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Maths in the news: uses and errors in Portuguese newspapers

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Abstract

The authors present a quantitative content analysis to assess the use of mathematical information in the news of five generalist Portuguese newspapers during a three-month period. Misuses of mathematics were also studied in this context. Results show that only a small percentage of the news articles have mathematical information when compared to previous studies in the field. Furthermore, over 30% of the news articles containing mathematical information have some type of mathematical error. Different categories of errors are defined and reasons why these might occur are discussed.

Keywords

Science and media

Introduction

In today's society, knowledge, or more properly the products of knowledge development are decisive in shaping various policies and in fostering the economy [Stehr, 2001; Giddens, 1991]. In this context, mathematics plays a key role, at least at three different levels: (1) as a tool for the development of industrial and economic processes and procedures [SIAM, 2012]; (2) as a tool used to analyse and communicate scientific results and (3) as a tool to help citizens make decisions that are based on the interpretation of quantitative or logical information [Peters et al., 2006; Peters, 2012; Apter et al., 2006; Cavanaugh et al., 2008; Almenberg and Widmark, 2011].

The growing dependence of citizens on mathematics and its applications requires them to develop new skills, essential not only to be successful but simply to be an active member of society. This scenario justifies the importance and need of mathematics communication, in order to improve citizens' numeracy, and ultimately decision making [Peters et al., 2006; Peters, 2012]. In this context, the media have an important role as main sources of information and as opinion makers. However, media coverage of mathematics is almost nonexistent, and the way it is used as a tool to communicate in the news is far from good [Maier, 2000; Meyer, 2009; Paulos, 1997; Cohn and Cope, 2001; Blastland and Dilnot, 2008] (A common experience of many newspaper readers is to feel confused by the presentation of graphs and data, and that is usually because errors are involved).

Although there are a few studies focusing on this problem, there is little systematic empirical research on the extent of the problem. Instead, this is a theme treated in

popular science books which provide examples of misuses of math in the news. Moreover, and as far as the authors are aware, no studies were ever conducted to analyse how Portuguese journalists use numerical data.

The study presented in this article intends to give a contribution in that direction. It focuses specifically on the use of mathematical information as means of describing issues, phenomena and events in the most important Portuguese generalist newspapers. The study encompasses the content analysis of news with reference to numerical data, the identification of mathematical errors present in the news, their incidence, as well as their differentiation into various types.

Mathematics in the media

Similarly to what happens with other sciences, mathematics can either be the theme of news or have a more secondary role, as a communication tool (e.g.: using graphics, statistical information on a study; results of arithmetic operations). As the theme of a news story, the press uses mathematics in two different ways. While in some news the topic is a discovery in mathematics (e.g. "New prime number discovered"— *O Público*, March 3, 2005), in others the focus is on a practical application of mathematical knowledge (e.g.: "Portuguese researchers create new method for dating ancient trees"— *O Público*, February 6, 2011).

However, and despite the increasing importance of mathematics in society, it rarely makes news headlines. Bucchi and Mazzolini [2003], who conducted a longitudinal content analysis in the Italian newspaper *Il Corriere della Sera*, concluded that "the newspaper's interest in mathematics appears to be entirely neglected." In other studies, such as the one Massarani et al. [2005] conducted in seven regional newspapers in Latin America, and the one Tichenor et al. [1970] carried out in 14 metropolitan American newspapers, the number of news stories that covered mathematical issues was so insignificant that the authors did not even add the category "Mathematics" to the content grid list.

According to Bucchi, it is very rare for a mathematical discovery to appear on the newspaper cover because it is hardly considered newsworthy or because it is difficult to relate the discovery to non-scientific topics [Bucchi, 2004]. Other researchers, such as Mazur [2004], emphasize that the "absence of time" in mathematical production makes it more difficult to make it interesting for the media. According to this author, this "absence of a time frame" is due to the fact that the study of many mathematical questions endures for centuries. Another difficulty is pointed by Emmer [1990], which stresses that the media present mathematical results as finished knowledge, not open to discussion (established beyond doubt). Thus, characteristics such as controversy, which add value to a media story, rarely exist. Lynn Steen [1990] points out that the editors consider that mathematics does not raise as much interest in audiences as other areas of study that are perceived as having immediate utility, such as health or medicine. Steen also notices that many journalists do not understand the mathematical information they have to write about and, on the other hand, that many mathematicians do not have the expertise needed to promote issues in a format that can be used by the press and the media in general.

Besides the possibility of being used as a news theme, mathematics is also used by the press as a tool to communicate all sorts of information: scientific, political,

medical, economic [Paulos, 1997; Cohn and Cope, 2001; Blastland and Dilnot, 2008; Dewdney, 1997]. This use is often associated with the quality of information and depth of the journalistic work [Berry, 1967; Tankard Jr. and Ryan, 1974], contributing to the understanding of the true meaning of the information presented in the news, and enabling the reader to discern about its validity and credibility [Maier, 2000; Curtin and Maier, 2001]. For example, if a news story describes the results of a given clinical study and it does not include information about the sample (size and characteristics of individuals), or the significance level associated with the results, how is the reader able to discern importance and validity of the study?

