

1 AssociationExplorer: A user-friendly Shiny application 2 for exploring associations and visual patterns

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10 Abstract

AssociationExplorer is an open-source interactive R Shiny application designed to help non-technical users explore statistical associations within multivariate datasets. Aimed particularly at journalists, educators, and engaged citizens, the tool facilitates the discovery and interpretation of meaningful patterns between variables without requiring programming or statistical expertise. Users can upload structured data (e.g., from surveys or open government datasets), select relevant variables, and dynamically visualize relationships via a correlation network and contextual bivariate plots. To illustrate its capabilities, we present a case study based on the European Social Survey (ESS), showcasing how users can investigate links between attitudes, behaviors, and socio-demographic indicators across countries. The app supports a range of association measures adapted to variable types (Pearson's r , Eta, and Cramer's V), ensuring both flexibility and statistical rigor. The visual interface enables users to adjust thresholds for association strength and examine results through interactive graphs and summary tables, making the app particularly well-suited for data storytelling, exploratory research, and public communication. AssociationExplorer demonstrates how open-source statistical tooling can enhance transparency, accessibility, and insight in the interpretation of complex social data.

11 **Keywords:** R Shiny, Exploratory data analysis, Correlation network

Nr.	Code metadata description	Metadata
C1	Current code version	v3.5.4
C2	Permanent link to code/repository used for this code version	https://github.com/AntoineSoetewey/AssociationExplorer
C3	Permanent link to Reproducible Capsule	For example: https://codeocean.com/capsule/0270963/tree/v1xxx
C4	Legal Code License	MIT License
C5	Code versioning system used	Git
C6	Software code languages, tools, and services used	R, R Shiny
C7	Compilation requirements, operating environments & dependencies	xxx
C8	If available link to developer documentation/manual	https://github.com/AntoineSoetewey/AssociationExplorer/tree/main/documentation to do write doc xxx
C9	Support for questions or issues	https://github.com/AntoineSoetewey/AssociationExplorer/issues

Table 1: Code metadata

12 Metadata

13 The metadata associated with the current version of the software is summarized in Table 1.

14
15 The remainder of this paper is structured as follows. Section 1 outlines
16 the motivation and significance of the application, highlighting its contribu-
17 tion to data accessibility and exploratory analysis. Section 2 provides a de-
18 tailed description of the software’s architecture and functionalities. Section 3
19 presents an illustrative example using data from the European Social Sur-
20 vey. Section 4 discusses the potential impact of the application in research,
21 education, and journalism. Finally, Section 5 concludes with a summary and

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22 future directions.

23 1. Motivation and significance

24 The growing availability of large, complex, and high-dimensional datasets in
25 the social sciences and public policy domains offers unprecedented opportu-
26 nities for insight but also presents significant challenges for exploration and
27 interpretation, particularly for non-specialist audiences. Journalists, educa-
28 tors, and engaged citizens often struggle to identify and interpret meaningful
29 relationships between variables without the aid of programming skills or for-
30 mal statistical training. This barrier limits the broader societal impact of
31 open data initiatives, which are designed to promote transparency, account-
32 ability, and informed public discourse.

33 To address this gap, we developed AssociationExplorer, a free, open-source
34 R Shiny [3] application that enables intuitive and statistically grounded ex-
35 ploration of multivariate associations. The tool guides users through a visual
36 journey of variable relationships by automatically computing appropriate bi-
37 variate association measures—Pearson’s r , Eta, and Cramer’s V —depending
38 on variable types, and presenting the results in an interactive correlation
39 network. Users can set thresholds for the strength of association and explore
40 linked bivariate plots or tables with descriptive labels. This workflow sup-
41 ports transparent, reproducible, and non-technical exploratory data analysis
42 (EDA).

