Revista ARACÊ
ISSN: 2358-2472

ANALYSIS OF THE EFFECTIVENESS OF THE DIFFERENT CHART FORMATS USED IN DASHBOARDS AIMED AT THE DECISION-MAKING PROCESS IN THE ADMINISTRATIVE/FINANCIAL AREA: A SYSTEMATIC REVIEW OF THE LITERATURE

https://doi.org/10.56238/arev6n4-256

Submitted on: 11/17/2024 **Publication date:** 12/17/2024

Fernando de Oliveira Santoro[1], André Ribeiro de Oliveira[2] and Dércio Santiago da Silva Júnior[3].

ABSTRACT

This article presents a Systematic Review of the Literature (RSL) on the effectiveness of chart formats used in dashboards in supporting decision-making in the administrative and financial areas. The growing importance of dashboards as strategic support tools underscores the need to understand how different visualization designs impact cognition and decision-making. The survey was conducted between September and November 2023 and included searches in the main scientific databases, such as Scopus, Web of Science, and Google Scholar. A total of 9,049 titles were identified, of which 19 showed full adherence to the research question. These papers have been analyzed in depth, highlighting experimental approaches that utilize methods such as EEG, eye-tracking, and cognitive load theories to assess the effectiveness of visualizations.

The results indicate that the clarity and integration of semantic and perceptual elements are determinant for the effectiveness of charts in dashboards. It has been observed that well-structured graphic designs can reduce cognitive effort, increase accuracy, and promote more assertive decisions. Limitations such as small sample size and lack of broader practical validations have been identified, suggesting opportunities for future research.

The main contribution of this article lies in the search for specific heuristics to evaluate data visualizations, promoting the theoretical and practical advancement of the field of information design. These heuristics can be applied to dashboard optimization and future experiments that explore the interplay between visual design and decisions in diverse contexts. This study reinforces the relevance of dashboards in strategic management and their ability to transform data into useful knowledge, with direct implications for organizational effectiveness.

Keywords: Dashboards and decision making, Effectiveness of graphical visualizations.

[1] Master's degree in Accounting from the State University of Rio de Janeiro (UERJ)
Email: fsantoro@pensarmais.com.br
ORCID: https://orcid.org/0000-0002-4591-5349
LATTES: http://lattes.cnpq.br/9733350839541866
[2] Dr. in Production Engineering from the Federal University of Rio de Janeiro (UFRJ)
E-mail: andre.ribeiro@eng.uerj.br
ORCID: https://orcid.org/0000-0003-2304-8288
LATTES: http://lattes.cnpq.br/8100443134568049
[3] Dr. in Collective Health from the Institute of Social Medicine IMS/UERJ
Email: derciojr@uerj.br
ORCID: https://orcid.org/0000-0003-2656-6400
LATTES: http://lattes.cnpq.br/2588039496562270

Revista ARACÊ
ISSN: 2358-2472

INTRODUCTION

Contemporary society is in constant and accelerated evolution, and technology is one of the main driving agents of this development. "At the end of the second millennium of the Christian era, several events of historical importance transformed the social scenario of human life. A technological revolution concentrated in information technologies has begun to reshape the material base of society at a rapid pace." (CASTELLS, 2011 p.1).

In this context, qualitative and quantitative data are produced, collected, and made available in a volume never seen in history.

> International Data Corporation (IDC) recently published its annual DataSphere and StorageSphere forecasts, which measure the amount of data created, consumed, and stored in the world each year. According to IDC's findings, the amount of data created and replicated experienced exceptionally high growth in 2020 due to the dramatic increase in the number of people working, learning, and playing from home. [...] In 2020, 64.2 Zettabytes were created or replicated. (adaptation of free translation). (accessed on 09-04-2023)(IDC, 2021)

This event, combined with the dissemination of the internet, the popularization of microcomputers and the creation of computer management programs, democratized the process of data analysis, which was previously expensive, complex and restricted to the IT (Information Technology) area, and started to be carried out by the information seekers themselves through programs such as, for example, Microsoft Powerpoint and Microsoft Excel, in the beginning, and Tableau and Microsoft Power BI more recently, thus starting the era of *self-service* BI. "This new BI modality emerged with the intention of bringing the tools closer to the people who will perform data analysis, and it is not necessary to have in-depth knowledge of the technology to start developing reports." (SIMÃO, 2021, p7)

Based on the context described, carrying out a strategic management of the data generated becomes relevant for the evolution of society, in general, as well as for the survival and prosperity of companies. This reality imposes on managers a complex and challenging scenario, in which products and services, offered on a global scale, are inserted in a highly competitive environment.

> Organizations, both public and private, are under pressure to react quickly to such developments and to innovate their modus operandi. This requires organizations to be agile and make frequent, fast, strategic, and tactical operational decisions, some of which are quite complex. Such decisions may require considerable amounts of relevant data, information, and knowledge. (SHARDA, DELEN & TURBAN, 2019, p1)

Revista ARACÊ
ISSN: 2358-2472

For an organization to survive and thrive within this uncertain environment, its leaders need to make correct, timely and assertive decisions. To achieve these goals, they need to equip themselves with tools to aid the decision-making process. Among the various tools available for this purpose, one considered relevant for conducting an organization is dashboards.

"A *dashboard* is a visual display of the most important and necessary information to achieve one or more objectives, consolidated on a single computer screen so that it can be monitored quickly. (FEW, 2006, p26)."

A well-developed dashboard can transform business questions into visuals without any or minimal bias, in order to allow the user to make the decision as clearly as possible. It works as an interpretation of data transformed into information that will become knowledge when the user makes a value judgment, absorbing the visual, and moving in the direction of making a decision. It is noteworthy, in this line of thought, that the poor development of a *dashboard* can induce its user to a wrong decision.

It is observed that both the Integrated Business Management Systems (EMIS) and the management assistance programs mentioned above provide a wide range of graphs and tables, serving as options for the visualization and analysis of the processed data.

Established graphs, such as pie, line and bars, began to divide the attention of users of the information with other types of visualizations, such as *treemap*, waterfall and speedometer.

> Throughout the 1990s and early 2000s, the media and businesses incorporated print infographics as a more enlightening way to represent numbers. The novelty was that users began to interact with such visualizations, a fact that enabled both the internet and technological advances related to computer programming. The ways in which we can show data have advanced exponentially: from infographics and network charts to command centers and war rooms. (SILVA F. C., 2019, p.217)

In this sense, both decision makers, analysts and professionals who develop the output pieces of the data worked on (Presentations, Infographics, Reports and Dashboards), need to deal with the creation and interpretation of the inserted visuals.

The lack of specialization in data visualization techniques, combined with the many options for visuals and ease of building them, can compromise the decision-making process, making it difficult to retain and interpret the information generated through the visual. "The growing popularity of data visualization has not been consistent with equivalent attention to the elementary principles that should guide its design. Most people who

Revista ARACÊ
ISSN: 2358-2472

regularly create charts or maps for slideshows, articles, documents, business reports, and the like don't learn visualization formally." (CAIRO, 2019, p. 118)

Considering the relevance of well-presented information, through graphic visuals, for the decision-making process, this article aims to describe the process of Systematic Literature Review (RSL) to survey the state of the art of research related to the context of data visualization to aid the decision-making process of business problems in the administrative/financial area.

The motivational factor for conducting the research comes from the need to determine which visual (graph or table) has the best application from a certain business question that it was created to answer, in addition to the correct way to view it, within *dashboards* of the administrative/financial area of companies.

METHODOLOGY

To advance in the research, it was necessary to structure the starting question. "As with any other scientific investigation, a good systematic review requires a well-formulated and clear question or question (SAMPAIO and MANCINI, 2007, p. 84)".

Thus, the research aims to answer the following starting question: What is the appropriate set of heuristics to evaluate the effectiveness of the different chart formats used in dashboards aimed at the decision-making process in the administrative/financial area?

The question has scientific relevance in view of the contribution that *dashboards* built based on the best practices of information design can exert in the decision-making process.