Mathematical information has an explanatory role in the news, providing elements that help to fully grasp a topic. However, this is not the only role it assumes as a communication tool in the media. The increasing use of databases and the open access policy represent new opportunities that journalists can take advantage of to discover new topics worthy of becoming news. In this context, research methods are fundamental to extract meaning out of data, and it is compulsory to interpret mathematical information. Meyer [1991] introduced this trend in journalism under the designation of *precision journalism* in the late 1960's. In precision journalism, mathematical and, particularly, statistical information is no longer used just for describing events or phenomena, but also to uncover news stories. This evolution makes it much more relevant that journalists develop some mathematical skills.

The mathematical errors in the news

The first studies that included the identification of mathematical errors in the news (though very rudimentary) aimed to analyse the accuracy of news articles. The first study of this scope was carried out by Charnley [1936], and his model established a reference for many future studies. Later, Blankenburg [1970] made an important contribution to the categorization of errors by classifying them into *objective* and *subjective* errors.

Objective errors were defined as factual errors that exist independently of who reads the news, while subjective errors were "mistakes of judgment" by the reporter, resulting in omission of important information, as well as overemphasis or underemphasis of some aspects Maier [2000] then used this classification when studying mathematical errors in the American newspaper *News & Observer*. This author developed another way of classifying errors. He grouped them into eleven different categories: "Numbers do not tally"; "Misinterpretation of numbers"; "Misuse of mathematical terminology"; "Inappropriate baseline"; "Missing breakline"; "Story-chart inconsistency"; "Needless numbers"; "Meaningless precision"; "Unquestioned use of numbers" and "Naked numbers".

Also regarding American newspapers, Meyer [2009] compared the incidence of mathematical errors in 20 newspapers, concluding that 13% of the news stories have errors categorized under "Numbers wrong", and 13% of the news stories have errors described as "Numbers misleading or misinterpreted". Furthermore, the incidence of "mathematical errors" varies among newspapers, ranging from 12.9% to 22.2%.

The study of mathematical errors in the news articles was also extended outside the context of American newspapers by Robert Brand, who analysed the news stories

of a South African newspaper [Brand, 2008]. Using Maier's work as reference, he analysed the frequency with which objective mathematical errors occured and identified them in 28% of the news.

Despite the important contribution of Maier, Meyer, Brand and other researchers to this field of study, none tried to describe in great detail the extent to which the different types of mathematical errors (objective and subjective) occur in a newspaper.

Apart from empirical studies, the topic of misuse of mathematics in the news articles has been more frequently addressed in popular science books. Among these works are *A mathematician reads the newspaper*, by Allen Paulos, or *News and Numbers*, by Victor Cohn and Lewis Cope. Authors like Dewdney [*200% of Nothing: An Eye-Opening Tour through the Twists and Turns of Math Abuse and Innumeracy*], Blastland and Dilnot [2008], Best [2001], and Huff [1954], also focus on the misuse of mathematics, but in a wider daily context.

These works provide insight into errors such as wrong calculation of percentages and fractions; misuse or omission of important statistical data in the description or interpretation of survey results; confusion between causality and correction; use of biased samples; distortion of number intervals in graphics or lack of contextualization of numbers.

Something common to empirical studies and the popular science books regarding the topic at stake is that they focus almost exclusively on American media. Although certain errors that exist in the Portuguese media are easily identified by some readers, we have no knowledge of studies carried out in this context. Thus, this study aims to investigate specifically how mathematical information is used in the Portuguese press, to assess the incidence of various types of mathematical errors. This approach allows for a better understanding of their dimension and characteristics in the Portuguese press, and is based on the following research questions:

Q1 — How does the use of mathematical information differ among the news stories in a newspaper?

Q2 — How does the use of mathematical information differ among the news articles of different Portuguese newspapers?

Q3 — What types of mathematical errors can be identified in the news articles?

Q4 — How does the frequency of various types of mathematical errors vary among newspapers?

Categories of mathematical errors

We used the definition and categorization of mathematical errors first introduced by Blankenburg and then developed by Maier. We also made an improvement to his work by doing a double categorization of the errors.

A double categorization of errors was chosen in order to allow a better understanding of the misuses of mathematics and identify possible reasons for

such errors. Hence, errors were classified according to their *objectivity* and *mathematical content*. Regarding objectivity, they were divided into objective and subjective errors, similarly to what Blankenburg and, later, Maier have adopted. Hence, an objective error exists if there are inaccuracies in the application of mathematical concepts or procedures, such as arithmetic operations. Subjective errors exist if there are omissions or distortions of important mathematical information needed to fully understand the news stories.

With respect to mathematical content, errors were classified into *numerical*, *graphical*, *statistical* and *logical*. Numerical errors are inaccuracies in measurements, quantities, proportions or arithmetic operations; statistical errors are mistakes in statistical concepts or omission thereof, necessary to understand the relevance of information (e.g.: degree of confidence, sample, probability); graphical errors are inaccuracies identified in graphs (e.g.: lack of proportionality in consecutive intervals on an axis) or omissions of information in graphs (e.g.: measurement units). Finally, logical errors exist in statements whose contents are false (e.g: "Alexis Tsipras loses only one percentage point relative to the result he had in the last elections, much more than was predicted by the polls" [Guimarães, 2015]) or reasoning fallacies, such as confusion between correlation and causality or generalizing a result based on a non-representative sample (e.g: Headline stating that the concentration of bacteria is above the one permitted by law in 95% of the Portuguese nurseries but in the development of the news article the reader is informed that the analysis only took place in a set of nurseries of two cities that is not even representative of the nurseries existing in those two cities, let alone the whole country).

