Article:
Baxter, M. orcid.org/0000-0002-3393-0824 and Lonsdale, M.D.S. orcid.org/0000-0003-0315-6169 (2023) Improving the design of public health infographics using a motion graphic educational resource to enhance design principle application. Information Design Journal, 28 (2). pp. 141-177. ISSN 1876-486X

https://doi.org/10.1075/idj.23006.bax

2023

Improving the design of public health infographics using a motion graphic educational resource to enhance design principle application

Matthew Baxter, Ph.D
Maria dos Santos Lonsdale, Ph.D

Author version | Accepted version

Specifications

Information Design Journal

Accepted for publication: May 1, 2023

Publication date: September 1, 2023

Issue 28.2

Keywords
Information Design
Information Visualization
Infographics
Public health information

Abstract

Infographics are commonly used in public health to disseminate key messages to wide audiences. Although health organisations are making increasing use of infographics, their designs are of variable quality. The research reported here aimed to develop an educational tool that could improve public health infographic design, using motion graphics to teach users with limited design experience how to apply research-based design principles. Results were positive, with significant improvements in performance (including information location time, memorability, and user perception) observed for the infographics designed after the resource was used, compared to the infographics created before.

1 Introduction

1.1 Background

Infographics are an effective tool in public health communication (Scott et al., 2016). This method of information visualisation makes information more accessible, easier to understand, and easier to remember when compared to written information (Lonsdale et al., 2019). In context, this engaging method of information communication can improve the understanding of medical literature (Huang et al., 2018), and significantly increase social media attention of research articles (Kunze et al., 2021). Infographics can also improve patient education, as it can communicate health-related information clearly to those with low health literacy (Stonbraker et al., 2022). The effectiveness of infographics within the field of public health has been documented (Egan et al., 2021), and there is evidence that infographics reduce the cognitive effort required to understand complex health information compared to information provided in written format (Martin et al., 2019). According to Barlow et al. (2021), the use of infographics is an effective educational strategy for the dissemination of health-related research. Through health-related infographics it is possible to tailor the information to a wide variety of audiences and enhance the patient experience through research education.

During the COVID-19 pandemic, infographics were utilised extensively by health organisations to disseminate important public health messages to worldwide audiences (see Figure 1), such as to address COVID-19 vaccine misinformation and hesitancy (Rotolo et al., 2021). The pandemic highlighted the relevance of infographics, with many studies focussing on the application of infographics in the context of public health. Hamaguchi et al. (2020) highlighted that infographics are a powerful tool in the dissemination of information, as they can convey the information accurately and in a simple visual format. The authors discuss the global enthusiasm for infographics. They state that infographics can be shared easily on social media facilitating the transmission of important information, and are a valuable means to address health literacy disparities.

Chan et al. (2020) created and shared on social media an infographic for medical professionals on the subject of COVID-19 airway management. This was rapidly seen in multiple countries, showing that social media infographics are an effective tool for disseminating key health-related messages.

1 2 3 4

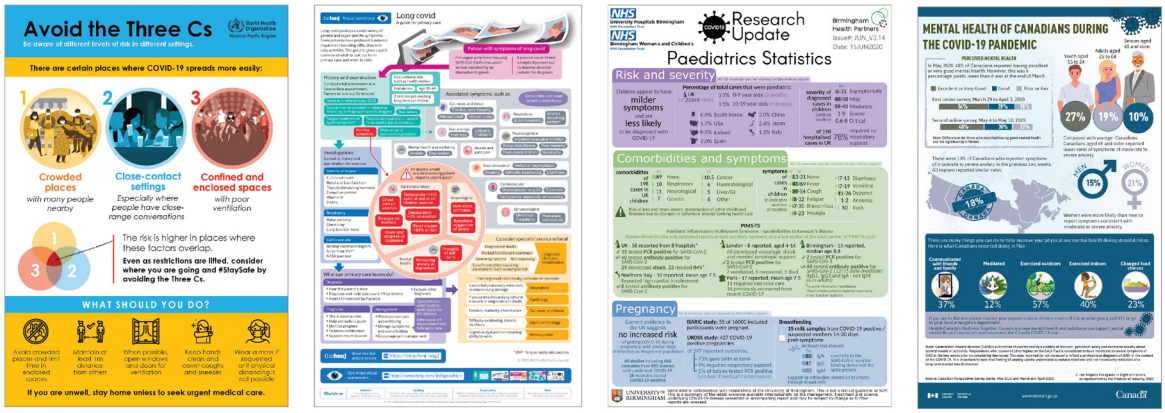


Figure 1. Examples of public health infographics displaying information related to COVID-19.
Sources: 1 = WHO, 2023, 2 = Greenhalgh et al., 2022 (BMJ), 3 = NHS, 2020, 4 = StatisticsCanada, 2019

1.2 Existing research

Research into public health infographics has reached beyond their general application and has begun to explore and evidence their contextual benefits. For example, in the context of the COVID-19 pandemic, studies have shown that the use of infographics promoted positive public behaviour. Crutcher and Seidler (2021) discovered that the dissemination of COVID-19 vaccine infographics to first time vaccine recipients resulted in higher second dose vaccine uptake. Egan et al. (2021) investigated the effect of infographics on public recall and willingness to use face masks during the COVID-19 pandemic. They reported that three out of the four infographics tested resulted in significantly higher average information recall scores, compared to no stimuli. Notably, no significant improvement in recall was observed in participants using written information from the UKGOV website, further supporting findings that have shown that an infographic format is more effective in communicating health-related information than a text-based format. The use of infographics to support self-isolation during the COVID-19 pandemic has also been investigated (Lunn et al., 2021). Significantly better information comprehension and recall was shown in participants using infographics, compared to participants who viewed the same information in a written format. This suggests that infographics can be a powerful tool for educating the general public on public health issues and can lead to positive behavioural changes.

Infographics have also been utilised to address the increase in the spread of public health related misinformation. The potential for the rapid spread of public health misinformation was demonstrated during the COVID-19 pandemic, where incorrect information was spread both widely and rapidly (Cinelli et al., 2020; Kouzy et al., 2020; Mian & Khan, 2020) resulting in harmful health effects (Kim et al., 2020; Loomba et al., 2021). Multiple studies have aimed to address this issue using infographics. Vraga and Bode (2021) found that exposure to an anti-misinformation infographic, created by the World Health Organisation, successfully reduced misperceptions; the positive effect lasting up to a week after viewing. Consequently, the authors endorsed the distribution of infographics by health organisations to improve public health knowledge. Similarly, exposure to an educational infographic that promoted health science was found to increase trust levels, potentially reducing public believability of misinformation (Agley et al., 2021). Domgaard and Park (2021) found that infographics are a more effective way of verifying false vaccine news when compared to a written text, thereby helping reduce vaccine hesitancy. Infographics, therefore, appear to play an important role in both the communication of accurate health information, and in the promotion of consequential behavioural changes that can benefit public health.

The quality of currently available health-related infographics can be variable. Preliminary interview data showed that healthcare professionals are required to create infographics and that these are displayed publicly in hospitals and educational settings. This may be problematic, since lower quality infographics can result in poorer user performance and perception (Baxter et al., 2021). Examples of poor infographic design practices are also found in public health infographic research. Although many studies have developed health-related infographics for testing (e.g. Stonbraker et al., 2019; Hamaguchi et al., 2020; Lunn et al., 2021), these often require considerable improvement. Improving the design quality of infographics used in research practices can have a positive impact on the quality of the research findings, particularly in cases where infographic usability is evaluated. Kemp et al. (2021) acknowledge that research into health-related infographics typically compares an infographic group with a control group, providing limited guidance on how to design effective infographics. Additionally, Stones and Gent (2015b) emphasise the need for improved infographic design practices within public health organisations, where infographics are frequently designed by in-house volunteers using sub-optimal software, and identify specific design principles for public heath infographic design. Design principle application can lead to the production of effective infographics (e.g. Stones & Gent, 2015a; Lonsdale & Lonsdale, 2019; Baxter et al., 2021). Hernandez-Sanchez et al. (2021) recognise that infographics are an effective method of communicating key medical information and propose a set of guidelines specific to medical infographics, with the aim of making them more effective. They stress the importance of the design process and

provide 12 research-based recommendations which they believe if followed will help to create effective health-related infographics. The use of infographic design principles as a way of improving the equality of infographics, however, assumes that the designer is capable of interpreting and implementing written guidelines into their design practice, which may require high levels of existing design knowledge. Given that infographics are often created by individuals with varying levels of expertise in design, including healthcare professionals, it would be unrealistic to expect the successful application of these often-complex design principles by those with limited design experience. The current research aims to address this problem by exploring user-friendly tools to allow the creators of infographics to improve their design outputs. To achieve this aim, a resource was developed to maximise the accessibility of infographic design principles. A two-stage approach was used. First, an educational resource that aims to teach the user how to apply a series of research-based infographic design principles was developed. Then, the functionality of the educational resource was tested by experimentally comparing infographics created by healthcare professionals before the resource was used with those created after the resource was used.

1.3 Research objectives

– To enhance public health infographic design through the development of a digital tool which would allow users with limited design experience to maximise the effectiveness of their infographic output through increased application of infographic design principles.
– To compare the effectiveness of the infographics developed both before and after accessing the educational tool to verify if use of the tool resulted in meaningful improvement to the infographic design output.
– To improve user performance through the use of public health infographics that have been designed after accessing the digital educational tool (as measured by information location time, memorability of information, and user perception).
– To assess the usefulness of motion graphics as an educational tool in the teaching of complex design concepts to those with limited design experience.

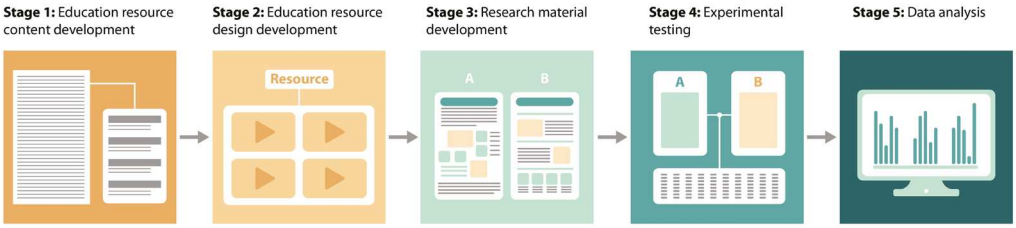
1.4 Hypothesis

It is hypothesised that use of the educational resource developed in this research would result in the application of a high proportion of design principles by users with limited design experience when designing public health infographics. Consequently, it is predicted that the infographics that were developed after using the educational motion graphics would be more effective (as measured by information location efficiency, memorability, and user opinion) — compared to the infographics created before using the tool.

1.5 Research timeline

A multi-stage methodology was utilised, with multiple design and research material development stages taking place before experimental testing, as summarised in Figure 2.

RESEARCH TIMELINE



Research stage	Publication section	Research details
1 **Education resource content development**	Section 2.2 - 2.4	• Literature review to define infographic design pricniples, then condensation to 20 core principles in four categories (layout, colour, typography, graphics). • The aim of this stage was to define the infographic design principles that would be used in the education resource, and which could be understood by an audience with lmited design experience. • **Methods used:** Literature review, principle condensation.
2 **Education resource design development**	Section 2.1, 2.5 - 2.7	• Creation of four motion graphic videos and supporting PDF to teach the previously defined infographic design principles. • The aim of resource was to teach people from a non-design background (e.g. healthcare professionals) how to create improved quality infographic outputs. • The resource was created by employing a user centred iterative design process. • **Methods used:** Literature review, interview, questionnaire, usability testing.
3 **Research material development**	Section 3.1 - 3.3	• Generative design process where the education resource is used by the target audience. • 2-stage process where the participants created an infographic with no input, then a second infographic after using the education resource. • **Participants:** 9 healthcare professionals • **Materials developed:** 18 infographics (9 before using education resource, 9 after). • Of these materials, 6 were taken to the next testing stage (3 before using education resource, 3 after). • **Methods used:** Generative design, interview, questionnaire.
4 **Experimental testing**	Section 4	• Comparative testing of the research materials with 2 groups. • Group 1: Using the infographics generated with no input. • Group 2: Using the infographics developed after the education resource was used. • Aim was to investigate the effect of the education resource, to see if it results in meaningful improvement in the design of public health infographics. • Data collected: Performance data (speed of info location, answer recall accuracy, recall time), opinion data (Likert scale questionnaire, interview, Microsoft desirability toolkit). • **Participants:** 60 members of UK general public (group 1: 30, group 2: 30) • **Methods used:** A/B testing, questionnaire, interview.
5 **Data analysis**	Section 5	• Analysis of the data collected in the experimental testing stage. • Analysis used: One-way ANOVA, principle application analysis, Microsoft desirability toolkit, thematic analysis.

Figure 2. Timeline of the research process completed in this study.

2 Content and design development

The first stage of the research involved developing an educational resource that could teach users with limited design experience how to apply research-based infographic design principles. The aim was to improve their infographic design outputs through successful knowledge acquisition, in the context of public health information. A user focused design methodology was employed in the development of the instructional motion graphic videos. The methods utilised are summarised in Table 1.

DESIGN DEVELOPMENT METHODOLOGY

Method	Sample	Process	Test material
Stakeholder interview	5 NHS doctors	• Informal interview discussion • Questions about current requirements to design infographics and any design teaching given to medical professionals	• Interview quesiton script
Literature review	**Stage 1:** 216 publications **Stage 2:** 25 publications	• **Stage 1:** Lit review to define infographic design principles for education content • **Stage 2:** Lit review on motion graphics to inform design of education output	• N/A
Infographic principle condensation	94 infographic design principles	• **Stage 1:** Logic based analysis • **Stage 2:** Exploratory factor analysis • **Stage 3:** Frequency analysis	• N/A
Motion graphics content development	Expert information designer	• **Stage 1:** Development of 4 infographics created based on principles • **Stage 2:** Feedback from expert	• 4 health-related Infographic designs
Motion graphics prototype development	N/A	• Creation of prototype video outputs informed by previous research	• N/A
Usability testing 1	• 5 health professionals • 20-56 years old • UK participants	• Require participants to watch prototype videos and complete memory task • Collect opinion on features of videos and what could be improved	• Initial prototype motion graphic • Online usability testing questionnaire
Usability testing 2	• 5 information designers • 25-28 years old • UK/International	• Require participants to watch 4 prototype videos and complete memory task • Collect opinion on features of videos and what could be improved	• 4 prototype motion graphic videos • Online usability testing questionnaire

Table 1. A summary of the user-centred design methods used in the development of the education resource.

