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WHAT TO DO WHEN YOU DO NOT SEE THE DATA

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The Team

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We are all from the University of Coimbra, Portugal.

- I teach at the Faculty of Psychology and Education Sciences.
- I teach classes from the first year of college to PhD programs.
- I am enjoying living in Coimbra tremendously, where the *University of Coimbra – Alta and Sofia* was recently classified as a **UNESCO World Heritage**, enjoying its 729 years of continuing existence.

Introduction

The Challenge of Teaching Statistics

We all know how certain basic knowledge of Statistics can enable individuals to reflect, criticize, interpret and participate in society as well-informed citizens in both their own country and the wider world.

Nevertheless, passing that message to our students seems to be sometimes an impossible mission. **Why?**

- Some of our students have little or no knowledge in mathematics;
- Many suffer from math phobia, or at the very least some display clear anxiety, tension and apprehension when dealing with numbers;
- Stress rises considerably, when learning software is part of the equation, either a very user-friendly option such as SPSS or a more programming oriented one such as R;

Now add to all of this the fact that you cannot rely on visual means when teaching Statistics.

A full semester in Statistics in which Statistical Thinking was explored using visual, aural and tactile senses.

A very pragmatic non-visual orientation required class planning to emphasize on contents from summarizing data numerically and graphically to making decisions in Statistics through understanding centrality, dispersion and hypothesis testing.

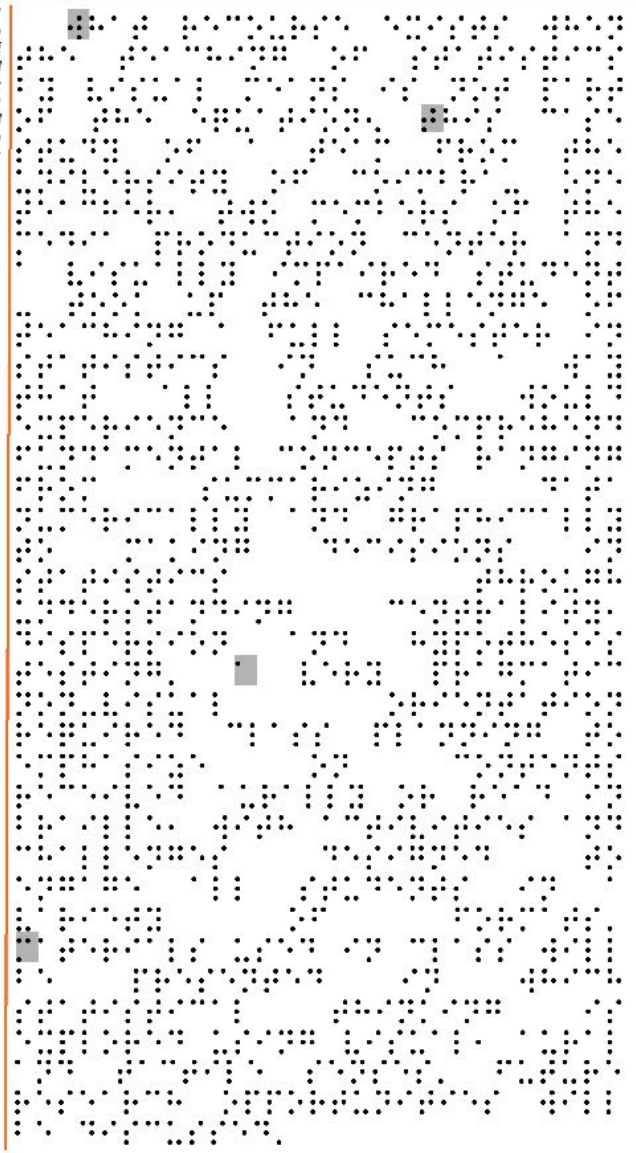
This took place within the context of a class with **104 students**, who from the beginning demonstrated strong support for the visually impaired student.

Motivation

Why not simply Braille?

Why a simple translation of the lecture contents and notes into Braille will not be sufficient to ensure a satisfying inclusive environment in class?

