

InfoNice: Easy Creation of Information Graphics

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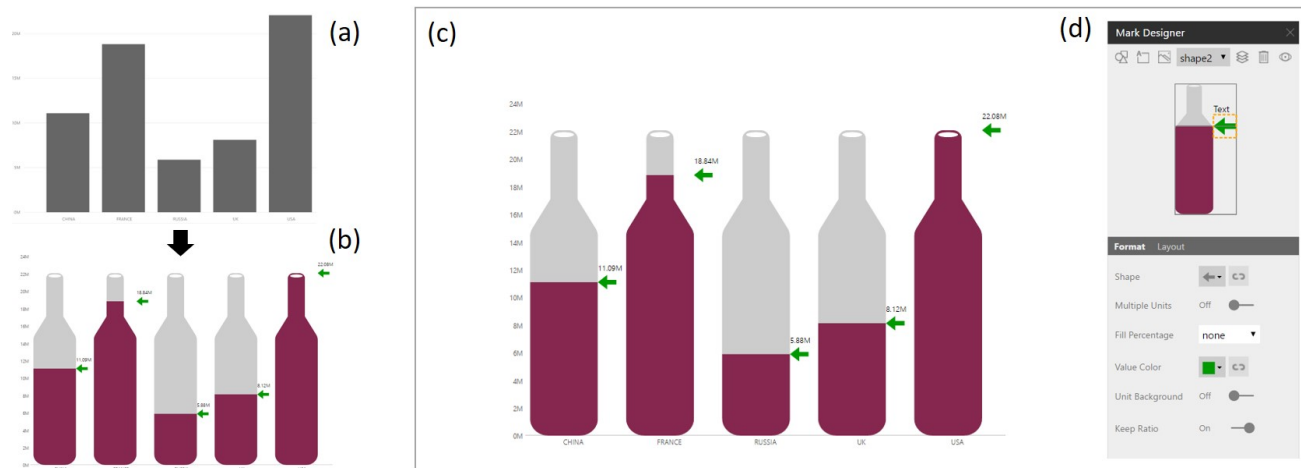


Figure 1. InfoNice mark customization: (a) the original column chart with default rectangle mark, representing wine consumption; (b) an infographic-style version with customized marks, using bottles filled with different amounts of wine to represent wine consumption; (c) the main view providing preview of the visualization in design; (d) the mark designer pane supporting mark editing.

ABSTRACT

Information graphics are widely used to convey messages and present insights in data effectively. However, creating expressive data-driven infographics remains a great challenge for general users without design expertise. We present InfoNice, a visualization design tool that enables users to easily create data-driven infographics. InfoNice allows users to convert unembellished charts into infographics with multiple visual elements through mark customization. We implement InfoNice into Microsoft Power BI to demonstrate the integration of InfoNice into data analysis workflow seamlessly, bridging the gap between data exploration and presentation. We evaluate the usability and usefulness of InfoNice through example infographics, an in-lab user study, and real-world user feedback.

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Our results show that InfoNice enables users to create a variety of infographics easily for common scenarios.

ACM Classification Keywords

H.5.m. Information Interfaces and Presentation (e.g. HCI): Miscellaneous

Author Keywords

Infographics; visualization; design tools

INTRODUCTION

Compared with traditional visualizations, information graphics (also known as infographics) [16] are specifically designed to serve a presentation purpose rather than data exploration and analysis [22]. In order to enhance data communication, infographics often utilize embellished versions of common chart types [21, 36]. The visual embellishments usually include pictographic elements [15], textual annotations [30], and elaborately designed figures and imageries [1, 9, 20]. When incorporating appropriate embellishments, infographics can effectively convey messages, present insights, and tell stories about data in an aesthetically pleasing, memorable, and engaging style [1, 15, 17, 22, 23]. As a result, infographics have become increasingly popular in a variety of fields. The

demands for crafting infographics have gone beyond graphic designers and visualization experts. Nowadays, non-experts also have a strong desire to add impressive infographic visualizations to data reports, business dashboards, or news articles.

In recent years, advanced visualization authoring systems, such as Lyra [34], iVisDesigner [31], iVoLVER [28], and DDG [21], have been developed to facilitate the creation of data-driven infographics. To enable highly expressive and customized designs, these systems usually provide a flexible, but complicated design environment. Consequently, although such authoring environments are familiar to graphic designers or visualization experts, they are much more difficult to use for general users without strong design background.

Moreover, these tools are separated from the systems where users conduct visual exploration and analysis, leading to a huge gap between chart generation and chart embellishment. Imagine a user obtaining a chart in a visual analysis tool (e.g., Tableau, Microsoft Power BI) and wanting to share it with others. If she looks for a compelling infographic-style presentation for the chart, she may have to switch to a dedicated infographic creation system, reload the data, and redesign the visualizations. Furthermore, whenever the data is changed, she has to repeat the whole procedure mechanically. Such additional efforts caused by the separation of tools make the whole design process time-consuming and error-prone, and are usually difficult for novice users in common scenarios.

We attempt to ease the creation of data-driven infographics for general users who are analysis-oriented but non-experts in graphic design and visualization. We present InfoNice, a novel tool that can be integrated or embedded into visual analysis systems to add design capabilities for creating custom infographics. More specifically, InfoNice employs a mark-customization approach. Starting from a traditional chart (e.g., bar chart, line chart) obtained from the data analysis process, while keeping its predefined chart template, InfoNice allows users to redesign the marks interactively (Figure 1) to achieve an embellished and customized appearance.

By integrating infographic design features into existing analysis and exploration systems, InfoNice helps bridge the gap between analysis and presentation, hence enabling smoother and faster iterations. With InfoNice, users can create visualizations in one system for both data analysis and presentation purposes. They can start data exploration and analysis with traditional-style charts, and easily convert them to infographic-style ones, without switching to other systems.

To verify our design and demonstrate how it can be integrated into data analysis workflow, we implement InfoNice into Microsoft Power BI¹, a leading product for data analysis and visualization, to make it available to all Power BI end-users. The first version was released in October 2016. The feedback we have received shows that users can easily create a variety of infographics for real world data and scenarios with InfoNice.

