Discussion paper

Past insights and future innovations in statistical communication design: towards cognitive friendly statistics

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Summary

Statistics Netherlands (CBS) is responsible for compiling and publishing reliable and high quality statistics of the Dutch society. Effectively communication of official statistics is important: it indicates the value for society. However, assessing quality aspects with respect to the design of visualizations and correct understanding of the message of statistical communication, have not received much attention yet. In this paper we aim to explore further directions of multi-disciplinary research to evaluate the quality of statistical information communication as a first step towards more cognitive friendly statistics. The central research question is how can statistical information be effectively visualized and communicated so that it is understandable and usable by the intended audience? As first explorations, several user evaluation studies are described were different types of visualizations, graphs, infographics, texts and pictures have been evaluated with various user groups. These findings illustrate relevant elements that indicate the perception, understanding and design quality of statistical information and communication products. Reflections on a holistic, interdisciplinary approach that unified guidelines for designing different types of statistical communication products with evidence based research, contributes to the development of quality framework for producing cognitive friendly statistics, i.e. an effective strategy of statistical information and communication.

Keywords

Statistical information communication, interdisciplinary approach, user evaluation studies, quality indicators, color theory, qualitative research, evidence-based research.

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1. Introduction

National Statistical Institutes (NSI's) publish statistical information on a daily basis in many forms: press releases, corporate articles on website, reports and tables. Sometimes infographics are used in a standalone form, e.g. in dashboards, or alongside the text as an illustration. The target audience for all these types of output is broad. It can be an interested citizen, a student, a journalist, a researcher, a government official, a member of parliament, etc. All of them have their own capabilities and wishes, and for all of them it is important that they understand and properly interpret our statistical publications (in whatever form) and that they can use the information for the intended purposes. Understanding how NSI's can get the message across to users or potential users, fits in the necessity that official statistics are widely considered to be public goods. NSI's need to serve the public good with statistical products who are understandable, easy to interpret and communicate accurately (Rademacher, 2020). In order to better serve the public good recent developments are aimed at including customer-centric perspectives on the use, interpretation and value of official statistics (Willis-Núñez & Potter, 2024; Nickson, 2024).

Just like any NSI, Statistics Netherlands (CBS) puts a lot of effort in the quality of the statistical data: quality is important at every stage of the statistics production process. Data collection, data sampling, processing, and estimation methods are designed to ensure that our statistics are 'unbiased and precise' (Bethlehem, n.d.). Quality frameworks, like the Total Survey Error (Groves et al., 2009; Lyberg & Stukel, 2017; Snijkers, 2016) or the GSBPM Framework (Generic Statistical Business Process Model) (UNECE, 2019; Jones & O'Byrne, 2023) are used to describe the quality issues at every step in the process. At the output stage quality criteria like timeliness, relevance and clarity are used (Eurostat Statistics Code of Practice) (Eurostat, 2017; Marker, 2017).

Quality aspects with respect to statistical communication designs are less prominent and have not received much attention yet. At CBS, we are expanding quality assessment to the final stage of the production process: statistical communication. This aligns with the European Statistics Code of Practice as in addition to the quality criteria for statistical information itself (such as relevance, timeliness, etc.), Principle 15 (Accessibility and Clarity) on page 18 states that "... statistics are presented in a clear and understandable form" (Eurostat, 2017) . However, what is meant by this is not specified.
We state that it is not always clear how published information comes across and how this in turn effects the understanding and interpretation of the published statistics. As presented at the 2023 Conference on New Techniques and Technologies for Statistics (NTTS) (Tennekes et al., 2023), we suggested several research directions that can improve the effectiveness of (visual) communication of NSI's. Although it may seem a trivial question, surprisingly little research has been done in this direction. Research has been done in several academic disciplines, such as information visualization, statistics, computer science

(information theory), science communication, and social psychology, but a holistic, interdisciplinary, approach is missing (Tennekes et al., 2023). In the 2023 NTTS presentation we encouraged the official statistics community to study how users perceive, interpret, and use their statistical information, and to develop methods and guidelines to elevate and assess the quality of statistical communication.

In this paper, based on the presentations for the NTTS of 2023 and the recent presentation for the NTTS of 2025 were we reflect on future developments (Stoel et al., 2025), we suggest an approach of combining several research directions that can improve the effectiveness of (visual) communication designs of statistical information. Several empirical research studies describe in an explorative way methods from different disciplines that can be applied in evaluation of different statistical communication designs and obtain innovative insights about the effectiveness of these communication strategies.

This paper reflects on several research directions that contributes to understanding the effectiveness of statistical communication designs. We describe some results from user experiences evaluations conducted within a pop up test setting of several communication designs of statistical output products. These exploratory empirical studies have been undertaken to evaluate methods to study and reflect on quality indicators of statistical communications at CBS. Section 2 describes different academic fields that relate to the quality of statistical communication designs and points out the necessity for a multi- disciplinary approach on studying statistical products from a user centric perspective. Section 3 presents main findings from several explorative user experiences studies conducted in collaboration with several departments from CBS. In Section 4 the main findings from these user studies are summarized and reflected in relation to the need for guidelines and evidence based research. Section 5 outlines further research and national and international collaboration.