43 Our software is particularly suited to survey-based datasets and public opin-
44 ion studies. As an illustrative case, we apply AssociationExplorer to the
45 European Social Survey (ESS), a cross-national survey that collects attitudi-
46 nal, behavioral, and socio-demographic data across European countries. The
47 tool allows users to uncover associations between trust in institutions, pol-
48 icy preferences, media usage, and demographic characteristics without any
49 coding. This type of interactive analysis can empower journalists to build
50 data-driven narratives, educators to teach statistical thinking, and citizens
51 to explore evidence underlying public debate.

52 While several tools and libraries exist for correlation analysis (e.g., `corrr` [7],
53 `GGally` [13], `corrplot` [17], `ggstatsplot` [11], `correlation` [9, 10], `lares` [8]
54 and `Hmisc` [6] in R [12], or Python packages like `seaborn` [16] and `pingouin`
55 [15]), they typically require programming proficiency and focus primarily on
56 numerical associations. Most of these tools do not handle nominal categorical
57 variables directly; if included, such variables are often transformed using one-
58 hot or dummy encoding, which can transform their original structure and
59 limit interpretations.

60 In contrast, AssociationExplorer is designed to handle both quantitative and
61 qualitative variables (including nominal factors) natively and transparently.
62 It provides a guided, end-to-end workflow that begins with data upload and
63 preprocessing, continues through variable selection and association filtering,
64 and ends with interpretable visualizations. This structured process is in-
65 tuitive and accessible for users of all backgrounds, making the app espe-
66 cially suitable for those without programming experience or formal statistical
67 training. By lowering the technical barrier for statistical exploration, Asso-
68 ciationExplorer contributes to a more inclusive data culture and supports
69 data-driven discovery in both academic and public-facing contexts.

70 2. Software description

71 2.1. Software architecture

72 The AssociationExplorer application is a graphical user interface built with
73 the R programming language using the Shiny framework. It adopts a mod-
74 ular, reactive structure where data inputs and user selections dynamically
75 trigger updates to the visualizations and underlying computations. The user
76 interface is styled using the `bslib` package [14] with a modern flat theme and
77 enhanced interactivity through the `shinyjs` [2] and `visNetwork` [1] packages.
78 The app is structured into distinct tabs: data upload, variable selection, cor-
79 relation network visualization, pairs plots, and a help section.

80 Upon upload, the dataset is preprocessed to exclude variables with zero vari-
81 ance, as these variables do not vary across observations and therefore cannot
82 contribute to meaningful associations or visualizations. Removing them helps
83 reduce noise and ensures that only informative variables are included in the
84 analysis. Optionally, the user can provide a variable description file, which
85 is integrated and used to annotate visual elements. The backend computes
86 association measures tailored to the variable types: Pearson's r for numeric
87 pairs, Cramer's V for categorical pairs, and the correlation ratio (η) for mixed
88 pairs. Associations are filtered using user-defined thresholds and represented
89 in a correlation network and complementary bivariate plots. The app handles
90 both CSV and Excel files.

91 The application is currently available as a standalone open-source R Shiny
92 application on GitHub.¹ It can be launched directly from an R session using
93 the following command, provided the `shiny` package is installed:

```
94 library(shiny)  
95 runGitHub("AssociationExplorer", "AntoineSoetewey")
```

¹<https://github.com/AntoineSoetewey/AssociationExplorer>

96 A fully web-based version, requiring no installation or technical setup, is also
 97 planned as part of its integration into a broader online platform developed
 98 within the ODALON (Open multimodal Data for Automated LOcal News)
 99 research project, which aims to support the production of local news (more
 100 information about this project in Sections 3 and 4).

101 2.2. Software functionalities

102 The major functionalities of the AssociationExplorer application include:

- 103 • **Data upload and cleaning:** The app supports CSV and Excel files.
 104 It automatically removes variables with only one unique value, as they
 105 lack variability and cannot contribute to association analyses. Addi-
 106 tionally, it can optionally integrate user-supplied descriptions of vari-
 107 ables, which are used to enhance the clarity and interpretability of
 108 visualizations, particularly for non-technical users.
- 109 • **Variable selection interface:** Users can interactively choose which
 110 variables to explore. When a description file is provided, a summary
 111 table links variable names to their descriptions.
- 112 • **Dynamic association filtering:** The app computes pairwise associ-
 113 ation measures between all selected variables, using a method tailored
 114 to the types of variables involved:
 - 115 – For pairs of numeric variables X and Y , the app calculates Pear-
 116 son’s correlation coefficient (r), and retains the association if the
 117 coefficient of determination (R^2) exceeds a user-defined threshold:

$$R^2 = r^2 = (\text{cor}(X, Y))^2 \quad (1)$$

118 where the Pearson’s correlation coefficient $\text{cor}(X, Y)$ is defined as:

$$r(X, Y) = \frac{\sum_{i=1}^n (X_i - \bar{X})(Y_i - \bar{Y})}{\sqrt{\sum_{i=1}^n (X_i - \bar{X})^2} \sqrt{\sum_{i=1}^n (Y_i - \bar{Y})^2}} \quad (2)$$

119 where \bar{X} and \bar{Y} are the sample means of X and Y , respectively,
 120 and n is the number of observations.

- 121 – For pairs of categorical variables, it computes Cramer’s V, a nor-
 122 malized measure of association derived from the chi-squared statis-
 123 tic:

$$V = \sqrt{\frac{\chi^2}{n \cdot \min(k-1, r-1)}} \quad (3)$$

where χ^2 is the chi-squared statistic, n is the total number of observations, and k, r are the numbers of categories in each variable.

- For mixed pairs (one numeric and one categorical variable), the app computes the correlation ratio (η), which quantifies how much of the variance in the numeric variable is explained by the grouping structure of the categorical variable. It is defined as:

$$\eta = \sqrt{\frac{SS_{\text{between}}}{SS_{\text{total}}}} \quad (4)$$

where:

- SS_{total} is the *total sum of squares* of the numeric variable:

$$SS_{\text{total}} = \sum_{i=1}^n (y_i - \bar{y})^2$$

with y_i the observed numeric values and \bar{y} their overall mean.

- SS_{between} is the *between-group sum of squares*, computed as:

$$SS_{\text{between}} = \sum_{g=1}^G n_g (\bar{y}_g - \bar{y})^2$$

where G is the number of groups (categories), n_g is the number of observations in group g , \bar{y}_g is the group mean, and \bar{y} is the overall mean.

This formulation captures the proportion of the total variance in the numeric variable that can be attributed to differences between the categorical groups. A pair is retained only if η^2 exceeds the numeric threshold defined by the user.

Each association is retained only if its corresponding strength metric— R^2 , η^2 , or Cramer’s V—exceeds the threshold set by the user. These thresholds can be adjusted interactively through the interface, and the filtering process is reactive: updates to the thresholds immediately propagate to the network and bivariate visualizations. This allows users to dynamically control the sensitivity of the association analysis and focus on relationships of substantive interest.

148 • **Interactive correlation network:** The filtered associations are displayed as an interactive graph where nodes represent variables and edges represent associations. Edge thickness and length reflect the strength of the association: stronger associations are shown with thicker and shorter edges, whereas weaker associations are displayed with thinner and longer edges. This dual visual representation helps users quickly identify the most meaningful relationships in the network. Variable descriptions are displayed when the user hovers over a node in the network, allowing for quick access to additional context without cluttering the visualization. The network is built using the `visNetwork` R package, which supports interactive, customizable graph layouts; full documentation is available at <https://datastorm-open.github.io/visNetwork/>.

161 • **Bivariate visualization of variable pairs:** For each variable pair exceeding the threshold:

- 163 – Scatter plots with linear regression lines are shown for numeric pairs, helping visualize the direction and strength of the relationship.
- 164
- 165
- 166 – Colored contingency tables with marginal sums are shown for categorical pairs, where cell background colors vary in intensity according to the frequency of observations, using a blue gradient to highlight higher counts.
- 167
- 168
- 169
- 170 – Mean plots are shown for numeric-categorical pairs, with bars ordered by mean value to make it easy to compare and rank categories based on the quantitative variable.
- 171
- 172

173 Confidence intervals for the regression lines and standard errors in the mean plots are intentionally omitted to maintain a clean, uncluttered visualization that prioritizes ease of interpretation. Mean plots were selected over boxplots to avoid overwhelming non-expert users with distributional information, focusing instead on clear, accessible insights about average group differences.