2.1 Design development — Stakeholder interview

Informal interviews were conducted with a group of five medical doctors to identify what form of media the educational resource should take. A digital format was considered the most appropriate format for its ease of access and storage. Participants also thought that the resource should be engaging and capable of holding the user's attention, and not just a written list of instructions. The interviewees also said that, because working in healthcare often involved working long hours and shift work, a resource that was time efficient would be ideal. The information obtained through the interviews seemed to suggest that either a website or a motion graphic video would be an appropriate design solution. Motion graphics and instructional videos are considered to be better learning tools when compared to presenting information in a static format (Snyder-Ramos et al., 2005; Höffler & Leutner, 2007; Hsueh et al., 2016). They are also seen as a useful tool to increase knowledge acquisition of health related information (Lonsdale & Liao, 2018; Lonsdale et al., 2020). The fact that motion graphics can efficiently convey complex information led to the decision that the educational resource would take the format of motion graphics videos.

2.2 Design development — infographic principles' content

Two separate literature reviews were conducted: one to inform the design of the motion graphics and one to inform the content to be displayed in the education material. The first literature review was used to define the content of the motion graphics videos. The aim was to outline infographic design principles that could be easily understood and applied by a non-design educated audience, principles that if applied, could improve the effectiveness of infographic design outputs. 84 research-based infographic design principles were defined. However, since it was unrealistic to expect the target audience of the educational resource to follow 84 complex design principles, these were condensed and combined, and reduced to 20. This was achieved through a three-stage process. In the first stage a logic-based analysis was utilised to remove principles that could not be practically applied by the target user. In the second stage, a basic form of exploratory factor analysis was used to group related principles. In the third and final stage, a survey and a critical review were used to further remove and combine principles. The final 20 principles were then renamed and reworded; complex academic words were removed so that the principles could be easily understood. So as to include as many of the applicable guidelines as possible in the final 20 principles, only 26 principles out of the 84 were removed, with the remaining 48 being combined. The 20 principles are summarised in Table 2.

LITERATURE REVIEW – INFOGRAPHIC DESIGN PRINCIPLES		
Category	Design principles	References
Layout	**1. Align elements** – Align your text and graphics to create an organised appearance, this can be achieved using a layout grid. **2. Proximity** – Placing information close together suggests it is related. Use this to group related information into a chunk. **3. Enclosure** – Enclose related information using coloured shapes or outlines, this can create information chunks that make your design easier to remember. **4. Noticeable headings** – Use headings to divide chunks of information. Make sure they are significantly bigger and bolder than the text body. **5. Connect information** – Connect related chunks of information and create a purposeful reading order using lines, arrows and numbers.	**1.** Stones & Gent, 2015; Majooni et al., 2018; Padilla et al., 2018). **2.** Graham, 2008; Mayer, 2009; Ali and Peebles, 2013; Gkogka, 2018 **3.** Miller, 1956; Mayer, 2009; Patterson et al., 2014; Tetlan and Marschalek, 2016; Gkogka, 2018). **4.** Williams and Spyridakis, 1992; Hyönä & Lorch, 2004; Kools et al., 2008; Jin, 2013; Lonsdale, 2014 **5.** Graham, 2008; Ali and Peebles, 2013; Murray et al., 2017; Gkogka, 2018
Colour	**6. Limit colour palette** – Choose a complimentary colour palette of 2 or 3 colours. **7. Clean backgrounds** – Use plain light backgrounds to reduce distractions, if in doubt use a white background. **8. Text contrast** – Ensure colour contrast is high between the text and the background to make it easier to read. **9. Highlight important info** – highlight the most important words or areas of information using a colour from your palette. **10. Colour coding** – Use colour purposefully to show information is related, by using the same colour for certain info.	**6.** Mayer and Moreno, 2003; Stone, 2006; Patterson et al., 2014 **7.** Gillan & Richman, 1994; Stones & Gent, 2015; Lonsdale & Lonsdale, 2019 **8.** Ling and Van Schaik, 2002; Hall and Hanna, 2004; Moore et al., 2005; Buchner and Baumgartner, 2007; Galitz, 2007; Mackiewicz, 2009 **9.** Schaie and Heiss, 1964; Farley and Grant, 1976; Schindler, 1986; Wichmann et al., 2002; Spence et al., 2006; Mayer, 2009; Kim, 2010; Dzulkifli and Mustafar, 2013; Jamet, 2014; Patterson et al., 2014 **10.** Dwyer and Moore, 1991; Worley, 1999; Mautone and Mayer, 2001; Keller et al., 2006; Mayer, 2009; Ozcelik et al., 2009; Ozcelik et al., 2010; Jamet, 2014; Richter et al., 2016
Typography	**11. Simple fonts** – Use up to 2 or 3 non-decorative fonts on the infographic, a good tip is to use one font for the text body and another complimentary font for the headings. **12. Appropriate text size** – Ensure your text is the right size; smaller than your headings but still easy to read. **13. Bold text** – Use bold or capitals to emphasise important words and information, be selective with its use. **14. Line spacing** – Increase line spacing in between paragraphs to make your information easier to read. **15. Align to the left** – Make sure your lines of text fit to the left to optimise readability.	**11.** Black, 1990; Hartley, 1994; Bernard et al., 2003; Hartley, 2004; Amdur, 2007; Josephson, 2008; Saltz, 2009; Chaparro et al., 2010; Banerjee et al., 2011; Babish, 2017; Murray et al., 2017 **12.** Tinker, 1965; Poulton, 1972; Bernard et al., 2003; Beymer et al., 2008; Lonsdale, 2014; Pušnik et al., 2016 **13.** Pelli et al., 2006; Mayer, 2009 Lonsdale, 2014; Macaya and Perea, 2014; Patterson et al., 2014 **14.** Ling and Van Schaik, 2006 **15.** Ling and Van Schaik, 2006
Graphics	**16. Simple design** – Make you design simple and consistent, using graphics that are easy to understand. **17. Avoid decoration** – Remove decorative graphics and only use them if they are representing your written information. **18. Use pictograms** – Use these simple forms of graphics to ensure easy understanding; avoid complex graphics and images. **19. Object similarity** – Make objects visually similar if they are related. This can be done by matching visual elements such as colour, shape and size. **20. Appropriate graphs** – If you are using graphs, ensure they are easy to understand and match your colour scheme.	**16.** Hick, 1952; Bettman et al., 1986; Mayer and Moreno, 2003; Houts et al., 2006; Zikmund-Fisher et al., 2008; Mayer, 2009; Patterson et al., 2014; Stones and Gent, 2015a; Mollerup, 2015 **17.** Zikmund-Fisher et al., 2008; Mayer, 2009; Gelman and Unwin, 2013; Patterson et al., 2014; Skau et al., 2015; Dunlap & Lowenthal, 2016; Lonsdale & Lonsdale, 2019 **18.** Mansoor and Dowse, 2003; Dowse and Ehlers, 2005; Kripalani et al., 2007; Tijus et al., 2007; McCready, 2016; Park and Zuniga, 2016 **19.** Graham, 2008; Ali and Peebles, 2013; McCready, 2016, Gkogka, 2018 **20.** Spence, 2005; Hawley et al., 2008; Hildon et al., 2012; Stones and Gent, 2015

Table 2. Summary of the 20 infographic principles defined through a literature review.

2.3 Design development — motion graphic principles

A second literature review was conducted to define research-based principles that would inform the design of the motion graphic educational videos. At the time of writing, research into motion graphic design principles was limited, so the principles were derived from three core publications, two of which focused on multimedia videos (Mayer & Moreno, 2003; Brame, 2016), and one focused on motion graphics (Lonsdale & Liao, 2018). The applicable principles defined in these publications are summarised in Table 3. The application of the motion graphic principles defined by Lonsdale and Liao (2018) was shown to significantly improve knowledge acquisition of their subject matter. Consequently, the principles listed in Table 3 were applied in the design of the motion graphic educational videos to maximise potential knowledge acquisition.

2.4 Design development — motion graphics content development

Prototypes of the motion graphic videos were created taking into account the needs of the target users identified in previous research, as well as considerations from research-based guidelines to inform design practices. The videos were developed in two stages. First, the static elements were created; this included the infographics used in each video. Each video had a unique infographic that was developed and perfected in five stages as the principles were applied throughout the video. Adobe Illustrator was used to create the illustrations and graphics, and Adobe InDesign was used to arrange the images and text to create the infographic. The four infographics created can be seen in Figure 3. Each infographic was used in only one of the 4 videos, each covering one of the following aspects: layout, colour, typography, and graphics. The subjects of the four infographics were as follows: 1. Sepsis (layout), 2. Vaccines (colour), 3. Stroke (typography), 4. Alcohol abuse (graphics). The public health information used in the infographics came from the following sources: sepsis (Healthline, 2021b; NHS, 2021c), vaccines (NHS, 2021e; PublicHealth, 2019), stroke (NHS, 2021d; StrokeAssociation, 2021), alcohol abuse (Healthline, 2021a; NHS, 2021a). The 20 infographic design principles that were previously defined (Table 2) were applied to the design of the infographics.

The developed infographics were then assessed by an expert in the field of information design. Changes were made to ensure that each one of the four infographics had a unique design. Suggested improvements to the infographics resulted in the following design alterations: improved text colour contrast, higher quality illustration, layout alterations, colour palette improvement, and typeface size increase.

LITERATURE REVIEW – MOTION GRAPHIC PRINCIPLES	
Reference	Design principles
Mayer and Moreno, 2003	**1.** **Coherence** – People learn better when extraneous material is excluded. **2.** **Signalling** – People learn better when essential material is highlighted. **3.** **Redundancy** – People learn better from graphics and narration than from graphics, narration, and on-screen text. **4.** **Spatial Continuity** – People learn better when on-screen words are placed next to the corresponding part of the graphic. **5.** **Temporal continuity** – People learn better when corresponding narration and graphics are presented simultaneously. **6.** **Segmenting** – People learn better from a multimedia lesson when words are presented in spoken form. **7.** **Segmenting** – People learn better when a multimedia lesson is presented in small user-paced segments. **8.** **Personalization** – People learn better when the words in a multimedia lesson are presented in conversational style rather than formal style. **9.** **Voice Embodiment** – People learn better from a human voice than from a machine-like voice.
Brame, 2016	**10.** Use key words on screen to highlight important information. **11.** Divide topics into individual videos and make them short (less than 6 minutes). **12.** Remove complex backgrounds. **13.** Narrate the animation; speak relatively quickly and with enthusiasm. **14.** Use conversational language (e.g. using personal identifiers, such as 'your design' instead of 'the design', to create social partnership between the instructor and user).
Lonsdale and Liao, 2018	**10.** Avoid excess movement, high speed, motion effects for type in motion. **11.** Avoid too much text in the same frame. **12.** Use sans serif typefaces to maximize legibility. **13.** Consider the conceptual interplay between typography, voice over and images. **14.** Carefully select colors for type and graphic elements in order to create sufficient contrast between elements, and between elements and background. **15.** Use color to differentiate levels of meaning and significance. **16.** Emphasize information by manipulating time (slowing or speeding it up). **17.** Ilustrate the relationships amongst different pieces of information. **18.** Direct viewers to selected pieces of information in order to help minimize misunderstanding. **19.** Use language and sound to support or emphasize the graphic elements, as well as establish a personal connection with the viewer. **20.** The viewer has a limited amount of time available to perceive the content, and different viewers perceive information at different rates. **21.** Sequences that are too long will tire the viewers. **22.** Consider established principles of motion design (e.g. timing, anticipation, staging, exaggeration, secondary action, squash & stretch, etc.) **23.** Use motion as a design tool to support usability.

Table 3. Summary of the motion graphic design principles used to inform the design of the education resource.

Once the infographics and content were finalised, the video prototype designs were developed taking into consideration the previously defined motion graphic principles (Table 3). The animation was created using Adobe AfterEffects, then a script was developed, and the voiceover recorded. The animated video, the voiceover, and the background music were arranged using Adobe Premiere Pro to create the motion graphic. Each video presented five principles, and these were divided into four categories: layout, colour, typography, and graphics. Each one of the four infographics developed was assigned to one of the video categories. They were then negatively altered to purposely not apply the five design principles of the category they had been assigned to. Next, the infographics were changed back to their original design by applying the design principles in a five-step process. This was screen recorded whilst using the Adobe InDesign software to create 'example' sections that displayed practical application of each principle.

The four videos followed the same format. First, an introduction section was animated. The introduction provided the context for the video and explained its content, including the five principles. Each principle was then described in greater detail along with the 'example' recordings that showed the user how to effectively utilise the described principle. Each 'example' was followed by a section that displayed the infographic before and after the principle was utilised. This was to further help the user to understand how to use the principle. Lastly, a summary section provided an overview of the five principles covered and how these impacted the design of the infographic. Once the first video was completed, it was taken to the first stage of the usability testing.