To evaluate the usefulness and usability of InfoNice, we conduct an in-lab user study, as well as a survey on real-world

end-users. We also create diverse example infographics to demonstrate its capability (Figure 2). Our results confirm that InfoNice is effective and efficient to facilitate the creation of custom infographics and conveying messages with data. Our main contributions can be summarized as follows:

- We propose a novel visualization design tool, InfoNice, to improve the ease of creating infographic-style visualizations for general users. InfoNice employs a mark customization approach to integrate infographic design features into data exploration and analysis systems.
- We implement InfoNice into Microsoft Power BI, a commercial product, to demonstrate that the integration of InfoNice into the data analysis workflow helps reduce the cost of switching between data exploration and presentation.
- We conduct an in-lab user study and a real-world end-user survey to reveal the potential benefits of this integrated design for data-driven infographics creation.

MOTIVATING SCENARIO

Nancy is a data scientist working on the analysis of wine consumption worldwide. She loads the wine consumption dataset into Microsoft Power BI, and explores it interactively. To compare wine consumption in different countries, she queries the data for some countries of interest, and creates a standard column chart (Figure 1(a)) to show the results. To share her analysis with team members, she needs to add this chart to a dashboard. But she is a little worried about the presentation effectiveness of her chart, as there are a few other column charts with similar styles on the same dashboard. She feels anxious that her chart may be overlooked by the audience at a glance and will not form a lasting impression. Nancy has learned that infographics can be more compelling, engaging, and memorable, so she decides to convert her chart into an infographic-style one. Without leaving Power BI, she can achieve this easily by customizing the marks of the chart in a dedicated design UI on the right side of the chart.

To replace the original rectangular marks, Nancy first adds a bottle icon selected from the built-in icon library to represent the "wine" concept in her data, and configures its fill-color area to match wine consumption values. She then adds a text element to display values and a left-arrow icon as indicator. With just a few clicks, Nancy finishes the design of customized marks, and has an infographic that uses bottles filled with different amounts of wine to represent the wine consumption in different countries (Figure 1(b)). Nancy is satisfied with the results and shares it on the dashboard. As Nancy expected, her chart stands out among all the charts on the dashboard, and quickly catches the audience's attention. Furthermore, it updates automatically each time the underlying data changes.

RELATED WORK

Information Graphics

Information graphics convey messages behind data engagingly [9]. While the forms of infographics greatly diverge, we focus on one of the most common categories, variations of common data visualizations with visual embellishments. Traditionally, visual embellishments are considered harmful [38]. Visualizations are usually kept plain for the effectiveness of data

¹<https://powerbi.microsoft.com/>

analysis. Recently, researchers have started to reveal the value of visual embellishments in data communication. For example, Bateman et al. [1] find the recall of embellished charts is significantly higher than plain charts. Haroz et al. [15] learn that ISOTYPE charts are equal to plain charts in terms of reading speed and accuracy, and the added visual information makes them more memorable. Others [5, 6, 7, 35, 36] also conclude that appropriate embellishments, such as color and the inclusion of recognizable objects, can increase memorability of visualizations. Besides, Byrne et al. find that figurative elements can effectively provide context, show content, and label data [9]. While these studies answer the question of why we need custom infographics, we aim to solve the problem of how to enable general users to easily create data-driven infographics to enhance data presentation and communication.

Design Process Paradigms

The typical design process of creating visualizations usually includes multiple steps, namely data analysis, filtering, encoding or mapping, and rendering [2, 10, 11, 12, 32]. Among them, data mapping is a key part. To understand the mapping process, Mendez et al. proposed bottom-up and top-down paradigms to categorize common visualization tools [27]. The bottom-up paradigm describes the process of creating visualization by manipulating individual data points and attributes, while the top-down one focuses on the overall mapping. Through the user study comparing the use of Tableau Desktop and iVoLVER [28] as representatives of the two paradigms, the authors find that the top-down paradigm enables speedy exploration of visualization solutions that users are acquainted with, while the bottom-up one requires initial thinking about the intended visualization and facilitates creative and critical thinking [27]. Our mark customization approach follows a hybrid paradigm to achieve a balance between design speed and flexibility. From the top down, users can initiate from a plain chart quickly instead of authoring from scratch; from the bottom up, during mark customization, we enable users to design data mapping and construct marks with visual elements without changing the chart layout to achieve flexible and expressive infographic designs.

Data Visualization Tools

Visualization authoring systems and tools have been developed to facilitate the creation of data visualization. For example, Polaris [37], Tableau [26], and Many Eyes [40] can help users to encode data with different visualization forms. These tools enable general users to create visualizations quickly without specialized programming knowledge, but tend to be less flexible and less expressive than code-generated visualization with programming languages such as D3 [8] and Processing [4].

SageBrush [33] is a pioneering tool for creating customized visualizations by performing simple drag-and-drop operations. More advanced techniques, including Lyra [34] and iVisDesigner [31], enable more expressive custom visualization designs without writing any code. These tools are based on graphical specifications [41] or a declarative model [18]. However, users can only change a small set of style parameters, such as color, fonts, scales, and layouts. The ability to create novel infographic design is still limited. Kim et al. develop

Data-Driven Guides (DDG), a technique that allows users to create infographics by freeform drawing and bind data with self-created shapes to achieve complex and expressive infographic designs [21]. However, targeting professional graphical designers, it adopts a graphical design interface similar to Adobe Illustrator, which increases the difficulty of creating infographics for general users. In addition, the system is separated from data exploration and analysis, which requires much effort to process the data to the specific data structure to conduct creative designs.

There are tools facilitating the process of creating visualizations. For example, Bigelow et al. emphasize the importance of enabling iterations and implemented Hanpuku that supports iterations between D3-created visualization and Adobe-Illustrator-enabled visualization editing [3]. Gratzl et al. propose the CLUE model to discuss the integration of data exploration and storytelling [14]. Our tool further promotes the iterations between data analysis and data-driven infographics creation. Specifically, to facilitate better authoring of infographics, we enable users to switch between data exploration and infographic design by integrating our tool into Microsoft Power BI. To reduce the difficulty of creating novel infographics, our tool enables users to edit charts by replacing the marks in classic visualizations with vivid icons, adding embellishments step by step, and binding data with visual properties to convey data insights. We provide a built-in icon library and enable users to upload their own icons and images so that users can bind data with appropriate visual elements.