2. Quality of a Statistical Communication Design: A multi-disciplinary Approach Application

Surprisingly little empirical research has been conducted to evaluate the quality of statistical communication. As for visualizations e.g., publications presenting new visualization techniques in high-impact journals often include a user study in which the proposed method is compared to alternatives. However, such studies typically have a narrow scope and rarely address all relevant aspects of quality. A notable exception is the work of Cleveland and McGill (1984), who systematically and empirically investigated how people perceive different visual variables. Their main finding was that some visual encodings are interpreted more accurately than others. For example, position along a common axis (as in bar charts) is perceived more accurately than angle (as in pie charts). This line of research was later extended by Heer and Bostock (2010), who confirmed and refined these findings. Already in 1988, Snijkers introduced the findings by Cleveland and McGill at CBS, but without any systematic, empirical follow-ups (Snijkers, 1988).

To the best of our knowledge, there are no empirical studies yet about the quality of statistical communication in general, including all output formats e.g. articles. Publications have not been tested for aspects such as clarity and understandability. One of the first challenges is unambiguously determining relevant quality criteria for these communications. This is certainly not trivial. For example, just as our statistics should be 'unbiased and precise', we could also state that statistical publications of CBS should be correctly interpreted, which may depend on user characteristics, like interest and background knowledge. Also, the communication format affects how the information is interpreted. Recently, some statistical researchers at CBS indicated that they were struggling with all communication formats used for their statistics, like Statline tables, quarterly articles, various dashboards, long and short web articles, etc. They were wondering what format would work best for specific user groups; do they correctly understand the communications, and if not, how can it be improved?

Additionally, the attractiveness and accessibility of publications can also be used as quality criteria: an infographic should be appealing to look at and attract attention; a table should use comprehensible, self-explaining labels, and a long paragraph of text is not accessible to read. There are therefore multiple quality criteria, and we can imagine that certain criteria maybe in conflict with each other, e.g. being short while still providing enough details to explain the statistics.
As for correctly interpreting statistical communications (one of the above quality criteria), we see several challenges. An underlying assumption is that people, i.e. users of statistical communication products, make an effort to read and process

information systematically. However, psychological research shows the opposite (Kahneman, 2011). What plays a role here is that people are reading less well and paying less attention: they have less patience for taking in and processing information. If a piece of text takes up more than one page, many people often find it too long already (Van den Eijnden, 2021; OECD, 2019; Delgado et al., 2018).

As a consequence, in a digital world, more texts are increasingly being supplemented with 'infographics'. This visual representation seems to be an appropriate design to get the message along in a straightforward and understandable, instead of long texts. However, both forms of communication designs i.e., visuals and texts- are needed and can be complementary. CBS takes these factors into account in all its standard communication with society. Moreover, in the Netherlands as well as elsewhere, we know that 'innumeracy', a lack of understanding of numbers, is a widespread phenomenon. In general, a growing number of citizens have troubles with working with numbers and interpreting them. This is also an aspect we need to deal with: we publish statistical data about the Netherlands, and as such, these data require interpretation. Here we speak of 'statistical literacy'. There has been a lot published on innumeracy and consequences of statistical and data literacy (Gal & Trostianitser, 2016; Gal & Ograjenšek, 2017; SJIAOS, 2011; Rademacher, 2020). This phenomenon is given attention by NSI's and Eurostat as follows e.g. from the conference 'Towards a More Statistically Literate Future' held by the NSI of Belgium in 2024 (StatBel & Eurostat, 2024).

The motivation to process information, as well as reading and numerical skills will vary per user and user group. Furthermore, cognitive factors, such as how our brains process information, and limitations (such as color blindness), also play a role. This requires a multidisciplinary approach. The challenge is to create communications of statistical output that is directly usable by users without them first having to learn how to work with numbers, hence create cognitive friendly statistics. New technology such as Artificial Intelligence, may help with this. In our research the focus will be on empirical research in which we put the user at the center. As for operationalizing the quality of statistical communication for different user groups, we defined the following research questions: How can we study the quality of communication designs of statistics? Which quality criteria for texts and graphics can we extract from this? Which knowledge domains are relevant here? What do these disciplines say about the quality of statistical communications? There are several approaches to study how people perceive visualizations of statistical output. The academic fields from which they originate are depicted in Figure 1. Although each approach is useful and well-thought of, an holistic, interconnected approach provides a deeper understanding of the different related aspects. The effectiveness of graph types studied by Cleveland & Mill (Cleveland & McGill, 1984) in the field of statistics, strongly relates to the visual perception and cognition of data visualization (Rensink, 2013). Information theory can henceforth be used to make design choices explicit using a cost-benefit analysis (Chen & Golan, 2016; Tennekes & Chen, 2021). The model by Rensink (2013) has a lot of similarities with the response model proposed by Tourangeau (Tourangeau et al., 2000) in the field of survey methodology, where the aim is to design and systematically empirically study the comprehensibility and

answerability of questionnaires, i.e., evaluating and pre-testing questionnaires (Vis-Visschers & Meertens, 2013; Giesen et al., 2010; Oksenberg et al., 1991; Snijkers, 2002).

As indicated above, the void in empirical research and developments of an overarching quality indicator framework can be filled with a multidisciplinary approach. Some relevant highlights from the NTSS presentation 2025 (Stoel et al., 2025):