2.5 Design development — usability testing 1

The usability testing aimed to identify any problems users may be having with the design. There were two stages of usability testing. Five healthcare professionals took part in the first stage: two dental students, one paediatric nurse, one physiotherapist, and one research physiotherapist. Participants' ages ranged from 20 to 56. Generally, feedback was positive with 100% of the participants stating that the motion graphic would help them apply the design principles when creating their own infographics. Participants thought that the step-by-step format was easy to follow, that the videos had the right amount of content to teach the principles and useful visual examples showing how to apply a principle. The following features were positively received by most participants: length of video, voiceover, layout, graphics, example section, before/after section, and transitions. Some participants, however, found the pace of the videos too fast, and one participant thought the videos were too long. One participant suggested making the before/after section clearer by having a visual indication of which infographic is the before and which is the after. There

were some mixed opinions on the background music with one participant describing it as distracting. Based on the feedback received the following changes were made to the motion graphic video:

- The pace of the video was reduced without greatly extending its overall duration. This was achieved through having slightly longer transitions to create longer breaks between sections and separate chunks of information.
- The overall length of the videos was reduced. This was achieved by re-recording all the 'example' sections of the motion graphics to ensure that these were shorter but still covered the same amount of content at an appropriate pace.
- "Before" and "After" labels were added to the before and after section. An animated arrow was also added to clearly indicate which infographic was being referred to.
- Animation was added to the "Before" and "After" section to show the changes which occurred after the design principle was applied.
- Better quality and less distracting background music was used.
- The light blue highlight colour was used more in the videos to make the colour palette of the videos more appealing.

Once these changes had been implemented, the other three videos were developed based on the first video, resulting in four motion graphics videos that together covered all 20 design principles. These were then submitted to further usability testing.

2.6 Design development — usability testing 2

The second stage of usability testing was undertaken with five information designers. All the participants had studied design and were currently working or researching in the field of information design. Information designers were recruited at this stage so that more detailed feedback could be obtained. Their previous design experience would allow for more comprehensive criticism based on design theory. Participants' ages ranged from 25 to 28. The usability testing criteria used in stage 1 were repeated, with the same questions asked. Again, participants' feedback was mostly positive. All participants thought the videos would help non-designers to use infographic design principles. The step-by-step principle application with examples was thought to be an effective method of educating non-designers. The motion graphics were said to be effectively designed and the information presented easy to understand. Again, there was some criticism of the audio quality, with two participants finding the background music distracting and too loud compared to the voiceover. One participant also

found the voiceover quality to be lacking in sections. One participant suggested adding a summary section at the end to summarise the five principles in each video. Participants were also asked if they thought the target audience would benefit from additional teaching material to help them understand the design principles. The majority thought that a pdf booklet should be added as this would allow the user to "have the design and the principles side by side".

Based on the feedback received, the following changes were made to the motion graphic video:

- Some of the voiceovers were re-recorded to improve the audio quality.
- Better quality and less distracting background music was used, and the volume was reduced so the voiceover is clearer.
- The quality of some of the animated elements in the videos was improved.
- An online pdf resource summarising the 20 infographic design principles was developed. It showed the infographics before and after the principles had been applied and where the principles had been applied.
- A summary section was added at the end of each one of the 4 videos. Each summary section summarised the 5 principles discussed in the video and displayed the infographic before and after the utilisation of the principles.

2.7 Design development — final design output

Additional supporting material was developed in accordance with the feedback received during the second stage of usability testing. Participants thought that the additional resource should provide a summary of the videos, and that the most appropriate format would be an online PDF file that can be consulted easily during the design process. Consequently, a five-page PDF summarising the 20 infographic design principles from the videos was created. Figure 3 shows screenshots of the final educational resource, including the four motion graphic videos and the additional PDF.

3 Research materials and methodology

Once finalised, the educational resource (Figure 3) was applied in context to develop the research materials that were used in the study. Nine healthcare professionals were involved in the research material development process. The aim was to use the educational resource to improve their ability to design an infographic. To achieve this, a generative design method was developed and employed to allow the creation of infographics before and after the healthcare professionals had accessed the educational resource.

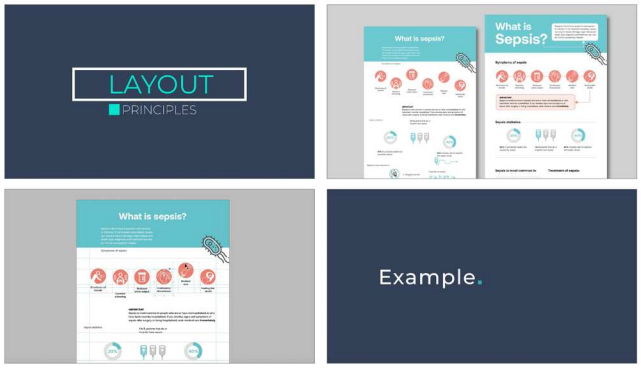
3.1 Research material generation process

A two-stage generative research process was implemented to create the infographic research materials. Due to the COVID-19 restrictions at the time of research, this process was conducted online using a remote methodology. Nine participants were recruited for the study: seven doctors, one nurse, and one research physiotherapist. Participants' ages ranged from 24 to 57, and they were all based in the UK and working for the NHS. Participants had no formal training or work experience in the field of graphic design. Participants were required to have a good level of computer literacy and some experience of using common design software such as Microsoft PowerPoint or Google Slides. In the first stage of the process, participants were provided with research instructions and asked to complete a short questionnaire providing personal information and details of their existing experience with infographic design. Participants were also provided with a definition and an example of an infographic and were given the opportunity to ask questions before starting the experiment. The questionnaire revealed that 100% of the participants had been previously required to create an infographic for their work or study programme. The content of these infographics included:

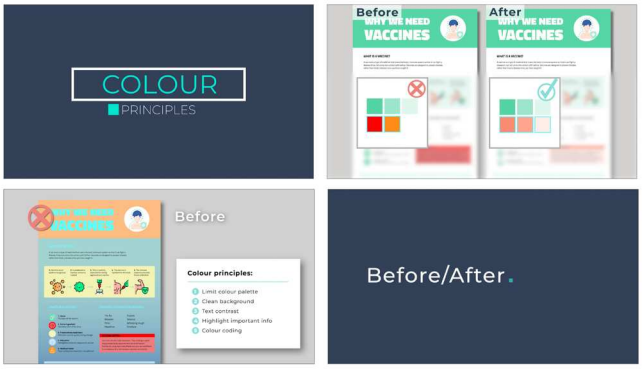
- Medical school infographic posters
- Medical study research presentation
- Clinical Audit results presentation
- Patient information posters
- Medical course group project presentation

MOTION GRAPHICS SCREENSHOTS

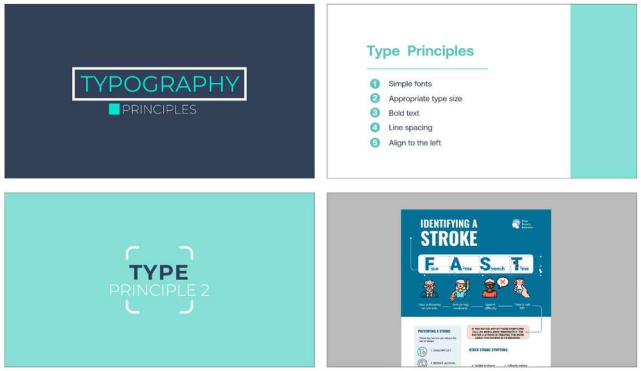
Layout video



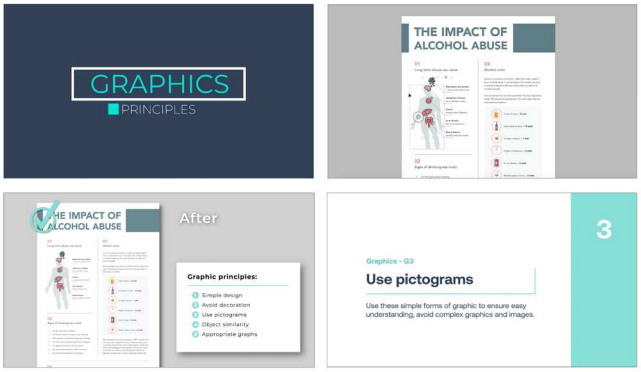
Colour video



Typography video



Graphics video



ADDITIONAL PDF

Figure 3. Screenshots of the final education resource output, including the four motion graphic videos and the supporting PDF.

and these were displayed in the following scenarios:

- GP practices
- University medical schools
- Group medical teaching sessions
- Medicine research conference (e.g., British Transplant Society conference, presented at both national and regional level)
- Hospitals (displayed within the trust)

This confirms that healthcare professionals are being required to design infographics which are displayed in public settings such as hospitals, GP practises and national conferences. Given participants' lack of design experience, this may explain the varying quality of the infographics sometimes published by public health bodies.

Next, participants were digitally supplied with a word document containing information about heart attacks, and with a selection of graphs of varying design and quality. The information content was collected online from NHS (NHS, 2021), Mayo Clinic (MayoClinic, 2021) and the British Heart Foundation (BHF, 2021) websites. Participants had 120 minutes to create an infographic that had to include all of the information from the word document, two graphs from the selection provided, and any images from the internet they wished to include. To create the infographic, participants were provided with a link to a blank Google Drawings template with set dimensions. A researcher was present during the entire process by video call, ready to answer any questions about the research or the software. None of the participants had any difficultly using the Google Drawings software.

The second generative design stage took place a week after the completion of the first stage. During the week between the two stages, participants were required to watch the four motion graphic videos and read the supporting PDF. At the start of the design process, participants were asked to watch the videos again and to keep the PDF open so that they could refer to it throughout the process. Participants were then asked to create a second infographic with the same information used in the first infographic in no more than 120 minutes. Although the content and the time frame were the same, this time participants had access to the educational resource which instructed them to apply what they had learned from the resource in their infographic generation process.

3.2 Infographic design outcomes

3.2.1 Initial design principle analysis

The infographic development stage resulted in the design of 18 infographics by nine healthcare professionals (Figure 5). Each participant created two infographics. The first infographic was created without any input, and the second after watching a series of instructional motion graphics aiming to educate them on how to create effective infographics through the application of design principles.. In this research, 'G1' will refer to the infographics designed in the first stage, i.e., those designed by the healthcare professionals with no input. 'G2' will refer to the infographics designed in the second stage, i.e., those created by the same participants after they had engaged with the educational resource. An analysis of the application of the 20 design principles to the design of the G1 and G2 infographics was conducted. It is acknowledged that this analysis was based on the opinion of the researchers, and it is, therefore, subjective. For that reason, its results were not presented as evidence of effectiveness. Instead, the results were used to inform the selection process of the infographics, and to test the designs that appeared to have made the most potential improvement. The results show that on average, 7.7/20 principles were used in the G1-before infographics, and 17.2/20 principles were used in the G2-after infographics. This is an average improvement of 9.5 principles, or 170.6%, between the G1 and G2 infographics. Every participant showed some improvement, with the number of principles used ranging from 3 to 14 principles. The infographics that were selected for testing were the ones that showed the most improvement between their designs in G1 and G2: infographic 3 (with an increase of 12 principles), infographic 5 (with an increase of 14 principles) and infographic 8 (with an increase of 12 principles). Limiting it to the 3 most potentially improved pairs allowed to test for the highest potential benefit of the educational process. It also made it possible to statistically compare the designs to see if specific infographics within G1 or G2 were more effective. The results of this initial analysis suggested that the educational videos can lead to improved application of infographic design principles. This is explored using experimental research later in the study. The results of the analysis can be viewed in Figure 4.

3.2.2 Infographic testing material selection

The three most improved infographics were selected for experimental testing. The purpose of the testing was to investigate if the infographics designed after the participants watched the videos were better-quality than those designed with no educational input. 'Improvement' would be measured by performance data including information location speed and recall accuracy, as well as user

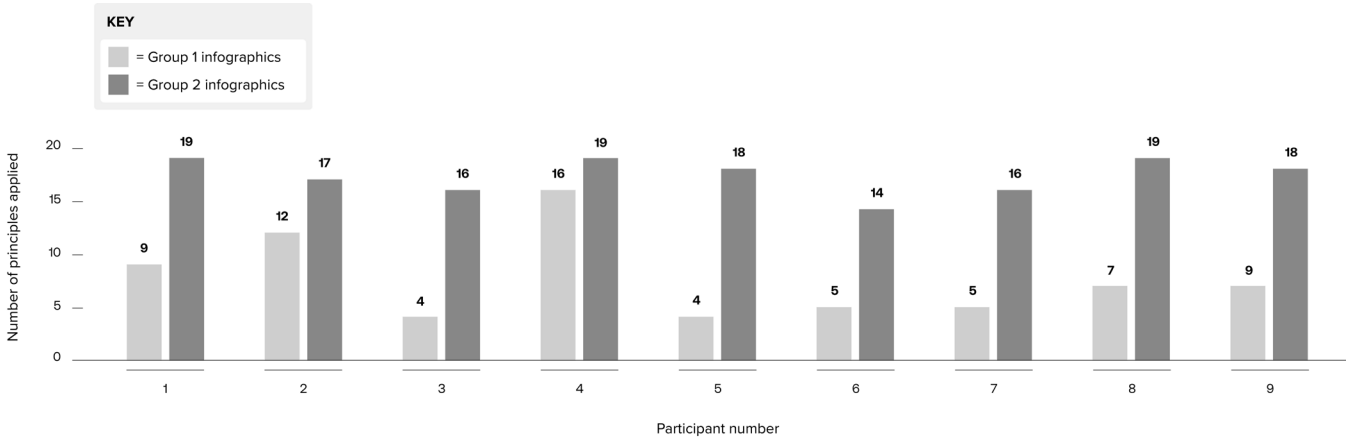


Figure 4. Number of design principles applied to the infographics before (G1) and after (G2) the users accessed the education resource.

opinion data. Significant improvement would suggest the design of the public health infographics had benefited from use of the educational motion graphics. The infographic outputs can be viewed in Figure 5, with those selected for testing shown larger.

3.3 Healthcare professionals' opinions

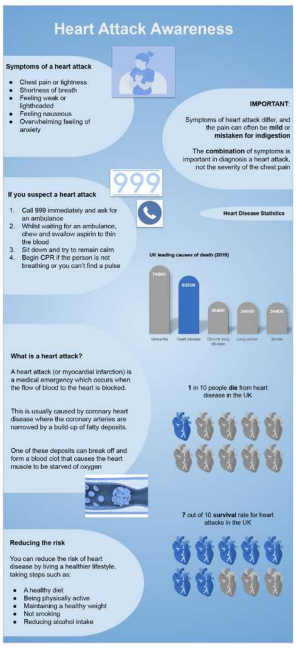
After completing the two design stages, participants completed an opinion questionnaire. The aim of the questionnaire was to gather participants' opinions on the motion graph videos and additional pdf they used to learn about infographic principles. The questionnaire consisted of Likert scale and open questions. The results of the Likert scale questions can be viewed in Figure 6.

