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DATA VISUALIZATION – THE EFFECT OF GRAPH ANIMATION ON PERSUASIVENESS

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ABSTRACT: To make data visualization more attractive, not just color or different shapes are used, but also animations are nowadays added to graphs. Software tools for data visualization use different representation styles or display features and include animation in the data visualization process. Until now, the positive effect of different representation styles has been taken for granted in practice. However, this raises the question of the extent to which such representation styles are effective and what results can be seen in research in this regard. A literature review on data visualization is given to examine this in more detail. It was considered to what extent there are already findings on whether animated graphs have an effect on consumers' behaviors. In the following work, we mean by an animated graph, a graph that is not visible from the beginning. Instead, the graph builds up over time. This way, motion is added to the graph. The literature review shows that data visualization has been studied more frequently in some areas. In marketing, this has received less consideration so far. Animations in graphs have not been studied much in the literature.

KEY WORDS: *Animation; Persuasiveness; Data Visualization.*

1. INTRODUCTION

In the era of big data, various visualization formats for the large amount of data are very common and often used. There is different software for data visualization with diverse representation styles (Camm et al., 2017; Caughlin & Bauer, 2019; Ertug et al., 2018). The representation styles can vary in several attributes. These attributes must be specified when creating data visualization, especially graphs. One of these attributes can be the display mode. The display mode of a graph can be animated or static. In a static graph, no additional motion is added to the graph. It is like an image, and all the information is fully visible from the beginning as soon as the graph is displayed. There are several ways how animation can be added to a graph. In this work, an animated graph is defined as a graph

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to which motion has been added. The graph is not fully visible at the beginning. Instead, it builds up first and is fully visible only after a certain time (J. Kim & Lakshmanan, 2021; J.A. Schwabish, 2014; Zhuang & Liu, 2022). An animated graph can show the change in data over time (S. Kim et al., 2007). Other than an interactive graph, an animated graph does not allow manipulation of the data points by the viewer (J.A. Schwabish, 2014).

Apart from business contexts, graphs are also used in the everyday life of consumers. They are, for example, very important in news reporting to show election results, unemployment rates, or the latest mood barometers. These graphs are increasingly used in animated format nowadays. Instead of being just static, motion is added to the graph. Animated graphs are also sometimes used on social media platforms, for example, to inform the public (Ancker, 2020).

The presentation of data to consumers is for many companies already very common (Wandel, 1997). Non-profit organizations use visualized (static) data to encourage consumers to donate or to convince other stakeholders of their goals (Waters, 2007). But also, companies in the beauty or health industry use data to persuade consumers of the benefits of a product and to make them buy their products (Peters et al., 2007; Schwartz et al., 2007). However, as far as is known, companies have not yet widely used animated graphs in their marketing campaigns.

This paper aims to provide an overview of the state of the literature on data visualization. The main objective is to analyze the extent to which this topic has already received attention in marketing and in relation to the consumer. Furthermore, it will be examined to what extent the graph attribute animation has already been investigated.

2. RESEARCH BACKGROUND AND RESEARCH QUESTIONS

2.1 Literature results on data visualization in general

Visualization is, in general, a function that displays one or more types of data (nominal, ordinal, interval, ratio, absolute) mapped to a shape or color (Chakrabarty & Mendonça, 2010). There are different definitions of data visualization. It can be defined as the "science of the visual representation of data" (Bačić & Fadlalla, 2016, p. 78) and refers to the "visualization or representation of raw data" (Tay et al., 2018, p. 664). Data visualization is a "computer-supported visual representation of data that allows users to select the information they wish to view, and its format is an important tool for achieving this objective" (Dilla et al., 2010, p. 1). For this work, data visualization is thus defined as the graphical mapping of data (nominal, ordinal, metric) with different types of representations. This mapping should help users to select and understand relevant pieces of information. The various visualization formats should support this process.