The macro theme of data visualization has been the object of study in several areas of knowledge, however, the effective application of graphs and tables in administrative and financial dashboards represents a field that is still little addressed, making the starting question delimited. The implementation of a set of specific heuristics to evaluate *dashboards* in this context, aiming to optimize decision-making, stands out as an original contribution in the design literature.

Finally, the question will be feasible to be answered from the survey of this RSL, as well as through other tests, such as quantitative and/or qualitative tests and questionnaires.

METHODOLOGICAL STRATEGY FOR SELECTION, EXTRACTION AND ANALYSIS OF ARTICLES AND BOOKS

SAMPAIO and MANCINI (2007, p. 84) define a systematic review of literature as:

Revista ARACÊ
ISSN: 2358-2472

> [...] a form of research that uses literature on a given topic as a source of data. This type of investigation provides a summary of the evidence related to a specific intervention strategy, through the application of explicit and systematized methods of search, critical appreciation and synthesis of the selected information. Systematic reviews are particularly useful to integrate information from a set of studies carried out separately on a given therapy/intervention, which may present conflicting and/or coinciding results, as well as to identify themes that need evidence, helping to guide future investigations.

This RSL was carried out between September and November 2023. Two strategies were used to select articles and books, namely: PICo Strategy, an acronym that divides the starting question into population, interest, and context; and, after the low return of relevant materials through the first strategy, the broad search of keywords. Both can be replicated, which validates this study. Terms in Portuguese and English were searched.

The detailed stages of the process are set out below.

KEYWORD SURVEY USING THE PICO STRATEGY

On 09-09-2023, the search terms were defined based on the use of the PICo strategy. The result is below.

Table 1 - Search terms based on the PICo strategy

Acronym	Part of the Question	Keywords PT-BR	Keywords EN
P (population/problem)	users of administrative/financial dashboards	"Decision making"	"Decision making"
I (interest)	Appropriate set of heuristics to evaluate effectiveness	(Effectiveness OR Efficiency OR Effectiveness)	(effectiveness OR efficiency OR Efficacy)
Co (context)	Chart Formats	("Data Visualization" OR "Information Visualization" OR Chart OR Dashboard)	("Data Visualization" OR "Information Visualization" OR Graph OR Chart OR Dashboard)

Source: the authors

SELECTION OF DATABASES FOR SEARCHING THE KEYWORDS CHOSEN THROUGH THE PICO STRATEGY

On the same day 09-09-2023, the databases for searching the terms were defined, as shown in the following table.

Table 2 - Databases for searching the terms of the PICo strategy

Database	URL
Theses and Dissertations Bank (BDTD)	https://bdtd.ibict.br
Web of Science (WoS)	https://www.webofscience.com
Scopus	https://www.scopus.com

Source: the authors

Revista ARACÊ
ISSN: 2358-2472

SEARCH STRING AND EXTRACTION OF TITLES

Also on 09-09-2023, the search string was defined using logical operators 'OR' and 'AND' to later integrate the selected keywords along with their respective synonyms and equivalents in Portuguese and English. This approach resulted in the configuration of the following *search strings*:

Portuguese: "Decision Making" AND (Effectiveness OR Efficiency OR Effectiveness) AND ("Data Visualization" OR "Information Visualization" OR Chart OR Dashboard)

Inglês: "Decision making" AND (effectiveness OR efficiency OR Efficacy) AND ("Data Visualization" OR "Information Visualization" OR Graph OR Chart OR Dashboard)

Table 3 shows the number of titles that were returned after the searches in the databases.

Table 3 - Search results for the PICo strategy

Database	Language	Number of titles
Theses and Dissertations Bank (BDTD)	Portuguese	40
Theses and Dissertations Bank (BDTD)	English	51
Web of Science (WoS)	English	1.463
Scopus	English	2.619
TOTAL		**4.173**

Source: the authors

KEYWORD SURVEY USING BROAD SEARCH

After performing a superficial analysis of the titles returned in the search using the PICo strategy, it was found that, due to the limitations of the acronym rules, relevant keywords were suppressed, such as, for example, "Type" or "Types" or "Objective" or "Objectives" or "Measure" or "Measuring" or "Measure" or "Task", as well as their respective English translations.

In order to have access to the largest number of relevant titles, it was proposed to test a broad search methodology in the Google Scholar (https://scholar.google.com.br/?hl=pt) and CAPES (https://www-periodicos-capes-gov-br.ezl.periodicos.capes.gov.br/index.php?) database aggregators.

On 09-11-2023, the search *strings* were defined using logical operators 'OR' and 'AND', integrating the selected keywords along with their respective synonyms and equivalents in Portuguese and English. This approach resulted in the configuration of the following *search strings* with their respective results:

Revista ARACÊ
ISSN: 2358-2472

Table 4 - Results by Google Scholar search

Terms	Results
"systematic review" (graphs OR graph OR "data visualization" OR "Information visualization" OR visualization OR visualizations OR dashboards OR dashboard)	18
"Systematic Review" (graphics OR graph OR "Data visualization" OR "information visualization" OR visualization OR visualizations OR charts OR chart OR dashboards OR dashboard)	217
Charts (Business OR Finance OR Administration OR "Decision Making")	11
Chart (Business OR Finance OR Administration OR "Decision Making")	9
"Data Visualization" (Business OR Finance OR Administration OR "Decision Making")	11
"Information visualization" (Business OR Finance OR Administration OR "Decision Making")	3
Visualization (Business OR Finance OR Administration OR "Decision Making")	27
Views (Business OR Finance OR Administration OR "Decision Making")	0
Dashboards (Business OR Finance OR Administration OR "Decision Making")	3
Dashboard (Business OR Finance OR Administration OR "Decision Making")	10
Graphics (business OR finance OR administration OR "Decision making")	439
Graph (business OR finance OR administration OR "Decision making")	508
"Data Visualization" (business OR finance OR administration OR "Decision making")	269
"Information Visualization" (business OR finance OR administration OR "Decision making")	109
Visualization (business OR finance OR administration OR "Decision making")	1.180
Visualizations (business OR finance OR administration OR "Decision making")	125
Charts (business OR finance OR administration OR "Decision making")	279
Chart (business OR finance OR administration OR "Decision making")	296
Dashboards (business OR finance OR administration OR "Decision making")	223
Dashboard (business OR finance OR administration OR "Decision making")	404
Graphs (Type OR Types OR Objective OR Objectives OR Effectiveness OR Efficiency OR Effectiveness OR Measure OR Measuring OR Measure OR Task)	78
Graph (Type OR Types OR Objective OR Objectives OR Effectiveness OR Efficiency OR Effectiveness OR Measure OR Measuring OR Measure OR Task)	130
"Data visualization" (Type OR Types OR Objective OR Objectives OR Effectiveness OR Efficiency OR Effectiveness OR Measure OR Measuring OR Measure OR Task)	3
"Information visualization" (Type OR Types OR Objective OR Objectives OR Effectiveness OR Efficiency OR Effectiveness OR Measure OR Measure OR Measure OR Task)	3
Visualization (Type OR Types OR Objective OR Objectives OR Effectiveness OR Efficiency OR Effectiveness OR Measure OR Measuring OR Measure OR Task)	35
Visualizations (Type OR Types OR Objective OR Objectives OR Effectiveness OR Efficiency OR Effectiveness OR Measure OR Measuring OR Measure OR Task)	0
Dashboards (Type OR Types OR Objective OR Objectives OR Effectiveness OR Efficiency OR Effectiveness OR Measure OR Measuring OR Measure OR Task)	1

