Tutorial for the SensMixed application

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1. The **SensMixed** package - an overview

The SensMixed package is an **R** package for analysing Sensory and Consumer data in a mixed model framework developed by Alexandra Kuznetsova, Per Bruun Brockhoff and Rune Haubo Bojesen Christensen. The package facilitates, among other things:

- analysis of sensory data in a mixed model framework

- novel tools for correcting scaling effects in sensory data

- analysis of consumer data in a mixed model framework

- post-hoc analysis

- plots

- ready to publish output

The package also provides a graphical user interface (GUI), which is based in shiny **R** package Chang et al. (2015), so that it becomes very user friendly and easy to use for sensory practitioners.

2. Obtaining **SensMixed**

You have to have the latest **R** program installed (at least 3.2-0) on your computer before you think about the SensMixed package. You can download and install the latest version of **R** from `http://cran.r-project.org/`. Once you have installed **R** you start using it, but many people (and I encourage that) want to install a suitable GUI (graphical user interface) or IDE (integrated development en- vironment). One suitable choice is the (also free) program RStudio, which you can download and install from `http://www.rstudio.com/ide/download/desktop`.

The Github subversion system `https://github.com/` hosts the SensMixed package. In order to download the SensMixed package from Github you need to run the following four lines in your **R** console:

```
install.packages("devtools")
require(devtools)
install_github("SensMixed", username = "alku86", ref = "master")
require("SensMixed")
```

If you encounter some installation problems, then you are more than welcome to contact the maintainer of the package Alexandra Kuznetsova (alku@dtu.dk).

3. The graphical user interface

The SensMixed package contains a shiny application Chang et al. (2015), that provides a graphical user interface for the functions contained in the SensMixed. In order to launch the application, one simply needs to run the following line in the **R** console:

```
SensMixedUI()
```

This command launches the application in your default web browser. The application supporting the package was designed with focus on simplicity and usability such that valuable information may be accessed in an easy way. Figure 1 represents the main widget of the GUI. In the *Choose type of analysis* panel to the left you can specify which type of analysis you would like to perform. There are two options: analysis of sensory or consumer data. The left panel consists of three tabs: *Input arguments*, *Modeling controls* and *Analysis controls*. In the *Input arguments* you select the names of the variables, that you would like to analyze - these variables are coming from the data. *Modeling controls* tab stands for a detailed specification of the type of modelling. The *Analysis controls* tab stands for specification of the type of analysis to be performed. These tabs are described in details in the following sections. The tabs at the top right of the widget are: *Data*, *Plot output*, *Table output*, *Step output*, *Post-hoc*. The first one stands for the import of the data and is the one that is selected in the figure, the other four tabs are dedicated for the output of results from the analysis. In the following sub sections each tab will be explained in detail. First, however, I will explain how the data is imported into the application.
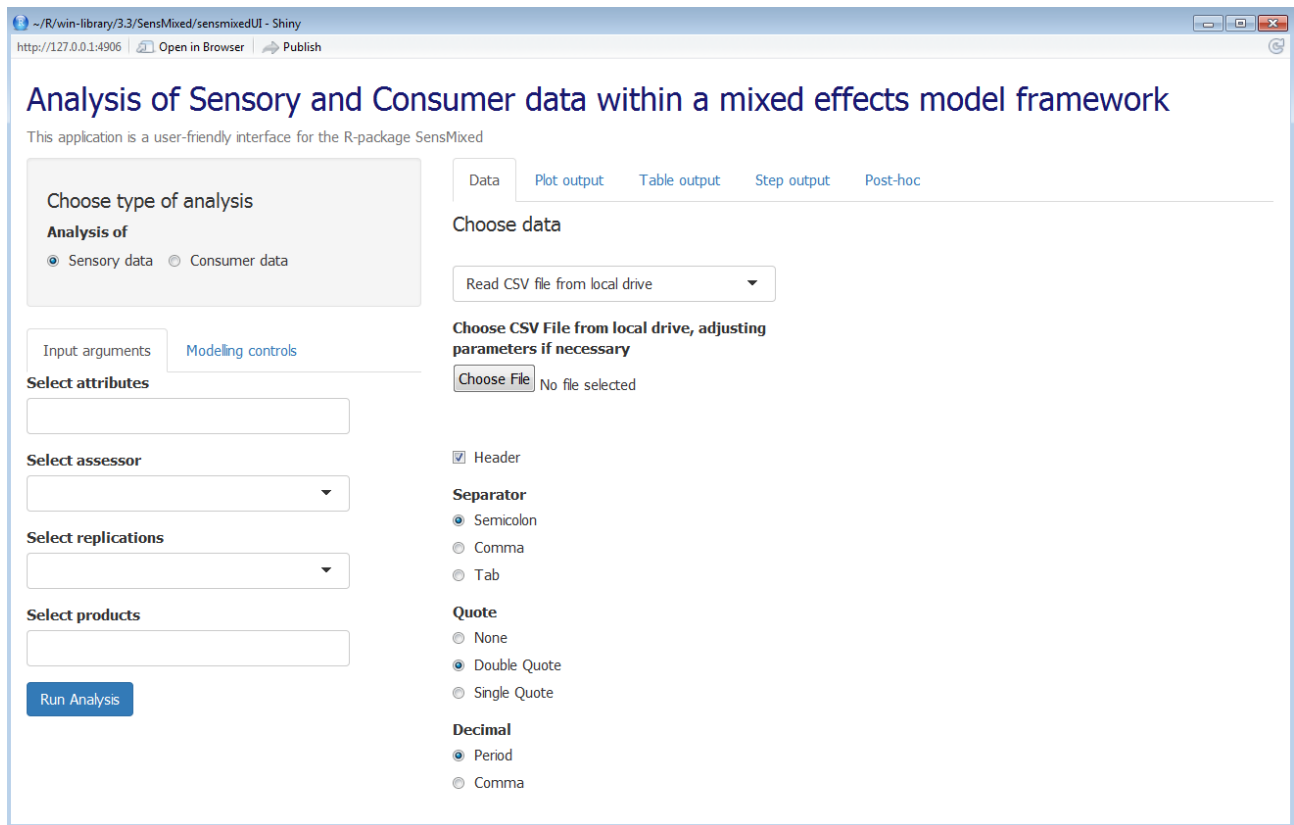
Figure 1: The main widget of the GUI of the SensMixed application

4. Data import

In Figure 1 the screenshot for the data import is displayed. As can be seen the user may choose, which data to use: either to import the data from the local files, or the user may choose two data sets, that are contained in the SensMixed: the TVbo data coming from the sensory studies and the ham data coming from the consumer studies - these two data sets I am going to use in this tutorial. The user is always welcome to play around with them.