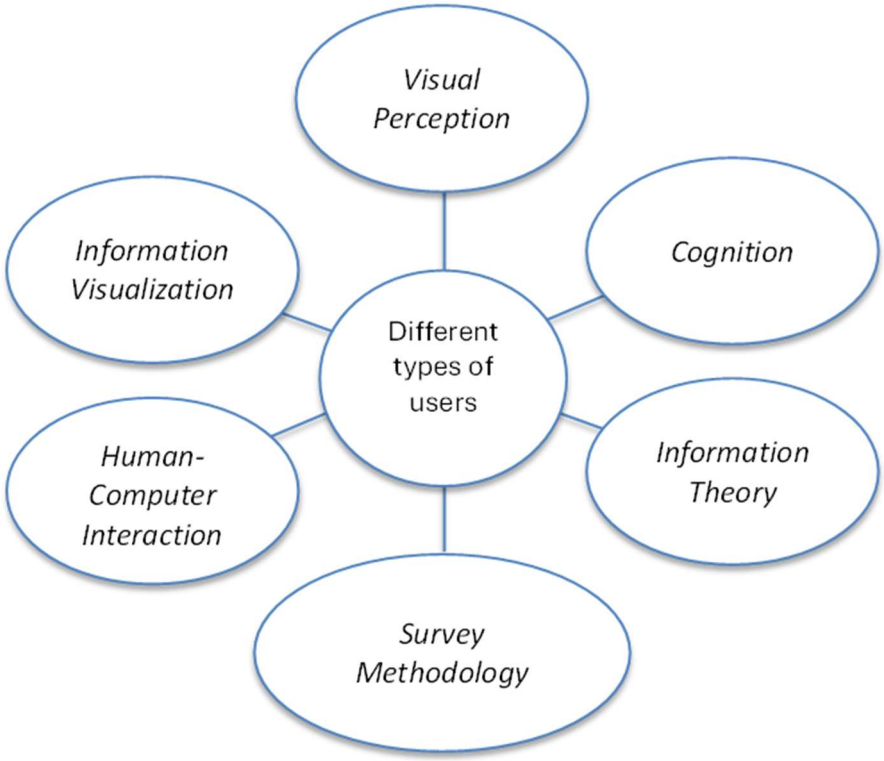
- No routine yet for empirically studying the quality of our publications.
- Extend the quality framework to the dissemination stage.
- Developing relevant criteria and indicators is challenging!
- Operationalize the quality of statistical information communication (for different user groups).
- Develop methods to measure the quality of the communication.
- Propose evidence-based ways to improve the quality, if needed, e.g. by means of user-studies.
- Foster collaboration with academia and other institutions.

We advocate that any quality framework for statistics should be extended with communication design. This will increase the understanding and the impact of official statistics. The CBS research theme 'Statistical Information Communication' is a first step towards more evidence-based communication designs.

These results of research among users contribute to knowledge and a preliminary attempt of best practices as well as guidelines for designing statistical information output products. An important topic related to this is further research and applications in both textual and visual communication of uncertainty of statistics (Snijkers, 2002). Although not generally communicated and acknowledged, statistics are estimates based on measurements, so every statistical estimate has an accuracy and a bias. An important part of communicating statistics should therefore be how to communicate its accuracy, potential bias and applicability. NSIs have the obligation according to the European Code of Practice to be clear on the quality of the produced numbers (Eurostat, 2017), but are traditionally cautious in communicating the uncertainty surrounding their statistical figures for various reasons. Firstly, they fear it may be too complex for the audience, although some studies indicate that users understand uncertainty measures (Tak et al., 2013; De Jonge, 2020; Van der Laan et al., 2015). Secondly, NSIs assume it might dimmish trust in the statistical institute, since the numbers are "less certain". This assumption should be tested and furthermore, a case can be made that the opposite might also be true. It might help in explaining differences in early preliminary figures and final figures. Understanding the cognitive perception of statistical information and communication products, resembles designing a data visualization as similar to designing and evaluating survey questions. Visual design and usability have a lot of influence on how users interpret, understand and respond (Toepoel & Dillman, 2011). Empirical studies of the underlying cognitive processes in the response model (Tourangeau et al., 2000) can help to understand perceptions of visual statistical output also from a UX testing perspective (Collins, 2015; Geisen & Bergstrom, 2017). Herewith, we can answer questions like: How do people perceive the (visual) communication of (visual) statistics? How can we ensure that users correctly understand how to read and apply the information we

provide? Have we taken the perspective from different users? And do we know what is needed in order to maximize understanding and proper use? Figure 1 illustrates these academic disciplines that are related.

Figure 1. Statistical Information Communication: related academic fields.



We do think, that based on the research in each of this discipline, insights can contribute to a holistic interdisciplinary approach to understand effective statistical communication information.< Figure 1 about here >Figure 1. Statistical Information Communication: related academic fields (Tennekes et al., 2023). In the next section we present results from some user studies that were applied to evaluate several statistical communication design. These empirical results based on a user centered perspective reveals evidence based research that fits into the interdisciplinary approach that was elaborated above.

3. User Evaluation Studies: Some First Explorations Discussion

In recent years, several studies have been conducted to explore methods to evaluate the perception of several types of statistical communication designs with different types of users and user groups. Their aimed is twofold: 1) to assess how users interpret and interact with these communications, and 2) to study the methodological design of these studies. These studies were initiated from different departments of CBS as well as from the research group. These results lay the groundwork for future research, as well as the basis for identifying relevant quality criteria.
A first study was conducted in 2017 on the interpretation of the word ‘most”' by (Krol, 2017). In this ad-hoc experiment, SN colleagues were asked to interpret the phrase: “In a jar of marbles of different colors, most of them are red.” Responses were split, with about 2 out of 3 of the respondents understood the term to mean ‘more than other colors’, while about 1 out of 3 understood the term to mean ‘more than half’. This indicated that even simple terms that seem straightforward on the surface like "most" can be understood differently.