Revista ARACÊ
ISSN: 2358-2472

Dashboard (Type OR Types OR Objective OR Objectives OR Effectiveness OR Efficiency OR Effectiveness OR Measure OR Measuring OR Measure OR Task)	7
Graphics (Type OR Types OR Objective OR Objectives OR Task OR Tasks OR effectiveness OR efficiency OR Efficacy OR measure OR measuring)	689
Graph (Type OR Types OR Objective OR Objectives OR Task OR Tasks OR effectiveness OR efficiency OR Efficacy OR measure OR measuring)	3.740
"Data Visualization" (Type OR Types OR Objective OR Objectives OR Task OR Tasks OR effectiveness OR efficiency OR Efficacy OR measure OR measuring)	208
"Information Visualization" (Type OR Types OR Objective OR Objectives OR Task OR Tasks OR effectiveness OR efficiency OR Efficacy OR measure OR measuring)	98
Visualization (Type OR Types OR Objective OR Objectives OR Task OR Tasks OR effectiveness OR efficiency OR Efficacy OR measure OR measuring)	2.590
Visualizations (Type OR Types OR Objective OR Objectives OR Task OR Tasks OR effectiveness OR efficiency OR Efficacy OR measure OR measuring)	218
Charts (Type OR Types OR Objective OR Objectives OR Task OR Tasks OR effectiveness OR efficiency OR Efficacy OR measure OR measuring)	768
Chart (Type OR Types OR Objective OR Objectives OR Task OR Tasks OR effectiveness OR efficiency OR Efficacy OR measure OR measuring)	1.120
Dashboards (Type OR Types OR Objective OR Objectives OR Task OR Tasks OR effectiveness OR efficiency OR Efficacy OR measure OR measuring)	97
Dashboard (Type OR Types OR Objective OR Objectives OR Task OR Tasks OR effectiveness OR efficiency OR Efficacy OR measure OR measuring)	193
TOTAL	14.119

Source: the authors

Table 5 - Search results on the CAPES Platform

Terms	Results	Filters
"systematic review" (graphs OR graph OR "data visualization" OR "Information visualization" OR visualization OR visualizations OR dashboards OR dashboard)	8	
"Systematic Review" (graphics OR graph OR "Data visualization" OR "information vasualization" OR vizualization OR visualizations OR charts OR chart OR dashboards OR dashboard)	109	Systematic Review; Visualization; Data Visualization; Literature Reviews; Review
Charts (Business OR Finance OR Administration OR "Decision Making")	24	
"Data Visualization" (Business OR Finance OR Administration OR "Decision Making")	2	
"Information visualization" (Business OR Finance OR Administration OR "Decision Making")	0	
Visualization (Business OR Finance OR Administration OR "Decision Making")	3	
Dashboards (Business OR Finance OR Administration OR "Decision Making")	4	
Graphics (business OR finance OR administration OR "Decision making")	185	Decision Making; Computer Graphics; Business; Social Sciences; Business & Economics;

Revista ARACÊ
ISSN: 2358-2472

		Visualization; Decision-Making
Graph (business OR finance OR administration OR "Decision making")	200	Decision Making; Graphs; Graphs Theory; Decision-Making; Business & Economics; Business
"Data Visualization" (business OR finance OR administration OR "Decision making")	46	Visualization; Data Visualization; Business & Economics; Business; Decision Making; Business Intelligence; Data Analysis
"Information Visualization" (business OR finance OR administration OR "Decision making")	35	
Visualization (business OR finance OR administration OR "Decision making")	291	Decision Making; Data Visualization; Business; Visualization; Business & Economics; Decision-Making
Chart (business OR finance OR administration OR "Decision making")	86	Control Charts; Business & Economics; Business; Management; Decision Making; Charts
Dashboards (business OR finance OR administration OR "Decision making")	95	Dashboards; Decision Making; Dashboard; Business Intelligence; Business & Economics; Information Management; Business; Decision-Making; Visualization
Graphs (Type OR Types OR Objective OR Objectives OR Effectiveness OR Efficiency OR Effectiveness OR Measure OR Measuring OR Measure OR Task)	4	Gráficos; Analysis
"Data visualization" (Type OR Types OR Objective OR Objectives OR Effectiveness OR Efficiency OR Effectiveness OR Measure OR Measuring OR Measure OR Task)	5	
"Information visualization" (Type OR Types OR Objective OR Objectives OR Effectiveness OR Efficiency OR Effectiveness OR Measure OR Measure OR Measure OR Task)	0	
Visualization (Type OR Types OR Objective OR Objectives OR Effectiveness OR Efficiency OR Effectiveness OR Measure OR Measuring OR Measure OR Task)	21	
Dashboards (Type OR Types OR Objective OR Objectives OR Effectiveness OR Efficiency OR Effectiveness OR Measure OR Measuring OR Measure OR Task)	1	
Graphics (Type OR Types OR Objective OR Objectives OR Task OR Tasks OR effectiveness OR efficiency OR Efficacy OR measure OR measuring)	166	Visualization; Data Visualization
Graph (Type OR Types OR Objective OR Objectives OR Task OR Tasks OR effectiveness OR efficiency OR Efficacy OR measure OR measuring)	808	Graphs

Revista ARACÊ
ISSN: 2358-2472

"Data Visualization" (Type OR Types OR Objective OR Objectives OR Task OR Tasks OR effectiveness OR efficiency OR Efficacy OR measure OR measuring)	25	Visualization; Data Visualizatin; Decision Making
"Information Visualization" (Type OR Types OR Objective OR Objectives OR Task OR Tasks OR effectiveness OR efficiency OR Efficacy OR measure OR measuring)	47	Visualization; Data Visualization; Decision Making; Design; Data Analysis
Visualization (Type OR Types OR Objective OR Objectives OR Task OR Tasks OR effectiveness OR efficiency OR Efficacy OR measure OR measuring)	159	Data Visualization
Charts (Type OR Types OR Objective OR Objectives OR Task OR Tasks OR effectiveness OR efficiency OR Efficacy OR measure OR measuring)	61	Charts
Dashboard (Type OR Types OR Objective OR Objectives OR Task OR Tasks OR effectiveness OR efficiency OR Efficacy OR measure OR measuring)	38	Dashboards; Dashboard; Management; Business & Economics; Decision Making
TOTAL	2.423	

Source: the authors

DEFINITION OF RULE FOR EXTRACTING TITLES

Also on 09-11-2023, the process of extracting the titles by the aggregators of Google Scholar databases and CAPES journal was defined, as such search engines did not provide, when the action was executed, an export file. In this way, it was defined that the titles would be copied using the *web scraping process* through the Microsoft Power Automate Desktop application and would be downloaded up to the two hundredth position, thus ensuring the quality of academic productions.

After extraction, 2,884 titles from the Google Scholar aggregator and 1,992 from the CAPES Journal were incorporated.

CONSOLIDATION OF TITLES AND EXCLUSION OF DUPLICATES

On 09-12-2023, the consolidation of the extracted bibliographic records was carried out, accompanied by the elimination of duplicate entries. A hierarchy was established for the retention of records by database, prioritizing, in this order, *Scopus*, *Web of Science*, Google Scholar and CAPES Journal.

The results are presented in the subsequent table.

Table 6 - Consolidated securities

Base	Downloaded titles	Deduplication	Remaining titles
BDTD	91	6	85
CAPES	1.992	46	1.946
Google	2.884	507	2.377

Revista ARACÊ
ISSN: 2358-2472

Scopus	2.619	0	2.619
Wos	1.463	882	581
TOTAL	9.049	1.441	7.608

Source: the authors

EXCLUSION OF TITLES WITH NEGATIVE KEYWORDS

On 12-09-2023, a strategy was developed for the analysis of titles and the subsequent exclusion of works that did not present relevance to the initial research question. To facilitate this process, the Microsoft Excel application was used. The guidelines adopted were established as follows:

- The titles were sorted in alphabetical order;
- Two columns called "manual action" and "automatic action" were created to identify the works to be excluded from the next phase;
- A table with negative keywords has been created;
- A formula called "automatic action" was implemented in the cells of the column, aiming to indicate, through the text "Delete" and a red flag, the presence of any negative keywords in the analyzed titles.
- The titles were read;
- Headings where the "Automatic action" column had the text "Delete" were not read;
- As the reading was carried out, titles that did not demonstrate adherence to the research question were identified in the "Manual action" column with the annotation "Delete". Additionally, if any title contained terms that could be added to the list of negative keywords, they were consequently included in that list;
- Titles with adherence to the starting question were not signaled in the columns mentioned above;
- After finishing reading all the titles that did not have the term "Delete" in the "Automatic action" column, a second round of reading was carried out to confront possible divergences between the "Manual action" and "Automatic action" columns;

As a result of the strategy, 434 titles were selected.