What recourse exists when the teaching of statistics by visual means is not part of the equation? This case study of a team from the University of Coimbra – one teacher, two members of the Media Production Center and a visually impaired student – took up the challenge of teaching a full semester in Statistics in such a way that all students would experience and comprehend fundamental concepts ranging from summarizing data numerically and graphically to making decisions in Statistics through understanding centrality, dispersion and hypothesis testing. A very pragmatic non-visual orientation required class planning to emphasize on contents received aurally or read in Braille, with activities and challenges designed to engage all students in a variety of formats. Materials used in class will be presented in which Statistical Thinking is explored using visual, aural and tactile senses. Future research opportunities will be discussed.



Using Visual, Aural and Tactile Senses

Undesirable variability

One of the fundamental objectives of Statistics is not to eliminate variability but to seek knowledge from studying the right kind of variability.

Quite easy!
(Click on the image to watch video)

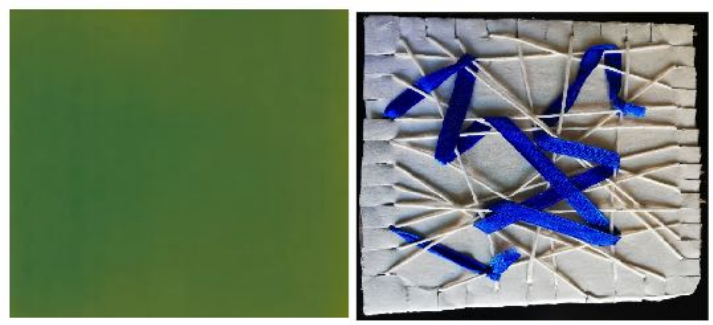
What you gon' do with all that junk?
All that junk inside your trunk?
I'm a get, get, get, get, you drunk,
Get you love drunk off my humps.
My humps, my humps, my humps, my humps, my humps,
My humps, my humps, my humps, my lovely little lumps.
(Check it out)

Count the number of letters "u" in the text.

Representative sample

How representative is any sample of a population?

How big should be your sample?

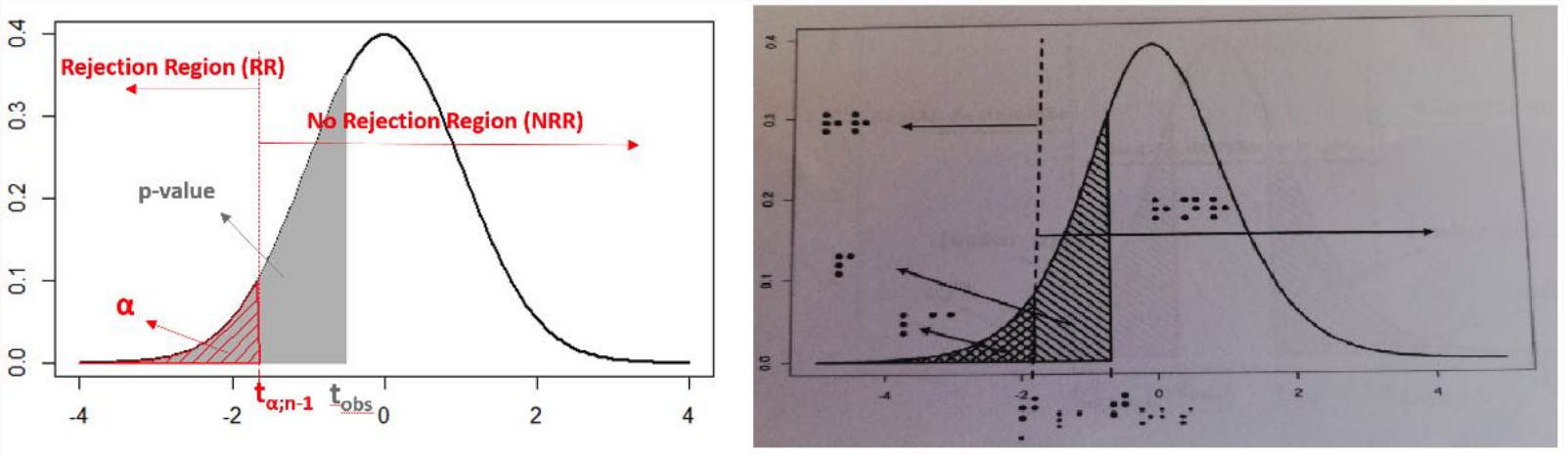


Tactile version.