Participants' answers to the interview questions provided additional positive support. Participants thought that the videos had an appropriate amount of content, were clear, engaging and easy to understand. They appreciated the structured approach, with quality content being covered in "manageable chunks". Participants were able to recognise the faults in their first designs that were highlighted in the videos and correct these using the principles that were "simple and easy to keep in mind" and which "dramatically improved my knowledge of how to make a good infographic".

Participants also stated that they would refer to the resources again to refresh what they had learned. Some participants stated that they are not taught about information presentation during medical training, despite it being something they often find themselves doing, and so they would use the resources to design posters in the future. They would also use the resources to create infographics

Test infographics 1

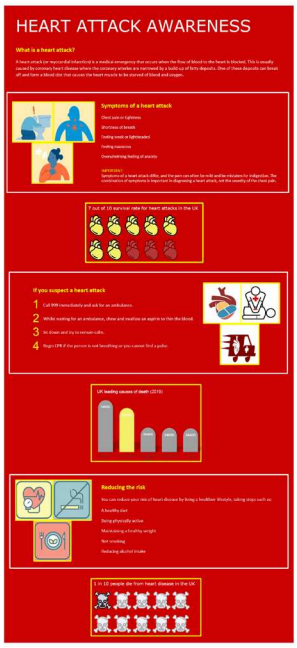
G1 - Before



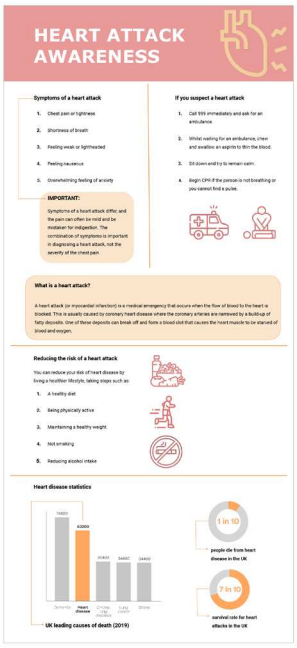
G2 - After

Test infographics 2

G1 - Before

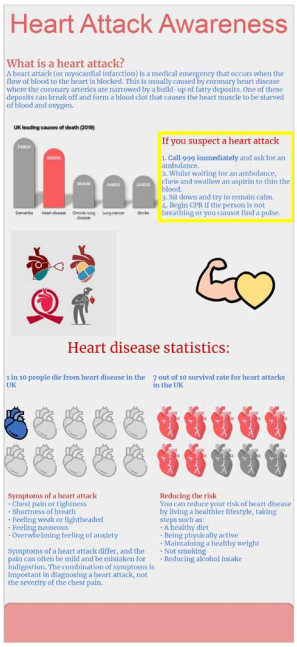


G2 - After

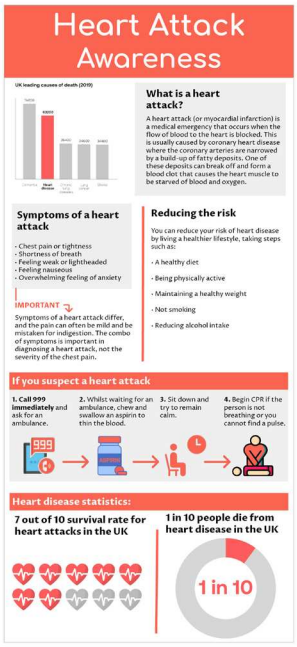


Test infographics 3

G1 - Before



G2 - After



Untested design outputs

G1 - Before

G2 - After

Figure 5. The infographics developed by the users both before (G1) and after (G2) using the educational resource. The three infographics chosen for testing are infographics 1, 2, and 3.

for medical audit results, teaching presentations, and research posters. The videos were considered a good introduction to design and a "cheat sheet" on how to make a good infographic. They were considered professional and easy to watch. The voiceover was clear, and the graphs were well designed with an appropriate amount of information. Participants also thought that the videos were concise with a good pace and were pitched at the right level. These results, alongside the highly positive Likert scale results (Figure 6) and principle analysis (Figure 4), provide preliminary evidence in support of the initial hypothesis. The next stage of the research looks to statistically determine if participants using the G2 infographics perform better than those using the G1 infographics.

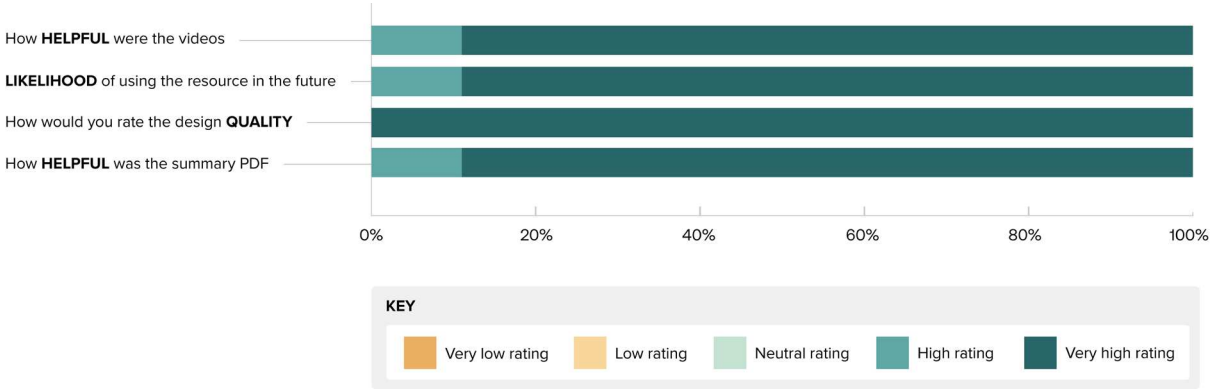


Figure 6. The results of the Likert scale questions in the opinion questionnaire.

3.4 Experimental methodology — justification

The purpose of the experimental methodology was to compare the performance of participants using the G1 infographics to that of participants using the G2 infographics. The previous preliminary results supported the hypothesis that the G2 infographics, created after the healthcare professionals accessed the educational resource, would exhibit better performance results than the G1 infographics. Therefore, the experiment aimed to find empirical evidence that use of the educational resource can improve the effectiveness of public health infographic design.

The improvement in effectiveness was determined by measuring the information location speed, memorability of information, recall time, and user opinion. Similar methods have been previously utilised by Lonsdale et al. (2019) and Lonsdale et al. (2020), who used information location time, comprehension and memorability accuracy, and user opinion to compare the effectiveness of information design outputs. Similarly, Wang et al. (2019) used information memorability and user opinion as a measure of the effectiveness of infographics.

Memory recall has also been used to measure the effectiveness of health communications using images (Houts et al., 2006). Houts et al. (2006) state that once a healthcare message is understood, it must be remembered for it to be used, reinforcing the importance of recall in the assessment of knowledge acquisition. The purpose of public health infographics is to educate a target audience on health-related information, and ultimately promote behaviours which will benefit the public health of large populations. Thus, information memory recall is key in determining the effectiveness of an infographic given that the information presented in the infographic has to be remembered to elicit behavioural benefits. In this study, short-term recall was measured rather than comprehension, as this appeared to be a more appropriate measure of the effectiveness of the design outputs.

Based on these existing methodologies, participants were asked to locate key information on an infographic. This was followed by a recall test and opinion questionnaire. Given that the purpose of a public health infographic is to engage the user and efficiently educate them on key health information (Scott et al., 2016), the timed location and recall accuracy of information tasks were considered appropriate for the experiment.

3.5 Experimental methodology — participants

60 participants from the general public were recruited for the study. Healthcare professionals and those studying in the field were excluded from the study. The reason for that being that these individuals would have a more in-depth knowledge of the subject matter to be used for the content of the infographics, i.e., heart attack, which could affect the recall testing results. Statistics related to participants' personal details can be viewed below (Figure 7).

Although a slight gender bias was displayed between the two groups, with group 2 having more participants that identified as female, this did not impact the results of the study. An independent sample t-test was performed in both groups comparing gender with both information location time and recall accuracy. In group 1, there was no significant difference between male ($M = 135.255$, $SD = 64.062$) and female ($M = 161.313$, $SD = 62.118$) information location time; $t(30) = -1.131$, $p > 0.05$, and no significant difference between male ($M = 4.827$, $SD = 0.941$) and female ($M = 4.493$, $SD = 1.212$) recall accuracy; $t(30) = 0.842$, $p > 0.05$. Equally, in group 2, there was no significant difference between male ($M = 94.986$, $SD = 8.483$) and female ($M = 102.889$, $SD = 16.749$) information location time; $t(30) = -1.335$, $p > 0.05$, and no significant difference between male ($M = 5.733$, $SD = 0.837$) and female ($M = 5.962$, $SD = 0.582$) recall accuracy; $t(30) = -0.863$, $p > 0.05$.

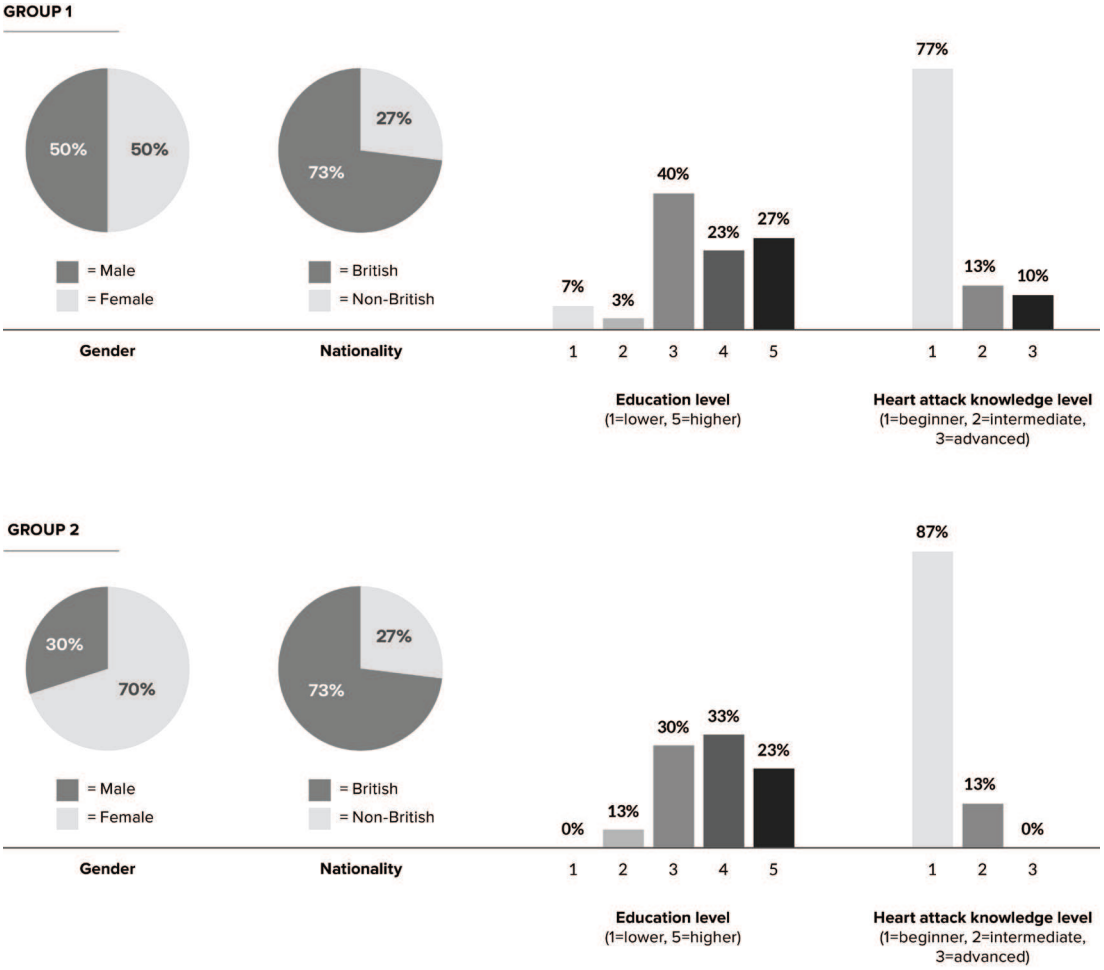


Figure 7. Graphs displaying the personal details of the participants in the two testing groups.

3.6 Experimental methodology — procedure

The 60 participants were randomly divided into two groups of 30 participants each. The first group used the infographics developed by healthcare professionals before using the motion graphic resource. The second group used the infographics developed by healthcare professionals after being educated on infographic principles using the motion graphics resource. Once assigned to a group, participants were then randomly assigned an infographic. Three infographics were tested in each group meaning that each infographic was tested with 10 participants.

The experiment took place over video call on Microsoft Teams. Participants were asked to follow a link to a Google Forms document that was divided into four sections. The first section explained the data collection process and contained a consent section. The second section was the personal detail section. In

the third section, participants were provided with a definition of infographic along with an example. This was to ensure participants understood what an infographic was before the experiment started. The fourth and final section of the form explained the experimental process. All instructions provided were repeated verbally to ensure understanding. The form also contained a link that opened the infographic that participants would be using during the experiment. Participants were asked to make sure that their internet browser was full screen so that the infographic would be displayed in the same way for all participants.

Once participants notified the researcher that the infographic was loaded, the experiment started. The experiment was divided into four sections. Section 1 was an information location task in which participants were required to locate on the infographic the answer to a question. There were seven questions in total. The questions appeared one at a time and once participants found the answer to the question, they were asked to read it out loud to ensure they had located the correct answer. There was no time limit for locating the information and only when the correct answer was located did the participant move on to the next question. All participants correctly located 100% of the answers. This section was timed by the researcher, starting when the first question was asked and ending when the last answer was located. Participants were then asked to close the infographic they were using, submit the Google Form and return to the video call.