The following is a table with the quantities of titles excluded by origin, as well as the use by base.

Table 7 - Titles excluded by origin

Base	Remaining titles	Excluded titles	Use
BDTD	85	81	4,7%

Revista ARACÊ
ISSN: 2358-2472

CAPES	1.946	1.861	4,4%
Google	2.436	2.130	12,6%
Scopus	2.560	2.533	1,1%
Wos	581	569	2,1%
TOTAL	**7.608**	**7.174**	**5,7%**

Source: the authors

The result above corroborates the success of the broad search strategy.

READING OF ABSTRACTS AND RANKING OF TITLES

On 09-19-2023, the stage of reading the abstracts and ranking the remaining titles began, with the following options: Total adherence; Lots of grip; Some adhesion; Poor adhesion and discard.

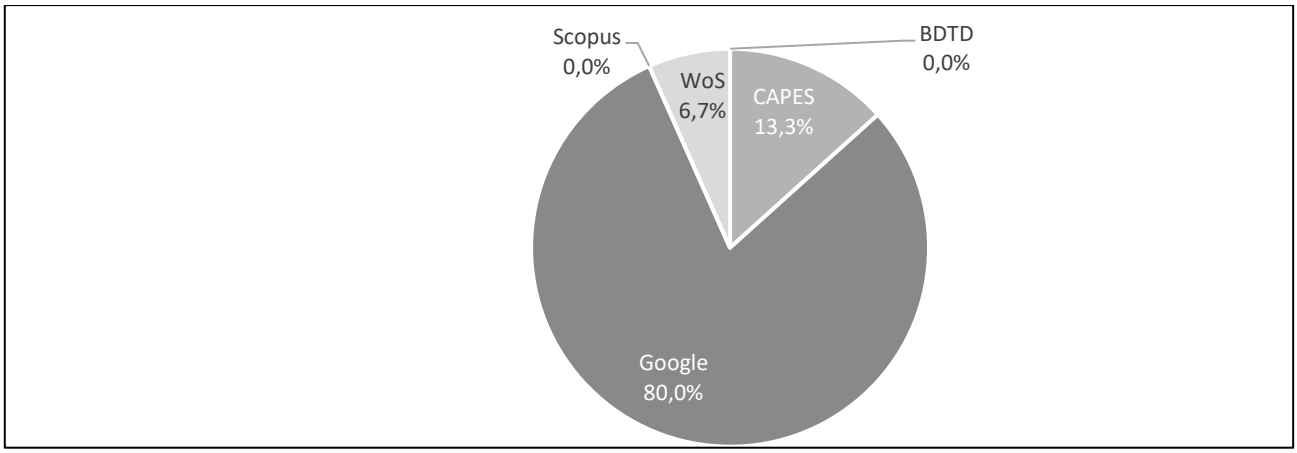
The detailed results are presented in the table and subsequent graph.

Table 8 - Number of titles by ranking

Ranking	BDTD	CAPES	Google	Scopus	Wos	Total
Total adhesion	0	2	12	0	1	15
Lots of grip	0	6	22	2	0	30
Some tack	2	20	63	7	3	95
Low grip	0	11	52	4	3	70
Discard	2	46	157	14	5	224
Total	**4**	**85**	**306**	**27**	**12**	**434**

Source: the authors

GRAPH 1 - PERCENTAGE PARTICIPATION OF THE "TOTAL ADHERENCE" RANKING BY SURVEYED BASE



Source: the authors

EXPANDING THE LIST USING THE *RESEARCH RABBIT APP*

Considering the fifteen titles that were completely consistent with the established research question, a search for related articles was carried out on 09-18-2023 in the

Revista ARACÊ
ISSN: 2358-2472

Research Rabbit application. The program aims to identify and return connections between academic works of similar profile.

It was decided to select the first 150 most relevant bibliographic works for a detailed analysis from the title and abstract. The results obtained are presented below.

Table 9 - Number of titles by ranking

Ranking	Total
Total adhesion	10
Lots of grip	24
Some tack	32
Low grip	14
Discard	70
Total	150

Source: the authors

EXCLUSION OF REPEATED TITLES AND FORMATION OF THE INITIAL WORKLIST

In the final stage, on 21-09-2023, the preliminary list was integrated with the list of articles extracted by *Research Rabbit*. Following this action, duplicate titles were eliminated, prioritizing the preservation of the records of the first compiled list.

The results of the titles extracted for the analysis of this RSL are below.

Table 10 - Number of titles per database

Ranking	BDTD	CAPES	Google	Research Rabbit	Scopus	Wos	TOTAL
Total adhesion	0	2	12	6	0	1	21
Lots of grip	0	6	22	21	2	0	51
Some tack	2	20	63	29	7	3	124
Low grip	0	11	52	13	4	3	83
TOTAL	**2**	**39**	**149**	**69**	**13**	**7**	**279**

Source: the authors

The next step was to download the available works, as well as to verify access to works in physical format, in order to compose the actual quantity accessible for reading and analysis.

The results of the titles available for analysis of this RSL are below

Revista ARACÊ
ISSN: 2358-2472

Table 11 - Number of titles accessible for reading

Ranking	BDTD	CAPES	Google	Research Rabbit	Scopus	Wos	TOTAL
Total adhesion	0	2	11	5	0	1	19
Lots of grip	0	6	20	20	2	0	48
Some tack	2	20	55	29	6	3	115
Low grip	0	10	46	13	4	3	76
TOTAL	2	38	132	67	12	7	258

Source: the authors

Based on the results, the identified titles were organized into two distinct categories, aiming at the continuity and methodological accuracy of the research. The first category, called "main", covers 19 works selected based on strict criteria of relevance and direct adherence to the initial research question. These works stand out for addressing the central objectives of the study with clarity and depth, being considered essential for the theoretical and methodological foundation of the systematic review. To integrate this category, it was necessary that the titles demonstrate not only explicit alignment with the central themes, but also a substantial contribution to the relevant academic literature, which was evaluated based on metrics of impact, originality and applicability to the topic investigated. This central core of the *corpus* was analyzed in detail, consolidating the critical and in-depth basis of the study.

The second category, called "secondary", comprises the remaining 239 works, which, although they do not present strict adherence to the initial research question, were considered valuable to offer a contextual and comprehensive perspective. This group includes studies whose relevance is less immediate, but which broaden the investigative scope by incorporating complementary or tangential perspectives.