It was clear to students that a large sample size is not a requirement for a representative sample.

Hypothesis testing

The concepts of hypothesis testing, such as one-sided versus a two-sided test, and the meaning of a p-value and level of significance, α, presented quite a challenge to all students.

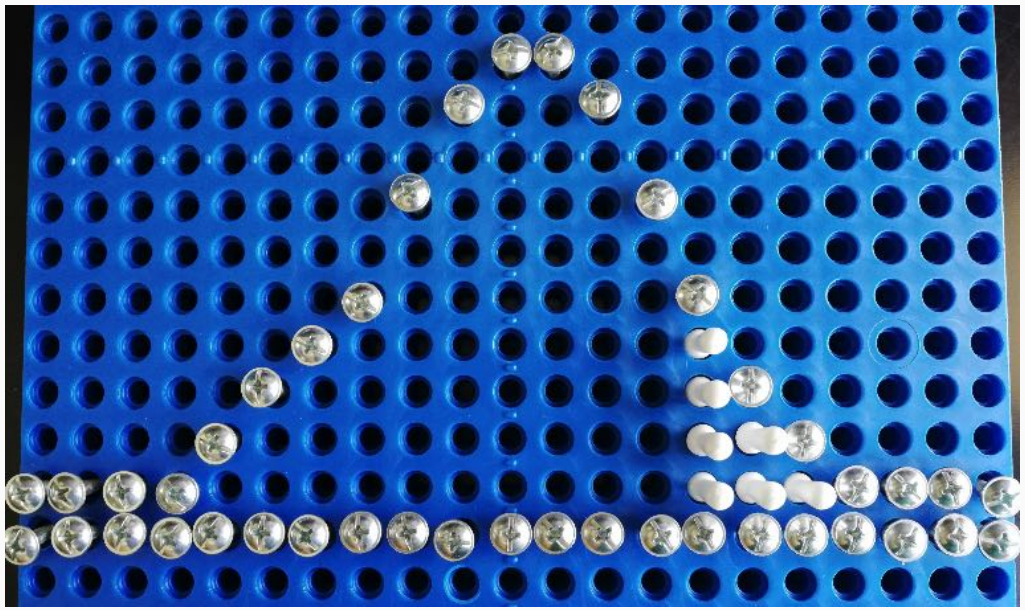


Representation areas in a one-sided test to the left.

The final version of the graphs in Figure 3 was constructed sequentially in a PowerPoint presentation for the normal visual students and in a multitude of embossed prints for the visually impaired student.

Concept of a Density Function

The concepts of a distribution and the representation of probabilities as the area under the density curve were concepts that needed some extra time and alternatives approaches with the visually impaired student.



Representation of a p-value in Multiplano.

For that we used a didactic tactile device called Multiplano, developed for visually impaired learners by Ruben Ferronato (2002).

Some adaptations were necessary. Notice in the above that the representation of the density curve is done by using metallic screws, and a p-value for a one-sided test to the right is represented by plastic pins. Having different types of materials for the pegs was, in fact, an important detail in distinguishing the density function and the area under the curve.

Multiplano was very useful to further explore the concepts in hypotheses testing, but one that is certainly more tailored to one-on-one sessions.

Using a software

Two softwares were crucial in overcoming certain barriers in this learning process, namely the screen reader **NVDA** (NVDA2019.1.1, 2019) and the statistical software **R Studio** (R Core Team, 2019).

NVDA (Non-Visual Desktop Access) is a free and open source screen reader for the Microsoft Windows operating system.

Unfortunately, SPSS, the software selected for class, could not be used because its menus are images and are thus impossible for NVDA to read.

R Studio also poses some challenges due to the existence of multiple windows when entering the program, which makes NVDA unable to recognize what is written in the different consoles.

The way to overcome this difficulty was to teach basic R commands to the visually impaired student and be able to work with some packages that allowed for hearing the results using NVDA.