Even if the first option for choosing the data says: *Read CSV file from local drive*, it accepts different formats:

- plain files such as .txt, .csv

- Excel files such as .xls, xlsx

The type of format is chosen through the *Separator* box. The details of import can be controlled: for example, whether to include a header in the imported data, or which type of decimal to use and others. These options give the flexibilities to import different data.

5. Analysis of sensory data

For illustrative purposes I will use here the TVbo data, which is a sensory data, contained in the SensMixed package. The TVbo data was produced by the highend HIFI company Bang and

Olufsen A/S, Struer, Denmark, and was used for a workshop at the 8th Sensometrics Meeting in Norway in 2008. In this data the main purpose was to assess 12 products, specified by two features: Picture (factor with 4 levels) and TVset (factor with 3 levels). The products were assessed by 8 assessors in 2 replications for 15 different attributes.

The first and foremost step in every analysis is to get the data that is to be analyzed.

5.1. Choose data

In the *Choose data* tab I select `TVbo`. Figure 2 shows the screenshot of the chosen data (here `TVbo`).
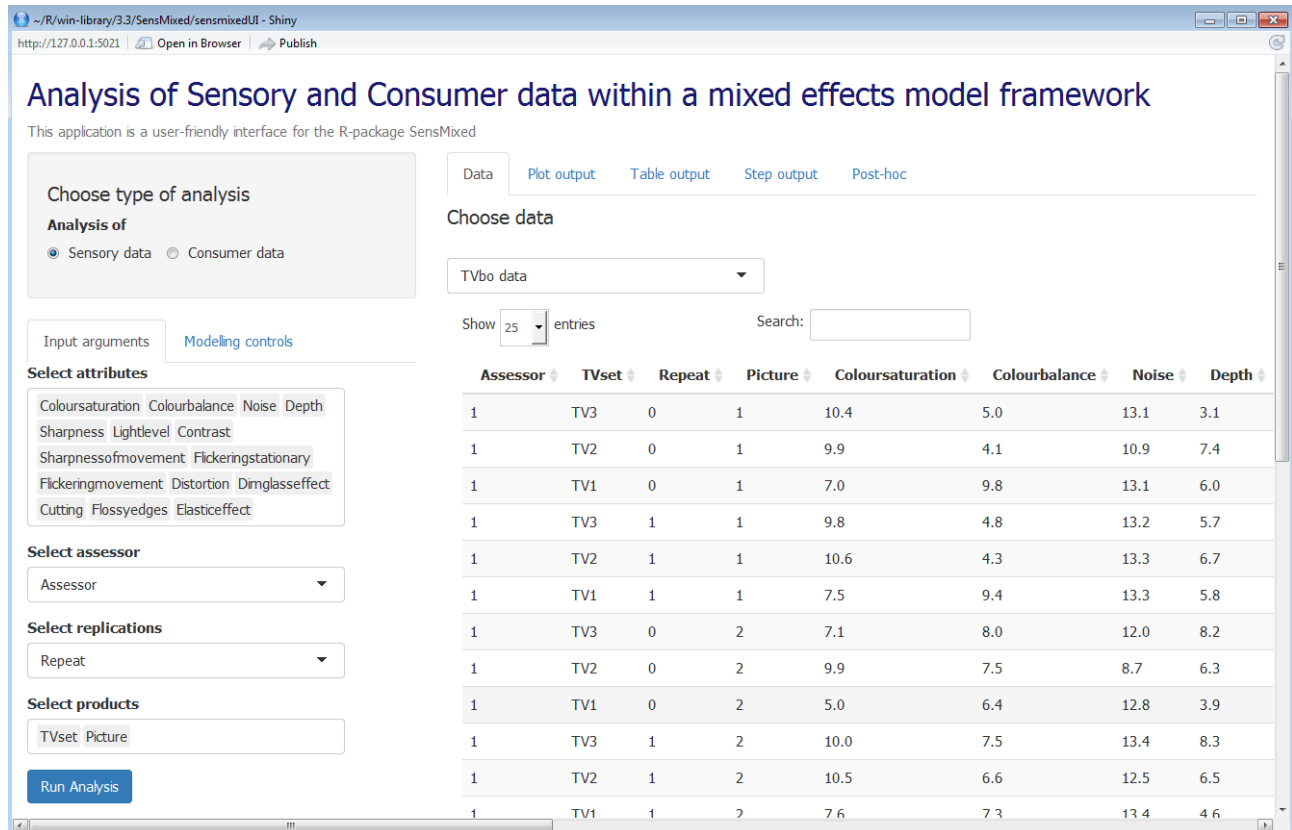

Figure 2: Screenshot for the TVbo data and input arguments for the analysis of the TVbo data

From Figure 2 it can be seen that the `TVbo` data contains column with the name `Assessor`, which has numbers for each of the eight Assessors. `TVset` column stands for the `TVset` feature, which has three levels: `TV1`, `TV2` and `TV3`. `Repeat` column contains two numbers (0 and 1) referring to the number of replication. `Picture` column stands for the `Picture` feature and contains numbers referring to the levels of the Picture feature: 1,2,3 and 4. The rest of the columns are the assessors' scores for 15 attributes.

5.2. Input arguments

In the *Input arguments* tab to the left you need to put the names of the variables for the analysis. Here I have put the following input arguments (see Figure 2):

Select attributes: the names of the columns in the data corresponding to the scores for the attributes. Here I have put `Coloursaturation`, `Colourbalance`, `Noise` and the rest of 15 attributes

Select Assessor: the name of the column corresponding to the assessors in the data (here I have put `Assessor`)

Select replications: the name of the column corresponding to the replication in the data (here I have put `Repeat`)

Select products: the names of the product factors. Here I have put `TVset` and `Picture`, that correspond to two features that form the 12 products. By choosing these two features I account for the multi-way product structure of the data (for discussions about how to analyze multi-way product structure data sets see Kuznetsova et al.).

Before clicking the *Run Analysis* button, I specify what type of analysis I would like to perform via the *Modelling controls* tab.