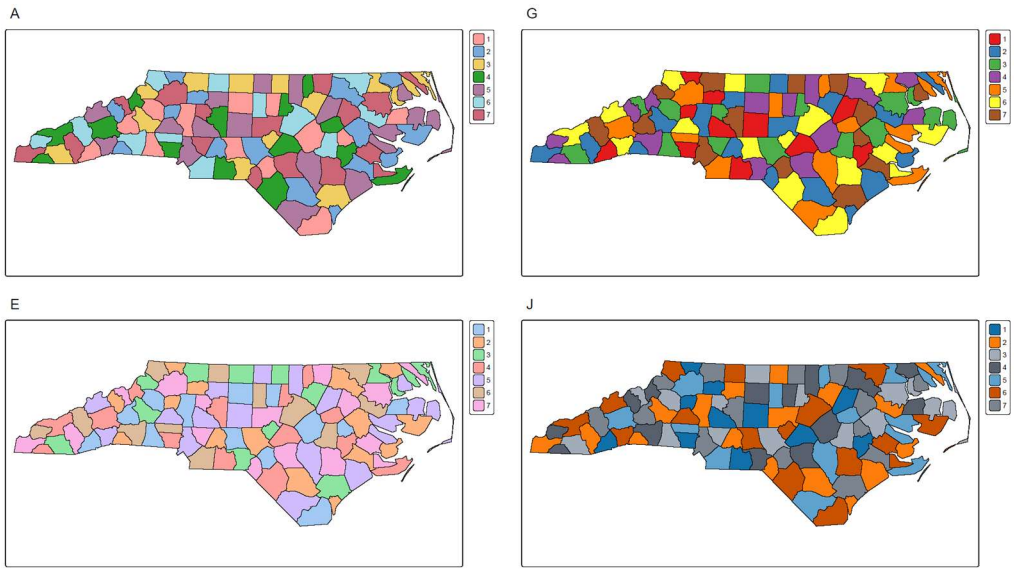
A pioneering study by de Jonge in 2020 (De Jonge, 2020) is a review of methods for communicating uncertainties in official statistics. It discusses verbal, numerical and visual ways for communicating the accuracy of official statistics. It refers to several user studies that indicate that many users, including less experienced persons, have an understanding of the uncertainty that is associated with statistics. The study introduces several ways for displaying uncertainty measures in statistical graphs and visualizations that proofed to add value to users and clarifies that statistical offices produce statistics. Visual methods include error bar, error bands, hypothetical outcome plots (HOP) and complementary cumulative distribution frequency (CCDF). The efficacy of and how statistical offices apply these communication methods for the accuracy of their numbers still has to be assessed.

Another exploratory user research was conducted on the Consumer Price Index (CPI) (Bongers & Hoogendoorn, 2024). In this study we focused on improving the usability of the CPI information in 2024 on the CBS website. The research identified several issues and positive aspects of the user experience, with a specific focus on CPI-related content. A mixed-methods approach was employed, with both qualitative (in-depth interviews, usability testing) and quantitative methods (expert review, usage statistics, keyword research, feedback analysis). The participants consisted of journalists and expert users. The results showed that the findability of CPI content was severely limited by the quantity and overlap of pages, leading to negative search experiences. Expert users preferred raw data without interpretation, such as Statline tables. They were less interested in statistical communication designs like dashboards, i.e., visual representation of subthemes that are connected to CPI, and longreads, i.e., several documentations including textual explanations and background of methodological and quality indicators. These designs had an overload of content that was not appropriate and

did not match the questions they had and the statistical information these types of users needed. Less experienced users, on the other hand, would like to find in an accessible way, summaries and interpretations, such as in CBS news releases. The news reports were perceived as valuable because of the interpretation they contained of the data, via visualizations and accompanying textual explanations.

From the research field on visualization and color perception, CBS conducted an exploratory study on color perception in graphs. Choosing suitable colors for a chart is far from trivial for several reasons. Each person receives colors differently and moreover, there are people with color vision deficiency. Users need to distinguish the colors sufficiently from each other and also from the background color. If all objects in the graph, e.g. lines, need to draw an equal amount of attention, it is preferable that the line colors stand out about equally. These aspects have been brought together in an interactive tool called cols4all (Tennekes & Puts, 2023). Via this tool, which is embedded in the R package cols4all, researchers and designers can analyze color palettes and find proper trade-offs between the mentioned aspects. In the conducted user study we focused on how well colors can be distinguished from each other in three graph types: categorical maps, line charts, and scatter plots. We selected these types because they represent the three elementary objects: areas, lines, and points. We presented each graph type in four color palettes (each consisting of 7 colors) and asked the participants how well they could distinguish the colors and how much they liked the colors, both measured on a 5 point Likert scale. The participants were from the same pop-up test as described below in the evaluation study of the booklet (in total 33 people, mostly between 12 and 14 years old and a few adults (teachers). From a color blindness test we found that one participant was likely to have color vision deficiency. This case was left out of the analysis. An example of four color palettes applied to a map is shown in Figure 2.

Figure 2. An example of four color palettes applied to a map



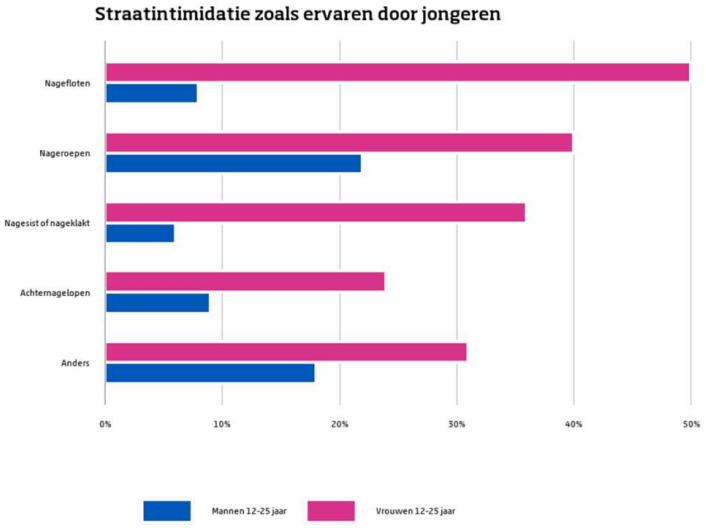
An example of four color palettes applied to a map. A set of 20 color palettes from cols4all were tested, and also our own corporate color palette. The palettes were