Sample and sampling method

News from the five generalist Portuguese newspapers with greater distribution, three dailies — *O Público*, *Correio da Manhã* (CM) and *Jornal de Notícias* (JN) — and two weeklies — *Sol* and *Expresso* — were analysed over a period of three months, (January 2013 to March 2013). Two of these newspapers are quality ("elite") newspapers (*O Público* and *Expresso*), and the other three are considered "popular" newspapers.

In this study, we adopted Maier's definition of "news article with mathematical information". These are news articles that explicitly or implicitly include mathematical calculations or quantitative comparisons. It does not include simple numerical representations such as age, weight, prices and dates, because although they are expressed in numbers, they do not require mathematical skills to be communicated [Maier, 2000]. Chronicles and news sections of culture, entertainment, obituaries and gastronomy were excluded given the low probability of finding mathematical information therein. Advertisements, horoscopes, weather information or television programming were also excluded.

We chose the systematic sampling method to select the news articles in dailies, analysing publications of each newspaper every three days (e.g.: days 1, 4, 7 . . .) [Hansen et al., 1998, pp. 103–104] and, therefore, avoiding the bias of weekly fluctuations of content. With regard to weeklies, we included all editions. Thus, 78% of the 115 editions we studied are from dailies, and therefore 22% are from weeklies.

Table 1. Examples of the several types of errors.

Categories according to objectivity	Categories according to mathematical content
	Numerical Error
Objective Error	– Inaccuracy in arithmetic operations. – Arithmetic operations using quantities measured in different units (without doing the necessary reduction). – Comparison of two quantities in different measurement units without converting them to the same units. – Disrespect of the ordering principle in numbers. – Incorrect rounding of number. – Confusion between percentage point and percentage. – Confusion between variation in GDP rate and variation in GDP. – Meaningless precision. – Figures that do not make sense (in a given context).
Subjective Error	– Omission of numbers in basic arithmetic operations. – Characterise a situation using only absolute numbers, in situations where the relative frequency would be essential to understand the meaning. – "Naked" numbers*
	Statistical Error
Objective Error	– Refer to average values as if they were specific values. – Misuse of the concept "margin of error", for example in the context of polls. – Variables defined in inadequate sets (or inadequate units).
Subjective Error	– Omission of the degree of confidence or margin of error associated with the result of a survey or study. – Omission of average, maximum and minimum values. – Omission of sampling method or population used in a study. – Omission of the impact of important variables in a given context.
	Graphical Error
Objective Error	– Lack of uniformity or proportionality in scales, whether linear scales or areas. – The range of values considered distorts the perception of real variation of variables values. – Use of different reference values (time intervals, for example) to compare performances.
Subjective Error	– Inconsistency between text and graph or infographics. – Omission of measurement units. – Omission of used scales.
	Logical Error
Objective Error	– Improper appeal to authority. – Confusion between correlation and causality. – Hasty generalization.

* This subtype of error refers to situations where numbers are presented without other quantitative data that provides context.

Instruments and procedures

A content analysis procedure was developed to analyse data. The coding scheme allows the categorization of the news articles' elements at three levels: (1) the structure,[1] (2) the content[2] and the (3) mathematical information[3] (which includes the identification of mathematical errors). This instrument was built based on work by Azevedo [2007], Sousa [2001], Gradim [2000], Maier [2000], Paulos [1997], and Cohn and Cope [2001], and was tested independently by three coders. In order to evaluate inter-coder reliability, the Cohen Kappa coefficient was calculated for all categories. Those categories for which the Cohen Kappa value was inferior or equal to 0.6 were excluded. The final version, with 48 categories (grouped into four main categories) was then used for the empirical phase of the study. The average inter-coder score of these categories was 0.868. The minimum inter-coder value was 0.625, and the maximum value was 1.000.

After validating the analysis instrument, the news articles belonging to the sections considered of interest (referred above) were counted and their content was categorized using the coding grid.

Results and discussion

Incidence of mathematical information in the news

From a total of 9589 collected news, only 1107 (about 11.5%) had mathematical information, a much lower proportion than the one reported by Maier [2000], who identified mathematical information in 48.1% of the news.

Of the 1107 news, 365 are from weeklies and 742 belong to daily newspapers. From these two sets, we found out that 19.5% of the news articles from weeklies and 9.6% of the news articles from dailies have mathematical information. The obvious difference of percentages may be related to the time available for the production of the newspaper edition, which is more extended in weeklies, meaning their staff have more time to verify the information and deepen the stories through the use of mathematical information.

Other differences among newspapers are noticeable. Namely, data from Table 2 also shows that the quality newspapers (*Expresso* and *O Público*) use mathematical information more often than popular newspapers (*Correio da Manhã*, *Jornal de Notícias* and *Sol*), something that can be explained by the goals of accuracy and objectivity that drive quality newspapers [Sousa, 2001].

Further analysis of the data from each newspaper regarding the distribution of mathematical information indicates that it is used preferentially to communicate information about economy and business, as illustrated in Figures 1 and 2. This is an expected result, considering that many of the stories about economy imply reporting quantitative information.