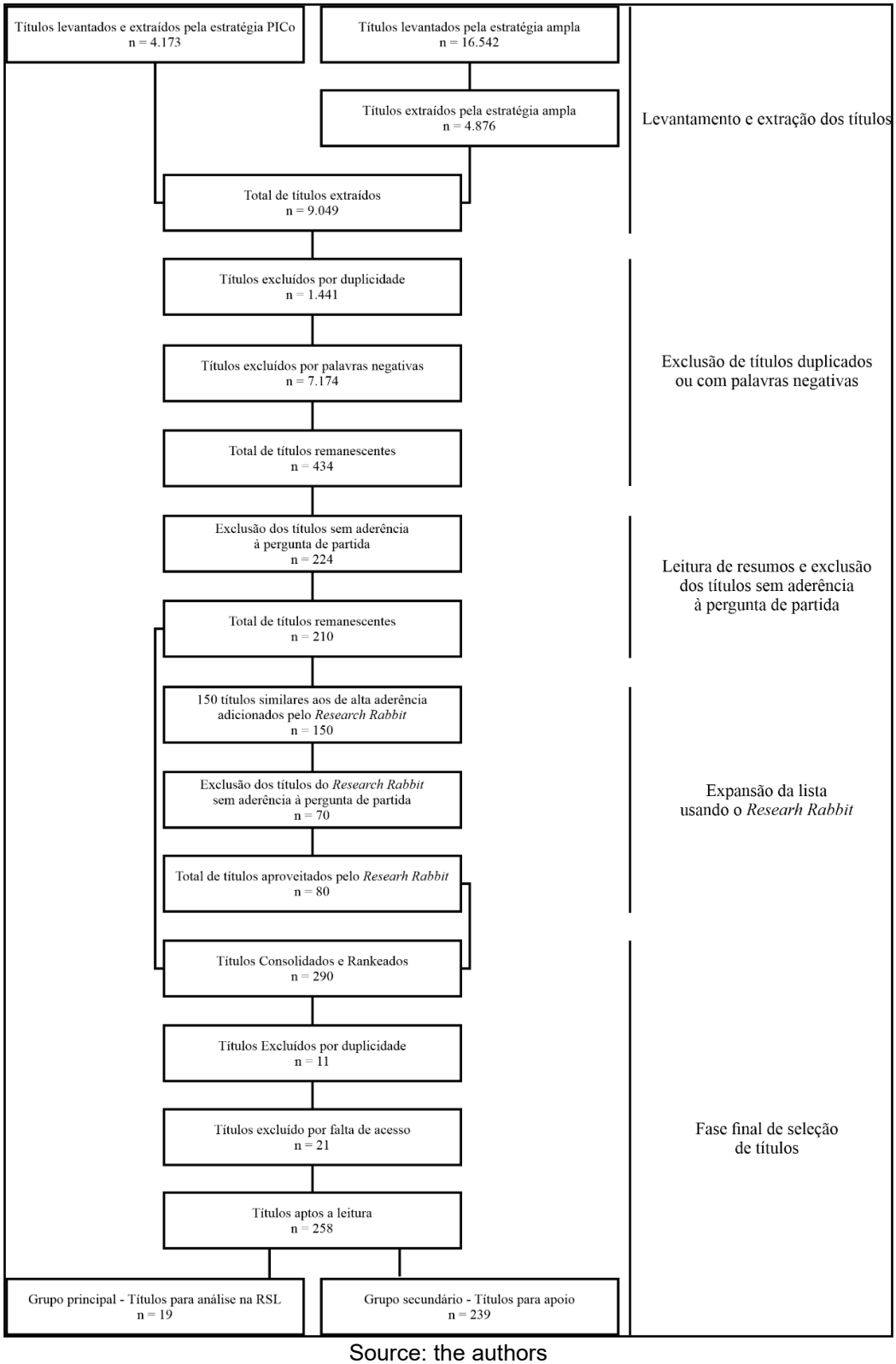
The decision to maintain this division is based on the need for a clear delineation between works that directly substantiate the main conclusions and those that contribute indirectly to enriching the global understanding of the theme.

Although the line between the categories may seem subtle, the methodological distinction is based on the depth and specificity of the contribution of each work to the research question. Such an approach ensures both the robustness and comprehensiveness of the review, allowing key findings to be supported by a core of highly aligned references, while additional sources offer complementary insights for a richer, multifaceted analysis.

Revista ARACÊ
ISSN: 2358-2472

SUMMARY OF THE EXTRACTION PROCESS AND ANALYSIS OF TITLES

FIGURE 1 – SUMMARY OF THE PROCESS OF EXTRACTION AND ANALYSIS OF THE TITLES



Source: the authors

Revista ARACÊ
ISSN: 2358-2472

RESULTS

The RSL was started with 9,049 works that could be used. After a rigid screening process, 19 relevant titles were selected for reading and surveying the state of the art of the research that aims to answer the starting question mentioned above.

Below is the details of the 19 works.

Table 12 – List of titles with full adherence to the starting question

ID	Title	Authors	Newspaper	Anus	Language	Country of Publication
T-01	A human cognition framework for information visualization	R. Patterson, L. Blaha, G. Grinstein, Kristen Liggett, David E. Kaveney, Kathleen C. Sheldon, P. Havig, J. Moore	Computers & Graphics	2014	English	United Kingdom
T-02	A proposal to measure the understanding of data visualization elements in visual analytics applications	Andrea Vázquez-Ingelmo; Francisco José García-Peñalvo; Roberto Therón; Vetria Byrd; Jorge D. Camba	CEUR Workshop Proceedings	2022	English	United States
T-03	A Task-Analytic Approach to the Automated Design of Graphics Presentations	Stephen M. Casner	ACM Transactions on Graphics	1991	English	United States
T-04	A task-based taxonomy of cognitive biases for information visualization	Evanthia Dimara; Steven Franconeri; Catherine Plaisant; Anastasia Bezerianos; Pierre Dragicevic	IEEE Transactions on Visualization and Computer Graphics	2018	English	United States
T-05	A user study of visualization effectiveness using EEG and cognitive load	E. W. Anderson, K. C. Potter, L. E. Matzen, J. F. Shepherd, G. A. Preston, C. T. Silva	Computer Graphics Forum	2011	English	United Kingdom
T-06	Application of visual perception principles to data visualization for decision making	Daniel de Oliveira Ferreira; Alan Petrônio Pinheiro; Felipe Augusto; Leandro José Duarte; Willian Douglas Caixeta Nunes	Brazilian Automatic Society	2021	Portuguese	Brazil

Revista ARACÊ
ISSN: 2358-2472

T-07	Aspects of performance on line graph description tasks: influenced by graph familiarity and different task features	Xiaoming Xi	Language Testing	2010	English	United Kingdom
T-08	Beyond Memorability: Visualization Recognition and Recall	Michelle A. Borkin; Zoya Bylinskii; Nam Wook Kim; Constance May Bainbridge; Chelsea S. Yeh; Daniel Borkin; Hanspeter Pfister; Aude Oliva	IEEE Transactions on Visualization and Computer Graphics	2015	English	United States
T-09	Comparing information graphics: a critical look at eye tracking	Joseph H. Goldberg; Jonathan I. Helfman	BELIV '10: Proceedings of the 3rd BELIV'10 Workshop: BEyond time and errors: novel evaLuation methods for Information Visualization	2010	English	United States
T-10	Comparing the effectiveness of visualizations of different data distributions	Ariane M. B. Rodrigues; Gabriel D. J. Barbosa; Hélio Lopes; Simone D. J. Barbosa	Proceedings - 32nd Conference on Graphics, Patterns and Images Tutorials, SIBGRAPI-T 2019	2018	English	United States
T-11	Do graph readers prefer the graph type most suited to a given task? Insights from eye tracking	Benjamin Strobel; Steffani Saß; Marlit Annalena Lindner; Olaf Köller	Journal of Eye Movement Research	2016	English	Switzerland
T-12	Evaluating effectiveness of information visualizations using cognitive fit theory: A neuroergonomics approach.	Joseph K Nuamah; Younho Seong 2; Steven Jiang; Eui Park; Daniel Mountjoy	Pubmed	2020	English	United States
T-13	Evaluating Information Visualizations	Sheelagh Carpendale	Information Visualization	2008	English	United Kingdom
T-14	Graphical Perception: Theory, Experimentation, and Application to the Development of Graphical Methods	William S. Cleveland; Robert McGill	Journal of the American Statistical Association	1984	English	United Kingdom
T-15	Measuring effective data visualization	Ying Zhu	International Symposium	2007	English	United States