179 • **Accessibility and user guidance:** A dedicated help section explains each step, allowing users with a limited statistical background to interactively explore their data.

182 2.3. Sample code snippets analysis

183 Below is a representative snippet from the application showing how the software selects the appropriate association measure depending on the types of the variable pair and filters associations based on user thresholds:

```

186 # Numeric vs numeric case
187 if (is_num1 && is_num2) {
188     ...
189     r <- cor(x, y, use = "complete.obs")
190     cor_val <- ifelse(r^2 >= threshold_num, r, 0)
191     cor_type <- "Pearson's r"
192
193 # Categorical vs categorical case
194 } else if (!is_num1 && !is_num2) {
195     ...
196     tbl <- table(x, y)
197     ...
198     n_obs <- sum(tbl)
199     df_min <- min(nrow(tbl) - 1, ncol(tbl) - 1)
200     if (df_min > 0) {
201         v_cramer <- sqrt(chi$statistic / (n_obs * df_min))
202         cor_val <- ifelse(v_cramer >= threshold_cat,
203                           v_cramer, 0)
204         cor_type <- "Cramer's V"
205     }
206
207 # Mixed case (numeric vs categorical)
208 } else {
209     ...
210     means_by_group <- tapply(num_var, cat_var,
211                               mean, na.rm = TRUE)
212     overall_mean <- mean(num_var, na.rm = TRUE)
213     n_groups <- tapply(num_var, cat_var, length)
214     bss <- sum(n_groups * (means_by_group - overall_mean)^2,
215               na.rm = TRUE)
216     tss <- sum((num_var - overall_mean)^2, na.rm = TRUE)
217
218     if (tss > 0) {
219         eta <- sqrt(bss / tss)
220         cor_val <- ifelse(eta^2 >= threshold_num, eta, 0)
221         cor_type <- "Eta"
222     }
223 }

```

224 This conditional structure ensures that the correct statistical method is ap-
225 plied for each type of variable pair, supporting a robust and interpretable

226 exploration of associations.

227 3. Illustrative example

228 To demonstrate the core functionalities of AssociationExplorer, we use a cu-
229 rated subset of data from the European Social Survey (ESS), Round 11.
230 The ESS is a large-scale, cross-national survey that measures attitudes, be-
231 liefs, and behaviors across European countries. The original dataset includes
232 responses from over 46,000 individuals on topics such as politics, trust, well-
233 being, media use, and health. The full ESS dataset, codebook, and docu-
234 mentation are freely available at <https://ess.sikt.no/en/> [5, 4].

235 For this example, we focus on the Belgian respondents, resulting in a re-
236 duced dataset of 1,594 individuals. We selected 60 variables covering areas
237 highly relevant for understanding public opinion and everyday life in Belgium:
238 interest in politics, confidence in institutions, lifestyle behaviors, perceived
239 discrimination, vaccination, and more. These variables include both numbers
240 (quantitative data) and labels or categories (qualitative data), making the
241 dataset ideal for exploring diverse forms of associations.

242 This example is particularly relevant for our research project ODALON,
243 which aims to develop a platform that supports the (semi-)automated pro-
244 duction of local news in Belgium. AssociationExplorer plays a key role in
245 this effort by offering journalists, researchers, and citizens an intuitive tool to
246 explore potentially newsworthy patterns in public and survey data, without
247 requiring programming skills or statistical training.

248 Data preparation for the curated dataset was carried out in R and included:

- 249 • Filtering the dataset to include only Belgian respondents.
- 250 • Converting survey-specific nonresponse codes (e.g., 77, 88, 9999, etc.)
251 to NA values, based on the ESS codebook.
- 252 • Reversing response scales to ensure consistency (e.g., higher values al-
253 ways indicate stronger agreement or frequency).
- 254 • Recoding several categorical variables to have meaningful and inter-
255 pretable labels (e.g., for gender, religion, political participation, or
256 health behaviors).