selected to achieve a wide variety of palette types. This is illustrated in the example with one palette consisting of saturated colors (G), one with pastel colors (E), one with several dominant colors (J) and one that was optimized for color blindness (A).Our hypothesis was that softer, pastel colors palettes were preferred over more vivid/saturated color palettes when applied to maps, and the reverse when applied to line graphs and especially scatter plots. We expected this because for lines and especially points the colors need to stand out more than for maps because the objects are much smaller. One of the surprising outcomes of this experiment was that on average, participants actually preferred the pastel palettes for line charts, also for distinguishability reasons. Another finding was that it was hard and sometimes impossible to distinguish the colors in scatter plots. Even the most saturated palettes with the highest contrast between the colors did not work well. Our final take away is that the preferences and also the ability to distinguish colors from each other varied a lot between persons. About half of the participants who saw Figure 2 preferred A and the other half G. An important lesson learned to conduct these kind of experiments is to control the environment as much as possible. In one group, we found that the participants on the window-side of the table preferred the brighter colors palettes and those on the other side of the table preferred the darked color palettes. Ideally, these varying lightning conditions should have been taken into account. In summary, this study highlighted the need for more thoughtful color selection in data visualizations, particularly in regard to accessibility (e.g., color blindness and color deficiency).

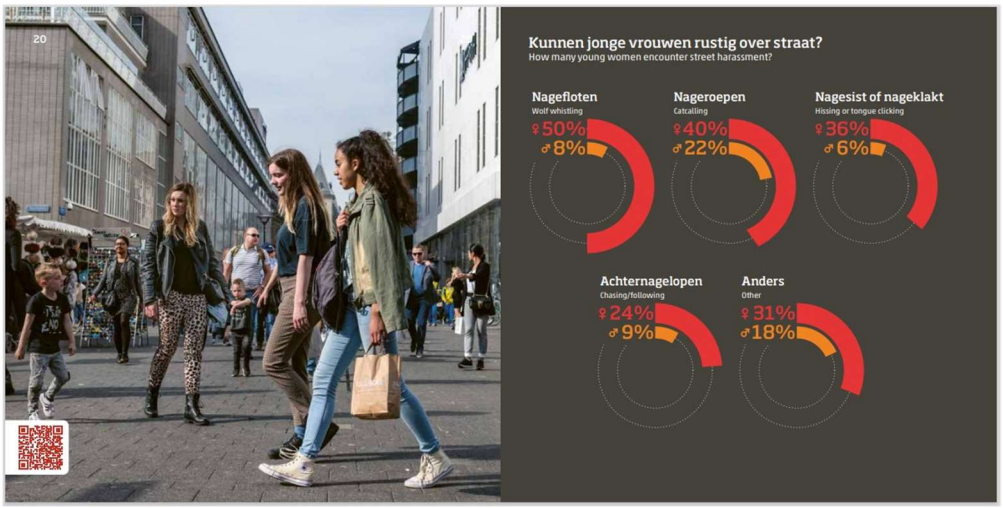
At Statistics Netherlands, the user experience team of the Communication Department and the Methodology Department collaborated to explore how to improve publications by combining different perspectives on visualizing statistics. An exploratory pop-up test was conducted in 2023 in a fast food restaurant in downtown The Hague. Up to 17 people were recruited form the streets and interviewed and observed in their reaction to visualizations (Krol & Bongers, 2025; CBS, 2022). The differences between the methodological and user experience perspectives were playfully highlighted: an attractive infographic from the communication department was juxtaposed with its ‘boring’ but functional bar chart equivalent. These visualizations depicted street harassment. About half of the participants was first confronted with the bar chart and thereafter introduced to the infographic, while the other half started with the infographic and concluded with the bar chart depicting the same data. The attractive infographics with accompanying stock photos, were presented in a booklet Netherlands in Numbers version 2022 (CBS, 2022), see figure 3.

One of the results of the small-scale experiment was a lot of inspiration that flowed around as researchers were confronted by a different perspective on conducting research by their colleagues of the other CBS department. Another result was that no ’’ One Size Fits All’ visualization was found. Some participants understood the infographic better, others found the bar chart easier to read. Information overload was a real risk in the infographic, were for some participants the data surrounded by a lot of (fun) details was overwhelming. Another finding was how much attention the accompanying stock photo demanded, and how details on the photo were connected to the perceived message in visualization.