The second section of the experiment consisted of an interview that took approximately five minutes to complete. The purpose of this section was to create a distracting task between the information location task and the upcoming short-term recall testing section, rather than to collect data. Previous research has used a similar technique in the testing of short-term memorability, implementing a task to distract the participant from the information they have just learned in order to test for short-term memorability as appose to comprehension (Bateman et al., 2010; Obie et al., 2019).

Participants were asked to provide detailed answers to the following questions:

1. Was there anything on the infographic that you found hard to find?
2. Was there anything on the infographic that you found hard to understand?
3. Do you think that infographics are a good way to communicate public health information?
4. Do you think the infographic you used was successful in teaching you about heart attacks?
5. What did you think of the design of the infographics you used?

The third section of the experiment was a short-term recall testing task. Participants were asked the same questions that they had been asked in the

information location task and were requested to recall the information they had previously located on the infographics. They were asked not to guess the answers to the questions or to use any existing knowledge. Again, there was no time limit for recalling the information and participants were allowed as much time as they needed to recall the answers.

The fourth and final section of the experiment was an opinion questionnaire to gather participants' opinion on both the functionality and the design features of the infographic used. With regard to the functionality of the infographic, participants were asked to agree/disagree with a statement based on a 5-point Likert scale: 1. Strongly disagree, 2. Disagree, 3. Neutral, 4. Agree, 5. Strongly agree. The statements were as follows:

1. The information was easy to find.
2. The information was presented in a way that was easy to understand.
3. The infographic was effective in teaching about heart attacks.
4. The infographic was memorable.
5. The infographic was attractive.

The second set of Likert scale questions aimed to gather participants' opinion on the design features of the infographic that they had used. Participants were asked to rate how effective/ineffective they considered a feature on 5-point Likert scale: 1. Highly ineffective, 2. Ineffective, 3. Neutral, 4. Effective, 5. Highly effective. The features they were asked to rate were as follows:

1. Layout
2. Colour
3. Text and headings
4. Graphics and graphs
5. Overall design

Next, an adapted Microsoft Desirability Toolkit was used to gauge participants' opinions of the design. Participants were asked to select three words out of 20 descriptive words (10 positive and 10 negative) to describe their opinion of the design. Lastly, participants were asked open questions about what they thought was successful and what could be improved about the infographic they used. Once this questionnaire was submitted the study was complete.

4 Results

4.1 Performance results

The information location time and information recall accuracy data were compared using independent sample t-tests. The 60 participants were assigned to either group one or group two, with one participant only using a singular design, meaning the participants from each group were independent of one another. Given that participants were randomly assigned one of three design variations within the group, one-way ANOVA tests were performed to examine any differences in information location or recall between the design variations.

4.1.1 Performance results — Information location

Participants located information significantly faster when using the G2-after designs ($M = 100.518$, $SD = 15.063$), compared to when using the G1-before designs ($M = 148.284$, $SD = 63.400$); $t(30) = 4.015$, $p < 0.001$ (Figure 8a).

4.1.2 Performance results — recall accuracy

Participants' accuracy of information recall scores were significantly better when using the G2-after design ($M = 5.893$, $SD = 0.662$), compared to when using the G1-before designs ($M = 4.667$, $SD = 1.085$); $t(30) = -5.289$, $p < 0.001$ (Figure 8b).

4.1.3 Performance results — recall time

Participants also recalled the information significantly faster after using the G2-after designs ($M = 106.819$, $SD = 25.607$), compared to after using the G1-before designs ($M = 125.941$, $SD = 24.864$); $t(30) = 2.934$, $p = 0.005$ (Figure 8c).

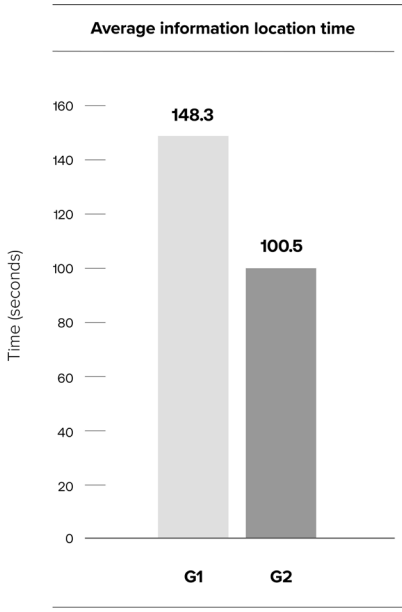


Figure 8a. Average info location time for G1 and G2.

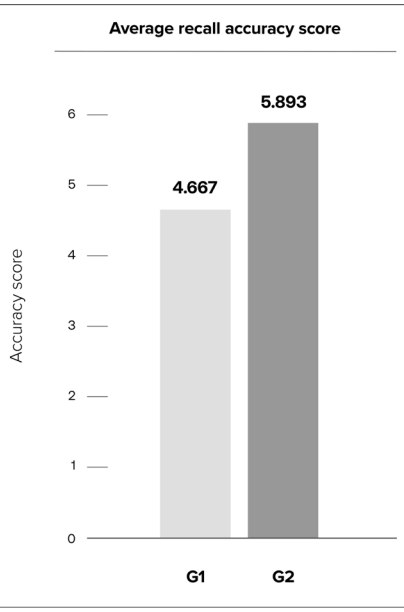


Figure 8b. Average recall accuracy secores for G1 and G2.

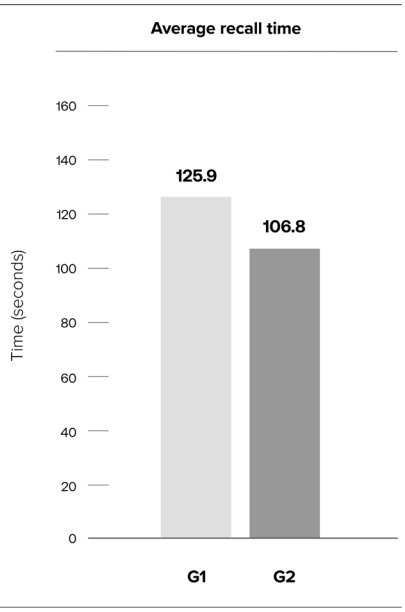


Figure 8c. Average recall time for G1 and G2.

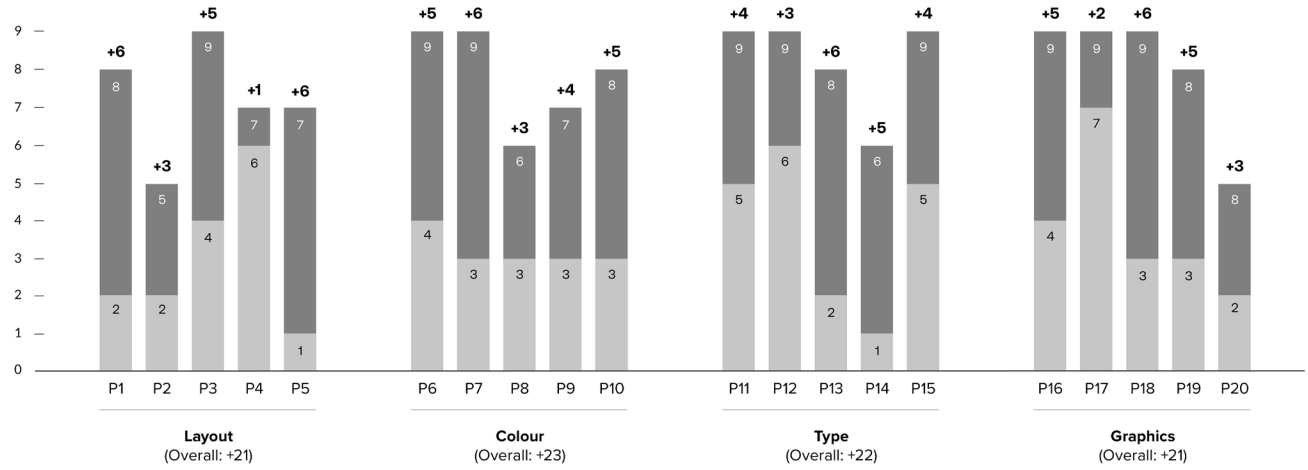
4.1.4 Performance results — one-way ANOVA tests

A one-way ANOVA was used to test for differences between the three design variations in both G1-before and G2-after. The one-way ANOVA for G1-before revealed that there were no significant differences between the design variations for the mean information location time ($F(2, 27) = [0.007]$, $p = 0.993$), recall accuracy scores ($F(2, 27) = [1.425]$, $p = 0.258$), and recall time ($F(2, 27) = [0.068]$, $p = 0.934$). The one-way ANOVA for G2-after also revealed that there were no significant differences between the design variations for the mean information location time ($F(2, 27) = [0.023]$, $p = 0.977$), recall accuracy scores ($F(2, 27) = [2.612]$, $p = 0.092$), and recall time ($F(2, 27) = [2.323]$, $p = 0.117$).

4.1.5 Performance results — principle application analysis

An analysis was conducted to compare the application of the 20 design principles to the infographics from G1 and G2. This analysis included all 18 infographics (9 from G1-before and 9 from G2-after) that were developed by the medical professionals (see Figure 5). Although this cannot be said to be statistically comparable analysis, it investigated trends in principle application, revealing those principles that were most improved after the educational resource was accessed. The results of the analysis can be viewed in Figure 9. 4.2

Principle improvement comparison



Principle improvement ranking

= Layout = Colour = Type = Graphics

+6

- **P1- Align elements -** Align your text and graphics to create an organised appearance, this can be achieved using a layout grid.
- **P5 - Connect information -** Connect related chunks of information and create a purposeful reading order using lines, arrows and numbers.
- **P7 - Clean backgrounds -** Use plain light backgrounds to reduce distractions, if in doubt use a white background.
- **P13 - Bold text -** Use bold or capitals to emphasise important words and information, be selective with its use.
- **P18 - Use pictograms –** Use these simple forms of graphics to ensure easy understanding; avoid complex graphics and images.

+5

- **P3 - Enclosure -** Enclose related information using coloured shapes or outlines, this can create information chunks that make your design easier to remember.
- **P6 - Limit colour palette -** Choose a complimentary colour palette of 2 or 3 colours.
- **P10 - Colour coding -** Use colour purposefully to show information is related, by using the same colour for certain info.
- **P14 - Line spacing –** Increase the line spacing in paragraphs to make your information easier to read.
- **P16 - Simple design–** Make you design simple and consistent, using graphics that are easy to understand.
- **P19 - Object similarity –** Make objects visually similar if they are related. This can be done by matching visual elements such as colour, shape and size.

+4

- **P9 - Highlight important info -** Highlight the most important words or areas of information using a colour from your palette.
- **P11 - Simple fonts** - Use up to 2 or 3 non-decorative fonts on the infographic, a good tip is to use one font for the text body and another complimentary font for the headings.
- **P15 - Align to the left –** Make sure your lines of text fit to the left to optimise readability.

+3

- **P2 - Proximity -** Placing information close together suggests it is related. Use this to group related information into a chunk.
- **P8 - Text contrast -** Ensure colour contrast is high between the text and the background to make it easier to read.
- **P12 - Appropriate text size -** Ensure your text is the right size; smaller than your headings but still easy to read.
- **P20 - Appropriate graphs –** If you are using graphs, ensure they are easy to understand and match your colour scheme.

+2

- **P17 - Avoid decoration –** Remove decorative graphics and only use them if they are representing your written information.

+1

- **P4 - Noticeable headings -** Use headings to divide chunks of information. Make sure they are significantly bigger/bolder than the text body.

Figure 9. The most improved design principles according to the principle improvement analysis.

4.2 Opinion results

4.2.1 Opinion results — microsoft desirability toolkit

The results of the Microsoft desirability toolkit word selection revealed clear differences between G1 and G2 (Table 4). In G1, 37% of the words chosen to describe the design were positive and 63% were negative. The five most common words used to describe the G1 designs were: accessible, helpful, dated, hard to use, and time consuming.

In G2, 96% of the words chosen to describe the design were positive and 4% were negative. The five most common words used to describe the G2 designs were: clear, accessible, straightforward, helpful, and calm. These results show that the designs from G2 were described far more positively than those from G1, supporting the hypothesis of the research.

	G1		G2	
+ Positive	**Accessible**	**8**	**Clear**	**22**
	Helpful	**8**	**Accessible**	**13**
	Straighforward	4	**Straighforward**	**12**
	Clear	3	**Helpful**	**11**
	Effective	3	**Calm**	**7**
	Calm	2	Effective	5
	Reassuring	2	Reassuring	2
	Clean	1	Clean	1
	Easy to use	1	Easy to use	1
	Novel	1	Novel	0
- Negative	**Dated**	**13**	Confusing	1
	Hard to use	**12**	Hard to use	1
	Time consuming	**8**	Overwhelming	1
	Confusing	4	Time consuming	1
	Comlpex	4	Complex	0
	Discouraging	4	Dated	0
	Ineffective	4	Discouraging	0
	Overwhelming	4	Unhelpful	0
	Unhelpful	2	Ineffective	0
	Stressful	2	Stressful	0

Table 4. The words selected to describe the designs from G1 and G2 using a Microsoft Desirability Toolkit.

4.3 G1 opinion results

4.3.1 G1 — positives features of the designs

Participants liked that the information was broken up into smaller chunks rather than presented as a paragraph, and that there wasn't too much information. Participants also liked the use of images and graphs to represent the written

information. Overall, participants did not consider the 'G1- before' infographics to have many positive features, some saying there was nothing they liked about the designs.

4.3.2 G1 — negative features of the designs

The colours used were thought to be either boring or inappropriate. One of the infographics had a red background which most participants said it was distracting or made them feel anxious. Participants also thought that the information was often poorly placed, with key information not effectively emphasised, and that the layout was unclear. Some also said that the images did not relate to the information. It was also thought that there was too much information, despite the content being the same in all designs, and that to locate the correct information the whole infographic had to be scanned. Some participants also thought the text was too small and hard to read.