257 The full R script used to perform this transformation is openly available in the
258 data folder of the GitHub repository at [https://github.com/AntoineSoetewey/](https://github.com/AntoineSoetewey/AssociationExplorer/tree/main/shiny_app/data)
259 [AssociationExplorer/tree/main/shiny_app/data](https://github.com/AntoineSoetewey/AssociationExplorer/tree/main/shiny_app/data).

260 Once the dataset is uploaded into AssociationExplorer via the Data tab (see
261 Figure ??), users are guided through a step-by-step process. In addition

262 to the main dataset, users can optionally upload a separate description file
 263 that provides human-readable explanations for each variable. In our exam-
 264 ple, this file was created using information from the official ESS codebook,
 265 allowing for clearer interpretation throughout the app interface. If no de-
 266 scription file is provided, the application will automatically use the vari-
 267 able names themselves as default labels in all visualizations and summary
 268 tables. In the **Variables** tab, they select the variables they wish to ex-
 269 plore, optionally assisted by a table of the variables' names and descriptions
 270 (see Figure ??). Next, users can adjust the association thresholds in the
 271 **Correlation Network** tab to focus on the most meaningful relationships
 272 among the selected variables (see Figure ??). Finally, the **Pairs Plots** tab
 273 displays detailed bivariate visualizations, including scatter plots, mean plots,
 274 and contingency tables, for each retained association (see Figure ??).
 275 This example shows how non-expert users, such as journalists or engaged cit-
 276 izens, can uncover unexpected or important relationships in a public opinion
 277 dataset. These insights can serve as the starting point for local news, public
 278 debates, or policy communication.
 279 Note that in this example, no survey weights have been applied. While the
 280 ESS dataset includes weights to account for complex sampling designs, we
 281 chose not to use them here in order to maintain clarity and responsiveness
 282 in the interface, and because our focus is on demonstrating the app's core
 283 functionality rather than producing nationally representative statistics.
 284 xxx to do: add screenshots and refer to them.
 285 xxx to do: add video : **Optional:** *you may include one explanatory video or*
 286 *screencast that will appear next to your article, in the right hand side panel.*
 287 *Please upload any video as a single supplementary file with your article. Only*
 288 *one MP4 formatted, with 150MB maximum size, video is possible per article.*
 289 *Recommended video dimensions are 640 x 480 at a maximum of 30 frames*
 290 */ second. Prior to submission please test and validate your .mp4 file at [http:](http://elsevier-apps.sciverse.com/GadgetVideoPodcastPlayerWeb/verification)*
 291 *[//elsevier-apps.sciverse.com/GadgetVideoPodcastPlayerWeb/verification](http://elsevier-apps.sciverse.com/GadgetVideoPodcastPlayerWeb/verification)*
 292 *. This tool will display your video exactly in the same way as it will appear*
 293 *on ScienceDirect.*

294 4. Impact

295 AssociationExplorer enables a broader range of users, including researchers,
 296 students, journalists, and engaged citizens, to explore complex datasets in-
 297 volving both quantitative and qualitative variables. By eliminating the need
 298 for advanced programming or statistical knowledge, the software lowers the
 299 barrier to entry for data-driven discovery and interpretation.

300 From a research perspective, the app facilitates the systematic screening of
 301 pairwise associations in survey or public data, offering insights that can guide
 302 hypothesis generation, variable selection, or further multivariate modeling.
 303 It is planned to be used in the context of the ODALON research project,
 304 which aims to support the semi-automated generation of local news. Ini-
 305 tially targeted at Belgian journalists, the platform, and the use of Associa-
 306 tionExplorer within it, may later be extended to other professional or public
 307 audiences. The app will help identify patterns in public opinion data that
 308 may serve as starting points for local news articles, for example, by revealing
 309 unexpected associations between political attitudes, trust in institutions, or
 310 lifestyle behaviors.