Figure 3. Bar chart versus infographic of street harassment



10



9

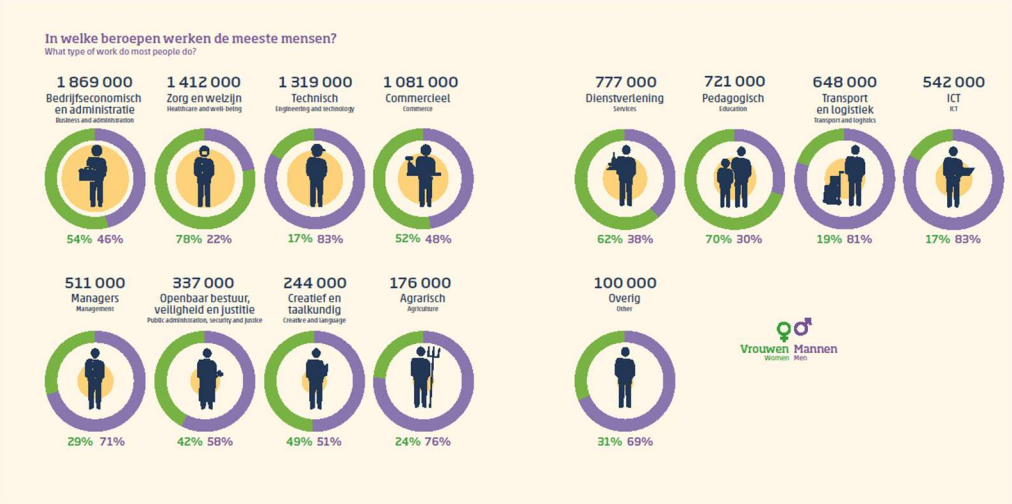
This study inputs the discussion on challenges in design choices and communication strategies of visualizations and emphasizes the need for further research on bridging the gap of perspectives in design of boring versus attractive visualizations at Statistics Netherlands (Krol & Bongers, 2025). The booklet 'Netherlands in numbers' (CBS, 2022; CBS, 2024) is a yearly publication on paper that includes graphical representations of statistical figures of a number of various themes relevant for Dutch society. These infographics represent visuals and figures of the recent year, i.e., 2024, as well as trends to give historical context of developments like demographics, green energy, prices etc. In developing and designing the booklet, the combining expertise in graphical design and visualization methodology improves yearly and appeared to be a fruitful approach and strengthens connection between methodology and communication departments. A challenge here is in finding the optimal balance between esthetics: how nice does the visualization look and functionalism; how rigorous is the visualization and how is this perceived by the Dutch public? To answer these questions the complete booklet from the anniversary edition 2024 (CBS, 2024), i.e. CBS celebrates its 125th anniversary, the infographics and additional pictures and

texts, were evaluated in a number of user evaluation studies. In 2024 and 2025, several pop-up tests were held on two coffee bars at Central Station of Utrecht and three user experience studies with youngsters at the Questionnaire Lab at CBS in Heerlen. These user evaluation studies were designed and conducted in a pop-up test setting were different types of users gave impressions on how they perceive, judge and to what extent they understand infographics, pictures and the statistical information that these infographics in the booklet communicate (Meertens, 2024; Meertens et al., 2025). Recruitment took place via different routes, one with help from a professional and experienced organization that recruit participants direct from the street. Another route with help from an organization that facilitates secondary schools to give pupils opportunities to visit several organizations like CBS, to convene them with different job possibilities. These pop up evaluation studies with youngsters took place at the Userlab of CBS. This is a room with test facilities where survey questionnaires, advance letters and other communication products like Apps and survey landing pages etc. are cognitively tested and evaluated with participants with different backgrounds.

In total, with 42 persons aged between 12 and 72, the booklet and specific infographics were evaluated. These participants have different background characteristics with respect to gender, educational degree, types of daily main activities and occupations. A protocol was written in which the structure and formulation of evaluation and probing questions was prepared like standardized probes and instructions on observations of (non-) verbal behavior. This group of 32 participants participated in an interview of about 20 minutes in which the booklet in general and specific infographics on selected pages were evaluated. A protocol based on the quality framework for cognitive interviewing studies, i.e., CIRF (Vis-Visschers & Meertens, 2013) guided these evaluations in design, approach and reporting and summarizing results. Methods that were used were cognitive interviewing techniques like i.e., standardized and spontaneous probing, in combination with observational of (non-) verbal behavior that could be used as input for additional evaluation questions or probes (Willis, 2005).A number of specific infographics were discussed as well as an evaluation of the general impression of the booklet. Special attention was given to visual aspects like the colors, icons, the chosen pictures, and the content of the subjects, as well as the style and formulation of the texts in the headers and labels. Participants were invited as a first step to browse through the booklet and mark everything that draws their attention. In a second step these remarks were discussed. Many interesting reactions, spontaneous quotes and opinions came around during these interviews. In a final step, specific infographics were evaluated with asking additional questions about content and understanding. For some a clarification was tested to give participants a little assignment about the content of the infographic for example can you tell how many women are working in health occupations?

Below, we share some most interesting findings that reflects the challenges of finding the optimal balance between esthetics and whether the visualizations is perceived and understand correctly by the Dutch public (Meertens, 2024; Meertens et al., 2025). First, some results from the user evaluation study with a visualization on occupations is described. See figure 4.

Figure 4. Infographics of number of men and women working in different occupations in the Netherlands.



Infographics of number of men and women working in different occupations in the Netherlands (CBS, 2024).This infographic includes the header text; what type of work do most people do? The visualization with circles and icons show percentages of men and women working in different types of occupations in the Netherlands. This infographic covers two pages in the booklet 'the Netherlands in numbers'. In general, most respondents appreciate the chosen colors green and purple. Also, using icons for different types of occupations is positively evaluated and appreciated. The circles and background color is perceived as easy, relaxed and with a good type of contrast. However, up to 10 respondents does not find the chosen colors logical to identify men and women, they would have preferred more stereotyping colors like blue and pink. Two respondents with color vision deficiency mention that they do not see the purple color. Also based on the observation of participants' behavior when looking at this infographic that covers two pages, it appeared that more than half of the test persons switch their head to the right and then at the end see finally -in a relative late stage-, the legenda with symbols for men and women. They spontaneously mention or asking to ratify that they recognized that these symbols and color resemble gender differences in percentages? They recognize this at a relatively late moment as it is crucial information needed to interpret and understand the message of the numbers, percentages, icons and symbols. They preferred that it would be better or more logical and understandable to include this information from the legenda at the start of the infographics.

