Physiological response to COVID-19 statistics

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Background

Data visualization is an important aspect of knowledge dissemination. Effective data visualizations transform a series of numbers into a digestible story with context and clear application. The use of data visualizations for social movements was first introduced during the golden age of statistics (1840–1910; Friendly, 2008), and has become particularly important in contemporary times, especially in relation to the relay of information during the COVID-19 pandemic. Data visualizations pertaining to COVID-19 statistics are widely available and have a large impact on societal behaviour and functioning, and as such, evoke an emotional response within their consumer.

Emotionality can be evoked by data visualizations in many ways, which can influence future decision making. Colour is often used to manipulate the audience into feeling a certain way about the data being presented (Murray, 2019). For example, the colour red in many western cultures is associated with fear or blood, which reinforces the narrative that the information being presented is potential harmful and thus should be avoided (Pravossoudovitch et al., 2014). Another way to evoke emotion is through novelty. Novel graphic presentations can elicit interest in the data being presented and instil a sense of curiosity, as seen in 1858 with Florence nightingale's Rose chart (Friendly, 2008). Developing an awareness of components that evoke emotion allows the data visualizer to enhance the understanding of their audience.

With advances to technology, additional innovations can be incorporated into data visualizations to increase responsivity of consumers. For example, the use of interactive features enable consumers to customize the data in a way that is relevant to them, which fosters a stronger emotional attachment and a sense of personal investment (Kostelnik, 2016). Emotional attachment is particularly important for behavioural change. In the example of healthcare

information, interactive visualizations that depict an individual's personal health information (i.e., blood work being above or below normal levels) were more likely to elicit behavioural change to avoid negative consequences (i.e., light regular exercise to prevent heart disease) than visualizations that depicted general (i.e., non-personal) risk of heart disease (Lourdais et al., 2020). As such, data visualizations should be tailored to meet the interests of the audience consuming the data.

With many techniques designed to increase interest and personal investment in the data being presented, it is also important to consider the personal relationship a consumer has with the data. Previous experience with a particular topic may cause individuals to have unique attitudes towards that topic (Garrett et al., 2012). These preconceived notions vary in terms of type and strength of emotion they elicit and affect the way consumers interpret the data being presented. These strong thoughts and attitudes may be implicit and subconscious and consequently, emotional responses can be difficult to self-report (Garrett et al., 2012).

Implicit emotional experiences of data consumers can be objectively inferred through galvanic skin responses (GSR). GSR measures changes in physiological parameters of the sympathetic nervous system like heart rate, respiratory rate, perspiration, and muscle tension. A change in physiological parameters indicate the experience of affective arousal (Christopoulos et al., 2016). Whether through cognitive appraisals (Schachter-Singer two factor theory), or simultaneous cognitive and physiological processes (Cannon-Bard theory), the brain labels affective arousal as an emotional experience (Christopoulos et al., 2016).

Generally, affective arousal is related to amplified reactions and evaluations of salient stimuli, which then increase learning and long-term memory for that event (Storbeck & Clore, 2008). Though a limited field of research, there is some evidence to suggestion that different data

visualizations elicit different physiological arousal levels and that these levels predict future decision making (Rose et al., 2019). For example, when reviewing monetary investments, more intricate visualizations, such as word clouds, elicited greater affective arousal than did standard visualizations, such as bar graphs, of the same information. This increased arousal was associated with greater attenuation to the reliability of the data and increased attention to any disconfirming information being presented. When asked to decide where to invest money based on the information provided, those who had viewed arousal provoking information were more likely to use the disconfirming evidence and make a more balanced decision (Rose et al., 2019).

Given the increased accessibility of COVID-19 data visualizations, it is important to understand how data consumers view, remember, and interpret such information. As affective arousal and personal proximity to the issue have been demonstrated to predict memory and decision-making processes, investigating the intersection between these factors is important for understanding the impact data visualization can have.

Objectives

The proposed research will examine the relationship between data presentation, affective arousal, and memory of the subject matter. This study will investigate whether different methods of data visualization, and data with a highly emotional component (i.e., data pertaining to the global pandemic), will produce different physiological responses within individuals compared to visualizations of neutral data. Next, we will measure whether the hypothesized differences in physiological responses will be enhanced when the individuals have a personal relation to the data. Last, we will examine whether the level of individual affective response to visualized data will predict their memory for those statistics two weeks following the initial exposure.