Revista ARACÊ
ISSN: 2358-2472

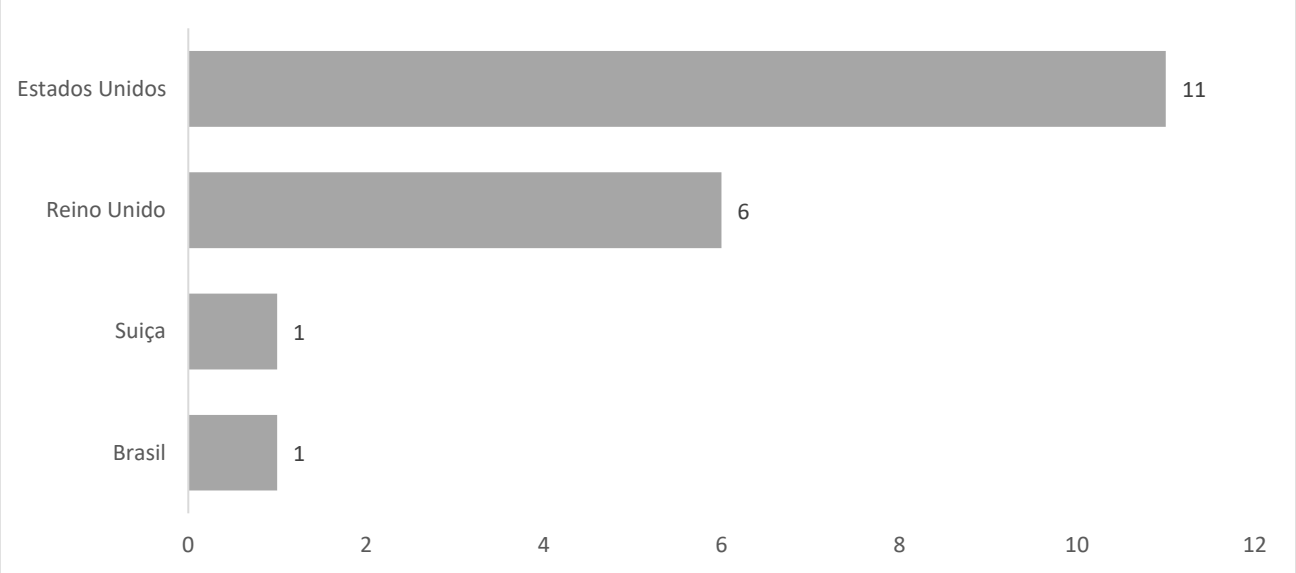
			on Visual Computing			
T-16	Measuring effectiveness of graph visualizations: A cognitive load perspective	Weidong Huang, Peter Eades, Seok-Hee Hong	Information Visualization	2009	English	United Kingdom
T-17	Memorability of Enhanced Informational Graphics: the effects of design relevance and chart type on recall	Alyssa Peña; Eric Ragan; Lane Harrison	Interdisciplinary Journal of Signage and Wayfinding	2020	English	United States
T-18	Task matters when scanning data visualizations	Laura Matzen, Kristin Divis, Deborah Cronin, Michael Haass	ArXiv	2020	English	United States
T-19	Understanding business dashboard design user impact: triangulation approach using eye-tracking, facial expression, galvanic skin response and EEG sensors	Dinko Bacic	Americas Conference on Information Systems (AMCIS) 2017	2017	English	United States

Source: the authors

The 19 articles were published in 17 different journals or academic events, in a time horizon ranging from 1984 to 2022. 94.7% (18) of the works were written in English while only 5.3% (one) in Portuguese.

The following are the distribution of articles by place and year of publication.

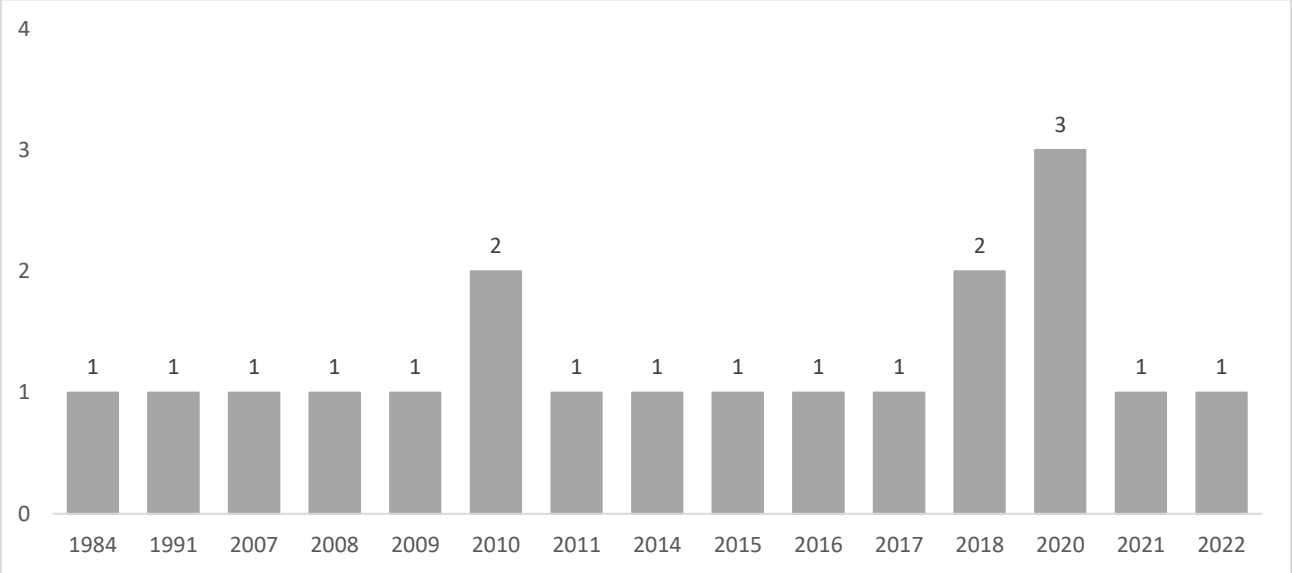
GRAPH 2 - DISTRIBUTION OF ARTICLES BY PLACE OF PUBLICATION



Source: the authors.

Revista ARACÊ
ISSN: 2358-2472

GRAPH 3 – NUMBER OF TITLES BY YEAR OF PUBLICATION



Source: the authors

The analysis of the previous graph reveals that 57.9% (11) of the works were published in the last ten years, evidencing the relevance of the theme in the contemporary academic context.

Proceeding with the reading stage, it was found that the 19 articles addressed diversified methodologies to evaluate the effectiveness of graphic visualizations on human cognition and decision-making, highlighting the growing interest in understanding how different designs influence information processing.

The approaches ranged from empirical studies that used electroencephalogram (EEG) and eye tracking to measure cognitive load and visual scanning strategies, to the development of conceptual models and meta-models to describe and improve the learning experience with data visualizations.

Cognitive experimental techniques and neuroergonomics methods have been applied to evaluate human performance, while controlled experimental studies investigate visual memory and the efficiency of specific graphics.

Together, the studies contribute to the construction of a solid theoretical foundation and to the advancement of practice in the optimization of dashboards and other data visualization tools.

Regarding the methodological choice, there is a predominance of the choice of the quantitative method (63.1%) with statistical analysis of dependent and independent variables, with the qualitative method being used in the studies that developed models and the literature review works not applying to any of the alternatives.

Revista ARACÊ
ISSN: 2358-2472

It was also observed that most of the studies analyzed used primary sources for data collection and treatment, totaling 14 articles (73.68%). This data shows a predominance of empirical approaches in the selected studies, with data directly collected by the authors to investigate specific issues. On the other hand, only one study (5.26%) used secondary sources, demonstrating that this type of approach was poorly represented in the sample. In addition, four articles (21.06%) were classified as "not applicable", indicating that, in these cases, data collection was not relevant or necessary, as occurs in theoretical studies or literature reviews. These results highlight the methodological emphasis on experiments and direct information collection in the field of data visualization applied to decision making.

Closing the analysis, tables 14 and 15 were prepared with the objective of evidencing the synthesis of the results of each study, as well as their limitations.

