THE BLIND COMMUNITY AND STATISTICS LEARNING

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Abstract

The blind community usually has to face some difficulties in the learning process. Statistics teaching is a clear example since it often relies heavily on formulas and charts. In this work, we present a webpage which facilitates an accessible learning of theoretical and practical Statistics concepts. It includes several guides which help the student with fundamental concepts and shows how to apply them using well-known statistical software. In addition to being adapted for an optimal accessibility, the contents cover the use of BrailleR, a library specifically designed for generating descriptive text from the usual graphical elements. The platform is of great help to college students in general and blind students in particular.

Keywords: blind community, statistics learning, e-learning.

1 INTRODUCTION

Nowadays, modern virtual environments facilitate the learning process for people with different physical and functional limitations. In this work, we focus on blind people and their ability to learn statistics (Godfrey and Loots, 2015).

We have been collaborating over the last years in an educational innovation project of our university whose main objective is teaching statistics and their application via different softwares. Specifically, we use SPSS, R, RStudio and RCommander. In order to design an accessible website, we have been in contact with Fundacion ONCE, the National Organization of Spanish blind people, which has helped and supported us with the realization of this project.

We will be working both with the SPSS and R softwares. SPSS is a well-known software for statistics which is able to work with big databases. It has a simple interface for most functions, although on the other hand it is a proprietary software. Therefore, we find R a comparable open source alternative.

The term R refers to a computational environment for statistical analysis and chart generation and also to the programming language used by said environment. It was created in 1993 and it is one of the most used programming languages for scientific research. In addition, different packages can also be loaded with specific statistical and graphical functions.

Closely related to R we find RStudio, which was launched in early 2011 and it is a free and open source integrated development environment for R which provides a friendly interface. This interface includes in a single window the script, the console, the memory and the manual even though we are still able to achieve the same goals as when writing code directly with R. We also find RCommander which is an R package which allows us to manipulate the data and carry out statistical analyses via simple drop-down menus. It can be used as a learning environment for numerous statistics courses.

R offers valuable tools for the blind community to carry out statistical analysis in an accessible manner. We

have also been working lately on a very important factor for this matter: using the BrailleR package (Godfrey, 2013; Godfrey et al., 2018). BrailleR is an R package whose purpose is generating text descriptions along with the graphical content which is usually returned.

2 CONTENTS

Throughout this section, the diverse contents included in the website, which can be accessed at https://wpd.ugr.es/~bioestad/ , will be described. Their purpose is to offer theoretical and practical Statistics knowledge. The different design choices taken regarding accessibility for the blind community will also be addressed. Please take into account that this innovation project is still in development and thus the guides will be expanded and new courses will be added in the future.

Note: The screenshots included are in Spanish since that is the language used for the initial development of the site.