There are a lot of different types of data visualization. The most common data visualization types are area charts, bar/column charts, line charts, pie charts, radar charts, pareto charts, maps, scatter plots, venn diagrams, and tables (Bajić et al.,

2019; Bajić & Job, 2021; Savva et al., 2011). Subcategories like donut charts, grouped or stacked bar charts, or box plots can be assigned to one of the categories (Bajić et al., 2019). There is a lot of research on the comparison of tables versus graphs (Benbasat & Dexter, 1985, 1986; Davis, 1989; DeSanctis, 1984; Frownfelter-Lohrke, 1998; Jarvenpaa, 1990; Jarvenpaa & Dickson, 1988; Lucas, 1981; MacKay & Villarreal, 1987; Remus, 1987; Vessey, 1991). Therefore, tables are separated from the other graph types in this work, like in previous studies. The different graph types can be separated between those with and those without a Cartesian coordinate system (Bajić & Job, 2023). It must be noted that graphs and graphics are not the same in this work. By graphics pictorial representations are meant.

"The first general principle in data visualization is that design and layout matter. The design and layout, including the type of chart or table used, should draw attention to the parts of the visualization that are important in conveying your message to your intended audience" (Camm et al., 2017, p. 474). The presentation format has an impact on consumers' information acquisition strategy. Graphs contain much information that needs to be understood by consumers. Therefore, the presentation format of the information must facilitate processing (Bettman & Kakkar, 1977). Visualizations help to present data more interestingly and to understand complex data easier (Archambault et al., 2015). Thereby, not only single graphics are used but also non-static or interactive representations (Bendoly, 2016). Data presented as graphs can look and be interpreted very differently depending on the scaling of the graph and its compression or elongation (Lurie & Mason, 2007). In addition, certain visualizations are often misunderstood and misinterpreted (Bendoly, 2016), or data are displayed in such a way that viewers automatically interpret them in the desired direction (Glazer et al., 1992; Jarvenpaa, 1990; Lurie & Mason, 2007). Thus, the first general principle of data visualization of Camm et al., (2017) is often not followed. Data visualization should therefore support the viewer's understanding and not overwhelm him. The animation could help reduce consumer overwhelm when viewing a graph and guide the viewing of the graph.

Since the 1980s, there has been a lot of research on data visualization and how to present data in the best possible way. In the area of accounting and management, there is much research comparing tables versus graphs and which visualization is best in which situation (Benbasat & Dexter, 1985, 1986; Davis, 1989; DeSanctis, 1984; Frownfelter-Lohrke, 1998; Jarvenpaa, 1990; Jarvenpaa & Dickson, 1988; Lucas, 1981; MacKay & Villarreal, 1987; Remus, 1987; Vessey, 1991). There are no consistent results across the different studies as to whether a table or a graph is better. Some studies show that there is no difference between tables and graphs (Benbasat & Dexter, 1985, 1986; Frownfelter-Lohrke, 1998; Jarvenpaa & Dickson, 1988), according to others, graphs are better than tables (Benbasat & Dexter, 1986; Cardinaels, 2008; Davis, 1989; DeSanctis & Jarvenpaa, 1989; Jarvenpaa & Dickson, 1988; Wright, 1995), and still other results say that tables are better than graphs (Benbasat & Dexter, 1986; Davis, 1989; DeSanctis, 1984). Other findings show that the effects vary according to the moderators (Benbasat & Dexter, 1985; DeSanctis, 1984; Lucas, 1981; MacKay & Villarreal, 1987; Remus, 1987; Vessey, 1991).

In marketing, research has so far not paid much attention to data visualization, especially not to graph animation. Research in this area is primarily limited to new visualization techniques (Klemz & Dunne, 2000; Ringel & Skiera, 2016), a literature review (Lurie & Mason, 2007), and one article on animated graphs (J. Kim & Lakshmanan, 2021). Following on from J. Kim and Lakshmanan (2021), animated graphs should be considered more deeply in marketing. This type of display mode has been studied little overall. Furthermore, when animations are considered, different types of animations are used than in this work.

2.2 Literature results on animation

Data that could be used for animated graphs is primarily time-varying data. Literature on how to present this data is mostly about static displays of financial data and decision-making (Bačić & Fadlalla, 2016; Benbasat & Dexter, 1985, 1986; Cardinaels, 2008; DeSanctis, 1984; Dilla et al., 2010; Duclos, 2015; Frownfelter-Lohrke, 1998; Jarvenpaa, 1989; Kelton et al., 2010; J. Kim & Lakshmanan, 2021; MacKay & Villarreal, 1987; Raghubir & Das, 2010).