5.3. Modelling controls

The analysis of the sensory data in SensMixed is performed in a mixed effects model framework. For each attribute a linear mixed effects model is constructed. The *Modelling controls* tab stands for the specification of the type of model to be considered

Analysis of Sensory and Consumer data within a mixed effects model framework

This application is a user-friendly interface for the R-package SensMixed

Choose type of analysis

Analysis of
- ⦿ Sensory data ◯ Consumer data

| Input arguments | Modelling controls |

Analysis controls

Select product structure

| 1 | ▼ |

| Help product structure |

Select error structure

| No_Rep | ▼ |

| Help error structure |

Correct for scaling

| No | ▼ |

Mult-way scaling

| No | ▼ |

One-way product MAM

| Yes | ▼ |

| Run Analysis |

| Data | Plot output | Table output | Step output | Post-hoc |

Choose data

| TVbo data | ▼ |

Show [25 ▼] entries   Search: [   ]

Assessor	TVset	Repeat	Picture	Coloursaturation	Colourbalance	Noise	Depth	Sharp
1	TV3	0	1	10.4	5.0	13.1	3.1	8.3
1	TV2	0	1	9.9	4.1	10.9	7.4	5.3
1	TV1	0	1	7.0	9.8	13.1	6.0	7.9
1	TV3	1	1	9.8	4.8	13.2	5.7	9.3
1	TV2	1	1	10.6	4.3	13.3	6.7	4.7
1	TV1	1	1	7.5	9.4	13.3	5.8	6.6
1	TV3	0	2	7.1	8.0	12.0	8.2	10.7
1	TV2	0	2	9.9	7.5	8.7	6.3	7.5
1	TV1	0	2	5.0	6.4	12.8	3.9	6.0
1	TV3	1	2	10.0	7.5	13.4	8.3	8.8
1	TV2	1	2	10.5	6.6	12.5	6.5	5.9
1	TV1	1	2	7.6	7.3	13.4	4.6	7.2
1	TV3	0	3	9.1	6.7	12.1	8.0	8.0
1	TV2	0	3	9.0	5.9	4.1	2.7	8.3
1	TV1	0	3	6.8	8.3	7.8	4.7	9.5
1	TV3	1	3	7.4	6.5	9.1	7.9	7.6

Figure 3: Screenshot for the Modelling controls for the TVbo data

Figure 3 represents the screenshot for the *Modelling controls* tab. The inputs in this screenshot stand for the specification of a linear mixed effect model for each sensory attribute. In the following I will describe each of the input for the specification of linear mixed effects models in general and will explain later on which inputs I have chosen for the analysis of the TVbo data.

Select product structure: This tab stands for the specification of the fixed effects in linear mixed effects models. There are three following options:

1 only main effects form the fixed part

2 main effects and 2-way interactions form the fixed part

3 all main effects and all possible interactions form the fixed part

The *Help product structure* button also shows the description of the options for the specification of the fixed effects

Select error structure: This tab stands for the specification of the random effects in linear mixed effects models. There are also three options here:

No-Rep assessor effect and all possible interactions between assessor and fixed effects

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2-WAY No-Rep option plus replicate effect and replicate assessor interaction effect

3-WAY assessor and replicate effect and interaction between them and interaction between them and all fixed effects

The *Help error structure* button also shows the description of the options for the specification of the random effects

One-way product random part

Yes considers just one product factor in the random part, where the product factor is chosen as the overall product factor combining each product-combination into a single factor with as many levels as there are different product combinations.

No considers multi-way product structure in the random part.

The default one is No, which I choose here

Correct for scaling:

Yes consider mixed assessor model, where additional fixed effect is added, standing for the scaling effect

No do not consider mixed assessor model

Multi-way scaling:

Yes considers mixed assessor model, where scaling effects are defined for each product feature.

No do not consider multiple scaling effects. If mixed assessor model is considered (*Correct for scaling: Yes*), then only one fixed scaling effect is added in the fixed part of a linear mixed effect model.

This input is not thoroughly investigated. I suggest to choose *No* option here (the default one)

5.4. Analysis controls

Figure 4: Screenshot for the Modelling controls for the TVbo data

The input tabs in Figure 4 stand for the specification of the type of analysis to be performed on models defined in input tabs in Figure 3 and are the following ones:

Simplification of error structure: This tab stands for the simplification of the random effects in linear mixed effects models. There are also two options here:

Yes sequentially eliminate non-significant random effects from the model according to the Type 1 error rate (0.1 the default one)

No do not eliminate random effects

Effects to keep in the model: Here one needs to type the effects that one would like to keep in the model even if not being significant. For example, one may type *Assessor*), then the *Assessor* effect will be part of the model even if likelihood ratio test claims that it is non-significant.

Type 1 error rate for testing random effects:

0.1 this option is recommended in Kuznetsova et al. (2015)

0.2

0.05

Type 1 error rate for testing fixed effects:

0.05 this option is recommended in Kuznetsova et al. (2015)

0.01

0.001

In this example, I have chosen *product structure = 3*. This is because the `TVbo` data has a multi-way product structure. Instead of considering one product effect, I choose to consider two main effects corresponding to `TVset` and `Picture` and interaction between them (`TVset` × `Picture`) effect. This will give additional insight into the data (for the discussions see Kuznetsova et al. (2015)). For the error specification part I have chosen *error structure = 3-WAY*, since I would like to consider the maximal possible model (for the discussions see Kuznetsova et al. (2015)). I have chosen to correct for the scaling effect (as advised by Brockhoff et al. (2015)) by choosing *Correct for scaling = Yes*. In the last two inputs I have put *No*, due to the reasons discussed in the description of these input tabs. According to the chosen controls for the model specification, the following linear mixed assessor model is constructed for each attribute:

$$y_{ijkl} = \mu + a_i + \underbrace{\texttt{TV}_j + \texttt{Pic}_k + \texttt{TVPic}_{jk}}_{\text{product effects}} + \underbrace{\beta_i x_{jk}}_{\text{scaling}}$$

$$+ \underbrace{a\texttt{TV}_{ij} + a\texttt{Pic}_{ik} + a\texttt{TVPic}_{ijk}}_{\text{disagreement}} \tag{1}$$

$$+ r_l + ar_{il} + r\texttt{TV}_{lj} + r\texttt{Pic}_{lk} + \texttt{TvPic}r_{jkl} + \varepsilon_{ijkl}$$

$$
\begin{aligned}
a_i &\sim N(0, \sigma^2_{Assessor}) \\
a\texttt{Tv}_{ij} &\sim N(0, \sigma^2_{Assessor \times TVset}) \\
a\texttt{Pic}_{ik} &\sim N(0, \sigma^2_{Assessor \times Picture}) \\
a\texttt{TvPic}_{ijk} &\sim N(0, \sigma^2_{Assessor \times TVset \times Picture}) \\
r_l &\sim N(0, \sigma^2_{Repeat}) \\
ar_{il} &\sim N(0, \sigma^2_{Assessor \times Repeat}) \\
\texttt{Tv}r_{jl} &\sim N(0, \sigma^2_{TVset \times Repeat}) \\
\texttt{Pic}r_{kl} &\sim N(0, \sigma^2_{Picture \times Repeat}) \\
\texttt{TvPic}r_{jkl} &\sim N(0, \sigma^2_{TVset \times Picture \times Repeat}) \\
\epsilon_{ijkrl} &\sim N(0, \sigma^2_{error})
\end{aligned}
\tag{2}
$$

Here, following Brockhoff et al. (2015), x_{jk}, are calculated as predicted values from a simple linear regression, where y is the response variable and `TV`, `Pic`, `TVPic` are the dependent variables. And then the predicted values are mean centered.