In addition, participants asking whether it is too stereotype to use symbols for men and women and also the necessity to include more diverse groups. For example, participants noticed that a person with longer hair that resembles women and the choice for an IT employee and manager is a male person with a tie, and a male doctor for medical occupations. A spontaneous reaction from a women working in a hospital saying with a little disapproval in her voice, "it is a male doctor, while the nurses mostly women, do most of the hard work". In general, almost all respondents, on behalf of those without a job yet, were looking up themselves and expected the numbers to resemble the amount of women or

men as they are experience in the occupational field they are working in. Participants had remarks about the texts that were used to label the occupations in the educational fields. The term ‘education’ was used in Dutch with ‘pedagogisch’, in English; ‘pedagogical’, and fostered some reactions among participants who are working as a teacher in primary school, high school or secondary education. Pedagogical does not cover the work or content of the work they do as a teacher. According to the participants, ‘education’ seems to be a more appropriate term. Comparable with the finding of interpreting and understanding symbols in the first, pop up test, results resembles the findings among the 30 pupils in pre-vocational secondary school aged between 12 and 15 years. A relative larger amount of them, did not understand the symbols ♂ and ♀ correctly.

Figure 5. How many people have good oral health



In this visual, information is shown about the level of oral health between men and women. Some pupils did not know what the symbols ♂ and ♀ mean, others knew that they resembles men and women or girl and boy, but did not know which symbol belongs to which group. Some mention that a legenda that explains the symbols is necessary to clarify, while other suggest to use other types of symbols like those used on doors in the toilet rooms would be better while these are those that “everybody knows”. Also the term ‘oral health’ in the header was differently interpreted, some thought it is about good or bath brushing of teeth, while others thought it was about visiting the dentist. As such the term oral health is not clarified in the header nor in the visualization.

These user evaluation studies of both types of infographics, occupations and oral health, showed that, the used icons, the colors and the style of language in the header or title, determines how statistical communication and information is perceived, evaluated and judged. As the context of the message triggers curiosity or if it leads to astonishing or negative perceptions than the message may become irrelevant? As an infographic has a goal to ‘trigger’ citizens in a way to be ‘neutral’

as a statistical office should be to inform the public and maintain trust in government, data and statistics, (Willis-Núñez & Potter, 2024). In general it is a guide line that appears from reactions that the style of the chosen icons and texts accompanying the perception of the message of the statistics next to the interpretation. In this example the question is whether the icons and place of the legenda aid or hinder correct interpretation? The results shows that a legenda is to guide or help users to understand statistical information products. Also we found that users not would like to put additional or much efforts in reader or understanding an infographic. They expected that the place of the legenda is logical and facilities to understand the message of the infographic immediately, i.e., it is cognitive friendly.

The term ‘cognitive friendly statistics’ does not appear in the literature yet as far as we know. We define cognitive friendly statistics (CFS) as: statistical information communicated in such a way that it aligns with human cognitive processes, resulting in enhanced intuitive understanding and reduced misinterpretation and bias. With cognitive friendly statistics, the aim is to bridge the gap between statistical complexity and human understanding. This involves designing and communicating statistics in ways that align with how people naturally think, perceive, and make decisions.

Another finding based on users’ reactions is the linkage with peoples aim to ‘personalize’ figures and the identification principle. As we found that people were looking up to find themselves, i.e., the occupations they were working in, as well as their gender, reflecting their situation. This can be linked to universal phenomena of psychological mechanisms that people are likely to identify themselves in comparison with others that resembles themselves in social, economic or gender groups (Allport, 1979). Apparently, this mechanism is applicable in relation to statistical communication designs. The features of the visual design like the chosen colors of purple and green as well as the features of the participants like color blindness or color vision deficiency, illustrate that these empirical findings can help to create statistical output from a users’ perspective.

As with the user studies of color as described above, these outcomes highlighted the need for more thoughtful color selection in data visualizations, particularly in regard to accessibility (e.g., color blindness and color deficiency). Focusing on the demands on accessibility guidelines of governments to communicate cognitive friendly statistics, appeared to be a relevant theme for further research (W3C, n.d.). It could be an option to produce different types of output for different types of users like a color blindness or friendly statistic.

4. Conclusions

The primary objective of these explorative users evaluation studies was to determine how different users understand, interact and evaluate communication designs of statistical products. These studies lay the groundwork for future research on the development and use of methods that triangulate different types of qualitative and quantitative studies and experiments. The used cognitive methods in survey methodology that assess the quality of survey questionnaires, appeared to have potential applications for evaluating statistical communication designs.

In common, the findings out of these explorations on user centric approaches, revealed an overall conclusion that verifies the statement that there is no 'one size fits all' way of communicating statistics, as well as the potential risk of information overload when 'embellishing' statistical information. We observed that photos of people next to the infographics attracted or even distracted attention and could influence the information's perception and content. Also we found that different purposes require different visualizations. On the other side, we also found some insights that serve as a first number of quality indicators, and input for future research projects. A general observation is that people use themselves as a reference point: they try to place themselves in a graph. The consequence is as a recommended general practice that when designing a graph, inclusivity is needed: make sure that all major subgroups in society are presented in one way or another. Also the choice in the formulation of headers or labels of categories does matter. In addition, it was demonstrated that it is necessary to have a legend with a graph and even if it seems trivial an important recommendation is that used symbols can be understood at all times and by all people.