In the literature, the use of animated and static graphics in the learning context has shown different results so far (Boucheix & Schneider, 2009; Dindar et al., 2015; S. Kim et al., 2007; Tversky et al., 2002). Meta-analysis has been conducted to better assess the effect of animated graphics. These have shown that animation often positively impacts learning (Berney & Bétrancourt, 2016; Höffler & Leutner, 2007). Animation can help to recognize trends in data. Studies that address this issue focus on outcomes like response times or error rates (Farrugia & Quigley, 2011; Robertson et al., 2008). There is literature on static versus dynamic node-link diagrams to illustrate the relationship between data points over time (Beck et al., 2017). It has also been observed that process models are better understood through animations that subjects could interact with (Aysolmaz & Reijers, 2021; see Table 1). How graph animations affect consumers has not yet been considered. Therefore, the usage of animation should also be applied to the presentation of data to consumers.

Table 1. Overview of sources on animation.

Author(s) (Year)	Animation	Dependent Variables	Hypotheses/ Research Questions
Graph Animation			
Aysolmaz and Reijers (2021)	Static vs. animated process models	Comprehension (test scores)	- Users of animation for process model visualization will have a higher comprehension performance than users of static process model visualizations. - The effect of animation on process model comprehension will differ according to the process modeling expertise of a user. - The effect of animation on process model comprehension will be greater for users with low expertise than those with a moderate level of expertise. - The effect of animation on process model comprehension will be greater for users with high expertise than those with a moderate level of expertise.

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Author(s) (Year)	Animation	Dependent Variables	Hypotheses/ Research Questions
Beck et al. (2017)	Animated node-link diagrams timeline-based dynamic approaches	State-of-the-art in visualizing dynamic graphs	- Build a hierarchical taxonomy of dynamic graph visualization and classify existing techniques into the taxonomy. - Applications for dynamic graph visualization approaches. - Bibliographic analysis of the collected publications reveals key topics and emerging trends. - Identify challenges for future research. - Feedback from the research community, based on questionnaires of experts in the field.
Farrugia & Quigley (2011)	Static vs. animated network images	Reaction time Error rates	- Hypothesize that animation will be beneficial, therefore (a) faster and (b) more accurate, in analyzing network overview tasks without time constraints. - Hypothesize that animation may be beneficial, therefore (a) faster and (b) more accurate, for tasks that require the user to follow a node throughout the network. - For localized tasks constrained by time, the overhead of interaction with the video for searching, stopping, and pausing might result in animated presentations constrained by time being (a) slower than static versions. The interaction overhead however should not impact the (b) accuracy of the results. - Hypothesize that the average response time will be (a) faster and (b) more accurate in lower-density networks than in higher-density networks.
J. Kim and Lakshmanan (2021)	Graph animation of line graphs and bar graphs	Risk judgments	- Risk judgments are greater when time-varying data are presented in an animated (vs. static) mode. - The salience of temporal transitions is greater when time-varying data are presented in an animated (vs. static) mode. - Temporal transitions are more likely to be utilized to infer risk when time-varying data are presented in an animated (vs. static) mode. - The salience and utilization of temporal transitions mediates the impact of animated display on risk judgments. - The effect of animated (vs. static) display on risk judgments through salience and utilization of transitions manifest with line graphs but attenuate with bar graphs. - The effect of animated display on risk judgments is attenuated in the presence of a global upward trend (but not in the presence of a global downward trend). - The effect of animated display on risk judgments is attenuated when investment goals reduce the association of transitions with risk (i.e., the effect will manifest for long-term but not for short-term investors).