Then the inputs standing for the type of analysis are to be chosen. Here, as can be observed from Figure 4, in the *Simplification of error structure* input I have put *Yes*. This is because the models, that I consider for each attribute have quite a lot of random effects. Most probably some of them do not contribute to the systematic variation in the data, so can be excluded from the model (see Kuznetsova et al. (2015) for the discussions). I do not enter effects, that

should be kept in the analysis anyway. And I choose the default numbers for the Type 1 error rates.

Finally, in order to view the results of the analysis of the constructed models, one may simply click on the *Plot output* tab (similarly one may open any of the results tabs).
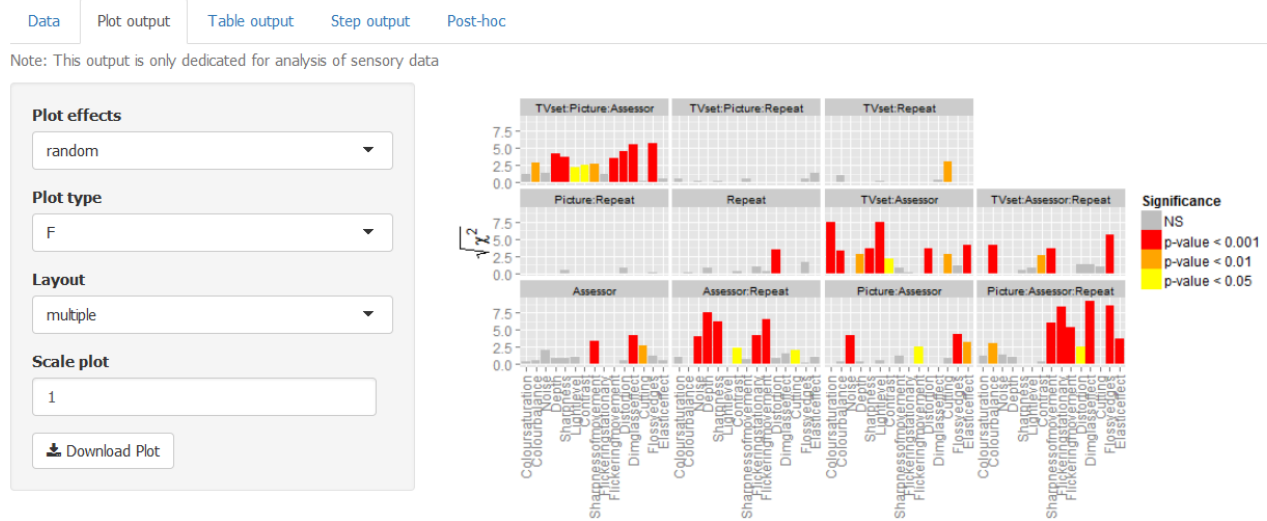
5.5. Plot output

Figure 5: Screenshot for the plot output for random effects for the TVbo data

Figure 5 shows the screenshot of the *Plot output* for analysis of random effects for the `TVbo` data. In the panel to the left I have chosen the plot for the random effects. Layout multiple means that I get multiple subplots for each random effect, The Plot shows the bars for the sequential χ^2 statistics of the likelihood ratio test applied to each random effect for each attribute. The sequential means that the χ^2 values come from the stepwise selection process of elimination of non-significant random effects. The x-axis stands for the attributes. An overview of the plot indicates that there is no replicate effect in the data. It seems like there is a disagreement between assessors in scoring the products (`TVset:Picture:Assessor` effect is significant for almost all the attributes). With the *Download plot* one may easily save the plot in the .pdf format to the local disc. With the *Scale plot* input one may scale the plot - this is valuable when downloading the plot: if it becomes too big, then one may write *2* in the *Scale plot* input and then try to download the plot again.
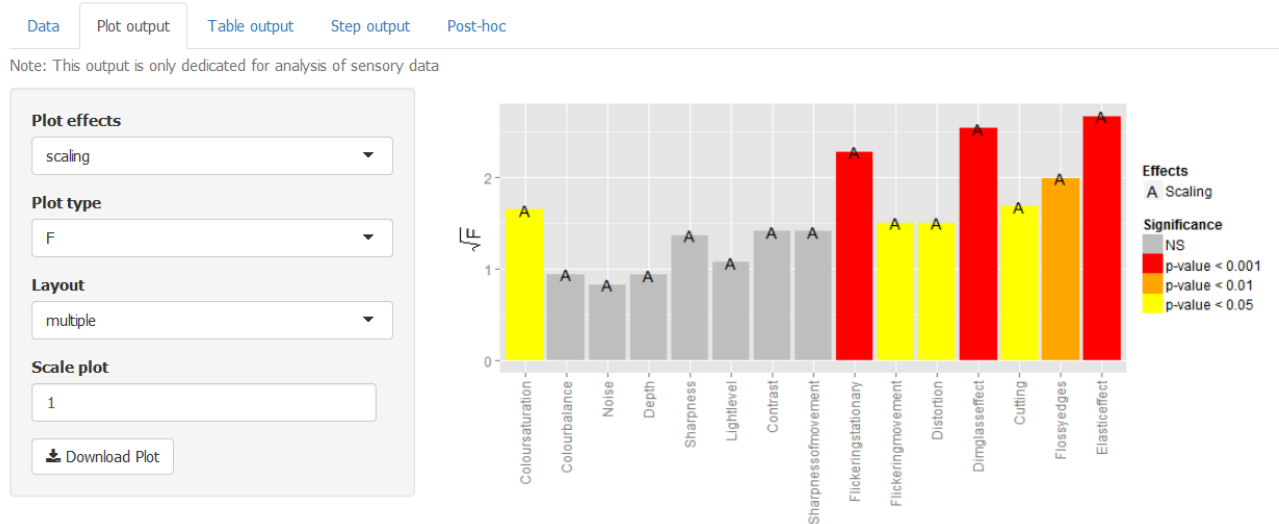
Figure 6: Screenshot for the plot output for the scaling effect for the TVbo data