The first R package worth note is `TeachingDemos` where, by using the functions `txtStart()` and `txtStop()`, we were able write the commands and outputs produced by R in a text file, a document that NVDA reads with no difficulty.

The second package used was `BrailleR`, a package that includes the text descriptions of some basic graphs, without the need for embossed printing all the graphics produced.

Among many other functions in this package, we emphasize the function `VI()` which allows for some of the outputs to be read horizontally.

```
install.packages("TeachingDemos")
install.packages("BrailleR")

library(TeachingDemos)
library(BrailleR)

txtStart("output.txt")

> d = read.csv("grade.csv")
> head(d)
id sex entrance_time age percentage_passing_grades before_8h30
1  1    1      7:32:46    15       60          1
2  2    0      7:42:50    13       42          1
3  3    1      8:33:09    18       48          2
4  4    0      8:20:02    13       38          1
5  5    1      7:12:23    18       75          1
6  6    0      8:33:34    15       52          2

> names(d)
[1] "id"           "sex"          entrance_time" "age"        "percentage_passing_grades"
[6] "before_8h30"

> summary(d$percentage_passing_grades)
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
  35.00   51.00   59.50   61.52   73.25   90.00

txtStop()
```

```
install.packages("TeachingDemos")
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5  5    1      7:12:23    18       75          1
6  6    0      8:33:34    15       52          2

> VI(d) # Using the function VI() from BrailleR package

The summary of each variable is
id: Min. 1   1st Qu. 25.75   Median 50.5   Mean 50.5   3rd Qu. 75.25   Max. 100
sexo: Min. 0   1st Qu. 0   Median 1   Mean 0.56   3rd Qu. 1   Max. 1
hora_entrada: 7:02:56 1   7:07:47 1   7:11:42 1   7:12:23 1   7:13:32 1... <truncated>
idade: Min. 13   1st Qu. 14   Median 15   Mean 15.18   3rd Qu. 16.25   Max. 18
perc_pos: Min. 35   1st Qu. 51   Median 59.5   Mean 61.52   3rd Qu. 73.25   Max. 90
antes_8_30: Min. 1   1st Qu. 1   Median 1   Mean 1.45   3rd Qu. 2   Max. 2
amostra: Min. 1   1st Qu. 1   Median 1   Mean 1.47   3rd Qu. 2   Max. 2

txtStop()
```
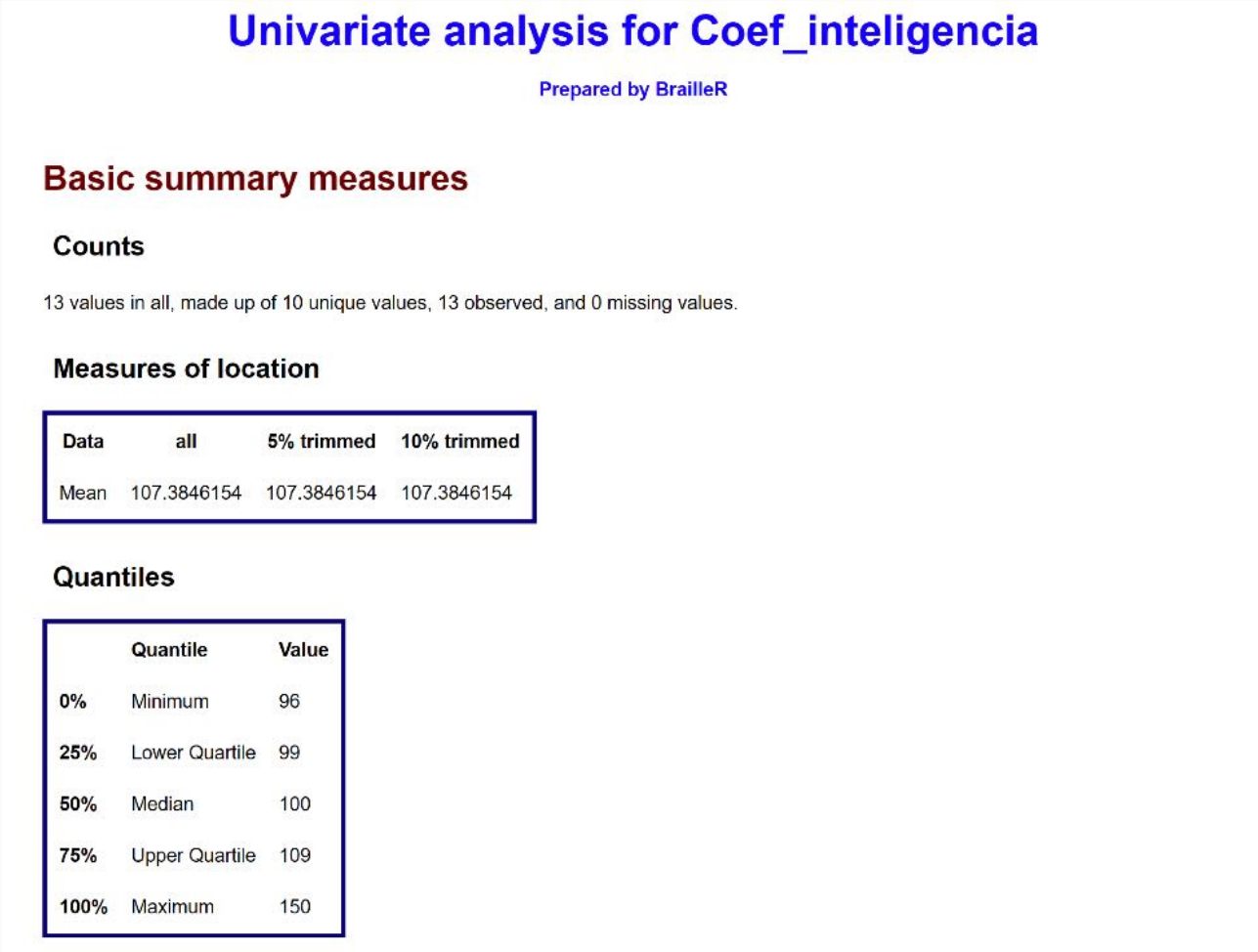

