Visual Infrastructures of COVID-19 Messaging

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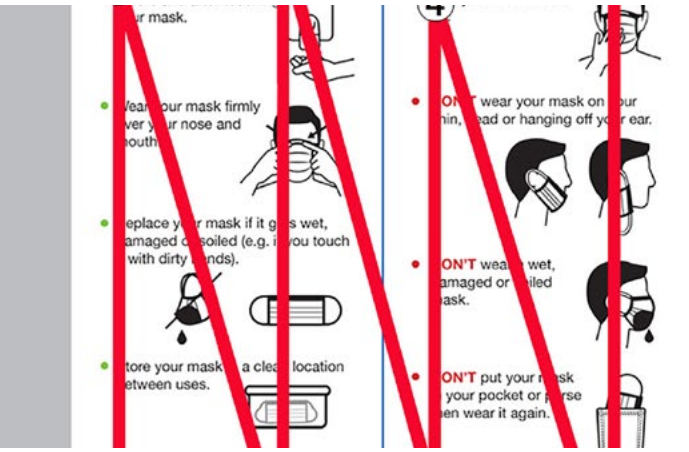

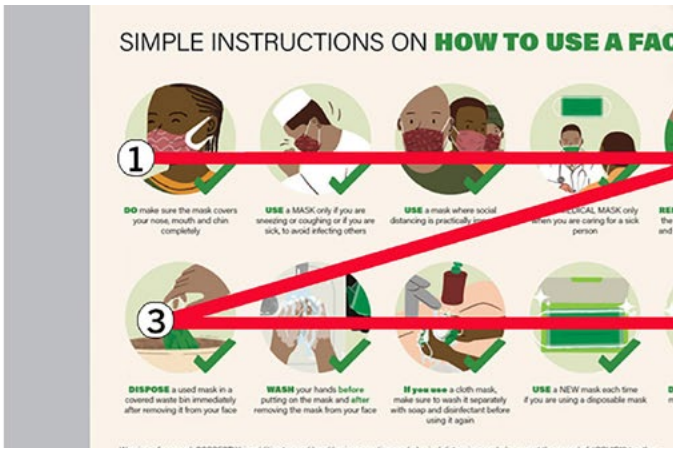

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Abstract

Infecting more than two hundred and nineteen million people internationally as of September 2021, SARS-Cov2 (COVID-19) remains a major health crisis despite the availability of vaccines in many countries and publicized guidance on effective preventative measures (WHO, 2021). To combat the spread of the virus, governments worldwide have found themselves relying on their ability to exert control over health behaviors in public and private spaces. Visual communication, which includes both graphics and text, is an integral component of how these behavioral advisories are communicated to the public. Authorities translate scientific information into digestible designs for the public to achieve effective understanding and actionable protective measures. How are governments presenting and assessing the effectiveness of COVID-19-related information? Are there opportunities to maximize communication and develop models using existing frameworks?

This interdisciplinary literary review pairs three models of risk and crisis communication with an information design framework to analyze COVID-19 materials shared by international governing agencies. *Crisis and Emergency Risk Communication* (CERC) blends two popular disaster mitigation approaches to create a model that considers all stages of disaster response (Reynolds and Seeger, 2007). *The Protective Action Decision Model* (PADM; Lindell and Perry, 2012) and the *Scenario Transition Model of Viewing and Reading* (Jaenichen, 2017) highlight the importance of considering context when crafting communication to increase the likelihood of message comprehension under stressful circumstances. Design perspectives are incorporated through the semiological lens of Jacques Bertin's research on effective visual compositions (Bertin, 1983). Graphics sampled from the websites of international governments are used to illustrate the importance of leveraging design and communication strategy when communicating about risk and crisis scenarios.

Keywords

Information design is the study of optimizing design for accessible and understandable use.

Graphic density measures the number of visual components included in the composition of a design.

Disaster defines a natural or manmade threat that causes large-scale calamity.
Risk communication encompasses preventative action to decrease the impact of a threat before it occurs.
Crisis communication is the public relations perspective on mitigating the consequences of a disaster while it happens or after the impacts are felt.

Resumen

Con más de 219 millones de contagios a escala mundial, el SARS-Cov2 (COVID-19) sigue constituyendo una gran crisis sanitaria, a pesar de la disponibilidad de vacunas en muchos países y de las guías publicadas sobre las medidas preventivas más eficaces (OMS, 2021). Para combatir la propagación del virus, los gobiernos han confiado en su capacidad para controlar las conductas sanitarias, tanto en espacios públicos como privados. Los gráficos son uno de los elementos empleados para comunicar las advertencias sanitarias: las autoridades traducen información científica en diseños comprensibles para el público. ¿Cómo se presenta la información relacionada con la COVID-19? ¿Existen oportunidades para maximizar la comunicación utilizando los marcos existentes?