Figure 6 screenshot for the *Plot output* for the analysis of scaling effects. The bars correspond to the square root of the F statistics. The colour of the plots stands for the significance of the effects. According to the plot, there are indications that the scaling effect is present for almost all the attributes.
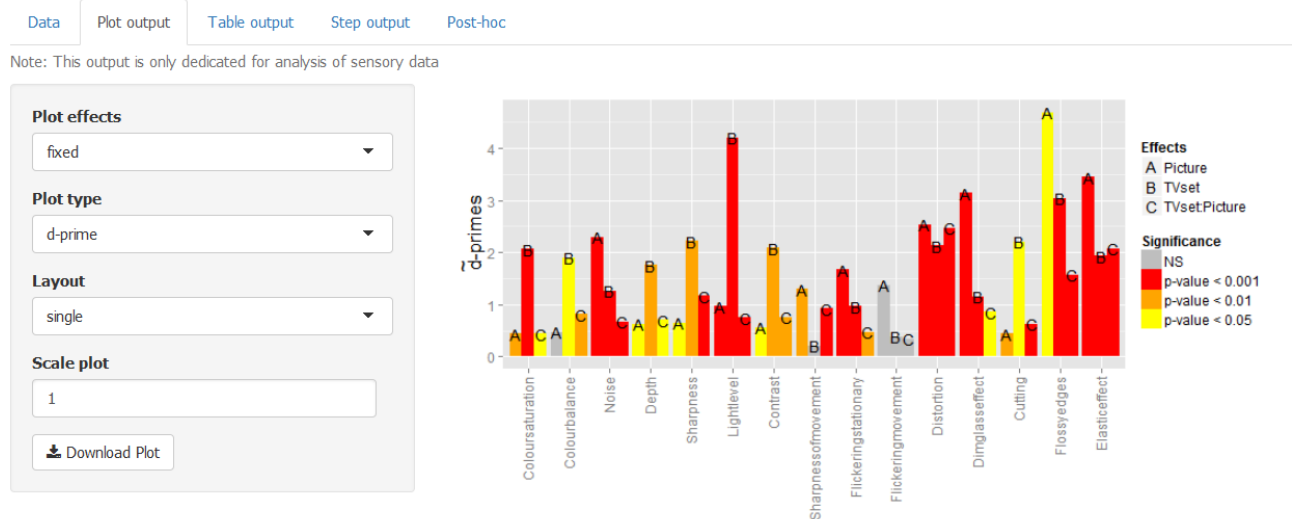
Figure 7: Screenshot for the plot output for the fixed effects for the TVbo data

Finally one turns to the results from the analysis of the fixed effects. Figure 7 shows the screenshot for the *Plot output* of the analysis of the fixed effects (`TVset` and `Picture` effects and `TVset:Picture` interaction effect). In the panel to the left I have chosen *d-prime* plot type, then the plot illustrates the estimates of the d-primes, as specified in Isabel et. al 2015 (working paper), which are the estimates of the effect sizes. The advantage of choosing *d-prime* plot is

that the barplots for the fixed effects can be compared between each other. In order to compare the barplots, I have chosen *Layout = single*, which generates one plot for all fixed effects. The d-prime plot for the fixed effects shows, for example, that for `Colourbalance` attribute it is mainly due to the `Picture` feature the products differ between each other. The effect size of the `Picture` effect for the `Lightlevel` and `Flossyedges` attributes are very high.

5.6. Table output

The *Table output* tab, which is next to the *Plot output* tab provides the same output as *Plot output* just in tables. Figure 8 visualizes the screenshot of the *Table output* tab for the analysis of the `TVbo` data. In the left panel one may select the result of which type of effects to present: fixed, random or scaling. In the *Type* selection list one may select how to download the table: either in *html* format, or in *latex*.

| | Data | Plot output | Table output | Step output | Post-hoc |

Note: This output is only dedicated for analysis of sensory data

Type of effects

| fixed ▼ |

Type

| html ▼ |

⬇ Download Table

F-test for the fixed effects

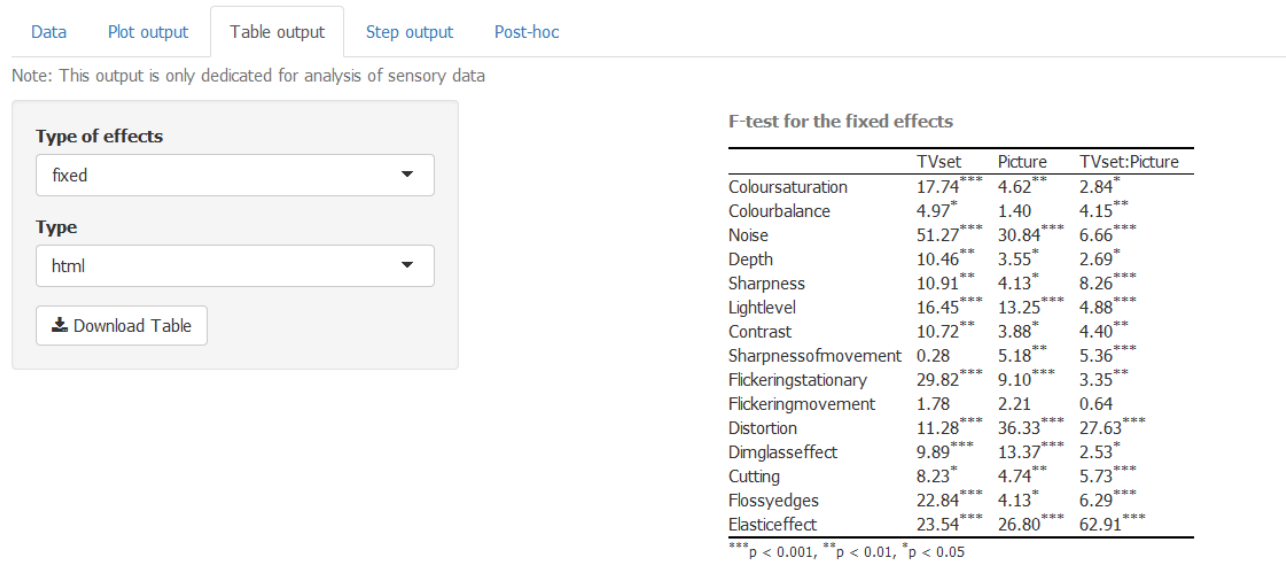|	TVset	Picture	TVset:Picture
Coloursaturation	17.74***	4.62**	2.84*
Colourbalance	4.97*	1.40	4.15**
Noise	51.27***	30.84***	6.66***
Depth	10.46**	3.55*	2.69*
Sharpness	10.91**	4.13*	8.26***
Lightlevel	16.45***	13.25***	4.88***
Contrast	10.72**	3.88*	4.40**
Sharpnessofmovement	0.28	5.18**	5.36***
Flickeringstationary	29.82***	9.10***	3.35**
Flickeringmovement	1.78	2.21	0.64
Distortion	11.28***	36.33***	27.63***
Dimglasseffect	9.89***	13.37***	2.53*
Cutting	8.23*	4.74**	5.73***
Flossyedges	22.84***	4.13*	6.29***
Elasticeffect	23.54***	26.80***	62.91***