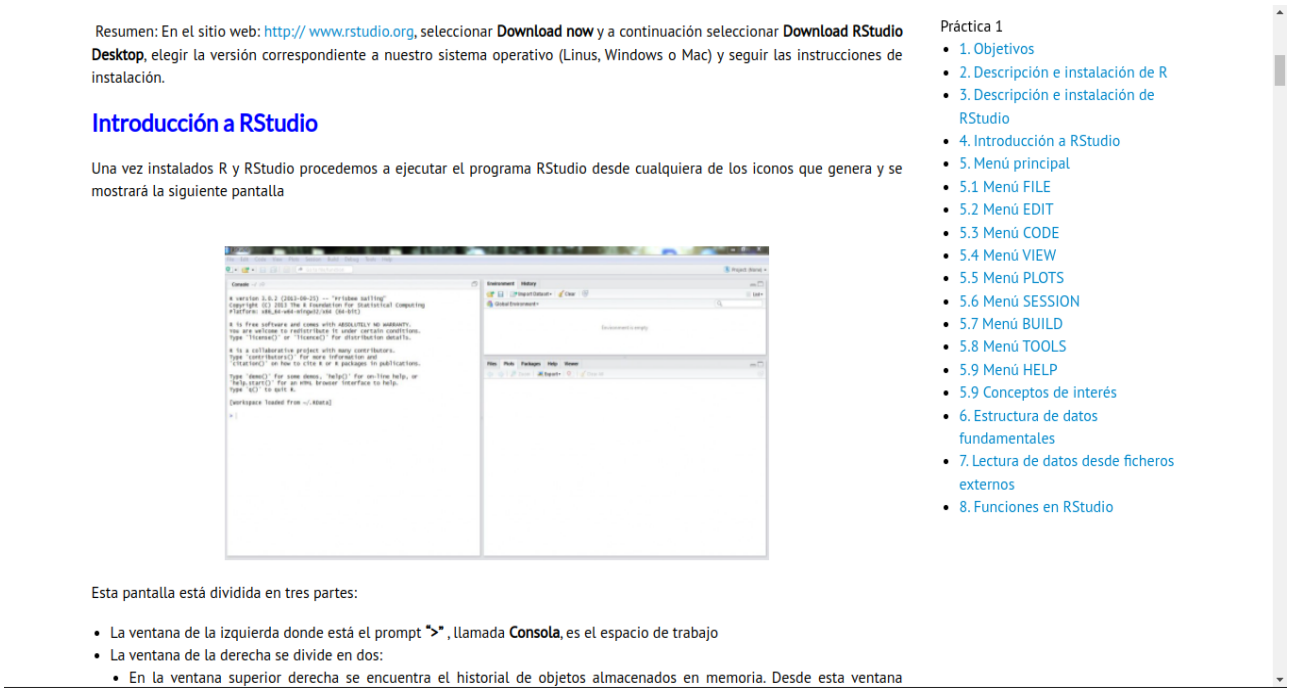
2.1 SPSS Guide

The course shown in Fig. 1 includes a guide in order to learn how to use the SPSS software throughout 8 lessons which cover its basic use as well as advanced techniques like cluster analysis. These include guided exercises as well as proposed exercises. However, SPSS relies heavily on its Graphical User Interface so it is recommended for the blind community to use the software described in the following courses instead.

Figure 1: SPSS guide screenshot

2.2 R-Studio Guide

The course shown in Fig. 2 covers the required knowledge in order to use the R-Studio software. The user learns with its 5 lessons how to install the required packages as well as how to apply the main functions for statistical analysis. Along its theoretical content, as well as the guided and proposed exercises, some tables and formulas which are fundamental for a full comprehension of the concepts are included. In those cases, either they are formatted with a HTML structure that the software guiding blind users can easily interpret, via MathJax (Cervone et al., 2016), or auxiliary files with text transcriptions are included.



Resumen: En el sitio web: http:// www.rstudio.org, seleccionar **Download now** y a continuación seleccionar **Download RStudio Desktop**, elegir la versión correspondiente a nuestro sistema operativo (Linus, Windows o Mac) y seguir las instrucciones de instalación.

Introducción a RStudio

Una vez instalados R y RStudio procedemos a ejecutar el programa RStudio desde cualquiera de los iconos que genera y se mostrará la siguiente pantalla

Esta pantalla está dividida en tres partes:

- La ventana de la izquierda donde está el prompt **">"** , llamada **Consola**, es el espacio de trabajo
- La ventana de la derecha se divide en dos:
  - En la ventana superior derecha se encuentra el historial de objetos almacenados en memoria. Desde esta ventana