Esta revisión interdisciplinar de la literatura combina tres modelos de comunicación del riesgo en crisis dentro del marco del diseño de la información. El objetivo es analizar los materiales sobre la COVID-19 compartidos por organizaciones gubernamentales de todo el mundo. *La comunicación del riesgo en crisis y emergencias* (CERC, por sus siglas en inglés) combina dos aproximaciones populares de mitigación para crear un modelo que tiene en cuenta todas las etapas de respuesta ante un desastre (Reynolds y Seeger, 2007). *El Modelo de Decisión de Acción Protectora* (PADM, por sus siglas en inglés; Lindell and Perry, 2012) y el *Modelo de Transición del Escenario de Ver y Leer* (Jaenichen, 2017), destacan la importancia de considerar el contexto al elaborar la comunicación, con el fin de incrementar la posibilidad de comprender un mensaje ante circunstancias de estrés. Las perspectivas del diseño se incorporan a través de la lente semiológica de Jacques Bertin sobre composiciones visuales efectivas (Bertin, 1983). Para ilustrar la importancia de aprovechar el diseño y las estrategias de comunicación cuando se comunican temas relativos a emergencias, se han usado ejemplos

gráficos extraídos de los sitios web de gobiernos de todo el mundo.

Palabras clave

El *diseño de información* es el estudio de la optimización del diseño para un uso accesible y comprensible.
La *densidad gráfica* define el número de componentes visuales a incluir en la composición de un diseño.
El *desastre* plantea una amenaza de origen natural o humana, que puede causar una calamidad a gran escala.
La *comunicación del riesgo* incorpora acciones preventivas para disminuir el impacto de una amenaza, antes de que ocurra.
La *comunicación de crisis* es la perspectiva de relaciones públicas, para mitigar las consecuencias de un desastre mientras ocurre o después de que se sienten los impactos.

Visual Infrastructures of COVID-19 Messaging

In January 2020, the World Health Organization announced the outbreak of SARS-CoV2, also known as COVID-19, in the Hubei Province of China (WHO, 2020). COVID-19 is a respiratory disease transmitted in droplets that spread when an infected person coughs, sneezes, or touches their eyes, nose, and mouth (CDC, 2021). Non-pharmaceutical mitigation behaviors include covering the mouth with a mask, more frequent handwashing, and reducing the likelihood of being around infected persons by staying socially distant (Perrotta et al., 2021). Governments were required to create and disseminate visual campaigns to communicate preventative actions to the public in an understandable way in a time when the public was struck with a sudden uncertainty for their own safety and when information was either scarce or mixed among competing sources.

Despite efforts to promote behavior that mitigates the spread of COVID-19, more than two-hundred and nineteen million people have tested positive worldwide as of September 2021 (WHO, 2021). The complexity of the COVID-19 pandemic necessitates an interdisciplinary approach due to its far-reaching implications across health, society, industry, and economy. In response, this analysis pairs research on information design with risk communication to provide a review on the current state of COVID-19 visual messaging distributed by governing bodies to the public.

COVID-19

Respiratory viruses are challenging to contain due to the efficiency with which the virus is transmitted (Fauci, Lane and Redfield, 2020). In the last twenty years, there have been two prior notable coronavirus epidemics (Kumar, 2020). SARS, or severe acute respiratory syndrome, became a global concern in 2003 (Ksiazek et al., 2003). In one year, SARS killed roughly eight hundred people after spreading to 26 countries (Christian et al., 2004). The outbreak helped reveal areas of improvement in national pandemic responses with scientists and public health educators collaborating to address the crisis (Parashar and Anderson, 2004). Nearly a decade later, an outbreak of the Middle East

respiratory syndrome (MERS) put coronaviruses on a high priority list for international study even before the rise of COVID-19 (Bonilla-Aldana et al., 2020). The SARS and MERS epidemics pale in comparison to the devastation caused by COVID-19, which has now killed over four and a half million people internationally (Wood et. al., 2021). Governments facing pandemics find themselves in a difficult position, negotiating control over typically individual behavior such as people's ability to choose what they wear, where they go, and what inoculations they choose to receive.