***$p < 0.001$, **$p < 0.01$, *$p < 0.05$

Figure 8: Screenshot for the table output for the fixed effects for the TVbo data

5.7. Step output

The *Step output* tab provides a detailed information on the analysis of the fixed and random effects. Figure 9 shows the screenshot for the *Step output* tab for the analysis of the `Colourbalance` attribute from the `Tvbo` data. In the panel to the left there is a selection list input: here one may choose for which attribute one wants to view the results of the analysis. Here I have chosen attribute `Colourbalance`. The first table at the top presents the analysis of the random effects. In the `elim num` column one may view the order in which non-significant effects were eliminated as being non-significant according to the chosen Type 1 error rate (here 0.1). 0 means the effect was kept in the model. The next table at the bottom represents the analysis of the fixed effects. It can be seen, that the scaling effect seems to be non-significant (p value = 0.517). The interaction effect is highly significant, the main `Picture` effect is non-significant according to the chosen Type 1 error rate (here 0.05) and the `TVset` effect is significant. One can easily save the table to the local disc via *Download Table* button. One may choose to download in *html* format or in *latex* format.
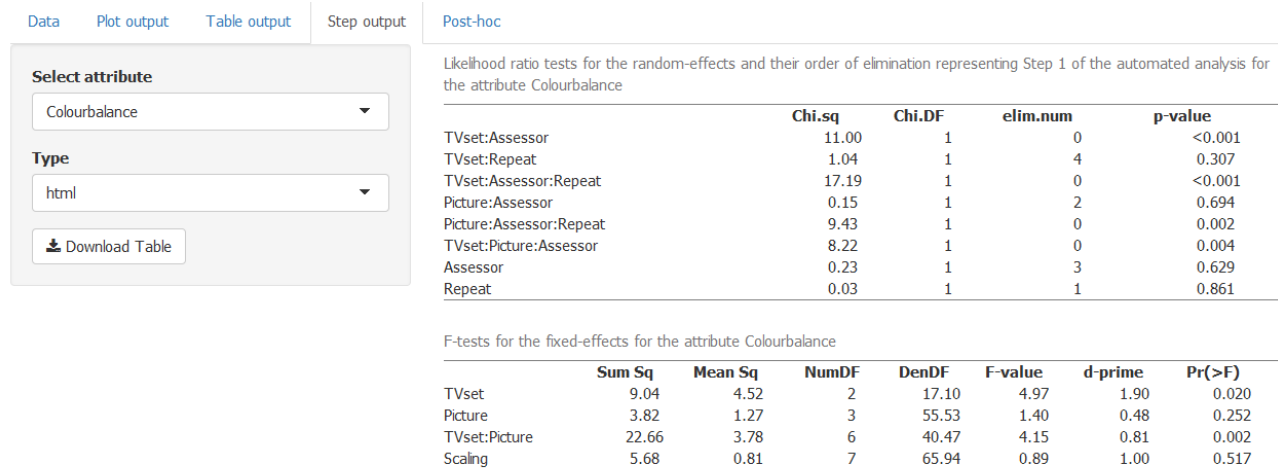
12

Select attribute

Colourbalance   ▼

Type

html   ▼

⬇ Download Table

Likelihood ratio tests for the random-effects and their order of elimination representing Step 1 of the automated analysis for the attribute Colourbalance

	Chi.sq	Chi.DF	elim.num	p-value
TVset:Assessor	11.00	1	0	<0.001
TVset:Repeat	1.04	1	4	0.307
TVset:Assessor:Repeat	17.19	1	0	<0.001
Picture:Assessor	0.15	1	2	0.694
Picture:Assessor:Repeat	9.43	1	0	0.002
TVset:Picture:Assessor	8.22	1	0	0.004
Assessor	0.23	1	3	0.629
Repeat	0.03	1	1	0.861

F-tests for the fixed-effects for the attribute Colourbalance

	Sum Sq	Mean Sq	NumDF	DenDF	F-value	d-prime	Pr(>F)
TVset	9.04	4.52	2	17.10	4.97	1.90	0.020
Picture	3.82	1.27	3	55.53	1.40	0.48	0.252
TVset:Picture	22.66	3.78	6	40.47	4.15	0.81	0.002
Scaling	5.68	0.81	7	65.94	0.89	1.00	0.517

Figure 9: Screenshot for the step output for the Colourbalance attribute for the TVbo data

5.8. Post-hoc output

The *Post hoc* tab represents the results of the post-hoc analysis, namely pairwise-comparison tests for the fixed effects. The Figure 10 represents the screenshot for the *Post hoc* tab for the the attribute Colourbalance. In the panel to the left there is a selection list input: here one may choose for which attribute one wants to view the results of the analysis. Here I have chosen the attribute `Colourbalance`. The selection input list *Type of Plot* has a few options: *DIFF of LSMEANS* showing the differences of least squares means for an effect in question and *LSMEANS* showing the least squares means of an effect in question. In selection list *Effects* one can select for which effect to view the results. Here I have chosen `TVset`. The results are shown in barplots and in table. Here, for example, the results show that products with levels `TV2` and `TV3` for the `TVset` feature significantly differ. The plot and the table can be easily downloaded via *Download Table* and *Download Plot* buttons.
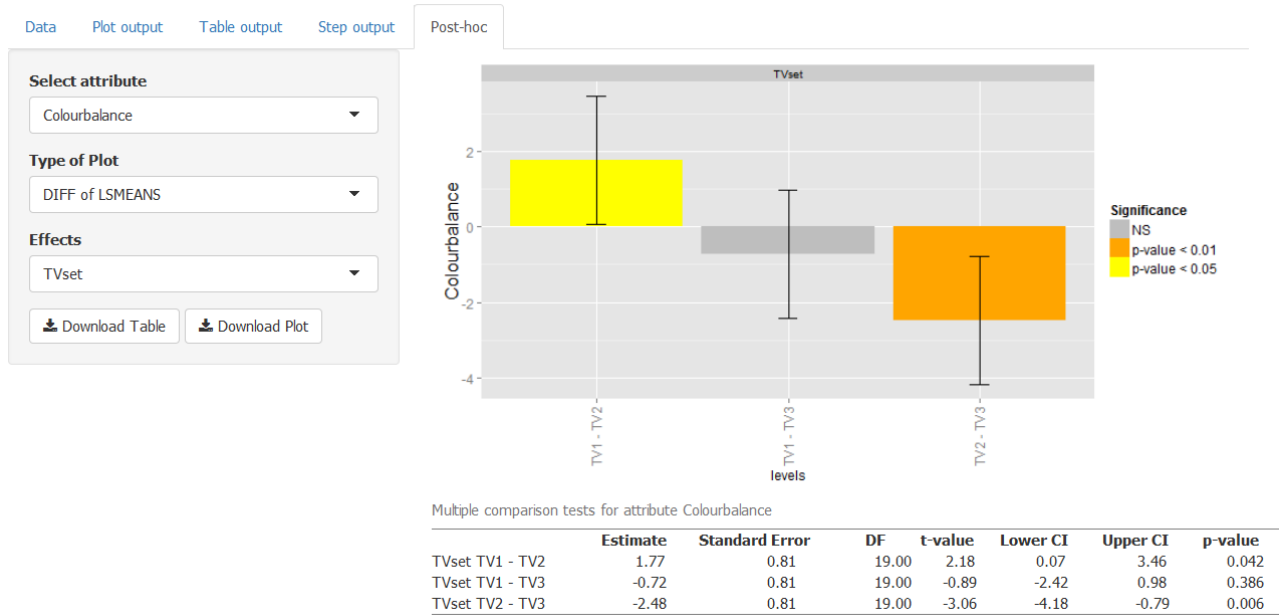
13