4.4 G2 opinion results

4.4.1 G2 — positives features of the designs

Participants liked the clean design style and calming colours of the 'G2- after' designs. They thought the reassuring tone suited the potentially overwhelming health-based content. Participants thought that the accompanying images were appropriately simple and made the information easier to understand and recall. Participants also liked the layout of the designs, stating it made it easy to locate the information. They liked that the design was not too text heavy, and that the information was divided into clear sections. Overall, participants considered the 'G2- after' infographics to have many positive features.

4.4.2 G2 — negative features of the designs

Some participants thought that some of the more important information could have been more strongly emphasised. Some thought that the small text and the small graphs in the statistics section made the information difficult to read at times. The definition of a heart attack was said to be too text heavy or to have been placed in the wrong section. Some participants stated there was nothing they would change about the designs.

4.5 Likert scale

4.5.1 Results — likert scale

Participants were also asked to rate the functionality and the design features of the infographic they used based on a 5-point Likert scale. The results of the Likert scales for both G1 and G2 can be viewed in Figure 10 below.

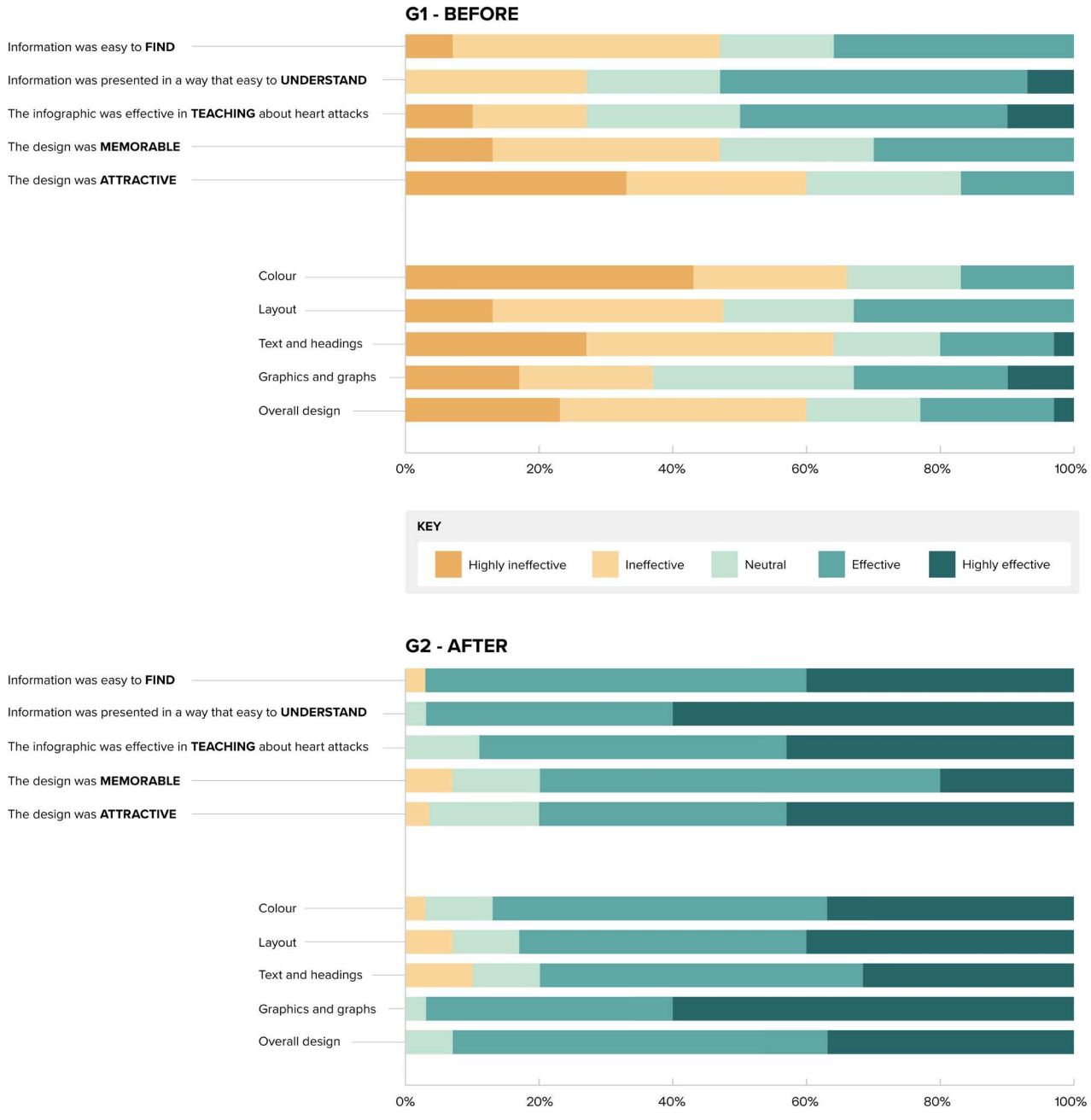


Figure 10. The results of the Likert scale questions for both G1 and G2.

5 Discussion and conclusion

The research results strongly support the initial hypothesis. It was theorised that use of a user centred educational tool could improve the design of public health infographics developed by healthcare professionals. The quantitative results, the data from the qualitative questionnaire and the interview data all support the hypothesis. This has potentially important implications for future design practices, given the current popularity and widespread application of infographics to display public health information. This also provides evidence that the use of design principles results in more effective public health infographics, and that the design principle education of non-designers using motion graphics is a valid approach to improving the quality of public health infographics.

5.1 Discussion — performance results

The following were used to measure performance: information location time, information recall accuracy scores, and recall time (Figure 8). It was hypothesised that the participants from G2 would have faster information location times, higher recall accuracy scores, and faster recall times than the participants from G1. Information was located significantly faster by participants using the G2 designs, compared to those using the G1 designs. The infographics from G1 and G2 displayed the same information in the same dimensions, the only difference between them being the design of the outputs. Information was also recalled significantly more accurately by participants using the G2 designs, compared to those using the G1 designs. Comparison of recall times also revealed that the participants using the G2 infographics recalled the answers significantly faster than the participants using the G1 infographics. So, 26 information was not only recalled more accurately, but it was also recalled significantly faster. Recall speed has previously been used to evaluate memory performance (e.g., van den Broek et al., 2014; Keresztes et al., 2014; Racsmány et al., 2018), and in combination with recall accuracy, it has been suggested as an appropriate measure of memory accessibility (Kubik et al., 2018).

Together, these results provide clear evidence of the superiority in usability of the infographics created after the educational resource was used, with the G2 outputs displaying information that was both easier to find and more memorable.

The infographics tested in G1 contained three design variations created by designers without any input, and those tested in G2 contained three design variations created by the same designers after using the educational resources. One-way ANOVA tests were performed to determine whether there were any potential performance differences in the design variations within each group. The results for both G1 and G2 revealed that there was no significant difference between the design variations with regard to the information location time and recall accuracy scores in neither of these groups. This showed that there was not a specific design variation that disproportionately affected the results of the research, providing evidence that the designs in the G2 group performed better than the designs in the G1 group.

Additional analysis was conducted to assess the application of the 20 infographic principles that the healthcare professionals were asked to use in their second design outputs. The difference between the frequency of application in the G1 and G2 designs was calculated for each individual principle in order to identify the principles that were most improved (Figure 9). As expected, every principle was applied more frequently in the second stage of infographic design (after using the educational resource). By revealing the principles that were most improved, this analysis may have contributed the most to the improvement in effectiveness observed in the G2 designs.

It is important to note that this analysis did not determine the most important principles, as some of the most impactful principles may have been those already applied by the participants in the initial design stage. The analysis identified the principles that were not typically applied by non-designers, but that the teaching resource had allowed them to apply, resulting in more effective infographic outputs. In other words, the analysis identified the principles that may have had the most impact on the improvement in effectiveness in the G2 infographics.

The analysis also compared the principle improvement between the principle categories (layout, colour, type, graphics) to determine if any one category was seen as more important than another. The improvement appeared to be consistent across all four principle categories. This suggests that the categories are of similar importance and emphasises the fact that all four categories of design need to be taken into account in the infographic design process in order to maximise effectiveness.

5.2 Discussion — opinion results

The data from the qualitative opinion questionnaire supported the positive quantitative findings. The results further confirmed the hypothesis, with the infographics from G2 more positively received when compared to the G1 infographics which received mixed responses (Figure 10).

Typically, participants' responses with regard to the functionality of the G1 infographics were neutral or negative. Notably, the majority of participants also disagreed or strongly disagreed with the statement 'the infographics were attractive', suggesting the infographics from G1 were considered aesthetically unappealing.

A similar pattern was observed with regard to the design features considered (layout, colour, text and headings, graphic and graphs, and overall design), with the majority of participants rating them as negative or neutral. These responses indicated that the participants using the G1 infographics found them poor in terms of functionality, and badly designed.

The responses to the G2 infographics were more positive. When considering the functionality of the designs, the majority of participants agreed or strongly agreed with all 5 statements (Figure 10). This was also true of all five design features with most participants considering them effective or highly effective. These responses indicated that the participants using the G2 infographics found them both functional and well designed.

The results of the Microsoft desirability toolkit reflected the Likert scale results. Mostly negative words were selected to describe the designs in G1 (63%), the top five words used being: accessible, helpful, dated, hard to use, and time consuming. In contrast, mostly positive words were selected to describe the designs in G2 (96%), the top five words used being: clear, accessible, straightforward, helpful, and calm (Table 4). The data from the interviews also support the quantitative results. Participants using the G1 infographics found the colours inappropriate, layouts confusing, and the way information was emphasised ineffective. Some participants said that there was nothing they liked about the designs. The designs were generally thought to be unattractive and hard to use. Participants using the G2 infographics offered more positive feedback: clear layout, clean colour schemes, simple images, and appropriately structured layouts.

The qualitative results showed a more positive user response to using the G2 infographics compared to using the G1 infographics. The G2 designs were considered more attractive, more functional, and better designed infographics, producing clear, straightforward, and calming emotional

responses. Perceived aesthetic and usability ratings can influence the willingness to engage with a design (Tractinsky et al., 2000; Harrison et al., 2015; Seo et al., 2015; Lau et al., 2021). Both the quantitative and qualitative results provide evidence that the infographics from G2 performed better than those from G1, which confirms that the use of the educational resource resulted in more effective design outputs.

5.3 Discussion — links to existing research

Infographics play a key role in the dissemination of public health information (Chan et al., 2020; Hamaguchi et al., 2020), and have been shown to be effective in inciting positive public behavioural changes (Crutcher and Seidler, 2021; Egan et al., 2021; Lunn et al., 2021). Although the effectiveness of infographics has been recognised, research into practical approaches for creating effective designs is limited, although the need has been acknowledged (Scott et al., 2017; Kemp et al., 2021). Infographic principle application has been recognised as a means to improve design practices (Stones and Gent, 2015a; Lonsdale and Lonsdale, 2019; Hernandez-Sanchez et al., 2021), and have been shown to be an applicable method for improving the effectiveness of public health infographics (Baxter et al., 2021).

However, those with limited design experience will find design principles difficult to follow, as exemplified in multiple COVID-19 infographic related publications (e.g., Stonbraker et al., 2019; Hamaguchi et al., 2020; Lunn et al., 2021). This research proposes a practical method for the application of infographic design principles. The principles have been adapted so as to make it possible for those with limited design experience, such as healthcare professionals, to create effective infographics. Usability testing results show that the motion graphic educational process resulted in the design of significantly more this study is the first study to propose a motion graphic educational tool to improve the effectiveness of public health infographics.

Motion graphics have been shown to reduce the cognitive effort required to understand information when compared to static graphics (Hsueh et al., 2016). They are also considered to be an effective learning tool in an educational setting (Wiana et al., 2018; Hapsari and Hanif, 2019). Motion graphics developed using a user centred design process have also previously been found to lead to significant improvements in knowledge acquisition after viewing (Lonsdale and Liao, 2018). The results of this study provide further support for the use of motion graphics in an educational setting. Here, they were utilised to teach complex design concepts and their application to an audience with limited experience in the field of graphic design.

Educators will also benefit from the results of this study. The motion graphics proposed in this study were highly effective in teaching complex design practices to an audience with no previous design training. They made it possible for these users to both understand and apply complex new knowledge in an efficient time frame. The learning time was less than one hour as materials were consumed in under 30 minutes (the four motion graphics were less than five minutes each). Moreover, materials were accessed twice by the participants, suggesting that a meaningful level of knowledge acquisition was achieved through this format. According to the feedback from the participants in the study, the motion graphics were both engaging and easy to follow. The findings of this study demonstrate that motion graphics are an effective method for conveying complex practical concepts to non-experts. Future research into educational procedures may wish to consider the development of instructional motion graphics to efficiently explain complex concepts.

5.4 Discussion — research limitations

A limitation of this research lies in the distribution of the findings. The motion graphics developed are not currently available online. For the education tool to be impactful on the development of public health infographics it would require an accessible and engaging distribution method. Ongoing work is looking to adapt and distribute the education resource through a continuous professional development programme available at the University of Leeds. The aim is to maximise the circulation of the resource so that it can be used in the development of infographics in public health and other applicable fields.

A further limitation is that the quality of the infographics developed after using the motion graphics could still be improved. However, it is unrealistic to expect an individual with very limited design experience, such as a healthcare professional, to produce an information visualisation to the same standard as an experienced information designer. Infographics are going to continue to be created by those with limited design experience, and an educational resource such as the one developed in this study may help maximise the effectiveness of the inevitable design outputs. It may also be argued that the improvements observed in the infographics in G2 were simply due to practice, given the same group of participants designed the outputs. However, all of the participants had previously created infographics outside of this study, suggesting previous practice had already taken place and would have similarly impacted both conditions.

5.5 Discussion — conclusion

The education resource developed in this study has the potential to improve the effectiveness of infographic design outputs. It should, therefore, be utilised to maximise the effectiveness of infographics displaying key healthcare messages, as it would increase the memorability and location efficiency of the information. Given the now widespread use of infographics to communicate public health messages, such a resource can offer great benefits. Although currently untested, it is believed that this motion graphic principle educational process can also be used to improve the design of infographics in areas other than public health, such as public security information, education, safety campaigns, business statistics, journalism, and publication abstracts.