As the pandemic progressed, vaccines were developed and disseminated first among vulnerable populations such as the elderly (Khan, 2021), health care workers (Ibarra and Ostrov, 2021), and those with complicating conditions like cancer or diabetes (Ostrov, 2021). Vaccine rollout looked promising in the United States until May 2021, when experts began to reassess vaccination projections due to a lack of registration for inoculation (Mandavilli, 2021). Unvaccinated Americans are hesitant to receive the vaccine, concerned about needing unnecessary shots in the future and fearing overreaching governmental control (Bosman et al., 2021). Now, a variant of COVID-19, Delta, is raising the alarm internationally, spreading considerably faster than other variants of the disease (Kupferschmidt and Wadman, 2021). As of September 2021, states in the U.S. are setting new records for the average number of COVID-19 cases reported per day, despite the availability of vaccines (Mendez, Towey, and Rattner, 2021). Vaccine hesitancy and the rise of viral variants continued fueling the need to exert compliance with the public with non-pharmaceutical preventative measures.

COVID-19 Messaging

Shelter in Place vs. Stay at Home vs. Safer at Home
Terms like "stay at home", "shelter-in-place", and now, "safer at home", have different implications for enforcement, leading to a lack of clarity (Noar and Austin, 2020). According to the National Institute of Allergy and Infectious Diseases, shelter-in-place is a procedure in which one must get to a safe location and stay there until the crisis is averted (2021). Shelter-in-place is not unique to pandemic response. It

is often issued to protect the public from a variety of dangerous scenarios like an active shooter, tornado, or a chemical spill. The Centers for Disease Control (CDC) includes "staying put" in their description of shelter-in-place, alongside detailed instructions on sealing oneself in a windowless room ("Shelter in Place," 2017).

In contrast, "stay-at-home" advises limiting activities outside of one's residence to health and state-related functions (Arango and Cowan, 2020). Shelter-in-place recommends staying in a safe and indoor location. Stay-at-home gives the public more freedom with the expectation that the order will remain in effect for a longer period. Unlike shelter-in-place, activities like leaving home for outdoor exercise have been permitted in the state of California since the onset of the guidelines (Ronayne and Thompson, 2020). Branding for these guidelines took on the name "Safer at Home" in cities like Los Angeles, which continues to struggle with COVID-19 infections (L.A. City Government, 2021).

Social vs. Physical Distancing

The term "social distancing" originated in the public health sector. The phrase has been used in the past to combat epidemiological hazards by encouraging physical separation and therefore decreasing the spread of a virus (Fong et al., 2020). This history made "social distancing" the default term used when announcing COVID-19 preventative measures. However, under COVID-19, "social distancing" adopted both a literal and intuitive meaning which could have resulted in increased negative health consequences from the pandemic as a result of increased levels of emotional isolation (Das Gupta and Wong, 2020). The scientific community has urged a distinction between the naming conventions of social and physical distancing, favoring the latter term in an effort to encourage the maintenance of relationships outside the home unit (Aminnejad and Alikhani, 2020). The phrase "social distancing" was not recommended by experts, causing some groups like the World Health Organization and the Canadian government to replace it with "physical distancing," a more accurate description of the recommended behavior (Gale, 2020; Public Health Agency of Canada, 2020). The clarification of terminology is an effort to encourage a more precise understanding of preventative measures that should be taken to reduce the likelihood of viral transmission as well as combat pandemic-related loneliness and isolation.

Distribution of Information

At the beginning of a pandemic, a higher density of information is to be expected in order to facilitate the public's understanding of new facts and protocols. As information was being introduced, secondary, summarized graphic presentations played a role as reminders, assuming the public already had significant exposure to the original, more detailed, messaging. For example, dense information on wearing masks led to storefront signage with brief phrases such as "Masks Required." The context and positioning of where messaging was distributed influences the amount of content density. There are three modes of mass distribution: print (e.g., flyers, signage, etc.), social media, websites, and devices (e.g., apps for mobile and tablets).

Messages for social media are more limited to the sizes of predisposed templates. As for websites, there are endless pages of available information. With video there are more opportunities to slow down the intake of information with timing and sequence than static formats. Information that is available online is only accessible if someone volunteers to access it (which does not usually happen until the information is needed). Apps also have the same vulnerability, as a person must volunteer to download the app. Social media content is vulnerable because it is faced with a deluge of unaccredited information that competes with credible sources.

Disaster, Crisis and Risk Communication

The United Nations Office for Disaster Risk Reduction defines a disaster as "a serious disruption of the functioning of a community or a society at any scale due to hazardous events interacting with conditions of exposure, vulnerability and capacity, leading to one or more of the following: human, material, economic and environmental losses and impacts" (2015). The terms *disaster*, *emergency*, and *crisis* are used interchangeably in this review to describe negative natural or manmade events. This analysis outlines disaster literacy, Crisis and Emergency Risk Communication, the Protective Action Decision Model, and the Scenario Transition Model of Viewing and Reading to provide a holistic understanding of the current approaches used to address disaster response.