[1]To code the structure of the News, we used the categories "Newspaper", "Page number", "Call to the first page", "Belonging to newspaper supplement", "Section", "Size", "Presence of images" and "journalistic genre".

[2]To code the news article regarding its content we used the following categories: "Author", "Main source of information", "Geographic context", "Presence of jargon", "Tone" and "Presence of graphical representation (of quantitative data)". "Presence of jargon" refers to the existence of technical language, specific to the topic addressed in the news article and "Tone" refers to the style used to present information: factual or sensationalist.

[3]To classify the mathematical information we used the category "Relevance of mathematical information" and other categories to classify the several possible errors.

Table 2. Frequency of news articles with mathematical information.

	Daily newspapers				Weekly newspapers		
	JN	CM	Público	Total	Expresso	Sol	Total
No. news articles	3130	3118	1469	7717	1097	775	1872
News articles with mathematical information*	218 (7%)	238 (7,6%)	286 (19,5%)	742 (9,6%)	254 (23,2%)	111 (14,3%)	365 (19,5%)

*No. of news stories with mathematical information over no. of news articles counted in each newspaper.

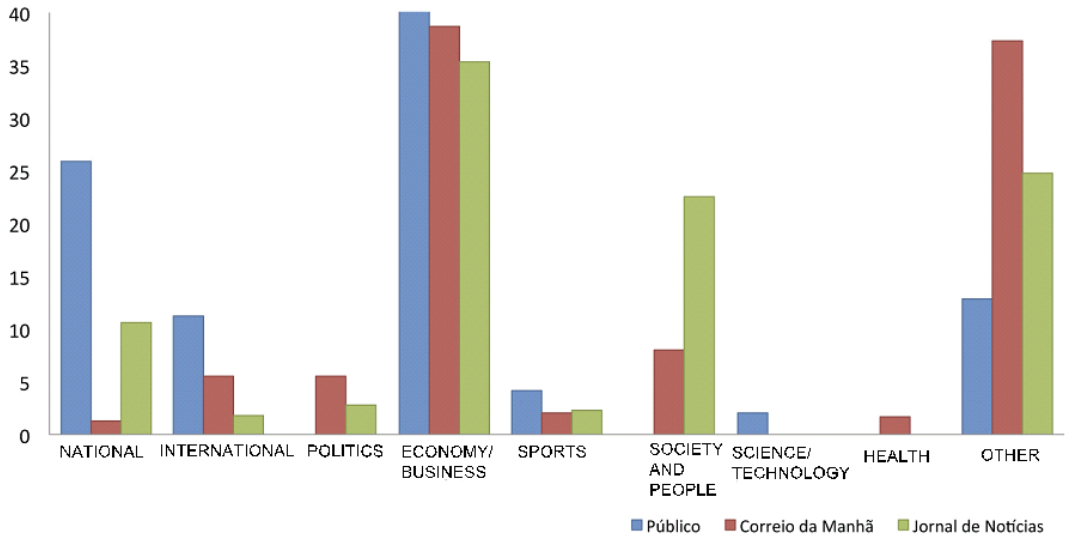

Figure 1. Distribution of news articles according to section in each daily newspaper.

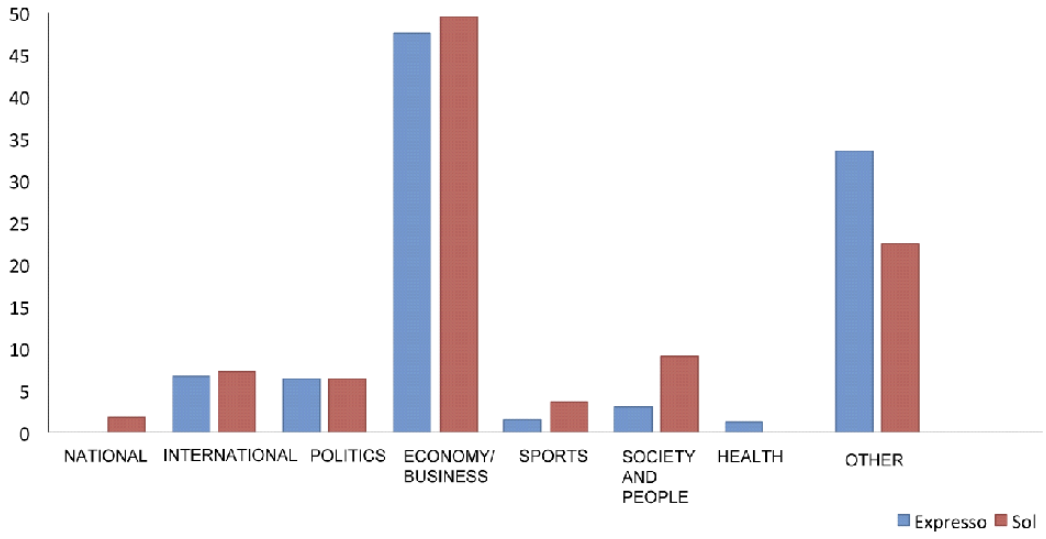

Figure 2. Distribution of news articles according to section in each weekly newspaper.

The distribution of news articles with mathematical information also reveals that all the newspapers use it preferentially in large size news articles (over half a page), except for *Correio da Manhã* (Figure 3).