DESIGN CONSIDERATIONS

Our goal is to facilitate the creation of data-driven infographics for general users. On one hand, general users without background on graphic design and visualization would mainly focus on data exploration. On the other hand, they may also need to create expressive infographics to enhance their data presentation. Therefore, the primary challenge is how to strike a good balance between functionality (powerfulness and flexibility) and usability (ease-of-use and ease-of-learning). We identify the design considerations as follows:

- **Lowering the barrier for authoring infographics.** Constructing new designs from scratch is usually not affordable for general users. The system should offer stepping stones and guide users through the infographics design process.
- **Supporting easy data binding.** The system should support users to easily specify and maintain the mappings between visual properties and data properties, to obtain interactive, accurate, and rich data-driven designs.
- **Gaining expressiveness through visual embellishments.** The system should enable users to create embellished visualizations that are more expressive than traditional ones. Users should be able to easily achieve the most commonly used infographic designs such as pictographs.
- **Facilitating fast and smooth iterations.** The system should enhance the design efficiency from the perspective of data analytics workflow. It should be easily integrated with data analysis tasks, and provide fast iterations between data exploration and presentation.

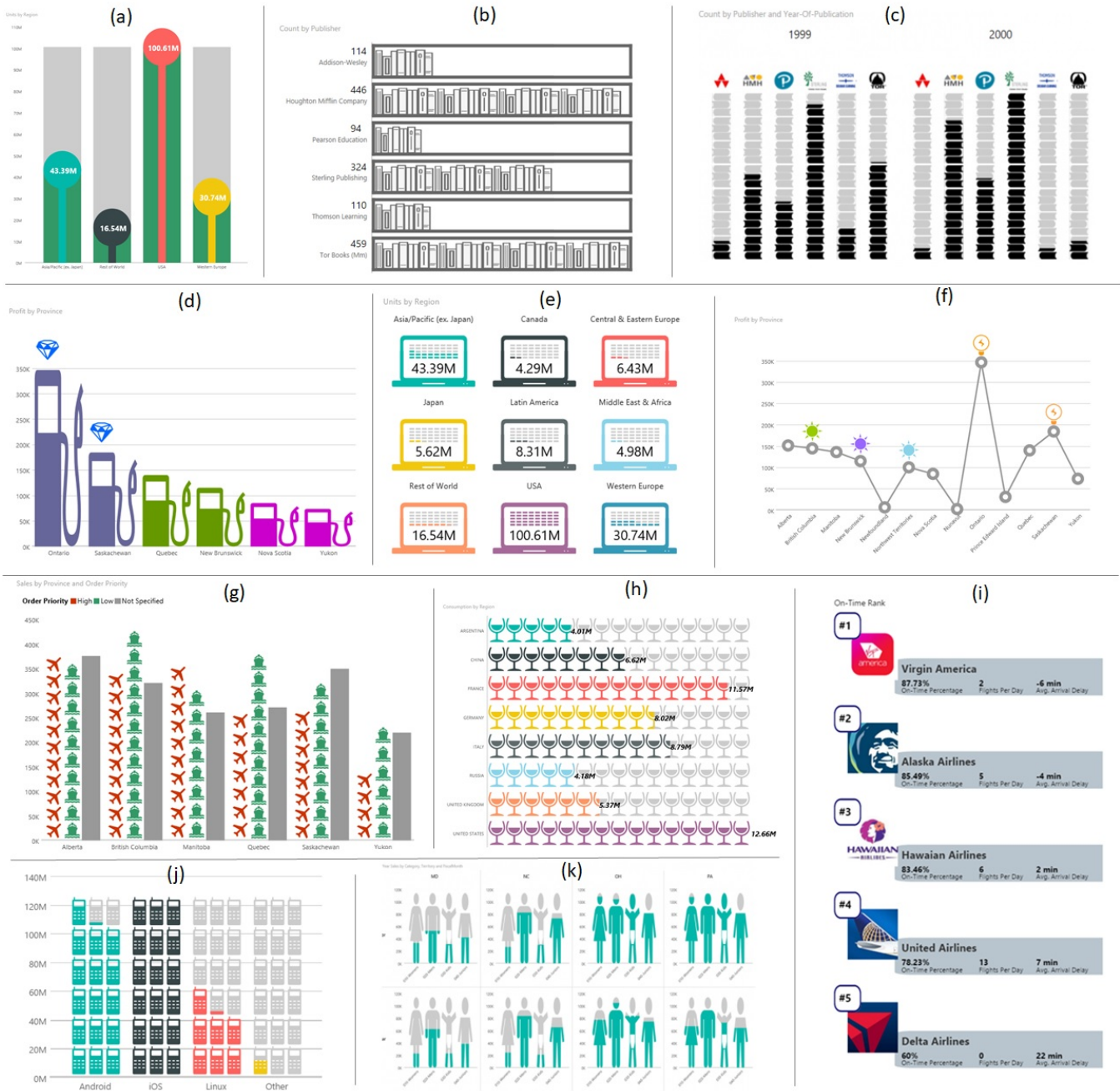


Figure 2. Example infographics created with InfoNice.

- **Enabling dynamic data updates.** The system should enable convenient data updates. Users should be able to insert the infographics into reports and dashboards to share data insights with others and monitor data changes.

INFONICE

Popular data analysis and exploration systems, such as Tableau, Microsoft Power BI, and Microsoft Excel, typically utilize a chart template or a shelf configuration approach to facilitate fast and easy construction of visualizations [13, 27]. To support analysis tasks, these visualizations always use a set of familiar, predefined chart types, and only allow very limited

customizations. To enable easy infographics creation, our idea is that while keeping the familiarity of the chart structure, we allow users to redesign the components of a chart. As marks are among the most important visually catching components of a chart, we focus on mark customization. Marks are the graphics that represent individual data points on a chart. For example, bar/column charts use rectangles as marks. InfoNice provides a variety of functionalities for users to customize mark designs by selecting appropriate graphical elements, specifying their formats and layouts, combining multiple elements, and mapping them to data properties.