Table 14 – Results of the survey

ID	Answer
T-01	The main result was the development of a human cognition framework for the visualization of information. This framework emphasizes the importance of understanding and harnessing human cognitive processes – such as attention, memory, and decision-making – to design better visualizations.
T-02	The study aimed to validate the learning dimension of the MetaViz model in terms of understanding the concepts of data visualization. The goal was to determine whether users can understand and recall concepts related to data visualization using MetaViz.
T-03	The main result was the demonstration that automated graphic design by the proposed BOZ model can improve user efficiency in information processing tasks. The graphs created by BOZ allow users to replace more demanding logical inferences with simpler perceptual inferences, resulting in time and effort savings.
T-04	The main result was the proposal of a task-based taxonomy of 154 cognitive biases organized into 7 main categories. This taxonomy aims to help visualization researchers relate their designs to potential cognitive biases and conduct new research that detects and addresses biased judgments and decisions in data visualization.
T-05	The study found that the canonical Box Plot placed the least amount of effort on users' cognitive resources for the task at hand, compared to other types of Box Plots.
T-06	The results showed that the visualization techniques studied had a positive impact on the participants' interpretation and decision-making, indicating the effectiveness of the principles of visual perception.
T-07	The research found that familiarity with charts and planning time were significantly related to the fluency, organization, and content of line chart descriptions. In particular, planning time was a significant predictor of fluency, organization, and content.
T-08	The study showed that the visual and semantic elements of a visualization significantly influence the memory and recognition of users. He pointed out that visualizations with recognizable human objects and clear titles proved to be more memorable and recognizable.
T-09	The study found that there was excessive scanning to locate the correct bar graph on easier tasks, while on more difficult tasks, participants scanned dimensions in bar and line graphs before comparing between graphs.
T-10	The research concluded that certain types of charts are more effective for certain tasks, regardless of the distribution of the data. Paired comparisons of graphs were performed to assess effectiveness in various tasks, resulting in recommendations for choosing appropriate graphs for specific tasks.

Revista ARACÊ
ISSN: 2358-2472

T-11	The research showed that participants showed a stronger preference for bar graphs in difference tasks and for line graphs in trend tasks, indicating a tendency to choose the type of graph that is computationally advantageous depending on the task.
T-12	The results indicated that proper visualization for an intuitive spatial task reduces cognitive effort and improves performance when it is in graphical or spatial format, compared to symbolic or numerical formats.
T-13	As a review and discussion article, the research did not present specific results, but rather a comprehensive analysis of evaluation methodologies in information visualization and the importance of a diversified approach to obtain more complete and reliable insights.
T-14	The study concluded that a relevant change is needed in many popular types of charts, offering alternative forms. The experiments validated elements of the theory and suggested that the set of elementary perceptual tasks should be expanded.
T-15	The paper proposed a more comprehensive definition of effective visualization and discussed a set of quantitative and qualitative measures for assessing effectiveness. These measurements are focused on the principles of visualization accuracy, usefulness, and efficiency.
T-16	The results of the research reinforced the proposal of a cognitive load model, demonstrating that cognitive load can be induced by several complexity factors and is reflected in both performance measures and mental effort.
T-17	The study found that pie charts were more memorable than bar and line charts in terms of visual recall, and related charts had higher scores in terms of theme recall than unrelated charts.
T-18	The results of the survey showed that the task assigned to participants had a substantial impact on the allocation of their attention within the scatter plots. Participants had significantly different eye fixation patterns depending on the task (describing trends or identifying outliers), indicating that the nature of the task influences how people interact with data visualizations.
T-19	The article proposed a research model that was still in the planned methodology phase, with practical implications for the evaluation of the usefulness and suitability of visual data displays, such as dashboards, in business contexts.

Source: the authors

Table 15 – What are the limitations pointed out by the study?

ID	Answer
T-01	The article does not explicitly discuss its limitations. However, given its theoretical nature, a possible limitation is the lack of empirical validation of the proposed framework.
T-02	The article does not specify explicit limitations, but as it was a work in progress at the time of its publication, future research may include other results.
T-03	The specific limitations of the study are not explicitly mentioned in the article. However, like any research, it may be subject to limitations in the scope of the BOZ tool's applicability to different types of tasks and charts.
T-04	The specific limitations of the study are not explicitly mentioned in the article. However, an implicit limitation may be the difficulty in covering the vast array of cognitive biases and their direct applicability in specific data visualization contexts.
T-05	The article discusses the difficulty in finding the appropriate interpretation task and the challenge of properly configuring EEG electrodes. In addition, it mentions the difficulty in analyzing and interpreting EEG data, which requires training and expertise.
T-06	The article does not explicitly mention its limitations, but the discussion of the results suggests a possible limitation in the incorrect interpretation of questions by the participants in the control group, indicating the need for clarity in the instructions and design of the questionnaire.
T-07	The article does not explicitly mention its limitations, but like any research, it may be subject to limitations in the generalization of the results, given the specificity of the tasks and the context of the test.
T-08	The article does not explicitly mention its limitations, but like any research, it may be subject to limitations in the generalization of the results, given the specificity of the tasks and the context of the test.
T-09	The study highlights the limitations of eye tracking, such as errors in locating the gaze, defining fixations, and defining metrics that can affect the interpretation of the data.
T-10	The article discusses the limitations related to the representation of data in graphs, the possibility of guesswork in questionnaire answers, and the impact of graph design choices on results.

Revista ARACÊ
ISSN: 2358-2472

T-11	The study points to the need for future research on the ability of graph readers to detect and utilize the computational properties of graphs, as well as suggests exploring individual differences in graph comprehension.
T-12	Limitations include the small sample size, the limited applicability of the task design to other operational contexts, and the practical difficulties of applying EEG.
T-13	The article discusses the inherent limitations of each evaluation methodology, such as the fact that the methods employed may not fully capture the complexity and realism of the use situations, as well as being subjective.
T-14	The article does not explicitly mention its limitations, but like any research, it may be subject to limitations in the generalization of the results, given the specificity of the tasks and the context of the test.
T-15	Limitations include the lack of standardized standards and procedures for measuring visualization effectiveness, as well as the need for a more cohesive visualization and data taxonomy to accurately assess effectiveness.
T-16	The article does not explicitly mention its limitations, but like any research, it may be subject to limitations in the generalization of the results, given the specificity of the tasks and the context of the test.
T-17	One limitation of the study is that it used data from the MASSVIS dataset and modified the visual representations to meet the needs of the experiment. This affected the style, tone, and message of the original fonts, and so the experiment didn't use actual infographics or informational signage.
T-18	The article does not explicitly mention its limitations, but like any research, it may be subject to limitations in the generalization of the results, given the specificity of the tasks and the context of the test.
T-19	The article does not explicitly mention its limitations, but like any research, it may be subject to limitations in the generalization of the results, given the specificity of the tasks and the context of the test.

Source: the authors

DISCUSSION

The results of this RSL highlight the centrality of dashboards as tools to support decision-making in the administrative-financial context, in addition to evidencing the impact of graphic design choices on the effectiveness of human cognition. The predominance of empirical approaches in the analyzed articles points to the consolidation of the use of experimental methods to evaluate the interaction between users and data visualizations. These methods reinforce the importance of understanding the underlying cognitive mechanisms in the decision-making process, such as cognitive load, visual memory, and attention.

The 19 studies that make up the main core of the reviewed corpus show a strong adherence to the research question, evidencing significant contributions in relation to heuristics to evaluate data visualizations. In addition, the analyzed articles indicate that visualizations that integrate semantic and perceptual elements clearly are more likely to reduce cognitive effort and increase the accuracy of decisions.

Despite the relevant contributions, the studies also have limitations, such as the small sample size, restrictions in the generalization of the results to different contexts, and

Revista ARACÊ
ISSN: 2358-2472

the lack of broader practical validations. These gaps open up possibilities for future research, including the development of more robust predictive models, the application of experiments in real corporate environments, and the expansion of the analysis to other sectors beyond the administrative-financial sector.

The integration of specific heuristics for evaluating data visualizations emerges as a promising advance in the field of information design. However, to ensure greater applicability, it is recommended that future investigations explore methodologies that reconcile theoretical and practical aspects, focusing on diversified contexts of use and responsive designs that meet different user profiles. The incorporation of artificial intelligence-based tools also emerges as an area of significant potential, allowing automation in the evaluation of dashboards and the customization of visualizations based on the user's needs.