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Author(s) (Year)	Animation	Dependent Variables	Hypotheses/ Research Questions
Robertson et al. (2008)	Gapminder Trendalyzer: Animated bubble chart	Reaction time Error rates	- Animation will be more effective than other techniques when used for presentation and less effective than other techniques when used for analysis. That is, participants will be (a) faster and (b) make fewer errors in the presentation condition. - Traces will be more effective than Animation when used for analysis. That is, participants will be (a) faster and (b) make fewer errors in the traces condition. - Small multiples will be more effective than animation when used for analysis. That is, participants will be (a) faster and (b) make fewer errors in the small multiples condition. - Participants will be more effective with small datasets than with large datasets. That is, participants will be (a) faster and (b) make fewer errors when working with small datasets
Learning			
Berney and Bétrancourt (2016)	Static vs. animated graphics displays of instructions (no graph)	*Meta-analysis learning outcome:* Knowledge Remember Understand Apply Analyze	- Are multimedia instructional materials containing animations overall beneficial to learning compared to static graphics display? If so, for which learning outcomes? - How are the animation effects influenced by factors related to the instructional material, such as the control over the pace, the function of the animation, the modality of the verbal commentary, and the type of animation media? - How do the animation effects vary according to the instructional domain of the content to be learned?
Boucheix and Schneider (2009)	Static vs. animated presentations user-control of an animated presentation (no graph)	Comprehension	- The presentation of integrated sequential static images describing a dynamic process and facilitating the elaboration of the mental representation of the movement led to a similar performance in a comprehension test as an animated presentation of the same process and to a higher performance than the presentation of sequential independent static images or a single static image. - Higher comprehension of the functioning of the mechanical system in the two controllable presentations as compared to the non-controllable.
Dindar et al. (2015)	Static vs. animated graphics (no graph)	Response time Response accuracy	- What is the difference between the response time of students who take the achievement test with static graphics and those who take the achievement test with animated graphics? - What is the difference between the response accuracy of students who take the achievement test with static graphics and those who take the achievement test with animated graphics?

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Author(s) (Year)	Animation	Dependent Variables	Hypotheses/ Research Questions
Dindar et al. (2015)	Static vs. animated graphics (no graph)	Response time Response accuracy	- What is the difference between the self-reported CL scores of students who take the achievement test with static graphics and those who take the achievement test with animated graphics? - What is the difference between the secondary task scores of students who take the achievement test with static graphics and the students who take the achievement test with animated graphics? - What is the relationship between response times, response accuracy, self-reports, and secondary task scores?
Höffler and Leutner (2007)	Static vs. animated pictures (no graph)	*Meta-analysis learning outcome:* Declarative Knowledge Problem-solving knowledge Procedural-motor knowledge	- Are animations better than static pictures in general? - Are representational animations better than decorational animations? - Are animations better for acquiring procedural-motor knowledge rather than declarative knowledge or problem-solving knowledge? - Are computer-based animations better than video-based animations? - Can static pictures be improved?
S. Kim et al. (2007)	Static vs. animated graphics displays of a bicycle pump (no graph)	Comprehensibility Interestingness Enjoyment Motivation Comprehension test	- Are there effects of animated graphics on comprehension, ratings of interestingness, and motivation to learn? - Are there interactions between the presentation mode of the learning material and the NFC of the learner? - Are there any developmental differences in comprehension, interestingness, and motivation as they respond to various types of graphic presentation?
Marketing			
Cian et al. (2014)	Logo dynamism	Attitude toward the brand	- A logo that evokes greater perceived movement (logo dynamism) generates more favorable attitudes toward the brand unless the perceived movement is incongruent with the brand characteristics. - The impact of logo dynamism on attitudes toward the brand is mediated by engagement.
Cian et al. (2015)	Icon dynamism	Perceived movement Vigilance Early Attention Reaction time Behavioral consequences Perceived risk	- A warning sign icon (e.g., a yield sign) with more (vs. less) perceived movement will attract earlier attention. - A warning sign icon with more (vs. less) perceived movement will evoke greater attentional vigilance. - A warning sign icon with more (vs. less) perceived movement will result in a faster reaction time. - A warning sign icon with more (vs. less) perceived movement will result in earlier stopping behavior (i.e., the stopping will occur farther back from the sign).

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Author(s) (Year)	Animation	Dependent Variables	Hypotheses/ Research Questions
Goldstein et al. (2014)	Animated Ads	Annoyingness ratings Website abandonment Distraction	- What is the economic cost of annoying ads to publishers? - What is the cognitive impact of annoying ads?
Jia et al. (2020)	Animation in video ad vs. static images of the video ad	Perceived product size Perceived distance Perceived quality Perceived durability Perceived reliability Perceived aesthetics Willingness to pay	- Consumers assess the size of a product to be smaller when the product is animated to move faster in a video ad. - The speed-based scaling effect is reduced for consumers who perceive low similarity of movement patterns between the focal product and the base domain of animate agents. - The speed-based scaling effect is reversed when consumers learn a positive association between body size and movement speed in the base domain of animate agents. - The speed-based scaling effect is reduced for consumers with more knowledge about the target product domain. - The speed-based scaling effect is reduced when explicit product size information is highlighted in video ads. - When a small product size is desirable, a faster animated movement speed leads to a higher willingness to pay than a slower animated movement speed. - When a large product size is desirable, a faster animated movement speed leads to a lower willingness to pay than a slower animated movement speed. - Size assessment mediates the effect of animated movement speed on willingness to pay.