Disaster Literacy

The ability to process, understand, and use information about emergencies is defined as disaster literacy (Brown, Haun, and Peterson, 2014). Disaster literacy involves all stages of responding to an emergency, going beyond education to implement preparedness behaviors. Taking actual behavior into account is crucial. For example, in the United States, an increasing population of citizens is reporting their intent to engage in preparedness behaviors while actions taken have remained stagnant over the last decade (FEMA, 2020).

The Proposed Disaster Literacy Model (PDLM) visualizes advancement through disaster response stages, moving through basic comprehension, functional understanding and communicative ability, and concludes when one can critically apply their knowledge (Brown, Haun, and Peterson, 2014). Disaster literacy is conceptually based on health literacy, a parallel area of study examining the public's ability to comprehend health messages and the useability of health information provided (Rudd, 2015; Nutbeam, 2000). Common themes in disaster literacy borrowed from health literacy include bolstering the graphic capacity of communication (Austin et al., 1995) and utilizing multiple channels for message delivery (Kreps, 2017).

The PDLM places a particular emphasis on reaching vulnerable populations (Brown, Haun, and Peterson, 2014). In an emergency preparedness context, vulnerable populations include groups of people who are differently-abled, the societally disadvantaged, and those with mental health problems (Levine, 2004). It is important to note that while everyone is technically vulnerable in an emergency, certain groups of people need extra care and assistance (Jennings et al., 2016). Incorporating diverse populations in disaster preparedness, response, and recovery phases is a crucial step forward for ethical emergency management (Andrulis, Siddiqui, and Purtle, 2011).

The Crisis and Emergency Risk Communication (CERC) Model

To mitigate the impact of disasters, risk and crisis communication perspectives are employed to understand decision-making phenomena in the face of large-scale negative events. These terms, while similar, have historically been used to describe different types of strategies (Reynolds and Seeger, 2007). Risk communication is defined as educated

individuals disseminating information to the public about health and environmental risks using various channels (Plough and Krimsky, 1987). Risk communication has parallels to fear appeals which involve making the public aware of threats (Witte, Meyer and Martell, 2001). Risk communication is typically proactive, often taking place even before a crisis occurs (Reynolds and Seeger, 2007). Examples of risk communication activities include disaster education, behavior change, disaster warnings, and problem-solving (Covello, Slovic and Von Winterfeldt, 1986).

Crisis communication is the act of mitigating a disaster by sharing information. Public relations strategies are used to decrease a disaster's impact after it has happened (Coombs, 1995). Historically, crisis communication is used to maintain an organization's reputation (Seeger, 2006). The perceived credibility of an organization affects its ability to respond appropriately following a crisis. The effect of perceived credibility is especially evident in the face of invisible threats like pandemics that force the public to rely on a government's knowledge and guidance to take appropriate action (Eichengreen, Saka and Aksoy, 2020).

When these two approaches are combined, they form a blended process lens called crisis and emergency risk communication (CERC). Together, CERC sees a disaster in phases moving through pre-event preparation, a triggering eruption leading to crisis, maintenance during the disaster, and subsequent recovery followed by evaluation (Seeger, Sellnow and Ulmer, 1998; Reynolds and Seeger, 2007). Recommended by well-established organizations like the CDC, the CERC model has been used in many studies evaluating the effectiveness of information dissemination (Miller et al., 2021; Lachlan et al., 2016). The model's five stages include recommendations for communication that are dependent on where the situation lies on the continuum.

COVID-19's pre-crisis phase in the United States involved restrictions on travel from China, even before the first reported death in the United States, in an attempt to mitigate the threat (Taylor, 2021). Some additional examples of pre-crisis preparation include creating an emergency kit for hurricanes (Burke, Spence and Lachlan, 2010), retrofitting buildings before earthquakes (Becker et al., 2017), promoting influenza vaccinations (Schumacher et al, 2021), and Federal Aviation Administration

pre-flight safety guidelines (2017). Successful pre-crisis messaging involves understanding emerging risks, gathering information from scientific experts, and sending specific warning messages to increase the general knowledge of the impending threat (Reynolds and Seeger, 2007).