Visual Elements

In InfoNice, a chart mark can be composed of one or more visual elements. Individual elements are placed using z-orders. We support three types of visual elements:

- A **shape/icon** is a basic shape such as rectangle and dot, or an ISOTYPE-style icon [15]. InfoNice provides a set of built-in icons. Users can add icons from SVG files.
- An **image** element can be uploaded from an image file. We support both raster images and vector images.
- A **text** element is a single-line or multiple-line text box. Users can specify the format parameters.

For example, for the chart in Figure 1(b), each mark contains two shape/icon elements (wine bottle and left-arrow), and one text element to display the values.

Element Layout

We define the Inner Bound and Outer Bound for each mark. The Inner Bound corresponds to the values of individual data points, while the Outer Bound corresponds to the data point with the maximum value on the chart (Figure 3).

When adding an element to the mark, users can specify its size and position according to the Inner or Outer Bound of the mark. To position an element, users specify how the element is aligned within the Inner or Outer Bound, as well as the distances to the corresponding boundaries. For example, a user can add a text element, and specify it to be on the top of the Inner Bound to place the text above each bar in a bar chart. With a measurement system based on the logical mark boundaries, users can easily arrange the layout of elements without calculating the absolute positions.

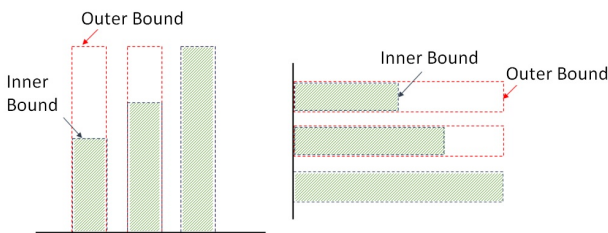


Figure 3. Illustrations of Inner Bound and Outer Bound for column chart (left) and bar chart (right).

Element Repetition

It is common to use stacks of individual elements to represent values [15] in infographic designs. We support such a design convention naturally through mark customization where each shape/icon or image element can be presented as multiple units, and users can specify how to stack multiple units in a flexible way. More specifically, users can provide exact numbers of units to be placed along the row and column directions (Figure 4). In addition, users can also specify the number for one direction and leave the number for the other direction as “Auto” to let InfoNice automatically calculate the numbers that fit the units in the element boundary. The “Auto” mode provides flexibility to ease users’ burden of manual calculation of element repetition. InfoNice provides flexible options for stacking multiple units so that users can trade off between different design variations. Users can achieve a design that

the units are well aligned as Figure 2(j), but it may lead to partial shapes/icons. Users can also choose to fill the space with complete units as Figure 2(g), but the shapes/icons may be unaligned across rows or columns.

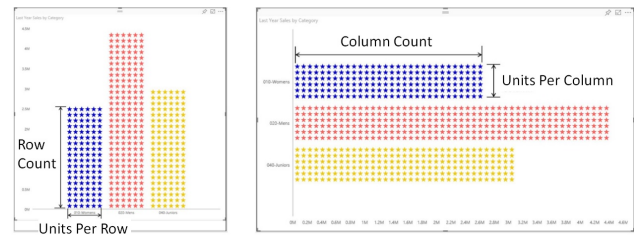


Figure 4. Element repetition: stack in vertical direction (left) or in horizontal direction (right).

| | Categorical Value | Numerical Value | Numerical Interval |
|--------|-------------------|-----------------|--------------------|
| Color | Supported | N/A | Supported |
| Icon | Supported | N/A | Supported |
| Text | Supported | Supported | Supported |
| Length | N/A | Supported | N/A |
| Ratio | N/A | Supported | N/A |

Table 1. Data bindings supported in InfoNice. The rows and columns correspond to element properties and data properties, respectively.

Data Binding

Data binding is an essential function to enable data-driven design for mark graphics. Element attributes can be associated with certain data attributes so that they vary with corresponding data accordingly to achieve diverse expressivity. As shown in Table 1, InfoNice provides rich data binding support.

- **Element property.** The attributes include *common properties* (e.g., fill color, height, and width) and *specific properties* (e.g., text content of text elements, and icons of shape/icon elements). Specially, we support an *element ratio* property. For a shape/icon element or an image element, either in a single unit or in multiple units, we can use a color different from the background to fill the area to represent certain ratios of data. The ratios can only be bound to numerical values. For example, in Figure 2(h), each bar highlights the ratio of wine consumption to the maximum wine consumption value using a non-gray color.
- **Data property.** The data can be *categorical* values of a dimension, or *numerical* values of a measure. Specially, we support a *numerical interval* property. For a numerical data field (measure), users can divide the data into *numerical intervals*, and mapping them to different element properties. For example, Figure 2(d) divides the profit values into three intervals: >150K, 100K-150K, and <100K, and then use three colors to fill the fuel dispenser icons respectively. It also adds additional diamond icons for the values >150K.

Multiple Views

Small Multiples

Small multiples are multiple views with the same encoding and different partitions of data [29]. They are widely used to facilitate comparison, presentation, and storytelling [19, 39]. In addition to individual infographic-style charts, InfoNice further supports automatically-generated small multiples