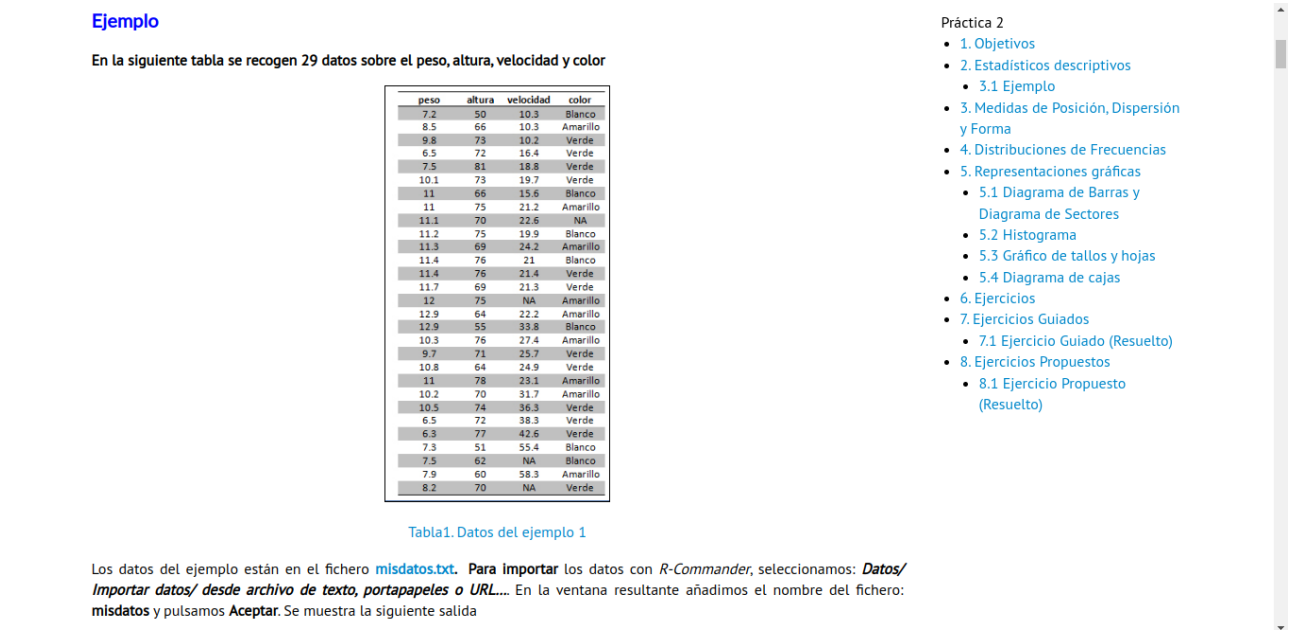
Práctica 1

- 1. Objetivos
- 2. Descripción e instalación de R
- 3. Descripción e instalación de RStudio
- 4. Introducción a RStudio
- 5. Menú principal
- 5.1 Menú FILE
- 5.2 Menú EDIT
- 5.3 Menú CODE
- 5.4 Menú VIEW
- 5.5 Menú PLOTS
- 5.6 Menú SESSION
- 5.7 Menú BUILD
- 5.8 Menú TOOLS
- 5.9 Menú HELP
- 5.9 Conceptos de interés
- 6. Estructura de datos fundamentales
- 7. Lectura de datos desde ficheros externos
- 8. Funciones en RStudio

Figure 2: R-Studio guide screeshot

2.3 R-Commander guide

R-Commander offers an alternative Graphical User Interface for the R environment. This interface relies on simple menus so it may be even more suitable for the blind community. The guide shown in Fig. 3 is adapted as well for a better accessibility.



Ejemplo

En la siguiente tabla se recogen 29 datos sobre el peso, altura, velocidad y color

peso	altura	velocidad	color
7.2	50	10.3	Blanco
8.5	66	10.3	Amarillo
9.8	73	10.2	Verde
6.5	72	16.4	Verde
7.5	81	18.8	Verde
10.1	73	19.7	Verde
11	66	15.6	Blanco
11	75	21.2	Amarillo
11.1	70	22.6	NA
11.2	75	19.9	Blanco
11.3	69	24.2	Amarillo
11.4	76	21	Blanco
11.4	76	21.4	Verde
11.7	69	21.3	Verde
12	75	NA	Amarillo
12.9	64	22.2	Amarillo
12.9	55	33.8	Blanco
10.3	76	27.4	Amarillo
9.7	71	25.7	Verde
10.8	64	24.9	Verde
11	78	23.1	Amarillo
10.2	70	31.7	Amarillo
10.5	74	36.3	Verde
6.5	72	38.3	Verde
6.3	77	42.6	Verde
7.3	51	55.4	Blanco
7.5	62	NA	Blanco
7.9	60	58.3	Amarillo
8.2	70	NA	Verde

Tabla1. Datos del ejemplo 1

Los datos del ejemplo están en el fichero misdatos.txt. **Para importar** los datos con *R-Commander*, seleccionamos: ***Datos/ Importar datos/ desde archivo de texto, portapapeles o URL...***. En la ventana resultante añadimos el nombre del fichero: **misdatos** y pulsamos **Aceptar**. Se muestra la siguiente salida