Outputs produced using TeachingDemos and BrailleR packages.

Very simple solutions that make a difference in overcoming certain barriers in this learning process.

Consider also the function `UniDesc()` which produces some univariate descriptions of a certain variable of interest.



Univariate analysis for Coef_inteligencia

Prepared by BrailleR

Basic summary measures

Counts

13 values in all, made up of 10 unique values, 13 observed, and 0 missing values.

Measures of location

Data	all	5% trimmed	10% trimmed
Mean	107.3846154	107.3846154	107.3846154

Quantiles

	Quantile	Value
0%	Minimum	96
25%	Lower Quartile	99
50%	Median	100
75%	Upper Quartile	109
100%	Maximum	150

The function UniDesc() from BrailleR

(Click on the image to see the html)

The Final Result

Did it work?

- **A very pragmatic non-visual orientation** required class planning to emphasize contents received aurally or read in Braille, with activities and challenges designed to engage all students in a variety of formats.
- Not all the materials used in class using audio, embossed printings, R programming scripts, and Multiplano were successful, **but they point in promising directions that can be taken in teaching Statistical Thinking to all types of learners.**
- The common thread for a successful activity was **its ability to be performed simultaneously with both the normal visual and visually impaired students.**
- **All students were submitted to the same Final Exam,** one which the visually impaired student took, obtaining a passing grade for the course.

Future Research

Future Research

- **The development of a macro in NVDA** that would allow the program to automatically read what scripts are produced in RStudio and their outcomes.

- We are developing a **bilingual publication of lecture notes in Statistics (Portuguese/Braille)** that can simultaneously be used by both blind and normal visual individuals.

- A research project is meant to start in September with normal and impaired visual individuals, where some of these learning objects will be further developed and new ideas and softwares will be explored (e.g. Videos and sound voices descriptions, new softwares such as TactileView `http://www.tactileview.com/`).

References

Aliaga, M. & Gunderson, B. (2006). Interactive Statistics, 3rd Edition. Upper Saddle River, N.J.: Pearson Prentice Hall.

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Terima Kasih, Banyak-Banyak!!

THANK YOU - LAH!!

Questions?

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