311 The software also improves the pursuit of existing research questions by mak-
 312 ing it easier to assess relationships between variables of different types (nu-
 313 meric, ordinal, and nominal) within a single unified interface. Unlike many
 314 tools that require preprocessing steps such as dummy coding, Association-
 315 Explorer handles categorical variables natively and automatically selects the
 316 appropriate statistical association measure (i.e., Pearson’s r , Cramer’s V ,
 317 correlation ratio η). This ensures that users can obtain meaningful and in-
 318 terpretable results without needing to master complex preprocessing steps or
 319 statistical diagnostics.

320 The app is also planned to be used as an interactive teaching aid in statistics
 321 and data literacy courses. It will allow students to upload real datasets and
 322 immediately visualize how variables relate, reinforcing theoretical concepts
 323 through intuitive, hands-on exploration. By presenting associations visually,
 324 the app encourages learners to engage with their data more actively and
 325 reflect critically on patterns, variable relationships, and data quality.

326 Although already fully functional, the software is currently made available as
 327 a standalone open-source R Shiny application on GitHub and can be launched
 328 directly from R. At this stage, it is therefore only accessible to users who have
 329 R installed on their machine. As part of the broader ODALON research
 330 project, which aims to build an integrated platform combining multiple tools
 331 for automated local news production, AssociationExplorer will serve as a key
 332 building block. A public, fully online version of the app will be released as the
 333 project progresses, and no later than December 2026 (which corresponds to
 334 the end of the project), ensuring that anyone, including those without access
 335 to R, can freely use the application through a user-friendly web interface.

336 Future impact is expected through integration into platforms for civic data
 337 storytelling, local journalism, and public communication. While not intended
 338 for commercialization, the application’s role in supporting open, inclusive,
 339 and responsible data exploration reflects its potential for broader societal
 340 relevance.

341 5. Conclusions

342 AssociationExplorer provides a user-friendly, open-source solution for explor-
343 ing statistical associations within multivariate datasets. By integrating ro-
344 bust statistical measures with dynamic and intuitive visualizations, the app
345 empowers non-expert users, such as journalists, educators, and engaged cit-
346 izens, to uncover patterns and relationships that might otherwise remain
347 hidden. Its ability to handle both quantitative and qualitative variables,
348 combined with an interactive interface and an easy-to-follow workflow, makes
349 it especially suitable for exploratory research, data storytelling, and public
350 communication.

351 Beyond its technical features, the application contributes to democratizing
352 access to statistical tools and supports data literacy in a wide range of con-
353 texts. The case study using the European Social Survey illustrates how users
354 can navigate from raw data to meaningful insights with minimal technical
355 knowledge.

356 While the app is currently accessible through R for users with basic technical
357 setup, a fully web-based version will make it universally available as part of
358 a broader data exploration platform being developed under the ODALON
359 project. By lowering barriers to data exploration and interpretation, Asso-
360 ciationExplorer supports more inclusive, transparent, and evidence-informed
361 engagement with complex social data.

362 Future improvements will be guided by user feedback and community con-
363 tributions. One planned feature is the ability to incorporate user-specified
364 weights, especially relevant for survey data. However, this functionality is
365 not yet implemented in the current version to preserve simplicity and ensure
366 responsiveness in the user interface, particularly for users unfamiliar with
367 survey weighting procedures.

368 Additional avenues for future research and development include extending
369 the application to compute partial correlations, which can help isolate direct
370 relationships between variables by controlling for confounders. Visualizations
371 involving three variables could also be introduced, for instance, scatter plots
372 where the size or color of points reflects a third variable, to uncover more nu-
373 anced patterns. Furthermore, users could be allowed to filter variables based
374 on missingness thresholds or variable types, and a module for longitudinal
375 data (e.g., panel structures or time series) could expand the app's relevance
376 to temporal analyses. Lastly, adding options for exporting results or gener-
377 ating automated summaries of key associations could further enhance its use
378 in reporting and collaborative workflows.

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