Methods

For this study, participants will be collected from various Toronto communities (N = 500) through online advertisements. Participants will be incentivised with the chance to win one of four $50 gift cards following the completion of both parts of the study. Participants will come to the lab and will provide informed consent and complete a basic demographic questionnaire including questions regarding the impact COVID-19 has had on their lives and their current attitudes towards it.

For part one of this study, various graphs will be designed based on publicly available statistics regarding COVID-19, or neutral data. To control for design factors, visual elements such as colour hue, font, etc., will be matched across both stimuli sets. A variety of visualization types (i.e., bar vs. line graphs) will be used for each statistic to measure the different levels of arousal produced by various visualizations (Rose et al., 2019). Pairwise comparisons will be made between all conditions of neutral and emotionally charged data.

Emotional arousal will be measured through skin conductance while viewing both the neutral and emotionally related stimuli. Electrodermal activity is an indicator to assess electrical properties of the skin. Higher activity is related to increased activation of the sympathetic nervous system which causes increased release of moisture from sweat glands, thus increasing electricity across the skin (Boucsein, 2012). In an observation room, equipment will be attached to record skin conductance using electrodes placed on the palm of the subjects non-dominant palm, and after an acclimation period of five minutes, participants will perform calibration exercises (Dawson et al., 2007). While keeping their non-dominant hand still, participants will face the computer screen. Using E-Prime software, a five-second fixation cross will be shown followed by stimuli be presented in ten second increments, followed by another fixation cross. Neutral and emotionally related figures will be presented in blocks of five (i.e., five neutral

figures will be presented, followed by five emotionally related figures). Five sets of blocks will be presented for a total of 12 minutes and 35 seconds. Physiological response data will be recorded continuously and stored for analysis.

To investigate various degrees of emotional relevance between subject matter and affective arousal, participants will complete a second condition. To increase interactivity with the data, participants will view second set of neutral and emotionally related figures, but in addition, will be required to answer a question about how personally relevant they find that statistic. For example, after viewing a COVID-19 graph depicting death rates in Canadian retirement homes, participants will then be asked to rate how much they relate to that statistic from 1-7 (1 = not at all, 7 = very relevant). This second set of data visualizations will not vary in visualization type (i.e., will all be presented as line graphs) to best understand the potential moderating effect of personal proximity on emotional experience when viewing emotionally charged data visualizations. The statistics represented by the second set of visualizations will differ from the first condition to reduce familiarity effects. The skin conductance methods in part one will be used again to measure emotional arousal levels across levels of personal relevance.

Further, the relationship between affective arousal and memory for data visualizations will be explored by having participants return within 14 to 21 days following their initial exposure to the stimuli. Participants will again sit in the observation room. In a free recall trial, participants will be asked to report what they remember from the information presented at the first visit (i.e., report the main statistic communicated by a figure). Additionally, participants will be asked to qualitatively report what other information or visual features pertaining to the figures had been most salient to them (i.e., colour, words, presentation (bar vs. line graph)). Following a free recall trial, participants will complete a recognition trial. Neutral and emotionally related

figures that had either been previously presented or are novel, will be randomly presented. Participants will be asked to indicate by clicking ‘yes’ or ‘no’ in response to whether they had been previously shown the stimuli.

Hypotheses

We hypothesize that physiological response as recorded by skin conductance will (1) be affected by the type of data visualization used, (2) be greater when participants look at emotionally related figures than neutral figures and that (3) interacting with graphs by reflecting and reporting their perceived personal relevance to the presented statistics will further increase an individual’s physiological reaction. Additionally, we hypothesize that figures that elicited greater levels of skin conductance will also be better remembered two weeks following initial exposure.

Significance and Impact

Data visualization is essential to how we interact with, interpret, and remember information. This research will provide additional insight into what factors elicit the most salient emotional response, and how factors such as of emotional relevance and type of visualization, influence an individual’s interaction with data. Last, it will provide a rational in the field of data visualization to support emotional appeals in data presentation in lieu of objectivity.

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