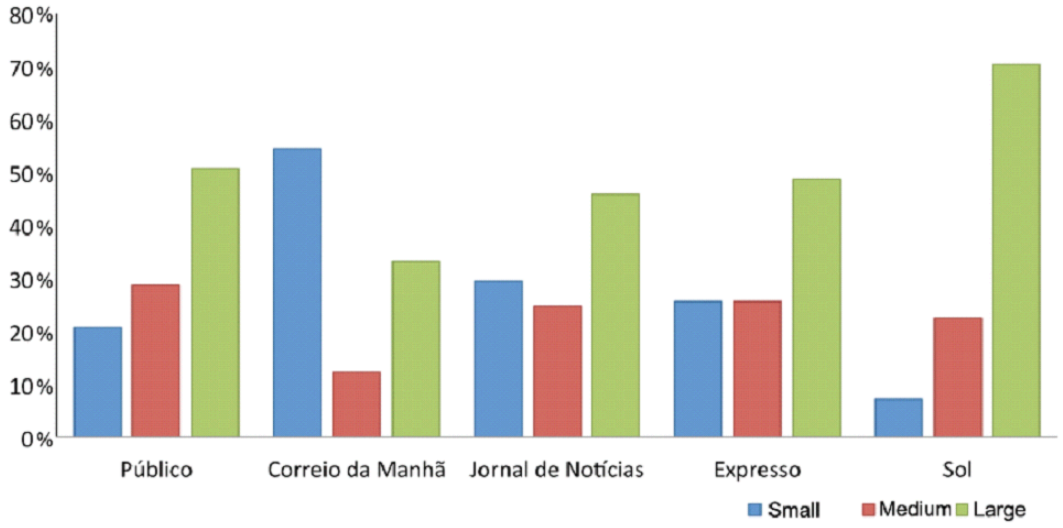

Figure 3. Distribution of news articles according to size in each newspaper.

This result corroborates Paulos' statement [Paulos, 1997] that mathematical information is used as means to deepen stories and present arguments that are more likely to be associated with long articles (news articles occupying more than half a page). Although *Correio da Manhã* seemingly contradicts this trend, data must be interpreted with caution because 54.6% of news articles in this newspaper are short (occupying less than ¼ of a page).

Variables such as the call of news to the first page, and the importance of mathematical information to understand the news story, show not only the distribution of this kind of information in the newspapers but also reveal its relevance. Data revealed that over 70% of the news articles with mathematics in all newspapers are not referenced in the first page, suggesting news stories with mathematics are not usually the most important for the editors.

Regarding the importance of such information to understand news stories, evidence indicates that mathematics is used as a subsidiary rather than a fundamental element in most of the news stories in four out of the five newspapers (*O Público*, *Correio da Manhã*, *Expresso* and *Sol*). Among these, *O Público* is an extreme case because mathematics is considered essential to the understanding of the news article in only 26.9% of the cases (according to the criteria used to select the sample).

Finally, regarding the presence of charts in the news, data show that, in all five newspapers, most of the news articles with mathematics have images but, of those, less than half are graphs (Table 3), suggesting once more that news articles with mathematical information are not the most relevant in the newspaper.

Concerning the distribution of news articles with mathematics according to the source of information used in the story, results show that they resort mainly to

Table 3. Frequency of news articles with graphics and graphs.

	Daily newspapers				Weekly newspapers		
	JN	CM	Público	Total	Expresso	Sol	Total
News articles with graphics*	158	200	232	590	181	91	272
News articles with graphs**	54 (34,2%)	75 (37,5%)	64 (27,6%)	193 (38,6%*)	83 (45,9%)	15 (16,5%)	98 (36,0%)

* No. of news stories with graphics over no. of news stories with mathematical information.

** No. of news stories with graphs over no. of news articles with graphics.

external sources (official and unofficial). Moreover, the quality newspapers are the ones that make more use of multiple sources of information in those stories, which is consistent with the accuracy and objectivity goals for the information they provide.

Mathematical error incidence in the news

Data reveals that, on average, more than 30% of the news articles, whether from a daily or a weekly newspaper, have mathematical errors.

The percentage of news articles with errors in this study is considerably higher than the one reported by Meyer [2009] regarding the analysis of 20 American newspapers, where the rate of error ranged between 12.9% and 22.2% of the news. In fact, in four out of the five newspapers analysed in this study the rate of mathematical errors is higher than 35%. Among the newspapers, *Correio da Manhã* stands out because almost half of the analysed news stories (45.4%) have some type of mathematical error. This is the newspaper with the highest incidence of mathematical errors, which was expected because it is a popular newspaper, which privileges the human interest of the stories over objectivity and accuracy [Sousa, 2001]. On the other hand, *O Público* and the *Expresso* (quality newspapers) have a percentage of news articles with errors that is surprisingly high (over 35%) (Table 4).

Table 4. Frequency of news articles with mathematical errors.

	Daily newspapers				Weekly newspapers		
	JN	CM	Público	Total	Expresso	Sol	Total
News articles with errors	39 (17,9%)	108 (45,4%)	101 (35,3%)	248 (33,4%*)	91 (35,8%)	39 (35,1%)	130 (35,6%)

* No. of news articles with errors over no. of news articles with mathematical information.