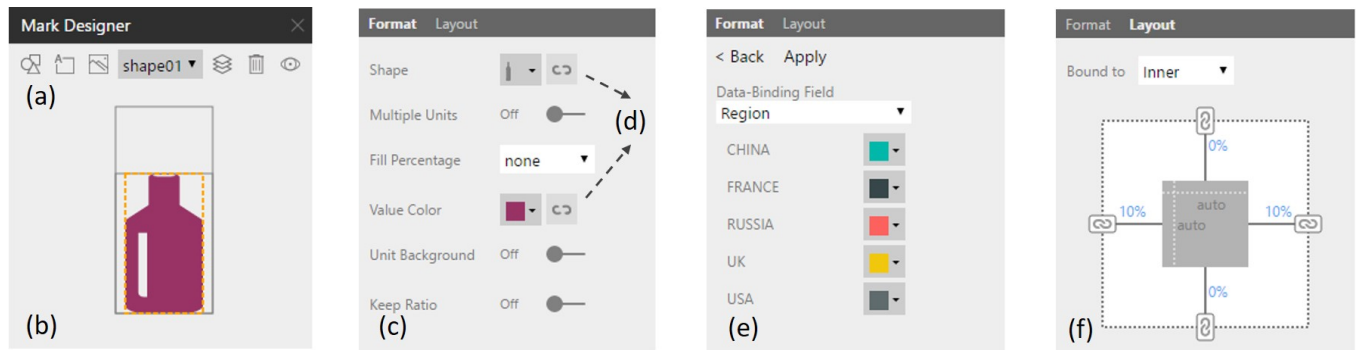


Figure 5. Mark designer interface: (a) the toolbar provides UI controls for managing elements on the mark; (b) the preview area provides a preview of the mark being edited; (c) the Format pane is for specifying the format settings of the selected element; (d) the data-binding buttons trigger data-binding editing; (e) the Data-Binding pane is for configuring data-binding settings; (f) the Layout pane is for specifying the layout settings.

based on individual infographics and data partitions specified by users. Figure 2 (c, e, k, i) shows examples of infographics created with InfoNice using small multiples design.

Linking and Brushing

The embellished charts created with InfoNice can be easily added to a dashboard or an exploration canvas to form coordinated multiple views [19, 29]. We support linking and brushing [19] interactions to allow users to select items in an InfoNice chart to highlight or hide corresponding data in the other charts, or vice versa. The interactive infographics enable further exploration of data. In addition, our infographics are updated automatically with data refreshing as they are seamlessly embedded into data exploration and analysis systems.

INTERFACE

We aimed at designing an easy-to-use interface for users to customize marks. By clicking on an “Edit Mark” button on the top-right corner of an InfoNice visualization, users can bring up the mark designer pane on the right side and edit the marks there. Figure 5 shows the mark designer interface, including a toolbar, a preview area, a format pane, and a layout pane.

By clicking on the data-binding button (Figure 5(d)) next to an element property, users can edit its data-binding settings in the Data-Binding pane. For example, in Figure 5(e), users can set different colors for the data values of the “Region” field. By specifying the layout of the selected element based on the Inner/Outer Bound (Figure 5(f)), users can bind the length of the element to the corresponding numerical data field.

IMPLEMENTATION

We build InfoNice into Microsoft Power BI to verify our design. Power BI provides a Custom Visuals framework² that allows third-party developers to plug in their own visualizations into Power BI. Based on this framework, we implement InfoNice as a Power BI custom visual called “Infographic Designer”. The Infographic Designer custom visual has been tested and certified by Power BI, and is published in the Microsoft Office Store for end-users to download and use.

²<https://powerbi.microsoft.com/en-us/custom-visuals/>

EVALUATION

In our evaluation, we first present a set of example infographics to demonstrate diverse designs that InfoNice can achieve. We carried out an in-lab user study to understand the usefulness and usability of InfoNice for general users. Since InfoNice has been released in production (as the Infographic Designer visual in Microsoft Power BI), we solicited real-world user feedback, and also conducted an online survey to evaluate how it is used by end users in the real world.

Example Infographics

To demonstrate the expressiveness of InfoNice, we show a diverse set of example data-driven infographics created with InfoNice in Figure 2. Many of the examples are embellished versions, with customized marks, of common chart types that users are familiar with, including bar charts, column charts, and line charts. InfoNice also supports charts with multiple series and allows users to design different marks for different series. For instance, Figure 2(g) shows a multi-series column chart of sales by provinces and order priorities. There are three data series for corresponding order priorities, each represented with a different mark design.

Pictographs are widely used in infographic design to make data quickly understood and easily remembered. It is easy to create pictographs with InfoNice. We support various pictograph designs. More specifically, to represent values, users can choose either stacking of multiple icons (b, c, g, h, j in Figure 2), or stretching the continuous extent of a single icon (d, k in Figure 2). In addition to icons from the built-in icon library, users can also use images uploaded from files. Charts (b) and (c) in Figure 2 show counts of publications by different publishers. They adopt a bookshelf metaphor to convey the concept in data, and constitute the bars and columns with book images. Besides representing data quantities, pictographic elements can be used as data labels as well. For instance, the logo images of different publishers are used to label corresponding publishers in Figure 2(c).

The data binding capability is essential to achieve data-driven designs. We provide a variety of data binding methods to enable flexible and expressive infographic designs with InfoNice. Various data binding methods are used in our examples (Figure 2). Users can bind lengths or ratios to numerical values (a, b, c,

d, e, g, h, j), colors or icons to categorical values (a, c, e, g, h, i, j) or numerical intervals (d, f), and text contents to categorical or numerical values (a, b, e, i). Multiple data binding methods are usually combined to enhance the information and show different perspectives in data.

InfoNice provides the flexibility of composing chart marks with various visual elements to create more complex and highly customized infographics. By combining a few simple rectangular and circular shapes, users can get a balloon-style column chart as shown in Figure 2(a). In an example visualizing the sales of tablet devices by regions (e in Figure 2), a group of rectangles and a text box are placed within a computer icon to show the sales data. Moreover, InfoNice supports arranging individual infographics as small multiples (c, e, k, i in Figure 2) to facilitate effective comparisons among data partitions and provide a richer infographic representation. Figure 2(i) is an infographic-style list view created as small multiples to show the on-time rates of different airlines. Each item in the list is designed with a few text boxes bound to airline name, on-time rate, average delay, etc., as well as an image element showing the logo of the corresponding airline.

In-Lab User Study

We performed an in-lab user study to understand the usefulness and usability of InfoNice. Because existing tools address audiences with design expertise, there are no ideal state-of-the-art tools to compare InfoNice to. We chose to compare it to DDG³ [21] which, despite being mostly a tool for designers, somewhat overlaps in goals and features with our tool. This comparison should offer information as to the acceptability of DDG for general use as well as the value of our UI design for non-designer audiences.