Figure 10: Screenshot for the post-hoc output for the Colourbalance attribute for the TVbo data

6. Analysis of consumer data

For illustrative purposes I will use here the `ham` data, which is a consumer data, contained in the `SensMixed` package. The `ham` data is a rating-based conjoint-type study and comes from Næs et al. (2010b). Four different hams were analyzed and compared with each other. The information about origin of the products (factor with 2 levels) was given in such way that both correct and incorrect information was presented to the consumers. Therefore the study was a 4*2 design. 81 consumers gave the liking scores to the products. Two consumer background information variables were available: sex as a factor and age as a continuous variable.

The first and foremost step in every analysis is to get the data that is to be analyzed.

6.1. Choose data

In the *Choose data* tab I select `ham`. Figure 11 shows the screenshot of the chosen data (here `ham`).

Figure 11: Screenshot for the ham data and input arguments for the analysis of the ham data

From Figure 11 it can be seen that the `ham` data contains column with the name `Consumer`, which has numbers for each of the 81 Consumers. `Product` column stands for the `Product` factor, which has four levels: `1`, `2`, `3` and `4`. `Informed.liking` column contains the liking scores of consumers. `Information` column stands for the information about the products: `1` correct information about the products and `2` incorrect information about products. The last columns `Gender` and `Age` stand for the gender and age of consumers.

6.2. Input arguments

First you need too choose the analysis of the consumer data in the left upper corner of the application. Then, in the *Input arguments* tab to the left you need to put the names of the variables for the analysis. Here I have put the following input arguments (see Figure 2):

Select response: the name of the column in the data corresponding to the liking scores. Here I have put `Informed.liking`

Select consumer: the name of the column corresponding to the consumers in the data (here I have put `Consumer`)

Select products: the names of the product factors. Here I have put `Product`

Select consumer characteristics: the names of the columns in the data corresponding the consumers' background information

Consumer characteristics treated as factors: which of the selected consumers' background information should be treated as factors in the model. Here I have put `Gender`.

Before clicking the *Run Analysis* button, I specify what type of analysis I would like to perform via the *Modelling controls* tab.

6.3. Modelling controls

The analysis of the sensory data in SensMixed is performed in a mixed effects model framework. For each attribute a linear mixed effects model is constructed. The *Modelling controls* tab stands for the specification of the type of model to be considered and type of analysis to be performed.

Figure 12: Screenshot for the Modelling controls for the ham data

Figure 12 represents the screenshot for the *Modelling controls* tab. The inputs in this screenshot stand for the specification of a linear mixed effect model for each sensory attribute. In the following I will describe each of the input for the specification of linear mixed effects models in general and will explain later on which inputs I have chosen for the analysis of the ham data.

Select structure: This tab stands for the specification of the fixed effects in linear mixed effects models. There are three following options:

1 Analysis of main effects. Consumer effect is considered as random. Random part also forms interaction between consumer and the main effects (Automated reduction in random part, NO reduction in fixed part).

2 Main effects AND all 2-way interactions form the fixed part of the initial mixed effects model. Random consumer effect AND interaction between consumer and all fixed effects (both main and interaction ones) form the random structure. (Automated reduction in random part, NO reduction in fixed part)

3 all main effects and all possible interactions form the fixed part (Automated reduction in random part, AND automated reduction in fixed part).

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As can be seen from the description, this tab also stands for the type of the simplification of the initial mixed effects model. The automated elimination process is the one coming from Kuznetsova et al. (2015)

In this example I have put `structure=3`, as suggested in Kuznetsova et al. (2015).

6.4. Analysis controls

Figure 13: Screenshot for the Analysis controls for the ham data

The input tabs in Figure 13 stand also for the specification of the type of analysis to be performed on models defined in input tabs in Figure 12 and are the following ones:

Type 1 error rate for testing random effects:

0.1 this option is recommended in Kuznetsova et al. (2015)

0.2

0.05

Type 1 error rate for testing fixed effects:

0.05 this option is recommended in Kuznetsova et al. (2015)

0.01

0.001

I choose here the default numbers for the Type 1 error rates.

Finally, in order to view the results of the analysis of the constructed models you need to click on the *Step output* tab and to click on *Run Analysis* button. The *Plot output* and *Table output* only are dedicated for the analysis of the sensory data, so you need not to look at those in this example.