The results indicate that it is not clear that the incidence of errors is higher in popular newspapers since *Jornal de Notícias* has a very low rate of news articles with errors when compared to other newspapers. Further analysis confirms that the association between the type of newspaper (quality vs. popular) and the existence of errors is negligible ($\phi = 0.029$).

Investigating the sections in newspapers where errors are more pervasive, data show that, in the dailies, the sections with higher percentage of news stories with mathematical errors are the *Science* section (50% of a total of 6 news articles in this

section) and the *International* section (49% of a total of 49 news articles in this section). Nevertheless, the small number of news stories collected from the *Science* section requires that the results be read with restraint. With respect to the weeklies, the topics belonging to the *Health* section are the most problematic, because all the examined news articles have mathematical errors. However, again due to the small number of health news stories analysed (3), it is necessary to read the results with reserve. The *International* section in the weeklies is also pervaded by news articles with errors — they are identified in 56% of the 24 news stories of this section.

Proceeding to other elements that characterise the incidence of mathematical errors, Table 5 indicates that the majority of the news articles from daily newspapers with graphs also have mathematical errors. It also shows that there is a considerable difference between dailies and weeklies (about 30 percentage points), which suggests that the time available to produce the news article is a factor that affects the accuracy of mathematical information presented in articles that use visual representation of quantitative information, a suggestion reinforced by the fact that the difference between *Expresso* and *Sol* is very small.

Table 5. Frequency of news articles with graphs that have errors.

	Daily newspapers				Weekly newspapers		
	JN	CM	Público	Total	Expresso	Sol	Total
No. News articles with graphs	54	75	64	193	83	15	98
News articles with graphs and errors	21 (38,9%)	59 (78,7%)	40 (62,5%)	120 (62,2%*)	25 (30,1%)	5 (33,3%)	30 (30,6%)

* No. of news articles with graphs and errors over no. of news stories with graphs.

Data regarding the newspaper *O Público* is surprising due to the fact that, although this is a quality newspaper, the majority of news articles with graphs have errors. But the results referring to *Correio da Manhã* are even more dramatic since over three-quarters of the news articles with graphs present some kind of mathematical error.

Regarding the presence of errors in news stories where mathematical information is considered critical to understand the narrative, the results of Table 6 indicate that in two out of three daily newspapers, the majority of such news articles have errors, which suggests that there is a significant limitation for the reader to correctly interpret the information. On the other hand, that percentage is considerably lower (about 30%) on the weekly newspapers.

Concerning the analysis of the prevalence of mathematical errors in the news articles according to the source of information used in the story, data show that, both in daily newspapers and weeklies, errors are more frequent in the news stories that are based on internal sources or on scientific or specialized documents than in news from official sources or others. Specifically, 89.2% of news stories of daily newspapers based on internal sources have mathematical errors, and 58.3% of the news articles based on technical or scientific documents also have errors. Further analysis ascertains that there is a moderate association between the existence of error and the source of information used in the stories of daily newspapers ($\phi c = 0.338$) [Chen and Popovich, 2002].

Table 6. Frequency of news articles with errors where mathematicalinformation is fundamental.

	Daily newspapers				Weekly newspapers		
	JN	CM	Público	Total	Expresso	Sol	Total
No. news articles in which mathematical information is considered fundamental	86	132	77	295	90	28	118
News articles with errors in which mathematical information is considered fundamental*	24 (27,9%)	88 (66,7%)	44 (57,1%)	156 (52,9%)	30 (333%)	9 (32,1%)	39 (331%)

*No. of news articles with errors in whichmathematical information is considered fundamental over no. of news articlesin which mathematical information is considered fundamental.

In weeklies, mathematical errors are more pervasive in news stories that are based on scientific or technical documents (75%), although half of the news articles in weeklies that use internal sources have mathematical errors. An additional test shows that there is also a moderate association between the existence of error and the source of information used in weeklies ($\phi c = 0.274$).

Results regarding the incidence of errors in news stories that rely on internal sources of the newsroom suggest that there is difficulty interpreting and operating with mathematical information autonomously. The data also point to the fact that journalists have problems in interpreting and using mathematical information from scientific or specialized documents.

Table 7. Frequency of news articles that use technical terms and haveerrors.

	Daily newspapers				Weekly newspapers		
	JN	CM	Público	Total	Expresso	Sol	Total
No. News articles with technical terms	36	48	90	174	162	33	195
News articles with errors and technical terms*	5 (13,9%)	30 (62,5%)	47 (52,2%)	82 (47,1%)	65 (40,1%)	9 (27,3%)	74 (37,9%)

*No. of news articles with technical terms and errors over no. of news articles with technical terms.

Types of mathematical errors in the news

Further analysis of mathematical errors showed that they are mainly subjective, both in dailies and weeklies, but the association between the type of newspaper (daily vs. weekly) and the type of error is negligible ($\phi c = 0.087$).[4]

[4]*Cramer's V* (or *Cramer's* ϕ) coefficient was used here instead of the ϕ coefficient because the variable "type of error" has three possible values: objective, subjective or both.

Table 8. Distribution of errors in the news articles according to theirtype.