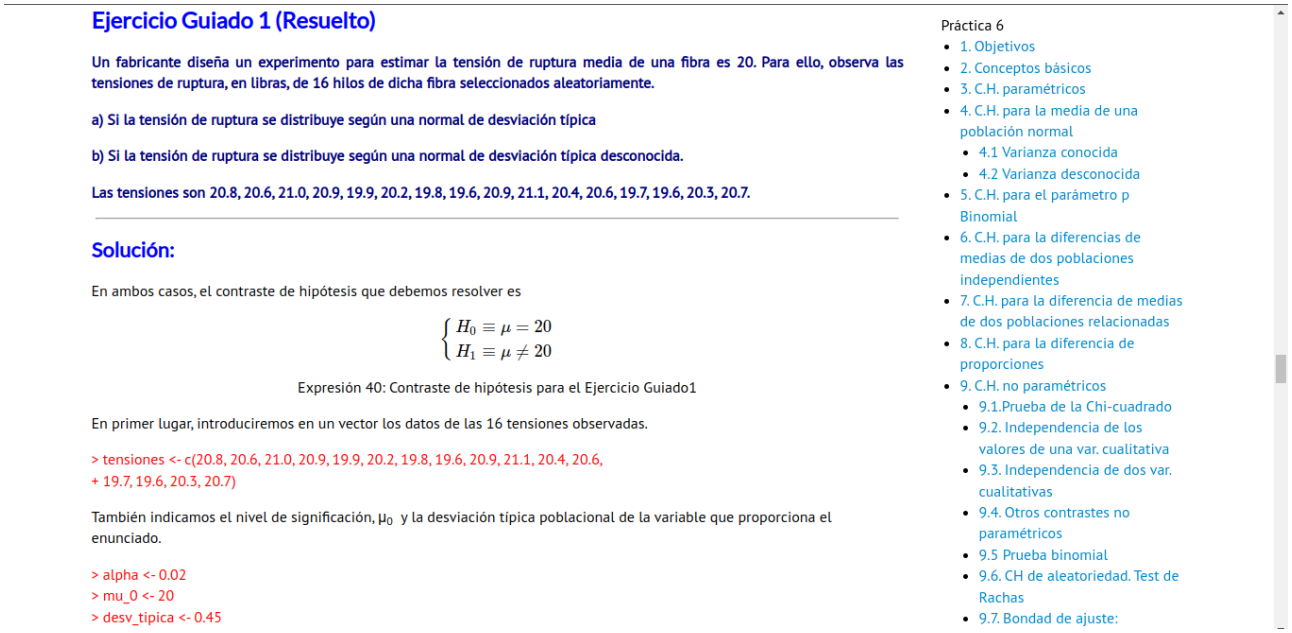
Práctica 2

- 1. Objetivos
- 2. Estadísticos descriptivos
  - 3.1 Ejemplo
- 3. Medidas de Posición, Dispersión y Forma
- 4. Distribuciones de Frecuencias
- 5. Representaciones gráficas
  - 5.1 Diagrama de Barras y Diagrama de Sectores
  - 5.2 Histograma
  - 5.3 Gráfico de tallos y hojas
  - 5.4 Diagrama de cajas
- 6. Ejercicios
- 7. Ejercicios Guiados
  - 7.1 Ejercicio Guiado (Resuelto)
- 8. Ejercicios Propuestos
  - 8.1 Ejercicio Propuesto (Resuelto)

Figure 3: R-Commander guide screenshot

2.4 R guide

A guide for the use of the base R software is also included, as shown in Fig. 4. This alternative relies mainly on the console, which is of course text based. This aspect would be highly beneficial for a blind user while keeping all the functionality of the previously described software as explained in the 7 lessons of the guide. The only exception would be the graphical content, such as charts, but this issue is addressed in the next guide.



Ejercicio Guiado 1 (Resuelto)

Un fabricante diseña un experimento para estimar la tensión de ruptura media de una fibra es 20. Para ello, observa las tensiones de ruptura, en libras, de 16 hilos de dicha fibra seleccionados aleatoriamente.

a) Si la tensión de ruptura se distribuye según una normal de desviación típica

b) Si la tensión de ruptura se distribuye según una normal de desviación típica desconocida.