It should be noted that the health professionals who took part in the study and who created the infographics had very limited design experience and no formal training in graphic design. The distinct improvement in infographic design practice observed further supports the value of the educational resource and teaching process. It also suggests that this process and similar teaching resources would be accessible to other audiences with no previous design experience and could be utilised to improve infographic outputs across various fields. It should also be noted that the participants in this study were educated to a high level, and that it is currently not known how applicable such a resource is across various levels of user education. This research focused on users with limited or no design experience, however, the educational resource described here may also be useful for designers with minimal infographic experience, who could use it as a design theory recap resource. Further research is required to investigate how the application of the educational resource would benefit other fields and target users.

The variable quality of infographic design outputs has been acknowledged in the context of public health, where the clear and efficient communication of information is imperative, highlighting the need for engaging and easy to use infographics to maximise adherence to key health messages. The current research presents design principle education and application as a viable method for maximising the effectiveness of public health infographics. The research found that this is achievable even if individuals have limited design experience, broadening the viability of this approach to anyone creating health-related infographics, no matter their level of design experience.

The findings of this study establish a useful practice for design theory education through the development of motion graphics teaching materials using an iterative user centred development process. This research also presents an educational tool that could improve the design of key public-health messages. This research addresses a knowledge gap in the field of infographic design by

applying previous knowledge of the feasibility of design principle in context, as well as establishing a viable educational practice to improve the effectiveness of infographic design outputs.

References

Agley, J., Xiao, Y., Thompson, E. E., Chen, X., & Golzarri-Arroyo, L. (2021). Intervening on trust in science to reduce belief in COVID-19 misinformation and increase COVID-19 preventive behavioral intentions: randomized controlled trial. Journal of Medical Internet Research, 23 x)(10), e32425. 10.2196/32425

Ali, N., & Peebles, D. (2013). The effect of gestalt laws of perceptual organization on the comprehension of three-variable bar and line graphs. Human factors, 55 (1), 183–203. 10.1177/0018720812452592

Barlow, B., Webb, A., & Barlow, A. (2021). Maximizing the visual translation of medical information: A narrative review of the role of infographics in clinical pharmacy practice, education, and research. Journal of the American College of Clinical Pharmacy, 4 x)(2), 257–266. 10.1002/jac5.1386

Bateman, S., Mandryk, R. L., Gutwin, C., Genest, A., McDine, D., & Brooks, C. (2010). Useful junk? The effects of visual embellishment on comprehension and memorability of charts. Proceedings of the SIGCHI conference on human factors in computing systems.

Baxter, M., Lonsdale, M., & Westland, S. (2021). Utilising design principles to improve the perception and effectiveness of public health infographics. Information Design Journal, 26 x)(2), 124–156. 10.1075/idj.20017.bax

Bernard, M. L., Chaparro, B. S., Mills, M. M., & Halcomb, C. G. (2003). Comparing the effects of text size and format on the readibility of computer-displayed Times New Roman and Arial text. International Journal of Human-Computer Studies, 59 (6), 823–835. 10.1016/S1071-5819(03)00121-6

Bettman, J. R., Payne, J. W., & Staelin, R. (1986). Cognitive considerations in designing effective labels for presenting risk information. Journal of Public Policy & Marketing, 5 (1), 1–28. 10.1177/074391568600500101 8

Beymer, D., Russell, D., & Orton, P. (2008). An eye tracking study of how font size and type influence online reading. People and computers XXII: culture, creativity, interaction: proceedings of HCI 2008. the 22nd British HCI Group annual conference, 10.14236/ewic/HCI2008.23

BHF. (2021). Heart attack. Retrieved 1 October 2021 from https://www.bhf.org.uk/informationsupport/conditions/heart-attack

Brame, C. J. (2016). Effective educational videos: Principles and guidelines for maximizing student learning from video content. CBE – Life Sciences Education, 15 x)(4). 10.1187/cbe.16-03-0125

Buchner, A., & Baumgartner, N. (2007). Text–background polarity affects performance irrespective of ambient illumination and colour contrast. Ergonomics, 50(7), 1036–1063. 10.1080/00140130701306413

Chan, A. K., Nickson, C. P., Rudolph, J. W., Lee, A., & Joynt, G. M. (2020). Social media for rapid knowledge dissemination: early experience from the COVID-19 pandemic. Anaesthesia, 75 x)(12), 1579–1582. 10.1111/anae.15057

Cinelli, M., Quattrociocchi, W., Galeazzi, A., Valensise, C. M., Brugnoli, E., Schmidt, A. L., Zola, P., Zollo, F., & Scala, A. (2020). The COVID-19 social media infodemic. Scientific reports, 10 x)(1), 1–10. 10.1038/s41598-020-73510-5

Crutcher, M., & Seidler, P. M. (2021). Maximizing Completion of the Two-Dose COVID-19 Vaccine Series with Aid from Infographics. Vaccines, 9 (11), 1229. 10.3390/vaccines9111229

Domgaard, S., & Park, M. (2021). Combating misinformation: The effects of infographics in verifying false vaccine news. Health Education Journal, 80 x)(8), 974–986. 10.1177/00178969211038750

Dowse, R., & Ehlers, M. (2005). Medicine labels incorporating pictograms: do they influence understanding and adherence? Patient education and counseling, 58 (1), 63–70. 10.1016/j.pec.2004.06.012

Dunlap, J. C., & Lowenthal, P. R. (2016). Getting graphic about infographics: design lessons learned from popular infographics. Journal of Visual Literacy, 35 (1), 42–59. 10.1080/1051144X.2016.1205832

Dwyer, F. M., & Moore, D. M. (1991). Effect of color coding on visually oriented tests with students of different cognitive styles. The journal of psychology, 125 (6), 677–680. 10.1080/00223980.1991.10543330

Greenhalgh, T., Sivan, M., Delaney, B., Evans, R., & Milne, R. (2022). Long covid – an update for primary care. BMJ, 378 x)(1), e072117. 10.1136/bmj-2022-072117

Dzulkifli, M. A., & Mustafar, M. F. (2013). The influence of colour on memory performance: A review. The Malaysian journal of medical sciences: MJMS, 20 (2), 3.

Egan, M., Acharya, A., Sounderajah, V., Xu, Y., Mottershaw, A., Phillips, R., Ashrafian, H., & Darzi, A. (2021). Evaluating the effect of infographics on public recall, sentiment and willingness to use face masks during the COVID-19 pandemic: a randomised internet-based questionnaire study. BMC public health, 21(1), 1–10. 10.1186/s12889-021-10356-0

Farley, F. H., & Grant, A. P. (1976). Arousal and cognition: Memory for color versus black and white multimedia presentation. The Journal of Psychology, 94 (1), 147–150. 10.1080/00223980.1976.9921410

Galitz, W. O. (2007). The essential guide to user interface design: an introduction to GUI design principles and techniques. John Wiley & Sons.

Gelman, A., & Unwin, A. (2013). Infovis and statistical graphics: different goals, different looks. Journal of Computational and Graphical Statistics, 22 (1), 2–28. 10.1080/10618600.2012.761137

Gillan, D. J., & Richman, E. H. (1994). Minimalism and the syntax of graphs. Human Factors, 36 (4), 619–644. 10.1177/001872089403600405

Gkogka, E. (2018). Gestalt principles in UI design. Retrieved 12 December from https://medium.muz.li/gestalt-principles-in-ui-design-6b75a41e9965

Graham, L. (2008). Gestalt theory in interactive media design. Journal of Humanities & Social Sciences, 2 (1).

Hall, R. H., & Hanna, P. (2004). The impact of web page text-background colour combinations on readability, retention, aesthetics and behavioural intention. Behaviour & Information Technology, 23 (3), 183–195. 10.1080/01449290410001669932

Hamaguchi, R., Nematollahi, S., & Minter, D. J. (2020). Picture of a pandemic: visual aids in the COVID-19 crisis. Journal of Public Health, 42 x)(3), 483–485. 10.1093/pubmed/fdaa080

Hapsari, A. S., & Hanif, M. (2019). Motion graphic animation videos to improve the learning outcomes of elementary school students. European Journal of Educational Research, 8 (4), 1245–1255. 10.12973/eu-jer.8.4.1245

Harrison, L., Reinecke, K., & Chang, R. (2015). Infographic aesthetics: Designing for the first impression. Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems. 10.1145/2702123.2702545

Hawley, S. T., Zikmund-Fisher, B., Ubel, P., Jancovic, A., Lucas, T., & Fagerlin, A. (2008). The impact of the format of graphical presentation on health-related knowledge and treatment choices. Patient education and counseling, 73 (3), 448–455. 10.1016/j.pec.2008.07.023

Hernandez-Sanchez, S., Moreno-Perez, V., Garcia-Campos, J., Marco-Lledó, J., Navarrete-Munoz, E. M., & Lozano-Quijada, C. (2021). Twelve tips to make successful medical infographics. Medical Teacher, 43 x)(12), 1353–1359. 10.1080/0142159X.2020.1855323

Höffler, T. N., & Leutner, D. (2007). Instructional animation versus static pictures: A meta-analysis. Learning and instruction, 17 x)(6), 722–738. 10.1016/j.learninstruc.2007.09.013

Hick, W. E. (1952). On the rate of gain of information. Quarterly Journal of experimental psychology, 4 (1), 11–26. 10.1080/17470215208416600

Hildon, Z., Allwood, D., & Black, N. (2012). Impact of format and content of visual display of data on comprehension, choice and preference: a systematic review. International Journal for Quality in Health Care, 24 (1), 55–64. 10.1093/intqhc/mzr072

Houts, P. S., Doak, C. C., Doak, L. G., & Loscalzo, M. J. (2006). The role of pictures in improving health communication: a review of research on attention, comprehension, recall, and adherence. Patient education and counseling, 61 x)(2), 173–190. 10.1016/j.pec.2005.05.004

Hsueh, C.-H., Chou, J.-K., & Ma, K.-L. (2016). A Study of using motion for comparative visualization. 2016 IEEE Pacific Visualization Symposium (PacificVis). 10.1109/PACIFICVIS.2016.7465274

Huang, S., Martin, L. J., Yeh, C. H., Chin, A., Murray, H., Sanderson, W. B., Mohindra, R., Chan, T. M., & Thoma, B. (2018). The effect of an infographic promotion on research dissemination and readership: a randomized controlled trial. Canadian Journal of Emergency Medicine, 20 (6), 826–833. 10.1017/cem.2018.436

Hyönä, J., & Lorch, R. F. (2004). Effects of topic headings on text processing: Evidence from adult readers' eye fixation patterns. Learning and instruction, 14 (2), 131–152. 10.1016/j.learninstruc.2004.01.001

Jamet, E. (2014). An eye-tracking study of cueing effects in multimedia learning. Computers in Human Behavior, 32 (1), 47–53. 10.1016/j.chb.2013.11.013
Jin, S. -H. (2013). Visual design guidelines for improving learning from dynamic and interactive digital text. Computers & Education, 63 (1), 248–258. 10.1016/j.compedu.2012.12.010

Keller, T., Gerjets, P., Scheiter, K., & Garsoffky, B. (2006). Information visualizations for knowledge acquisition: The impact of dimensionality and color coding. Computers in Human Behavior, 22 (1), 43–65. 10.1016/j.chb.2005.01.006

Kim, D. -Y. (2010). The interactive effects of colors on visual attention and working memory: In case of images of tourist attractions International CHRIE Conference-Refereed Track. 1,

Kemp, D., King, A. J., Upshaw, S. J., Mackert, M., & Jensen, J. D. (2021). Applying harm reduction to COVID-19 prevention: The influence of moderation messages and risk infographics. Patient education and counseling, 105 x)(2), 269–276. 10.1016/j.pec.2021.09.006

Kim, H. K., Ahn, J., Atkinson, L., & Kahlor, L. A. (2020). Effects of COVID-19 misinformation on information seeking, avoidance, and processing: A multicountry comparative study. Science Communication, 42 x)(5), 586–615. 10.1177/1075547020959670

Kools, M., Ruiter, R. A., Van De Wiel, M. W., & Kok, G. (2008). The effects of headings in information mapping on search speed and evaluation of a brief health education text. Journal of Information Science, 34 (6), 833–844. 10.1177/0165551508089719

Kouzy, R., Abi Jaoude, J., Kraitem, A., El Alam, M. B., Karam, B., Adib, E., Zarka, J., Traboulsi, C., Akl, E. W., & Baddour, K. (2020). Coronavirus goes viral: quantifying the COVID-19 misinformation epidemic on Twitter. Cureus, 12 x)(3). 10.7759/cureus.7255

Kripalani, S., Robertson, R., Love-Ghaffari, M. H., Henderson, L. E., Praska, J., Strawder, A., Katz, M. G., & Jacobson, T. A. (2007). Development of an illustrated medication schedule as a low-literacy patient education tool. Patient education and counseling, 66 (3), 368–377. 10.1016/j.pec.2007.01.020

Kunze, K. N., Vadhera, A., Purbey, R., Singh, H., Kazarian, G. S., & Chahla, J. (2021). Infographics Are More Effective at Increasing Social Media Attention in Comparison With Original Research Articles: An Altmetrics-Based Analysis. Arthroscopy: The Journal of Arthroscopic & Related Surgery, 37 (8), 2591–2597. 10.1016/j.arthro.2021.03.056

Lau, N., O'Daffer, A., Joyce, P., & Rosenberg, A. R. (2021). Popular evidence-based commercial mental health apps: analysis of engagement, functionality, aesthetics, and information quality. JMIR mHealth and uHealth, 9 (7), e29689. 10.2196/29689

Ling, J., & Van Schaik, P. (2002). The effect of text and background colour on visual search of Web pages. Displays, 23 (5), 223–230. 10.1016/S0141-9382(02)00041-0

Ling, J., & Van Schaik, P. (2006). The influence of font type and line length on visual search and information retrieval in web pages. International journal of human-computer studies, 64 (5), 395–404. 10.1016/j.ijhcs.2005.08.015

Lonsdale, M. (2014). Typographic features of text. Outcomes from research and practice. Visible Language, 48 (3), 29–67.