Participants

We recruited 16 participants (13 males, 20–44 years old, average age = 27.25) by posting advertisements in a high-tech company, including employees and interns. We intentionally invited two designers (p6, p7), so that we can compare the experience of users with or without design background. The other 14 participants include graduate students, data analysts, managers, researchers, and engineers. They are general users who need to analyze and present data in daily work, but are not experts in graphic design and data visualization. Only two of them (p10, p12) had a little experience with Adobe Illustrator-like design tools. Regarding the use of visualization creation tools, all the 16 participants had used Microsoft Excel to create charts before. Eight of them described themselves as frequent Excel users. Six participants had used other tools such as Microsoft Power BI or Tableau. None of the participants had used DDG or InfoNice before the study.

Study Procedure

The experiment was run as a within-subject study. To reduce learning effect, we counterbalanced the order of the two tools. We used two different datasets, namely, *car sales data* and *tablet sales data*. Both datasets are tabular data with 5 columns (4 categorical and 1 numerical) and a few hundred rows.

³<http://hyecoo.namwkim.org/>

At the start, we asked participants to fill out a pre-experiment questionnaire to collect their background information. Then, the study was divided into two parts for using InfoNice and DDG. Each part started with a 10-minute training, after which the participant was asked to create infographics using InfoNice or DDG. In the training, each participant watched a tutorial video, and had a quick try using the tool to confirm the understanding of the core concepts and features. After the training, we asked each participant to complete a basic task to create an infographic-style visualization with the sales column as measure and another categorical column as category, followed by an open-ended task to further explore the dataset and create more infographics. Participants had access to the Internet in case they needed to download images or icons. The visualization creation processes were timed.

We adopted the think-aloud protocol. We observed, took notes of participants' interaction processes, video-captured all on-screen activities, and collected the visualization outcomes. After finishing the tasks, we conducted a semi-structured interview with our participants to further understand their creation process, the final visualization charts, and their thoughts. We asked the participants to compare InfoNice and DDG and provide their views on benefits and limitations of each tool. Each session lasted for about one and a half hours.

Findings

Our participants created 31 infographics with the two tools for the basic task, 16 with InfoNice and 15 with DDG. One participant (p5, male) gave up using DDG after the training phase. The average time for creating an infographic visualization with DDG and InfoNice was 15.3 minutes and 7.9 minutes, respectively. To independently assess the overall quality of these infographics, we asked 37 external volunteers to view them in random order and rate them from 1 (very poor) to 10 (very excellent). To reduce the effect of the participants' design background, we compute the difference between the InfoNice scores and the DDG scores and show the average numbers in Figure 6. The infographics created with InfoNice received higher scores than those created with DDG.

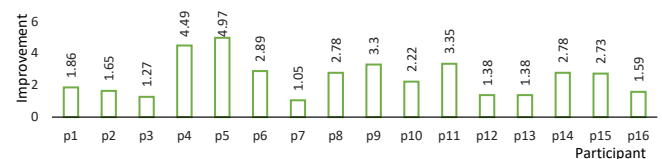


Figure 6. The overall quality improvement of infographics created by each participant with InfoNice compared with DDG.

Expressiveness: Both tools allow users to create abundant variations of common chart types, or implement more creative infographic design. Among the diverse infographics created by our participants, pictographic-style ones are prevalent, indicating that pictographs are well-received and familiar to our participants. The pictographs created by our participants rely on informative icons and various data bindings to effectively convey messages from different angles (Figure 7). During our study, we observed that in InfoNice, a set of high-level intrinsic design functions such as icon library, element repetition, and data binding greatly supported the participants

to achieve flexible and expressive designs conveniently. One participant mentioned, “*There are so many functions to use to make a very compelling infographic chart. I can either create infographics quickly following the tutorial, or create a wide variety of creative infographics by combining these functions diversely (p13, male).*” In DDG, participants heavily relied on the low-level functions to create expressive designs, requiring proficient design skills. Usually for general users, the expressiveness of infographic designs will be constrained by their drawing abilities. In our study, many participants (11/16) were not satisfied with the shapes they drew. On the other hand, with its freeform drawing capability, DDG provides more design flexibility and enables users to create more complex infographics that cannot be achieved with InfoNice, such as the infographics with radial layout.

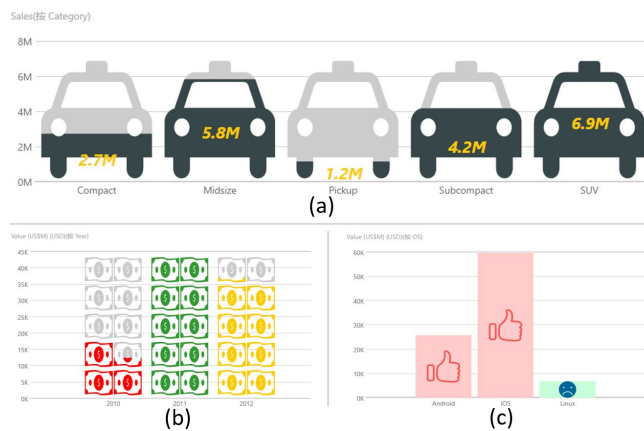


Figure 7. Infographics created by three participants with InfoNice: (a) uses car icons to show the subjects of the sales data; (b) uses money to emphasize sales data, and red color to indicate the lowest-number alert; (c) uses “thumbs up” and “crying face” icons to convey sentiments.

Usability: As commented by most of our participants in the interview (15/16), InfoNice was very easy to learn and use. From our observations, the ease of use mainly comes from two aspects. One is the inherent support of common infographic design conventions. For example, it is very convenient to create a pictograph with stacked icons in InfoNice, with only a few clicks to specify the element repetition parameters. InfoNice automatically arranges the icons appropriately, while DDG lacks a high-level design abstraction of element repetition. One participant intended to draw pictographs with stacked icons in DDG, but found that DDG generated overlapping stretched shapes out of his expectation. He had to copy the icons and place them manually, which is very tedious and time-consuming. The other is the familiarity of the operations. The InfoNice operations are more familiar to general users. As one participant pointed out in the interview, “*I can finish the infographics very quickly and easily, drag to import data and click to do customization (p7, female).*” All participants agreed it was easy to learn and operate when creating charts. “*Once I understand all the features, it is very easy to use. It is definitely much easier to think of improvements than to start from a blank page (p11, female).*” In comparison, our participants found that although they could easily find the functions

they need through DDG’s clean and concise UI design, they were not familiar with the operations. All of our non-designer participants (14/16) found drawing, dragging, and selecting were “*very difficult to control*” in DDG. However, our two designer participants found they were familiar with the DDG interface and were comfortable using it. One of them (p6, male) told us, “*The pen tool is especially similar to the one in Adobe Illustrator. I feel smooth to switch to this design environment.*” The different results according to design experience suggest that DDG might be more suitable for designers and InfoNice for non-designers.