During an initial event or in the early onset of a disaster, rapid communication is needed to inform the public of actions to increase their safety and reduce uncertainty and anxiety (Reynolds and Seeger, 2007). CERC highlights the importance of uncertainty reduction during this phase (Berger and Calabrese, 1975). Additionally, empathy is a powerful tool that should be leveraged by organizations to improve crisis communications, particularly while the public is adapting to their new reality (Dolamore et al., 2020). Overall, this phase centers around acquiring and sharing information in a formal, credible, accessible, and reassuring way.

Currently, the world is in the maintenance stage of the CERC model, in which the public is encouraged to continue increasing their self-efficacy through personal response activities (Reynolds and Seeger, 2007). During the maintenance stage, messages can be designed with a greater understanding of the crisis and how to combat it, allowing for more comprehensive communication. A pandemic scenario expands this phase of the model, stretching emergency communicators by creating a need for proactive management throughout the maintenance period to reduce risks to the public. Following the initial impact of a disaster, the resolution and evaluation phases are initiated, when organizers are left with the task of persuading clean-up efforts, potentially introducing new mitigation procedures, and evaluating responses to improve future strategies (Reynolds and Seeger, 2007).

The CERC model has been used to examine governmental response in the United States, revealing weaknesses in the organizational reactions to viral outbreaks prior to COVID-19 (Freimuth et al., 2008). In Qatar, the CERC model was partially employed to combat the MERS epidemic, which resulted in an increase of the public's trust (Nour et al., 2017). After a measles outbreak, the CERC model was used by the government to evaluate and make recommendations on message framing, suggesting the public would benefit from messages of comfort followed by reminders of the severity of health consequences (Meadows et al., 2019).

The Protective Action Decision Model (PADM)

The Protective Action Decision Model illustrates the cognitive process behind an individual's likelihood to take preventative action in a crisis (Lindell and Perry, 2012). First, one's awareness of a disaster is heightened through environmental, social, and informational cues. These cues are experienced in no particular order and differ based on how tangible a threat seems. For example, in an earthquake, the seismic event is detectable only moments before occurring, leaving many with little to no warning before they feel the ground shaking (Wu and Kanamori, 2008). In contrast, the COVID-19 pandemic began in Wuhan, China, where many citizens were unaware of the onset of a viral outbreak due to government suppression of information (Shangguan, Wang and Sun, 2020). Cues conveyed through communication are understood through the foundational Source-Channel-Message-Receiver-Effect-Feedback Model (Lasswell, 1948).

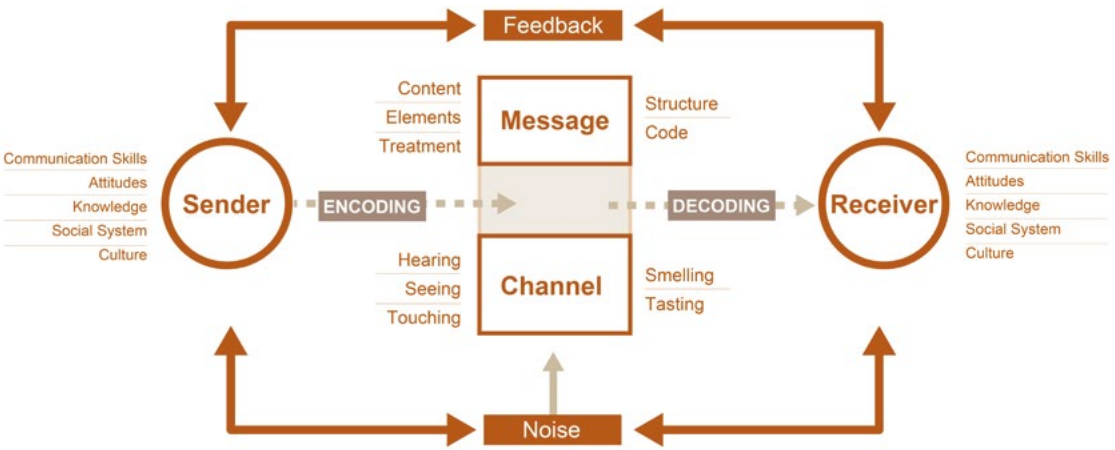

Fig. 1 Source-Channel-Message-Receiver-Effect-Feedback Model (Lasswell, 1948)

All cues lead to the psychological stage of the model. First, the pre-decisional process captures the individual's attention to and comprehension of the messages. If the viewer cannot digest information due to circumstances such as language or cultural barriers or the use of emergency-specific jargon, they will be unable to accurately interpret the message (Lindell and Perry, 2012). If comprehended, the receiver will progress to threat, protective action, and stakeholder perceptions. Threat perception refers to an individual's belief that disaster will affect their lives in some way, either significantly, through death, personal injury or property damage, or with disruptions to everyday actions like grocery shopping, working, or going to school (Lindell and Prater, 2000). Hazard intrusiveness, or the frequency with which thoughts, conversations, and news media mention the disaster, is also analyzed to further understand environmental threat perceptions (Lindell and Perry, 2012). Hazard intrusiveness has been shown in certain contexts to be correlated with the adoption of preventative measures (Ge, Peacock and Lindell, 2011). These considerations are filtered through the lens of the intensity of one's personal experience, the recency of the last disaster, and the frequency with which one encounters crisis phenomena (Lindell and Hwang, 2008).