Lonsdale, M., & Liao, H. (2018). Improving obesity prevention among university students through a tailored information design approach. Information Design Journal, 24 x)(1), 3–25.

Lonsdale, M., & Lonsdale, D. (2019). Design2Inform: Information visualisation https://www.researchgate.net publication/330825479%5fDesign2Inform%5fInformation%5fvisualisation

Lonsdale, M., Lonsdale, D., Baxter, M., Graham, R., Kanafani, A., Li, A., & Peng, C. (2019). Visualizing the terror threat. The impact of communicating security information to the general public using infographics and motion graphics. Visible Language, 53 x)(2), 37–71.

Lonsdale, M., Ni, L.-C., Twiddy, M., & Gu, C. (2020). Information design for bowel cancer detection. The impact of using information visualization to help patients prepare for colonoscopy screening, using a booklet, a motion graphics and an App. Information Design Journal, 25 x)(2), 125–156. 10.1075/idj.25.2.01lon

Loomba, S., de Figueiredo, A., Piatek, S. J., de Graaf, K., & Larson, H. J. (2021). Measuring the impact of COVID-19 vaccine misinformation on vaccination intent in the UK and USA. Nature human behaviour, 5 x)(3), 337–348. 10.1038/s41562-021-01056-1

Lunn, P. D., Timmons, S., Julienne, H., Belton, C. A., Barjaková, M., Lavin, C., &

McGowan, F. P. (2021). Using decision aids to support self-isolation during the COVID-19 pandemic. Psychology & Health, 36 x)(2), 195–213. 10.1080/08870446.2020.1849701

Macaya, M., & Perea, M. (2014). Does bold emphasis facilitate the process of visual-word recognition? The Spanish journal of psychology, 17 (3).
Mackiewicz, J. (2009). The Newest Tool for Technical Communicators – Redux. Technical Communication, 56 (1), 3–13.

Majooni, A., Masood, M., & Akhavan, A. (2018). An eye-tracking study on the effect of infographic structures on viewer's comprehension and cognitive load. Information Visualization, 17 (3), 257–266. 10.1177/1473871617701971

Mansoor, L. E., & Dowse, R. (2003). Effect of pictograms on readability of patient information materials. Annals of Pharmacotherapy, 37 (7–8), 1003–1009. 10.1345/aph.1C449

Martin, L. J., Turnquist, A., Groot, B., Huang, S. Y., Kok, E., Thoma, B., & van Merriënboer, J. J. (2019). Exploring the role of infographics for summarizing medical literature. Health Professions Education, 5 x)(1), 48–57. 10.1016/j.hpe.2018.03.005

Mautone, P. D., & Mayer, R. E. (2001). Signaling as a cognitive guide in multimedia learning. Journal of educational Psychology, 93 (2), 377. 10.1037/0022-0663.93.2.377

Mayer, R. E. (2009). Multimedia Learning (2nd ed.). Cambridge University Press. 10.1017/CBO9780511811678

Mayer, R. E., & Moreno, R. (2003). Nine ways to reduce cognitive load in multimedia learning. Educational psychologist, 38 x)(1), 43–52. 10.1207/S15326985EP3801_6

MayoClinic. (2021). Heart Attack. Retrieved 1 October 2021 from https://www.mayoclinic.org/diseases-conditions/heart-attack/symptoms-causes/syc-20373106

McCready. (2016). 6 Ways to Use Infographic Icons Like a Pro. Retrieved 17 April from https://venngage.com/blog/infographic-design-6-ways-to-use-icons/
Mian, A., & Khan, S. (2020). Coronavirus: the spread of misinformation. BMC medicine, 18 x)(1), 1–2. 10.1186/s12916-020-01556-3

Miller, G. A. (1956). The magical number seven, plus or minus two: Some limits on our capacity for processing information. Psychological review, 63 (2), 81. 10.1037/h0043158

Mollerup, P. (2015). Data design: visualising quantities, locations, connections. Bloomsbury Publishing.

Moore, R. S., Stammerjohan, C. A., & Coulter, R. A. (2005). Banner advertiser-web site context congruity and color effects on attention and attitudes. Journal of advertising, 34 (2), 71–84. 10.1080/00913367.2005.10639189

Murray, I., Murray, A., Wordie, S., Oliver, C., Murray, A., & Simpson, A. (2017). Maximising the impact of your work using infographics. The British Editorial Society of Bone and Joint Surgery London, 6 (11), 619–620.

NHS. (2020). COVID-19 research briefing infographic. Retrieved 12 April from https://www.birmingham.ac.uk/university/colleges/mds/coronavirus/covid-19-research-briefing.aspx

NHS. (2021). Heart Attack. Retrieved 1 October 2021 from https://www.nhs.uk/conditions/heartattack/#:~:text=A%20heart%20attack%20(myocardial%20infarction,you%20suspect%20a%20heart%20attack

Obie, H. O., Chua, C., Avazpour, I., Abdelrazek, M., Grundy, J., & Bednarz, T. (2019). A study of the effects of narration on comprehension and memorability of visualisations. Journal of Computer Languages, 52 x)(1), 113–124. 10.1016/j.cola.2019.04.006

Ozcelik, E., Arslan-Ari, I., & Cagiltay, K. (2010). Why does signaling enhance multimedia learning? Evidence from eye movements. Computers in human behavior, 26 (1), 110–117. 10.1016/j.chb.2009.09.001

Ozcelik, E., Karakus, T., Kursun, E., & Cagiltay, K. (2009). An eye-tracking study of how color coding affects multimedia learning. Computers & Education, 53 (2), 445–453. 10.1016/j.compedu.2009.03.002

Padilla, L. M., Creem-Regehr, S. H., Hegarty, M., & Stefanucci, J. K. (2018). Decision making with visualizations: a cognitive framework across disciplines. Cognitive research: principles and implications, 3 (1), 29.

Park, J., & Zuniga, J. (2016). Effectiveness of using picture-based health education for people with low health literacy: An integrative review. Cogent Medicine, 3 (1), 1264679. 10.1080/2331205X.2016.1264679

Patterson, R. E., Blaha, L. M., Grinstein, G. G., Liggett, K. K., Kaveney, D. E., Sheldon, K. C., Havig, P. R., & Moore, J. A. (2014). A human cognition framework for information visualization. Computers & Graphics, 42 (1), 42–58. 10.1016/j.cag.2014.03.002

Pelli, D. G., Burns, C. W., Farell, B., & Moore-Page, D. C. (2006). Feature detection and letter identification. Vision research, 46 (28), 4646–4674. 10.1016/j.visres.2006.04.023

Poulton, E. (1972). Size, style, and vertical spacing in the legibility of small typefaces. Journal of Applied Psychology, 56 (2), 156. 10.1037/h0032670

Pušnik, N., Možina, K., & Podlesek, A. (2016). Effect of typeface, letter case and position on recognition of short words presented on-screen. Behaviour & Information Technology, 35 (6), 442–451. 10.1080/0144929X.2016.1158318

Richter, J., Scheiter, K., & Eitel, A. (2016). Signaling text-picture relations in multimedia learning: A comprehensive meta-analysis. Educational Research Review, 17 (1), 19–36. 10.1016/j.edurev.2015.12.003

Rotolo, S. M., Jain, S., Dhaon, S., Dokhanchi, J. K., Kalata, E., Shah, T., Mordell, L. J., Clayman, M. L., Kenefake, A., & Zimmermann, L. J. (2021). A coordinated strategy to develop and distribute infographics addressing COVID-19 vaccine hesitancy and misinformation. Journal of the American Pharmacists Association, 62 (1), 224–231. 10.1016/j.japh.2021.08.016

Schaie, K. W., & Heiss, R. (1964). Color and personality. Grune & Stratton.

Schindler, P. S. (1986). Color and contrast in magazine advertising. Psychology & Marketing, 3 (2), 69–78. 10.1002/mar.4220030203

Scott, H., Fawkner, S., Oliver, C., & Murray, A. (2016). Why healthcare professionals should know a little about infographics. British Journal of Sports Medicine, 50 x)(18), 1104–1105. 10.1136/bjsports-2016-096133

Scott, H., Fawkner, S., Oliver, C. W., & Murray, A. (2017). How to make an engaging infographic? British Journal of Sports Medicine, 51 (1), 1183–1184. 10.1136/bjsports-2016-097023

Seo, K. -K., Lee, S., Chung, B. D., & Park, C. (2015). Users' emotional valence, arousal, and engagement based on perceived usability and aesthetics for web sites. International Journal of Human-Computer Interaction, 31 (1), 72–87. 10.1080/10447318.2014.959103

Skau, D., Harrison, L., & Kosara, R. (2015). An evaluation of the impact of visual embellishments in bar charts. Computer Graphics Forum, 34 (3), 221–230. 10.1111/cgf.12634

Snyder-Ramos, S. A., Seintsch, H., Böttiger, B. W., Motsch, J., Martin, E., & Bauer, M. (2005). Patient satisfaction and information gain after the preanesthetic visit: a comparison of face-to-face interview, brochure, and video. Anesthesia & Analgesia, 100 x)(6), 1753–1758. 10.1213/01.ANE.0000153010.49776.E5

Spence, I. (2005). No humble pie: The origins and usage of a statistical chart. Journal of Educational and Behavioral Statistics, 30 (4), 353–368. 10.3102/10769986030004353

Spence, I., Wong, P., Rusan, M., & Rastegar, N. (2006). How color enhances visual memory for natural scenes. Psychological Science, 17 (1), 1–6. 10.1111/j.1467-9280.2005.01656.x

StatisticsCanada. (2019). Firearm-related violent crime in Canada Retrieved 25 November 2018 from https://www.statcan.gc.ca/eng/subjectsstart/crime%5fand%5fjustice

Stonbraker, S., Flynn, G., George, M., Cunto-Amesty, S., Alcántara, C., Abraído-Lanza, A. F., Halpern, M., Rowell-Cunsolo, T., Bakken, S., & Schnall, R. (2022). Feasibility and acceptability of using information visualizations to improve HIV-related communication in a limited-resource setting: A short report. AIDS care, 34 x)(4), 535–541. 10.1080/09540121.2021.1883517

Stonbraker, S., Halpern, M., Bakken, S., & Schnall, R. (2019). Developing Infographics to Facilitate HIV-Related Patient–Provider Communication in a Limited- Resource Setting. Applied clinical informatics, 10 x)(04), 597–609. 10.1055/s-0039-1694001

Stone, M. (2006). Choosing colors for data visualization. Business Intelligence Network, 2 (1).

Stones, C., & Gent, M. (2015a). The 7 Graphic Principles of Public Health Infographic Design. https://improvementacademy.org/documents/Projects/air_quality/The%207%20Graphic%20Principals%20of%20Public%20Health%20Infographic%20Design.pdf

Stones, C., & Gent, M. (2015b). "If The Guardian can do it, we should be able to do it!" Examining Public Health Infographic Strategies used by Public Health Professionals. Design4Health 2015 Proceedings.

Stones, C., & Gent, M. (2015). The 7 Graphic Principles of Public Health Infographic Design. https://improvementacademy.org/documents/Projects/air_quality/The%207%20Graphic%20Principals%20of%20Public%20Health%20Infographic%20Design.pdf

Tetlan, L., & Marschalek, D. (2016). How Humans Process Visual Information: A focused primer for designing information. Visible Language, 50 (3), 65–88.

Tijus, C., Barcenilla, J., De Lavalette, B. C., & Meunier, J. -G. (2007). The design, understanding and usage of pictograms. In Written documents in the workplace (pp. 17–31). Brill. 10.1163/9789004253254_003

Tinker, M. A. (1965). Bases for effective reading. University of Minnesota Press.

Tractinsky, N., Katz, A. S., & Ikar, D. (2000). What is beautiful is usable. Interacting with computers, 13 (2), 127–145. 10.1016/S0953-5438(00)00031-X

Vraga, E. K., & Bode, L. (2021). Addressing COVID-19 misinformation on social media preemptively and responsively. Emerging infectious diseases, 27 x)(2), 396. 10.3201/eid2702.203139

Wang, Z., Wang, S., Farinella, M., Murray-Rust, D., Henry Riche, N., & Bach, B. (2019). Comparing effectiveness and engagement of data comics and infographics. Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems. 10.1145/3290605.3300483

WHO. (2023). Avoid the Three C's infographic. Retrieved 12 April from https://www.who.int/brunei/news/infographics---english

Wiana, W., Barliana, M. S., & Riyanto, A. A. (2018). The Effectiveness of Using Interactive Multimedia Based on Motion Graphic in Concept Mastering Enhancement and Fashion Designing Skill in Digital Format. International Journal of Emerging Technologies in Learning, 13 (2), 4. 10.3991/ijet.v13i02.7830

Wichmann, F. A., Sharpe, L. T., & Gegenfurtner, K. R. (2002). The contributions of color to recognition memory for natural scenes. Journal of Experimental Psychology: Learning, Memory, and Cognition, 28 (3), 509.

Williams, T. R., & Spyridakis, J. H. (1992). Visual discriminability of headings in text. IEEE Transactions on Professional Communication, 35 (2), 64–70. 10.1109/47.144865

Worley, G. M. (1999). The effects of highlight color on immediate recall in subjects of different cognitive styles. International Journal of Instructional Media, 28 (2).

Zikmund-Fisher, B. J., Fagerlin, A., & Ubel, P. A. (2008). Improving understanding of adjuvant therapy options by using simpler risk graphics. Cancer, 113 (12), 3382–3390. 10.1002/cncr.23959

Authors biography

Dr Matthew Baxter, PhD, is a research fellow at the School of Design, University of Leeds. He received both his MA in graphic communication and PhD from the University of Leeds and has research interests in information design, user centred design and multi-method approaches for improving visual communication. His research currently explores this in the context of healthcare information.

Professor Maria dos Santos Lonsdale, PhD, is a Professor of Information and Communication Design, University of Leeds, UK. At its core, her research is human-centered and interdisciplinary in nature, focusing on the effective use of design to improve user performance and wellbeing across sectors such as Education, Healthcare and National and Global Security.