6.5. Step output

The *Step output* tab provides the automated analysis of the fixed and random effects as proposed in Kuznetsova et al. (2015). Figure 14 shows the screenshot for the *Step output* tab for the analysis of the `ham` data. The first table at the top presents the analysis of the random effects. In the `elim num` column one may view the order in which non-significant effects were eliminated as being non-significant according to the chosen Type 1 error rate (here 0.1). `kept` means the effect was kept in the model. The next table at the bottom represents the analysis of the fixed effects. It can be seen, that 13 effects were eliminated as being non-significant according to the selected type 1 error rate (0.05 here). Only two main effects `Product` and `Information` form the final reduced fixed structure of the mixed effects model. You can easily save the table to the local disc via *Download Table* button. You may choose to download in *html* format or in *latex* format.
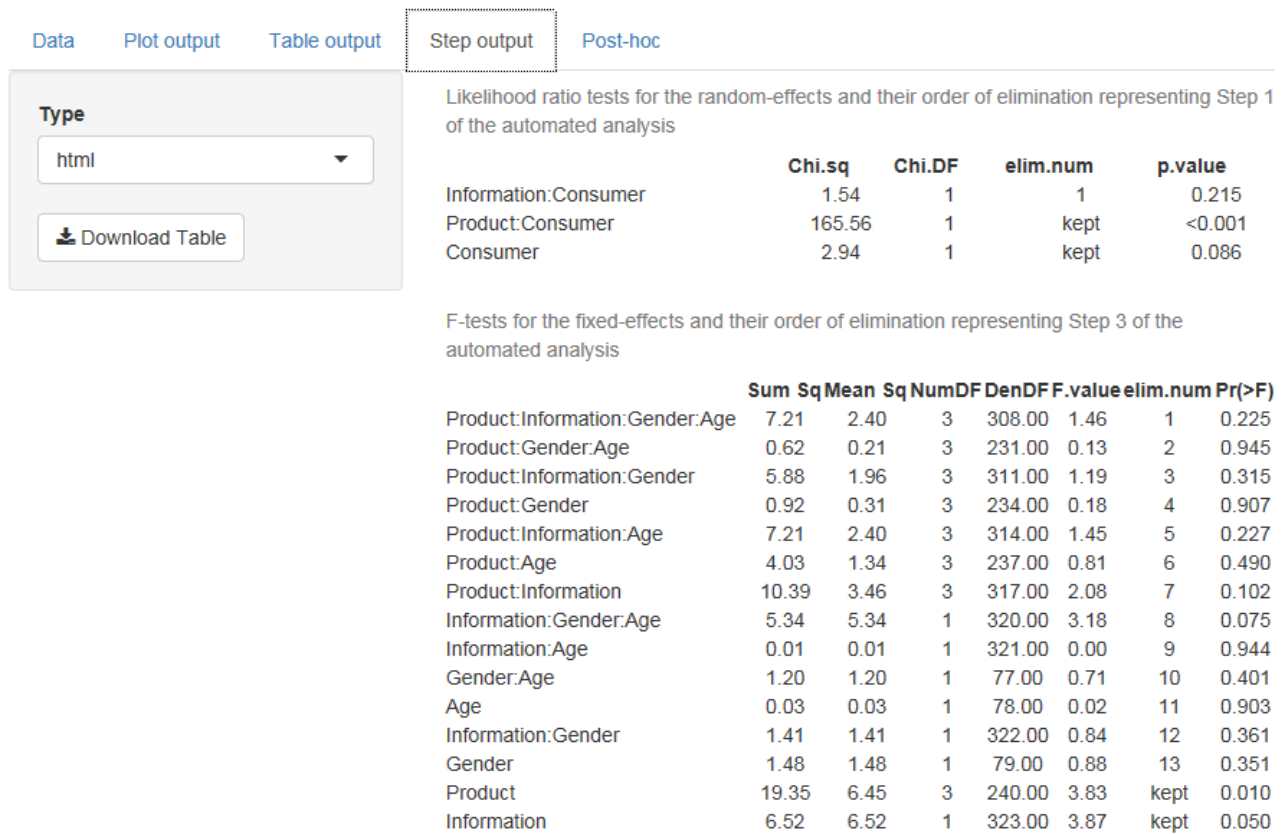
Data	Plot output	Table output	Step output	Post-hoc

Type

html	▾

⬇ Download Table

Likelihood ratio tests for the random-effects and their order of elimination representing Step 1 of the automated analysis

	Chi.sq	Chi.DF	elim.num	p.value
Information:Consumer	1.54	1	1	0.215
Product:Consumer	165.56	1	kept	<0.001
Consumer	2.94	1	kept	0.086

F-tests for the fixed-effects and their order of elimination representing Step 3 of the automated analysis

	Sum Sq	Mean Sq	NumDF	DenDF	F.value	elim.num	Pr(>F)
Product:Information:Gender:Age	7.21	2.40	3	308.00	1.46	1	0.225
Product:Gender:Age	0.62	0.21	3	231.00	0.13	2	0.945
Product:Information:Gender	5.88	1.96	3	311.00	1.19	3	0.315
Product:Gender	0.92	0.31	3	234.00	0.18	4	0.907
Product:Information:Age	7.21	2.40	3	314.00	1.45	5	0.227
Product:Age	4.03	1.34	3	237.00	0.81	6	0.490
Product:Information	10.39	3.46	3	317.00	2.08	7	0.102
Information:Gender:Age	5.34	5.34	1	320.00	3.18	8	0.075
Information:Age	0.01	0.01	1	321.00	0.00	9	0.944
Gender:Age	1.20	1.20	1	77.00	0.71	10	0.401
Age	0.03	0.03	1	78.00	0.02	11	0.903
Information:Gender	1.41	1.41	1	322.00	0.84	12	0.361
Gender	1.48	1.48	1	79.00	0.88	13	0.351
Product	19.35	6.45	3	240.00	3.83	kept	0.010
Information	6.52	6.52	1	323.00	3.87	kept	0.050

Figure 14: Screenshot for the step output for the ham data with structure 3

6.6. Post-hoc output

The *Post hoc* tab represents the results of the post-hoc analysis, namely pairwise-comparison tests for the fixed effects. The Figure 10 represents the screenshot for the *Post hoc* tab for the the product factor. In the panel to the left there is a selection list input *Type of Plot*, which has a few options: *DIFF of LSMEANS* showing the differences of least squares means for an effect in question and *LSMEANS* showing the least squares means of an effect in question. In selection list *Effects* one can select for which effect to view the results. Here I have chosen

`Product`. The results are shown in barplots and in table. Here, for example, the results show that products with levels `2` and `4` and `3` and `4` significantly differ. The plot and the table can be easily downloaded via *Download Table* and *Download Plot* buttons.

Figure 15: Screenshot for the post-hoc output for the Product factor for the ham data

7. Getting help

To get help on a particular function, e.g. `sensmixed`, you can write `help("sensmixed")` or equivalently `?sensmixed` (or just by typing sensmixed in a help tab of RStudio). This works well if you know which function you want help on. And of course you can always use google to search for a particular function.

8. Final remarks

In the analysis of sensory data, quite a lot of random as well as fixed effect can be part of the mixed effects model - this slows down the process of analysis of the data. Depending on the size of the data set, the calculations may take up to few minutes. Whenever one has clicked the *Run analysis* button, in the upper corner a small notification appears, that the calculations have started and one should wait. If one would like to change the modelling controls of the analysis, then it is important to click the *Run analysis* button in order to run the analysis for the newly selected modelling controls.

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