Preventive actions in the PADM are also referred to as hazard adjustments. Hazard adjustments measure perceived efficacy to protect oneself, others, and property as a significant correlate with the intent to adopt new emergency behaviors (Lindell and Whitney, 2000). To gain a holistic understanding of hazard adjustments, resource-related behavior attributes like cost, time, and effort requirements are included and generally negatively correlate with the likelihood of engaging in preventative action. Studying attitudes about recommended actions has been shown to be more predictive in measuring behavior than researching solely perceptions about a disaster itself (Fishbein and Ajzen, 2009). The last perceptive dimension considers stakeholders' influence. Previous disaster literature identified stakeholders as government authorities, scientific officials, and workplace leaders (Pijawka and Mushkatel, 1991). The variability in perceived attributes like stakeholder trustworthiness, expertise, and level of responsibility for safety, affects intention to adopt hazard adjustment behaviors (Arlikatti, Lindell and Prater, 2007).

Once it has been decided there is a threat, the need for action is assessed. Protection motivation is activated when a threat is deemed worthy of preventative action (Fritz and Marks, 1954). To decide which steps to take, past knowledge and experience relating to disaster response are referenced in a protective action search (Lindell and Perry, 2012). Emergency communicators must include recommendations for preventative actions to take in order to effectively promote behavior change (Mileti and Peek, 2000). After learning about or referencing an existing disaster response, a plan of action is formulated once the available choices are considered. If a threat is deemed eminent enough, the behavior will be carried out immediately (Lindell and Perry, 2012).

Due to the model's basis on information, questions can arise from gaps in knowledge about what action to take at any point in the process. The psychological processing is brought to fruition through a behavioral response such as actively searching for more information, engaging in protective measures, and emotion-focused coping (Strahan and Watson, 2018). Because this response does not exist in a vacuum, situational facilitators and impediments affect the expression of behavior (Lindell and Perry, 2012). Additionally, a feedback loop occurs as the crisis progresses and more information is sought, or different channels are investigated (Lindell, 2018).

A case study of disaster preparedness promotion in a rural Chinese community supported using the PADM as a framework when researchers statistically illustrated the effect of current knowledge on what new information and proactive behaviors were taken (Yu et al., 2020). When researching the public's adoption of disaster response efforts using the PADM, an organization's perceived trustworthiness emerged as an important influence on behavioral intent (Liu, Ouyang and Chen, 2019). The model's design has contributed to an increased understanding of disaster response scenarios.

The Scenario Transition Model of Viewing and Reading

The required change in public understanding, response, and behavior during the initial weeks of the pandemic, although not felt as suddenly as an earthquake, affected the way people were able to understand, process, and remember information. Reading and compre¬hension are categorized in four proposed scenarios (**fig. 2**): *leisure*—being able to process information voluntarily with minimal anxiety; *direct*—processing instructions or noticing a change in environment but not necessarily as one that is threatening or limited by time; *urgent*—processing information with alertness within various levels of anxiety and time limitations; and *emergency*—immediately affected by the environment in a threatening way, resulting in less time to process informa¬tion, reading and comprehension susceptible to tunnel vision, and temporary cognitive paralysis (Jaenichen, 2017).