Design Process: When using InfoNice, participants explored data and created infographics in the same environment. But for DDG, participants needed to use another tool for data exploration and then switch to DDG to create infographics. We find that such separation of tools introduces extra efforts into the design process for DDG. In our study, most of the participants chose Microsoft Excel to explore the data. When they finished data analysis in Excel, they needed to transfer the analysis results to DDG for infographics creation. The data transfer between Excel and DDG is purely a manual effort. In contrast, when using InfoNice, participants do not need to switch tools between data exploration and infographics creation. They operated directly within one system (Microsoft Power BI), resulting in a more integrated design process and much faster iterations. In our interviews, many participants (13/16) appreciated such a smooth design process enabled by InfoNice. They said InfoNice is consistent with “*users’ habits*” and “*the logic of making charts (p10, male)*”.

Designers’ Perspectives: While InfoNice is designed for non-designer users, the designer participants expressed their appreciation of InfoNice as well. They were satisfied with the capabilities that InfoNice provides to accomplish expressive designs. They especially liked the element repetition feature and a variety of data binding methods. They thought such functionalities can significantly boost the creation of pictographs. Our designer participants further commented they would like to use InfoNice in the future because “*it is easy to learn and time-efficient for creating infographics (p7, female)*”.

Limitations: Although the results show that the participants in this sample created higher-ranked infographics in less time with InfoNice, the results and insights should be treated with caution. First, InfoNice and DDG address different audiences and have different levels of expressivity and different learning curves. Our study shows an advantage of InfoNice mostly for its target audience, which is not DDG’s. Second, InfoNice is integrated within a tool that enables data analysis while DDG remains a standalone tool that only enables the creation of graphics. We did exclude the time that participants spent preparing the data in the DDG condition in our time comparisons, but we do not know how they would have performed with DDG if it was fully integrated in a data analysis tool. Third, the ratings from the external volunteers are necessarily subjective and noisy. Fourth, our participant sample comes from a high-tech company, which might have biased the results. Many of these threats to validity can only be addressed through further studies with more diverse populations.

Real-World Feedback

With the public release of InfoNice to Microsoft Power BI users, we provided a customer-support email address and encouraged users to send their feedback. In total, we have received 118 emails from 94 users by the end of July 2017. The users explicitly express positive comments in 108 emails.

Users are very impressed by the capability that InfoNice provides to empower them to create compelling infographics: *“(InfoNice is) something we have all been wanting for a long time, and in most cases, it does a great job.”*; *“(InfoNice) enables so many potential new ways of presenting our data in a new and eye-catching way”*; *“It opened the doors for me to illustrate complex information in much more versatile and easy to grasp ways.”* One user is the director of data analytics department of a company. He wrote, *“It took us some time to realize the power of this visual component, but now that my team has shown me the output. I am amazed at the capability of this visual. Simply one of the best visuals so far!”*.

Users are really delighted at the infographics created using InfoNice. They confirm these infographics can make their dashboards and reports much more attractive. For example, two participants commented: *“Our team really likes your infographic design add-in. We have found it makes our dashboards much more engaging than traditional bar charts would be.”*, and *“I’ve started using it and the results are awesome - everybody loved what they saw.”*

The users also report issues (in 48 emails) or suggest new features (in 41 emails). We utilized such feedback to improve InfoNice accordingly. For example, to solve image loading issues found by our users, we systematically refined the image processing module to make it much more robust. In response to increasing demands for supporting multiple-series bar/column charts, we quickly implemented them in a recent version to meet our users’ needs.

End-User Survey

To get a more comprehensive understanding about how InfoNice is used in real-world scenarios, we further conducted an online survey on InfoNice end-users.

Survey Design

The survey form contains three sections: Overall Experience, Features, and Usage. In the Overall Experience section, we used 14 5-point Likert-scale questions (1 = strongly disagree and 5 = strongly agree) to assess the overall functionality and usability of InfoNice. The questions are adapted from previous studies [24, 25], covering the effectiveness (in conveying messages), powerfulness (of creating infographics), aesthetics, ease of use, ease of learning, and satisfaction. In the Features section, we asked the users to rate individual features, regarding how helpful they are. In the Usage section, we asked the participants to provide information about their jobs and usage, including the frequency and the amount of infographics created by InfoNice. In addition, participants can write down what they like or dislike, and any additional comments in free text. The survey is anonymous and done online to maximize accessibility for our users. We did not collect demographic information due to privacy considerations.

Participants

We sent invitations to InfoNice end-users who have contacted us by email (94 in total). 35 of them participated in and completed the survey form, resulting in a 37.2% participation rate. More than half of the participants (62.9%, 22/35) described themselves as data analysts/scientists. Among the others, 6 were sales and marketing people; 4 came from education, government, or journalism; 2 worked in IT; and 1 was a business intelligence consultant. Note that the participants are only a small subset of the users. Additional surveys are required in the future to cover more end-users and gain a deeper understanding of their experience.