Las tensiones son 20.8, 20.6, 21.0, 20.9, 19.9, 20.2, 19.8, 19.6, 20.9, 21.1, 20.4, 20.6, 19.7, 19.6, 20.3, 20.7.

Solución:

En ambos casos, el contraste de hipótesis que debemos resolver es

$$\begin{cases} H_0 \equiv \mu = 20 \\ H_1 \equiv \mu \neq 20 \end{cases}$$

Expresión 40: Contraste de hipótesis para el Ejercicio Guiado1

En primer lugar, introduciremos en un vector los datos de las 16 tensiones observadas.

```
> tensiones <- c(20.8, 20.6, 21.0, 20.9, 19.9, 20.2, 19.8, 19.6, 20.9, 21.1, 20.4, 20.6,
+ 19.7, 19.6, 20.3, 20.7)
```

También indicamos el nivel de significación, μ_0 y la desviación típica poblacional de la variable que proporciona el enunciado.

```
> alpha <- 0.02
> mu_0 <- 20
> desv_tipica <- 0.45
```

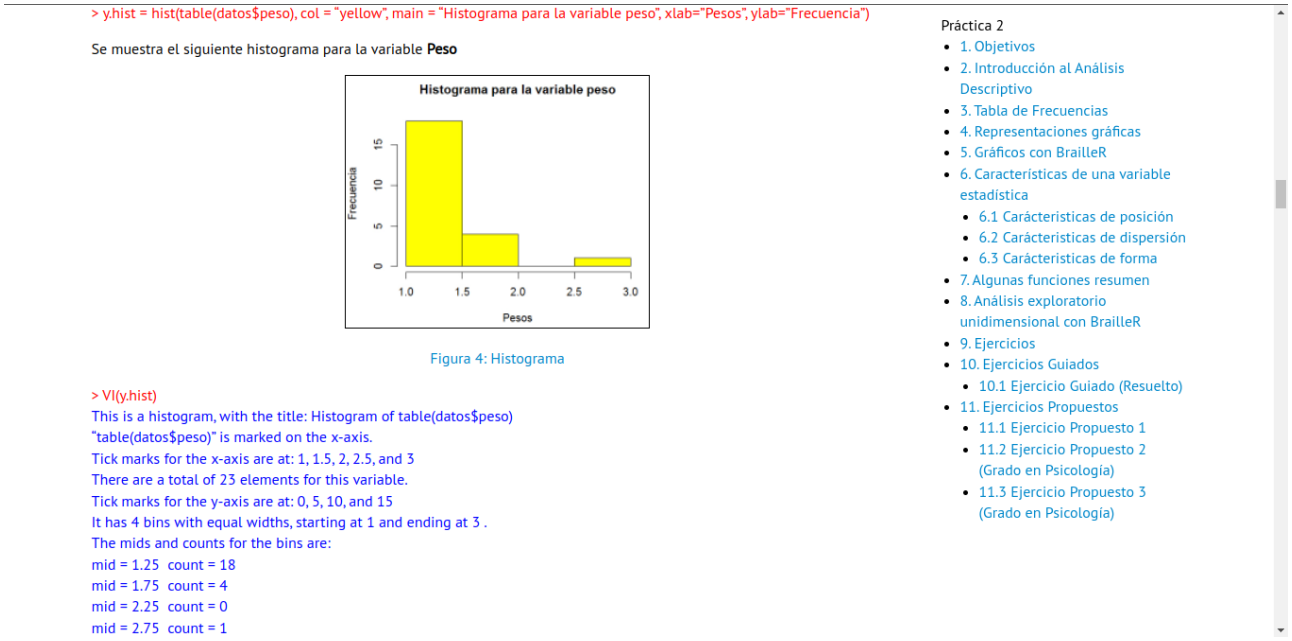
Práctica 6

- 1. Objetivos
- 2. Conceptos básicos
- 3. C.H. paramétricos
- 4. C.H. para la media de una población normal
  - 4.1 Varianza conocida
  - 4.2 Varianza desconocida
- 5. C.H. para el parámetro p Binomial
- 6. C.H. para la diferencias de medias de dos poblaciones independientes
- 7. C.H. para la diferencia de medias de dos poblaciones relacionadas
- 8. C.H. para la diferencia de proporciones
- 9. C.H. no paramétricos
  - 9.1.Prueba de la Chi-cuadrado
  - 9.2. Independencia de los valores de una var. cualitativa
  - 9.3. Independencia de dos var. cualitativas
  - 9.4. Otros contrastes no paramétricos
  - 9.5 Prueba binomial
  - 9.6. CH de aleatoriedad. Test de Rachas
  - 9.7. Bondad de ajuste:

Figure 4: R guide screenshot

2.5 BrailleR guide

This would be the main go-to guide for a blind student in order to learn how to apply computational analysis functions in Statistics. It also includes basic R concepts so it can be used as a starting point. However, it focuses on the advantages of the BrailleR package which can generate descriptive text results for several statistical analyses and charts, as shown in Fig. 5. The contents of this course are of course adapted as the rest of the site so the information included in important tables and formulas is not lost on those with vision impairment.



```
> y.hist = hist(table(datos$peso), col = "yellow", main = "Histograma para la variable peso", xlab="Pesos", ylab="Frecuencia")
```

Se muestra el siguiente histograma para la variable **Peso**

Figura 4: Histograma

```
> Vl(y.hist)
This is a histogram, with the title: Histogram of table(datos$peso)
"table(datos$peso)" is marked on the x-axis.
Tick marks for the x-axis are at: 1, 1.5, 2, 2.5, and 3
There are a total of 23 elements for this variable.
Tick marks for the y-axis are at: 0, 5, 10, and 15
It has 4 bins with equal widths, starting at 1 and ending at 3 .
The mids and counts for the bins are:
mid = 1.25  count = 18
mid = 1.75  count = 4
mid = 2.25  count = 0
mid = 2.75  count = 1
```

Práctica 2

- 1. Objetivos
- 2. Introducción al Análisis Descriptivo
- 3. Tabla de Frecuencias
- 4. Representaciones gráficas
- 5. Gráficos con BrailleR
- 6. Características de una variable estadística
  - 6.1 Carácteristicas de posición
  - 6.2 Carácteristicas de dispersión
  - 6.3 Carácteristicas de forma
- 7. Algunas funciones resumen
- 8. Análisis exploratorio unidimensional con BrailleR
- 9. Ejercicios
- 10. Ejercicios Guiados
  - 10.1 Ejercicio Guiado (Resuelto)
- 11. Ejercicios Propuestos
  - 11.1 Ejercicio Propuesto 1
  - 11.2 Ejercicio Propuesto 2 (Grado en Psicología)
  - 11.3 Ejercicio Propuesto 3 (Grado en Psicología)

Figure 5: BrailleR guide screenshot

2.6 Specific Courses

The webpage also includes some courses about specific fields and concepts such as Biostatistics (see Fig. 6), experimental design or Chemistry. These are being used by professors at the University of Granada for their classes. In particular, the Chemistry course was motivated by the presence of a blind student who can now benefit from it.

Figure 6: Biostatistics course screeshot

3 CONCLUSIONS

Thanks to the website, a large amount of information explaining basic statistics and inference concepts in a clear and concise manner is available to anyone, including blind people. We are also developing solved and proposed exercises in which each step is explained for a better understanding of the topics.

These tools are especially useful for teaching statistics courses at college degrees since they cover the required content, including the theory topics and their corresponding application with the software, in a way that is effective and accessible for everyone.

REFERENCE LIST

Cervone, D., Krautzberger, P., & Sorge, V. (2016). Towards universal rendering in MathJax. In Proceedings of the 13th International Web for All Conference (pp. 1-4). https://doi.org/10.1145/2899475.2899494

Godfrey, A. J. R. (2013). Statistical Software from a Blind Person's Perspective. R J., 5(1), 73. https://doi.org/10.32614/RJ-2013-007

Godfrey, A. J. R., & Loots, M. T. (2015). Advice from blind teachers on how to teach statistics to blind students. Journal of Statistics Education, 23(3). https://doi.org/10.1080/10691898.2015.11889746

Godfrey, A. J. R., Murrell, P., & Sorge, V. (2018, July). An accessible interaction model for data visualisation in statistics. In International Conference on Computers Helping People with Special Needs (pp. 590-597). Springer, Cham. https://doi.org/10.1007/978-3-319-94277-3_92