	Daily newspapers				Weekly newspapers		
	JN	CM	Público	Total	Expresso	Sol	Total
News articles with objective errors*	21 (53,9%)	39 (36,5%)	34 (33,7%)	93 (37,5%)	38 (42,2%)	12 (30,8%)	50 (38,5%)
News articles with subjective errors*	20 (51,3%)	95 (88%)	71 (70,3%)	186 (75%)	60 (65,9%)	30 (76,9%)	89 (68,5%)

*Percentage calculated over the total number of news articles with errors in each newspaper. Note that the same news article may have both objective and subjective errors.

A more detailed observation of the data also shows that, despite subjective errors being the most common among daily newspapers, that is not so for *Jornal de Notícias*, where subjective and objective errors occur in similar percentages.

The most frequently identified subjective errors were: (1) Omission of the sampling method or the population used in a study; (2) Omission of the degree of confidence or the margin of error associated with the result of a survey or study; (3) "Naked" numbers (use of numbers without context, without giving them a meaning); (4) Omission of used scales in graphs; (5) Omission of measurement units (in graphs). On the other hand, the most common objective errors were (1) inaccuracy in arithmetic operations and (2) lack of uniformity or proportionality in scales, whether linear scales or areas (in graphs).

Illustrations of some of these errors are:

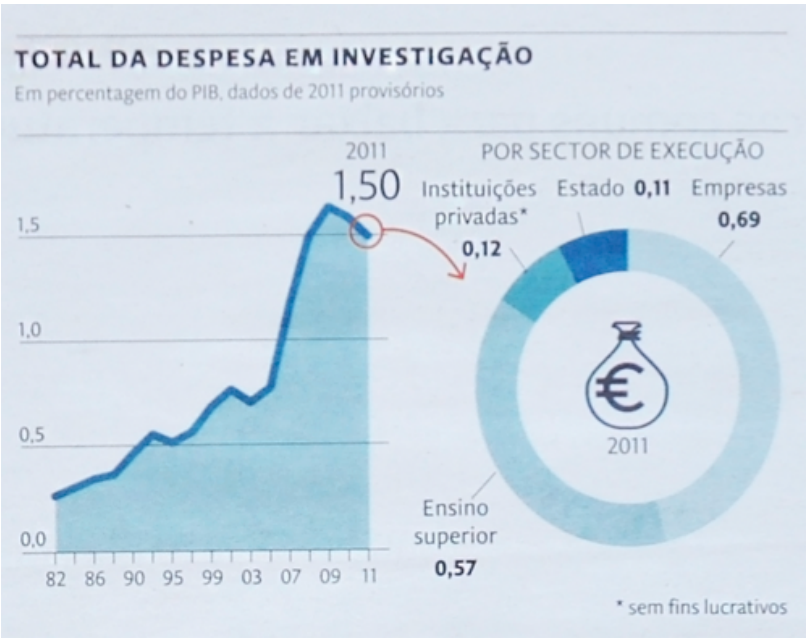

Figure 4. Charts referring to research expenses from 1982 to 2011 in Aveiro University, Portugal [Paulo and Silva, 2013].

It is possible to identify two distinct mathematical errors in Figure 4. The chart on the left was produced using a horizontal scale where the length between consecutive marked values is not proportional to the interval of years it represents. This is an example of objective graphical error.

Additionally, the chart on the right, in the same figure, has an objective numerical error because the sum of all the percentages on the pie chart is not 100%, despite the fact that pie charts are used to visualize parts in a whole (100%).

A different kind of error is identified in the edition of 18th of February, 2013 of *Correio da Manhã*. The title of the news article in question refers to changes in preferences regarding political parties and is entitled "PS slides and PSD recovers".[5] At a certain point it is written that "The general secretary of PS slid 2.5 percentage points in the trust for government leader" but no additional technical data are given in the news articles about how the poll was conducted, such as margin of error, sample size or level of confidence, information that is crucial to understand if a change of 2.5 percentage points is an effective change of the results or if it is a variation smaller than the one defined by the confidence interval.

To give a clearer view of the kinds of errors identified in the news articles, we present two other examples. The first consists of an error in calculating a percentage and the second is an example of the use of naked numbers, which are numbers used without providing the reference values that allow their interpretation within a context.

The first example was published in the edition of 3rd of February, 2013 of *O Público*. The title of the news article is *"Facebook profits do not please everyone"*. It is written that the company registered gains of 1002 millions of dollars in 2012, an increase of 66% in comparison to the 606 millions of dollars gained in 2010. Looking closer at the data, it is possible to conclude that an increase of 66% using as basis 100% the 606 millions of dollars corresponds to, approximately, 1006 million dollars, not 1002 million dollars.

The last example refers to a news story about an insurance coverage in case of a person having cancer. The title of the news story is *"Protection in case of cancer"* and was published in the edition of the 2nd of March 2013 in the newspaper *Expresso*. It is stated that the coverage of the insurance includes a capital that goes up to 20 thousand euros, paid upon confirmation of the disease. For example, the article does not include any information about the average cost and number of sessions of the most frequent cancer treatments; neither provides additional information that would allow the reader to understand the real value of 20 thousand euros in this particular context.

As referred before, errors were not only classified according to their objectivity but also their mathematical content. With respect to this second categorization, Table 9 indicates that statistical errors are the most frequent ones in the daily newspapers while numerical errors predominate in weeklies.

Data from Table 9 also shows that, although the overall prevalent errors in daily newspapers are statistical, in *O Público*, the numerical ones are the most common (identified in 41.6% of the news stories with errors).