As their goal is to contribute to a straightforward comprehensiveness of an infographic, as such the words need to be carefully chosen as they need to fit to people's perception and communication style. However, in case that those words or formulation of texts initiate reactions or evoke discussion among users, it might lead to unforeseen doubts of the correctness of numbers in the graphs or infographics. This should be avoided as much as possible as it is a potential risk of inappropriate misunderstandings and not advisable in relation to developments of mistrusts of news, data and information of governmental institutes i.e, such as NSI's (Rademacher, 2020).
As for the use of colors we found that in theory a palette of colors may seem to work well, in practice, when presented to people, the conclusions are not that strong. This points at the relevance of conducting empirical user-based evaluation studies.

These findings still need to be backed up with quality indicators as discussed in the literature, but they illustrate the need to a systematic approach to verifying the correct understanding of statistical communication products. It is the challenge to inform and educate all type of users about statistical information and output to

understand the statistical content in a comparable and informative way as well as in unambiguous way.

A key takeaway in current area of growing resources of data and information, risks of public mistrust and information overload, is the essential need for methodological and visualization guidelines in designing infographics to increase the likelihood of correct interpretation of the statistical information provided. These empirical results from a user perspective, reflecting the challenges of choices for visual design aspects versus understandable and comprehensible infographics. The collaboration between different disciplines could be an inspiration to other organizations that are dealing with the question on how the combat statistical illiteracy and how to foster accurate understanding of statistical information among the public, i.e., serve the public good (Willis-Núñez & Potter, 2024; Nickson, 2024).

5. Further Innovations and Research Directions

At CBS, as stated above, we realized that there is a void in the quality framework, which needs to be extended to the dissemination stage, not just in a theoretical way, but by systematically conducting empirical research focusing on the user. As such, in 2024 the research program focusing on statistical information communication was established. As discussed in section 3, a number of pilot studies have been conducted as a start, in order to get a feeling of how this research can work in practice. In the next years we intend to expand this kind of research.

First of all, we communicate the existence of this program within CBS, in order to find internal clients from different departments, and to see if there is a need for such research. Internal discussions indicate that there is definitely a need for this kind of research. Every time when we discuss this topic, colleagues who are involved in producing publications (in any form) respond in very positive way, and find this very interesting. In addition, they indicate that they would like to know better how to communicate, with the user in mind, and propose concrete topics for new research projects.

At the moment of writing, three projects are being set up in close collaboration with CBS colleagues. These projects focused on:
1) The total package of all publications on labor market statistics. This is a very relevant topic for which the number of publications (in various formats) has exploded in recent years. The research questions here are: Are all these publications used, is there a demand for all publications? Who uses specific publications? How are they received and comprehended? And, how are press releases stated in the media? This study should result in recommendations on how to improve this package of publications, and working towards a user evaluation tool.
2) Studying the information that is presented in dashboards, in particular dashboards used by CBS UDCs (Urban Data Centers). The research questions here are: does the dashboard present the relevant statistics? Is anything missing? How do users interpret the presented indicators? And, how can the presentation of statistics be improved, if needed?
3) Communicating margins of uncertainty. In recent discussions it turned out that colleagues from statistics departments are struggling with this: How to tell a wider audience that the numbers are statistics with margins of uncertainty? In what cases is this essential to tell? Can we develop some guidelines for this, so that we don’t need to discuss this internally again and again? And, how does this affect trust in statistics?

For these projects we can build on the experiences we have thus far, as discussed in section 3. It is our intention to use a mix of methods to study these research

methods, including user evaluation methods, analyzing web access data, face reader software and eye tracking, content analysis, among other methods.

These projects and their related research questions indicate the relevance for studying statistical communication designs. By conducting these studies, we get more experiences with the use of various methods, and we will get insights in quality criteria as used by users. This will be input for a quality framework for publications, thus working towards cognitive friendly statistics. It goes without saying that for all projects the relevant literature will be studied.

In addition, the linkage with national and international projects and initiatives will broaden this research field. We foster collaboration, with universities and consortiums in the Netherlands, like the Research in Science Communication and Society department at Leiden University, headed by Prof Dr. Ionica Smeets (who discussed science communication at the 2025 ISI Statistics World Congress, International Statistics Institute). Abroad we collaborate in a research project on evaluating data visualizations with eye-tracking, supervised by Dr. Mojca Bavdaž of the University of Ljubljana, School of Economics and Business (Bavdaž et al., 2025).

Also we would like to mention the participation at international conferences like an Innovative session at the 2025 ISI Statistics World Congress: “Making the communication of statistical information a priority. What is needed and how can we collaborate?” This was an inspiring session that supports the importance and relevance of research on communication of statistics and evokes further directions for research projects. Next, we present results of a recent conducted user study on dashboards in a upcoming session of the Annual Meeting of the Expert Group on Dissemination of European Statistics in November 2025, online meeting.

Furthermore, there is the linkage with other projects, initiatives of Eurostat and the UN, like contributions in Effective communication of Statistics (2020), and Eurostat’s Communication and Dissemination Strategy 2021 – 2024, as well as participation in Eurostat projects like Communicating Uncertainty In Key Official Statistics and the 2024 Statistics Belgium/Eurostat conference ‘Towards a more statistically literate future’ (StatBel & Eurostat, 2024).

We would like to encourage other NSI’s to share initiatives or projects that study how users perceive, interpret and use their statistical communication products as well as to develop guidelines to evaluate the quality of statistical communication. We invite readers to engage and respond with their perspectives and views. A joint adventure can help to understand and create guidelines and ‘best practices’ of evidence based knowledge that serves an overarching goal of cognitive friendly statistics.

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Explanation of symbols

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