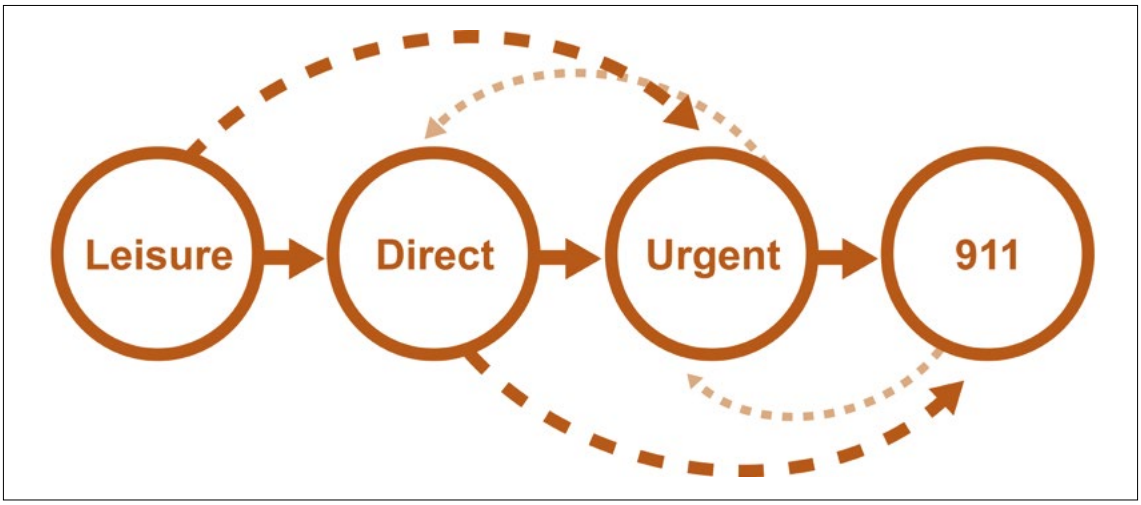

Fig. 2 The Scenario Transition Model of Viewing and Reading (Jaenichen, 2017)

People experiencing various levels of crisis during the pandemic, with sustained uncertainty and vulnerability, were required to learn and unlearn new information. A small percentage of the public who have been trained for pandemic protocols and emergency response (e.g., doctors and first responders) may rely on previous experiences that enabled them to more easily access new information.