Research in marketing on the effect of animation on consumers is primarily focused on advertising and does not include graphs. The results show that originally static advertising is increasingly shown in animated format. Banner ads online and other online display ads often contain videos or other forms of animation, and outdoor advertising is also increasingly dynamic instead of static (Goldstein et al., 2014; Jia et al., 2020). When logos or signs express a movement, more attention is paid to them, leading to a better attitude towards a brand or a faster response to the signs (Cian et al., 2014, 2015).

J. Kim and Lakshmanan (2021) are one of the first to investigate the effects of animated versus static graphs in a marketing journal. Therefore, this investigation is essential for the present work and will be considered intensively. They tested animation as a salience-inducing mode of displaying time-varying data (see Figure 1). Transitions in graphs on stock prices are noticeable through animations. Temporal variations are emphasized more than in static diagrams, where attention is to be drawn by, i.e., visual elements such as color or arrows (J. Kim & Lakshmanan, 2021). Animation enhances the salience of transitions. This increases the usage of transitions in forming risk inferences

and enhances risk judgments. The effect of animation only occurs with line graphs, not with bar graphs. Only for a downward trend the perception of risk is higher because of the salient animation. When the investment goal is long-term, risk judgments rise, and the investment amount lowers. For short-term investments, animated display does not increase risk judgments, and more is invested as a result (J. Kim & Lakshmanan, 2021).

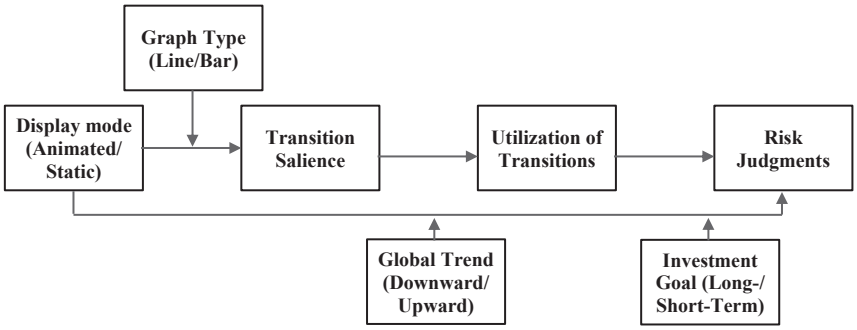

Figure 1. Summary of the theoretical framework of J. Kim and Lakshmanan (2021, p. 5).

J. Kim and Lakshmanan (2021, p. 3) "propose that animated display of a data string draws viewers' attention in real-time to the moment-to-moment unfolding of the data string". They use attention as an explanation but then attribute the actual effect to the salience of the transitions. They focus on risk judgments and investment amounts. According to their results, the salient transitions in animated graphs are used for making risk judgments. To find out, participants were explicitly asked about transitions, and one study measured what participants used to make their judgments. Thus, participants explicitly thought about the transitions and used them as explanations.

In their study, J. Kim and Lakshmanan (2021) look at the effect of animated graphs. Thereby, they focus on the effect of animated graphs on the risk judgments of managers. The effect of animated graphs on consumers is not yet investigated. In addition, the question still arises what happens subconsciously when subjects are not explicitly asked about the transitions in graphs? Depending on the focus area, animation can trigger different psychological mechanisms (J. Kim & Lakshmanan, 2021). Can animation be the reason why a graph triggers something in the consumer and is therefore effective? Consideration should be given to the mechanism behind the salience. How can animated graphs be used suitably? Can the more vivid visualizations cause a higher persuasiveness of a message?

As one moderator variable J. Kim and Lakshmanan (2021) look at the graph type (line vs. bar) and the overall trend of the graph (downward vs. upward). The effect of other graph attributes should also be investigated. Furthermore, participants have been told that they must make financial judgments. Financial judgments are made very thoughtfully and

consciously. Therefore, one might expect different results in other contexts. What happens if there are no noticeable transitions? What is the reason for the effects discovered by J. Kim and Lakshmanan (2021)?

