258591 | 0.0424710 | 103.81572 | 10.9746890 |
| Afrikaans | 3 | 0.6686971 | 0.1106225 | 0.7645862 | 0.0399458 | 146.19560 | 10.5008501 |
| English | 1 | 0.7266667 | 0.2969374 | 0.7449933 | 0.1016043 | 371.01291 | 31.0356653 |
| English | 2 | 0.7976190 | 0.3234127 | 0.8728814 | 0.1070707 | 375.17797 | 35.3555556 |
| English | 3 | 0.8608059 | 0.3156934 | 0.8811700 | 0.1023766 | 377.87127 | 23.3816514 |

# C Descriptive Statistics

The in Figure 2 we can see the number of native speakers of each in the dataset, coloured by the sex of the individual.

Figure 2: Native Language and Sex

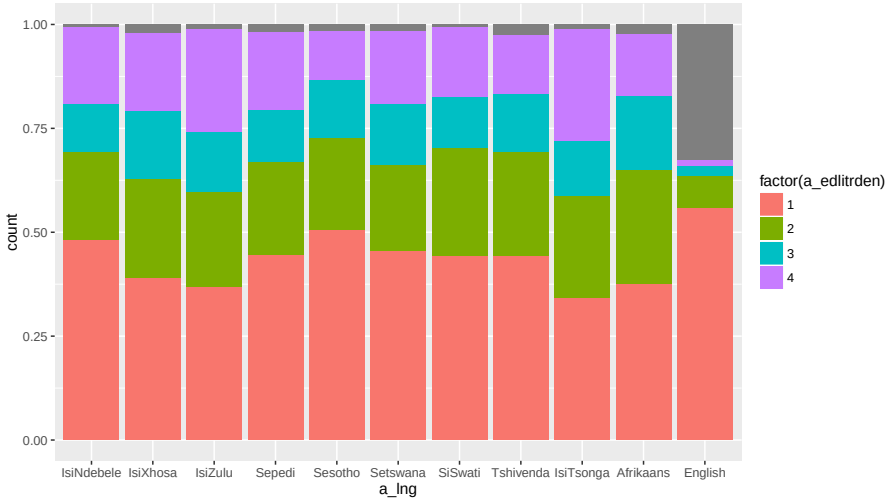
```
ggplot(adulthh, aes(x = a_lng, fill = a_woman)) + geom_bar()
```




The following figure describes the skill of individuals in reading the English language, where 1 the best and 4 is the worst, grey values are `NA`.

Figure 3: English Language Reading Skills

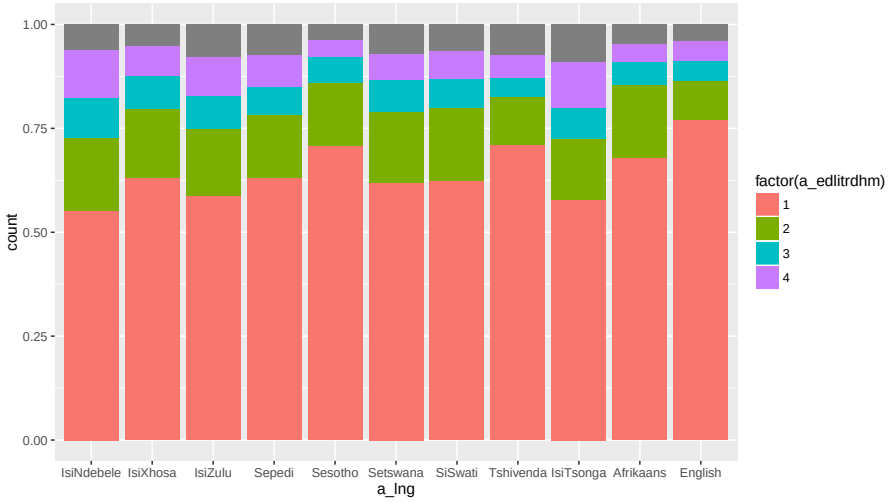
```
ggplot(adulthh, aes(x = a_lng, fill = factor(a_edlitrden)) ) +
        geom_bar(position = 'fill')
```




The following figure does the same but with regards to the native language.

Figure 4: Native Language Reading Skills

```
ggplot(adulthh, aes(x = a_lng, fill = factor(a_edlitrdhm)) ) +
        geom_bar(position = 'fill')
```




# D Language Switching on Mobile

The graphics in Figure 5 illustrate the process of switching the mobile `google.co.za` interface language to Setswana, from the default English. The mobile interface language can automatically be changed based on the system language of the operation system (in most cases Android), however, as Setswana and many African languages are not available as system languages in Android, the website interface on `google.co.za` will default to English.

Figure 5: Changing Interface Language on Mobile