Similar differences are also noticed among the weeklies: in general, numerical errors are the most frequent ones (identified in 59.7% of all news stories from weeklies); however, statistical errors are the most commonly identified in *Sol* (64.1%).

[5] PS and PSD are Portuguese political parties.

Table 9. Distribution of errors in the news articles according to their type.

	Daily newspapers				Weekly newspapers		
	JN	CM	Público	Total	Expresso	Sol	Total
News articles with statistical errors*	15 (38,5%)	85 (78,7%)	37 (36,6%)	137 (55,2%)	24 (26,4%)	25 (64,1%)	49 (37,7%)
News articles with graphical errors*	11 (28,2%)	28 (26,2%)	28 (27,7%)	67 (27,1%)	10 (11,1%)	4 (10,3%)	14 (10,9%)
News articles with numerical errors*	15 (38,5%)	19 (17,8%)	42 (41,6%)	76 (30,8%)	62 (68,9%)	15 (38,5%)	77 (59,7%)
News articles with logical errors*	0	1 (0,9%)	1 (1%)	2 (0,8%)	0		

*Percentage calculated on the total news articles with errors in the respective newspaper. Note that the same news article may have more than one type of error.

Nevertheless, the association between the type of newspaper (daily or weekly) and the type of error (numerical, statistical, graphical and logical) is moderate [Rea and Parker, 1992] ($\phi c = 0.283$).

Comparing quality and popular newspapers, data show that whereas numerical errors are more frequent in quality newspapers, errors in popular newspapers are predominantly statistical.

Further analysis shows that the association between the type of newspaper (quality or popular) and the type of error (numerical, statistical, graphical and logical) is also moderate ($\phi c = 0.341$).

Interestingly, and contrarily to what the literature states [Paulos, 1997; Blastland and Dilnot, 2008], fallacies of reasoning were rarely identified in the five newspapers.

The dual categorization of errors used in this study allows a deeper analysis of the data. Namely, it is evident that, regardless of the type of newspaper (daily or weekly), the most common statistical errors are subjective. There are even extreme cases (*Jornal de Notícias* and *Correio da Manhã*) where all the statistical errors are subjective. This indicates that they are mainly omission or distortion of information, which is not necessarily due to the lack of technical or mathematical knowledge of journalists. There are some other reasons that can justify these errors, based in the literature: the choice of the journalist, the lack of recognition of the importance of such information for the credibility of information or even the structure of the news, which being that of an inverted pyramid leads to omission of information.

Graphical errors, contrarily to the statistical ones, are predominantly objective, both in dailies and weeklies in general. However, it is important to notice that this is not true for the newspaper *O Público*, where the number of subjective graphical errors (28) is considerably higher than the number of objective graphical errors (6). By the very definition of subjective errors, this indicates that the graphical errors in *O Público* are mainly due to the omission of elements in graphs (e.g.: scales or units), while in other newspapers graphical errors are mainly due to incorrect application of technical knowledge related to the construction of graphs.

Concerning numerical errors, data show that, while in the daily newspapers objective errors are more frequent than the subjective ones, the opposite happens in the weeklies. In both weeklies, the most frequent numerical errors are subjective.

Conclusion

The results indicate that mathematics is far less used in the news articles in Portuguese newspapers than what is indicated by previous studies conducted on American newspapers. That finding, together with similar differences between Portuguese and American news stories regarding mathematical errors, opens an interesting line of research in terms of comparative studies on numerical data in the news articles between different countries.

Results also indicate that mathematical information is used mainly as a way of developing in-depth news, since in almost all the analysed newspapers, mathematical content is more frequent among large articles.

Concerning the characterisation of errors, we concluded that most of them are omissions, overemphasis or underemphasis of information. Contrary to our results, Maier [2000] identified that most errors in the American newspaper *News & Observer* were objective. Although the studies have methodological differences, this disparity of results raises an interesting question: is the predominance of objective and subjective errors influenced by cultural or educational differences among countries?

Subjective errors may be due to several factors, namely the journalistic judgments about the importance of the underlying mathematical information in news stories; the interpretation that the journalist makes of this kind of information or even due to the very structure of news story, which somehow "obscures" the information [Paulos, 1997]. Low numeracy levels may also justify the way journalists use mathematical information, a problem that, in the context of Portuguese newspapers, seems to exist, at least regarding the construction of graphs, since, in our study, the most predominant errors in graphs are objective.

Thus, it became manifest that journalists have difficulty applying basic mathematical skills to the construction of graphs.

Another conclusion of this study is that there are differences among newspapers regarding the most predominant type of errors. Namely, numerical errors are more common among news articles from weeklies while statistical errors are the most predominant ones in news articles from dailies. We also realized that although subjective errors are the most common ones in both types of newspapers, they are more frequent among news stories from dailies. These differences can be explained by differences in production times [Berry, 1967].

Although several reasons were pointed out to explain the errors, further investigation is needed to understand to what extent each of them really is the cause of the different types of errors.

The research findings are relevant because they provide the first grasp on the extent to which mathematical information is used in Portuguese newspapers, and this study contributes with a characterisation of the incidence and typology of errors that most affect those newspapers. It also alerts to the fact that, despite the

increasing importance of quantitative data in society, and particularly in journalism, Portuguese newspapers and journalists still invest little in the use of quantitative analysis as a communication tool.

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