It has already been shown that animated graphs can change judgments and decision-making compared to static graphs (bar/line) (J. Kim & Lakshmanan, 2021). No other dependent variables have been considered yet with these types of graphs. Other literature on animation focuses on investigating specific visualization tools like animation as the transition from one graph type to another (Heer & Robertson, 2007). Beck et al. (2017) only look at static versus dynamic node-link diagrams. Robertson et al. (2008) investigate bubble charts, which are animated in one condition, and participants can interact with the graphs. No other graph types are studied in these articles. As considered in this work, graphic animation has not been investigated extensively yet. In addition, other processes and outcomes than judgments, recall, reaction time, and the effects of animated graphs on decision-making have not been considered (Farrugia & Quigley, 2011; J. Kim & Lakshmanan, 2021; Robertson et al., 2008). Therefore, other dependent variables should be considered, and how animated graphs can affect consumers compared to static graphs. They could be the impulse needed to change consumer persuasion, leading to a change in attitudes and beliefs.

However, the question arises in which marketing contexts the effects of animated graphs for presenting data should be studied and where they might help better communicate information to consumers. Fifty years after the publication of "Marketing's Changing Social/Environmental Role" in the Journal of Marketing, "better Marketing for a better world" topics should be given a central position in marketing scholarship (Chandy et al., 2021). Marketing should make an impact on the world (Chandy et al., 2021). Social marketing is used to achieve this impact in the world. "Social marketing is the adaptation of commercial marketing technologies to programs designed to influence the voluntary behavior of target audiences to improve their personal welfare and that of the society of which they are a part" (Andreasen, 1994, p. 110). The target and intention are to persuade others to change their behavior, attitudes, and ideas or to select messages which influence these (Fogg, 1998; Nowak & Siska, 1995; Stewart, 2014). "Problems of pollution control, mass transit, private education, drug abuse, and public medicine are in need of innovative solutions and approaches for gaining public attention and support" (Kotler & Zaltman, 1971, p. 11; see Fox & Kotler, 1980). Animated graphs could be an approach to gain attention for these problems. Therefore, the effect of animated graphs should be investigated in such contexts.

3. METHODOLOGY AND OBJECTIVES

To see what has been studied so far on the topic of data visualization and animated graphs we conducted a literature review. In doing so, we searched for journal literature using the key words "Data Visualization" and "Animated Graphs" as well as their synonyms. We have limited ourselves to the subject areas that are linked to the economic sciences.

These are Accounting, Management, Marketing, Computer Science, Information Science and Education Science. In addition, only literature that matches the presented definition of data visualization was considered. An exception was the literature on animated graphs, since graphics were also considered here.

The aim of this work is to examine the extent to which data visualization has been considered in the literature to date and what results have emerged. In particular, the focus is on the communication of data to the consumer and thus on marketing. As a property of graphs, their animation will also be examined in more detail, since this is being used increasingly in practice. In practice, it should be known how to use graphs and especially animated graphs appropriately and how they may help to persuade consumers about a topic. Knowing when to use animated graphs instead of static graphs is relevant.

4. CONCLUSION AND PLANNED NEXT STEPS

As the review of the literature has shown, the effect of animated graphs on consumers has not been studied so far. To address the research questions identified, the next step is to conduct a study. We would like to examine the effect of animated graphs on consumers. Our question is whether the message of a graph is more persuasive when it is animated than when the graph is static. In the process, quantitative, experimental, primary data will be used. Therefore, participants will complete an online programmed questionnaire. The sample will primarily consist of students from the Ansbach University of Applied Sciences. Participants will be shown a graph about a health, social, or ecological issue. When using statistical evidence, negative framing of a cause is more persuasive than positive framing (Das et al., 2008). Therefore, the stimuli will be negative framed data about a social marketing topic. They will then be asked how persuasive the message of the graph was and what their attitude towards the topic is after seeing the graph. In the process, they will see either an animated or static graph.

This research will help to understand the reason for the effect of animated graphs. It will show if an animated graph catches more attention and is therefore more effective. Understanding this can help graphs in distracting environments to be more noticed and thus their content to be more involved by consumers in their decisions and actions.

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CONFLICT OF INTERESTS

No potential conflict of interest was reported by the authors.

AUTHOR CONTRIBUTIONS

Hoffmann, Franziska: Conceptualization; Methodology; Writing - Original Draft, Resources, Writing - Review & Editing. Sauer, Sebastian: Supervision. González-Ladrón-De-Guevara, Fernando: Supervision, Review & Editing.

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