Therefore, this study contributes not only to the mapping of the state of the art on data visualizations in dashboards, but also to the theoretical and practical advancement of the field, proposing ways for a more effective and user-oriented design, with direct implications for the improvement of the decision-making process in organizations.

CONCLUSION

The objective of this RSL was to survey the state of the art of research that deals with the use and effectiveness of graphic visuals in dashboards in the administrative/financial area. Although the theme is quite specific and the academic production does not return many publications to the dashboard segment, it could be concluded that there is relevant material to continue the research and contribute scientifically to the evolution of society, improving the structure of these pieces so used in companies.

The methodology used in the selection and analysis of the bibliographic works pertinent to the initial research question was delineated from a bipartite division of the research corpus, establishing two distinct categories to continue the study. The first category, called "main", was composed of 19 works that are closely aligned with the starting question, exhibiting a direct relevance and a substantial contribution to the theme investigated. These texts, rigorously selected, constitute the core of the research and were submitted to a careful analysis in order to consolidate the state of the art in RSL.

Revista ARACÊ
ISSN: 2358-2472

The second category, called "secondary", includes the 239 remaining works. Although they are not strictly linked to the central question of the research, these works are considered valuable because they offer a broader view and a richer context for the subject under analysis. This strategic categorization allows for a more detailed methodological approach and more effective management of sources, ensuring that additional perspectives are considered and evaluated.

The methodology employed not only reinforces the importance of current research, but also opens possibilities for expanding the number of pertinent titles through the citations contained in these works, creating research vectors that can be explored, thus expanding the scope and depth of the ongoing study.

Finally, the work is positioned as a step towards the advancement of the academic and practical understanding of data visualization in dashboards, with ambitions to advance knowledge in the field of information design and strategic management in organizations.

Revista ARACÊ
ISSN: 2358-2472

REFERENCES

1. Anderson, E. W., Potter, K. C., Matzen, L. E., Shepherd, J. F., Preston, G. A., & Silva, C. T. (2011). A user study of visualization effectiveness using EEG and cognitive load. Computer Graphics Forum, 30, 791-800.

2. Borkin, M. A., et al. (2016). Beyond memorability: Visualization recognition and recall. IEEE Transactions on Visualization and Computer Graphics, 22(1), 519-528.

3. Cairo, A. (2019). Why data visualization fails if we don't think about its purpose. Lumina, 117-125.

4. Carpendale, S. (2008). Evaluating information visualizations. In Information Visualization (Vol. 4950, pp. 495-506). Springer, Berlin.

5. Castells, M. (2011). The rise of the network society: Information age: Economy, society, and culture (Vol. 1). Paz e Terra.

6. Cleveland, W. S., & McGill, R. (1984). Graphical perception: Theory, experimentation, and application to the development of graphical methods. Journal of the American Statistical Association, 79, 531-554.

7. Dinko, B. (2017). Understanding business dashboard design user impact: Triangulation approach using eye-tracking, facial expression, galvanic skin response and EEG sensors. Conference on Information Systems (AMCIS), 2017.

8. Dimara, E., Franconeri, S., Plaisant, C., Bezerianos, A., & Dragicevic, P. (2020). A task-based taxonomy of cognitive biases for information visualization. IEEE Transactions on Visualization and Computer Graphics, 26(2), 1413-1432. https://doi.org/10.1109/TVCG.2018.2872577

9. Ferraresi, A. A., & Santos, S. A. (2006). Business intelligence and knowledge management as practices supporting strategic decision-making. Revista de Administração e Inovação – RAI, 3(1), 102-114.

10. Few, S. (2006). Information Dashboard Design: Effective Visual Communication of Data. O'Reilly.

11. Galvão, M. C. B., & Ricarte, I. L. M. (2019). Systematic literature review: Conceptualization, production, and publication. Logeion: Filosofia da Informação, 6(1), 57–73.

12. Goldberg, J. H., & Helfman, J. I. (2010). Comparing information graphics: A critical look at eye tracking. 3rd BELIV'10 Workshop: BEyond time and errors: novel evaLuation methods for Information Visualization, New York.

13. Huang, W., Eades, P., & Hong, S.-H. (2009). Measuring effectiveness of graph visualizations: A cognitive load perspective. Information Visualization, 8(3), 139-152.

Revista ARACÊ
ISSN: 2358-2472

14. IDC, International Data Corporation. (2021, March 24). Data creation and replication will grow at a faster rate than installed storage capacity, according to the IDC Global DataSphere and StorageSphere forecasts. IDC. Available at: https://www.idc.com/getdoc.jsp?containerId=prUS47560321. Accessed on September 9, 2023.

15. Magalhães, T. G., Dalmau, M. B. L., & Irineu, M. S. (2014). Knowledge management for decision-making: A case study at a junior company. Revista Gestão Universitária na América Latina – GUAL, 7(2), 108-129.

16. Matzen, L., Divis, K., & Cronin, D. (2020). Task matters when scanning data visualizations. ArXiv.

17. Nuamah, J. K., Seong, Y., Jiang, S., Park, E., & Mountjoy, D. (2020). Evaluating effectiveness of information visualizations using cognitive fit theory: A neuroergonomics approach. Applied Ergonomics, 88, 103191.

18. Okoli, C. (2019). Guide to conducting a systematic literature review. (D. W. A. Duarte, Trans.; J. Mattar, Rev.). EaD em Foco, 9(9).

19. Peña, A., Ragan, E. D., & Harrison, L. (2020). Memorability of enhanced informational graphics: The effects of design relevance and chart type on recall. Interdisciplinary Journal of Signage and Wayfinding, 4(1), 19-33.

20. Patterson, R. E., Blaha, L. M., Grinstein, G. G., Liggett, K. K., Kaveney, D. E., Sheldon, K. C., Havig, P. R., & Moore, J. A. (2014). A human cognition framework for information visualization. Computers & Graphics, 42, 42-58.

21. Rodrigues, A. M. B., Barbosa, G. D. J., Lopes, H., & Barbosa, S. D. J. (2019). Comparing the effectiveness of visualizations of different data distributions. In 32nd SIBGRAPI Conference on Graphics, Patterns and Images (pp. 84-91). Rio de Janeiro, Brazil.

22. Sampaio, R., & Mancini, M. (2007). Systematic review study: A guide for rigorous synthesis of scientific evidence. Brazilian Journal of Physical Therapy, 11(1), 83-89.

23. Sharda, R., Delen, D., & Turban, E. (2019). Business intelligence and data analysis for business management (4th ed.). Bookman.

24. Silva, F. C. (2019). Data visualization: Past, present, and future. Liinc em Revista, 205-223.

25. Simão, J. A. (2021). Impacts of implementing a self-service BI tool in a distribution center: A case study. (Unpublished master's thesis). Universidade Federal de Pernambuco, Pernambuco, Brazil.

26. Casner, S. M. (1991). Task-analytic approach to the automated design of graphic presentations. ACM Transactions on Graphics, 10(2), 111-151.

Revista ARACÊ
ISSN: 2358-2472

27. Strobel, B., Saß, S., Lindner, M. A., & Köller, O. (2016). Do graph readers prefer the graph type most suited to a given task? Insights from eye tracking. Journal of Eye Movement Research, 9(3), 1-14.

28. Theophilo, R. G., Gonçalves, A. A., Avelino, M. R., & de Gois, S. R. S. M. (2021). Application of visual perception principles to data visualization for decision-making. RISTI, E45, 556-572.

29. Vázquez-Ingelmo, A., García-Peñalvo, F. J., Therón, R., Byrd, V., & Camba, J. D. (2022). A proposal to measure the understanding of data visualization elements in visual analytics applications. Learning Analytics Summer Institute Spain 2022 (LASI Spain 2022), Salamanca, Spain, 70-76.

30. Xi, X. (2010). Aspects of performance on line graph description tasks: Influenced by graph familiarity and different task features. Language Testing, 27(1), 73-100.

31. Zhu, Y. (2007). Measuring effective data visualization. In Lecture Notes in Computer Science (Vol. 4842, pp. 110-119). Springer, Berlin.