Results

Overall Assessment: The overall ratings are listed in Table 2. The participants highly rate their experience with InfoNice. On a 5-point Likert scale (with 1 = strongly disagree and 5 = strongly agree), the overall satisfaction is rated as 4.29. Almost all participants (88.6%, 31/35) would like (agree/strongly agree) to share the infographics created by InfoNice with others. Nearly all participants (94.3%, 33/35) would love (agree/strongly agree) to recommend InfoNice to others.

| Ratings | Mean | SD |
|------------------|------|------|
| Effectiveness | 4.49 | 0.56 |
| Powerfulness | 4.51 | 0.51 |
| Aesthetics | 4.34 | 0.68 |
| Ease of use | 4.00 | 0.91 |
| Ease of learning | 3.91 | 0.89 |
| Satisfaction | 4.29 | 0.57 |

Table 2. Ratings on the overall experience from the end-users.

| Feature | Mean | SD |
|-----------------------------------|------|------|
| Elements Combination | 3.84 | 0.69 |
| Built-in Icon Library | 3.89 | 0.88 |
| Upload Images | 3.95 | 0.91 |
| Multiple Units/Element Repetition | 3.79 | 0.92 |
| Fill Percentage | 3.58 | 1.12 |
| Data Binding - Text | 4.05 | 0.78 |
| Data Binding - Color | 4.00 | 0.75 |
| Data Binding - Icon/Shape | 4.00 | 0.82 |
| Small Multiples | 4.00 | 0.79 |

Table 3. Ratings of individual features (1 = not helpful, 2 = slightly helpful, 3 = helpful, 4 = very helpful, 5 = extremely helpful).

More specifically, the ratings regarding the usefulness aspects are near the top of the scale, with a score of 4.51 for powerfulness (of creating infographics), a score of 4.49 for effectiveness (in communicating data), and a score of 4.34 for aesthetics, respectively. All participants (35/35, 100%) think InfoNice is helpful and useful for them to create expressive infographics. Some participants also left comments to express their satisfaction. For example, one participant wrote, *“(InfoNice) is very flexible and gives ability to build your own charts with a bit of creativity.”* The ratings on the usability aspects are also good, but slightly lower than the usefulness scores. The participants rated 3.91 for ease of learning and 4.0 for ease of use, which indicates room for further improvement.

Features: We asked our users to rate the usefulness of the individual features on a 5-point Likert scale. The ratings are listed in Table 3. All the ratings are around 4 - “very helpful”, indicating the users are content with the features.

Usage: Answers to the usage questions indicate that InfoNice became a frequently-used tool for the end users. Nearly two-thirds (62.9%, 22/35) of the participants use InfoNice on a regular basis, including four (11.4%, 4/35) of them using it every day, seven (20%, 7/35) using it every week, and 11 (31.4%, 11/35) using it every month. Most of them (91.4%, 32/35) have created more than five infographics with InfoNice and 28.6% (10/35) have created more than 15.

DISCUSSION

Designer-oriented vs. Analyst-oriented: The creation of infographics is traditionally a job of graphic designers and visualization experts. Hence, existing infographic authoring systems are geared towards optimizing the design experience for designers. With the widespread adoption of infographics, general users, who mainly focus on data analysis, also have the need of generating infographic visualizations. As our user study reveals, current designer-oriented tools might not be ideal for general analysts without design background. New research opportunities are emerging for designing novel analyst-oriented infographic creation tools. Our work makes progress along this direction. InfoNice can be smoothly integrated into current data analytics workflows to extend its infographic design capabilities. The integration of InfoNice into Microsoft Power BI verifies the technical feasibility of our solution. Our work suggests that building analyst-oriented infographic creation tools is a promising topic demanding more research. Future work is required to deeply understand the design practice of analyst users, and further enhance their infographic design experience.

Efficiency vs. Flexibility: InfoNice seeks balance between design flexibility and efficiency. It improves the efficiency by providing inherent support for infographic design conventions. For example, users can easily create ISOTYPE-style infographics through automatic element repetition and rich data bindings. To further lower the barrier and save time for the users while keeping the flexibility, we will provide more frequently-used infographic templates in the future. Thereby, users can directly modify the templates with their own datasets and add functions freely by themselves. We will also enable more operations for users to easily control visual elements in our system, such as drag-and-drop to place individual elements. InfoNice gives users flexibility to create original visual forms by separating functions and giving users the freedom to apply. Users can combine the functions to enhance the expressiveness of the charts. However, novice users still need some time to understand the functions. Meanwhile, the design space of infographics is quite large, and we only focus on the customization of marks at the current stage. Compared with designer-oriented tools, we have more restrictions on the modifications of the layouts of marks. Currently, we only support customization of bar charts, line charts and column charts. In the future, we will explore ways to improve flexibility while retaining good usability. We will enable users to customize the layouts of the charts, and support more chart types such as scatter plot and pie chart.

Ease-of-Learning: Although our in-lab study participants gave very good feedback on usability, our real-world users

rated ease-of-use and ease-of-learning relatively lower than other aspects. This might be due to the relatively unfamiliarity of general users with the concept of “mark”. Real-world users with little or no training (compared with in-lab users receiving 10-minute training) may need some time to familiarize themselves with the tool. To further improve the learnability, we will provide more effective directions, tutorials, and examples to guide users to understand the functions of InfoNice.

Integration: Our mark customization approach avoids switching tools between data exploration and infographics creation and enables an integrated workflow (Figure 8). In our user study, our participants commended the convenience of integrating InfoNice into Microsoft Power BI. One participant even suggested having InfoNice integrated into presentation tools such as Microsoft PowerPoint. In addition to the convenience of creating data-driven visual elements, the integration of data analysis and presentation allows deeper data exploration during the design process and encourages complex infographic designs with more data dimensions.



Figure 8. The integration of infographic authoring into data analysis workflow.

Potential Misuse: As a flexible authoring tool, InfoNice enables users who are not visualization experts to create diverse infographic design variations easily. However, this might open the door to the creation of graphics that are hard to read or lead to biases due to perceptual issues that non-experts might not be aware of (e.g., the possible misjudgment of quantities from the change in aspect ratio of icons in Figure 2(d)). Our tool does not prevent this in its current version, but assisting users with these issues is an interesting area for future research.

CONCLUSION

In this paper, we introduced InfoNice, an authoring tool for designing infographic-style data visualizations. InfoNice allows users to follow an integrated workflow of data exploration, data visualization, and visualization embellishments, hence lowering the barrier to create engaging infographic design and bridging the gap between data exploration and presentation. Through flexible data binding options, users can easily bind data with visual elements and combine them together to create infographic designs. We demonstrated the expressiveness through example graphics and conducted a user study and a real user survey to understand the use of InfoNice. In the future, we will continue releasing new versions and provide more functions to facilitate users’ design of infographics.

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