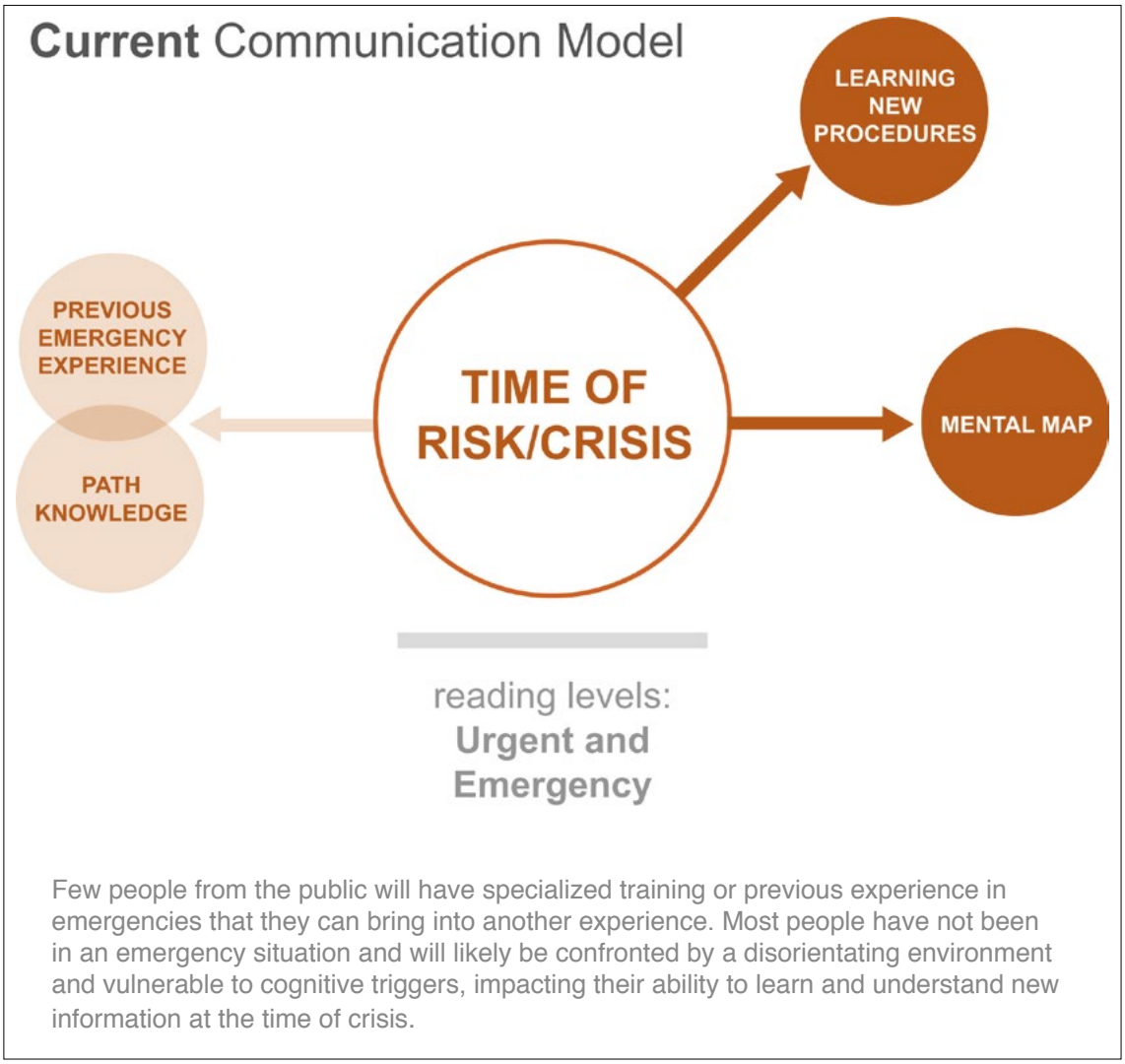

Fig. 3 illustrates the current communication model showing the distribution of public-facing information that is new and given at the time of crisis. It takes more time to learn information, and at a time of crisis when cognition is already stressed, the time to learn new information and accuracy of understanding will be impacted.

Fig. 4 is a proposed effective communication model for emergency information preparedness showing the role of a pre-established campaign of new information as it relates to the levels of reading and comprehension.

Visual Communication

Informing and reminding the public of mitigation behaviors is often done through communication campaigns with graphic components. Visual communication, or stimuli primarily processed by seeing (Worth, 1968), is a crucial component of health campaigns. Information presented in a visual way is more likely to promote recall of events than that conveyed in an auditory or written form (Jaenichen and Schandler, 2017). In the field of marketing, visual strategies are used to increase engagement with consumers (Manic, 2015). When tested in a health communication context, visuals have proven to be more effective in translating warning information and remembered for a longer time than written text alone (Gallopel-Morvan et al., 2011). Across disciplines, visual communication is used to enhance messages and increase understanding.

Visuals have the potential to be more inclusive and therefore reach a larger audience. According to UNESCO's research institute, there are approximately 773 million illiterate adults in the world (2021). Visuals also increase the useability of information for those who can read. In a study of medical students' learning styles, almost two-thirds preferred a hybrid approach combining graphics with text (Lujan and DiCarlo, 2006). When studying health communication, visuals like line drawings increased comprehension of messaging (Choi, 2011). In an effort to meet this demand, public health campaigns have been increasingly bolstering their graphic capacity. The purpose of this research is to analyze COVID-19 visual campaign materials with the ultimate goal of producing accessible guidelines for future emergency risk communication scenarios.

Jacques Bertin authored *The Semiology of Graphics* to aid in the systematic study of visual communication, which establishes visual variables as units for analysis (1983). Bertin writes that every visual variable can have a significant impact on the viewer's interpretation of a graphic. His methodology highlights the importance of creating visuals that are useable by the audience through thoughtful consideration of design elements. For example, the author warns against using color strictly for esthetic purposes in informative content because it could cause unwanted associations between the way the content is displayed

and the intended meaning (Bertin, 1983). In the case of symbols, the viewer's experience and familiarity with visual representations become an external identification that adds an additional layer to interpretation (Bertin, 1983). Bertin's graphic recommendations are grounded in the field of semiology, or the study of sign symbols, which examines graphics as representations of words imagined in the mind upon prompting from a visual cue (Morita, 2018). Bertin's style of analysis has been referenced by cartographers when optimizing the presentation of content in maps (Palsky, 2018). Maps and data visualization are useful to disaster communication as they both involve the presentation of complex and often new information in a visual way.

Visual Analysis

Using Jacques Bertin's Semiology of Graphics, published in 1983, as a point of reference in assessing semiotics, we reviewed visual materials distributed by the California Department of Public Health and the Centers for Disease Control and Prevention, as well as a sample of international government agencies from August 2020. The visual materials were categorized to illustrate the following criteria: *components*—external identification, internal identification, level of organization and length of components; *graphic variables*—size, value, texture, color, orientation, and shape; *rules of legibility*—graphic density, angular separation, retinal separation and combination of variables.

Graphic variables function within specific perceptions such as size, value, texture, color, orientation, shape, composition, and the relationships that variables have to one another (Bertin, 1983, Monmonier, 1991). These variables influence the productivity of each component and therefore affect the overall image and message. If there is a weakness or error in these variables, the overall image, individual categories of perception, and message will also be in error. It is important to note that text-only material is included because it requires sight and visual processing similar to image-based work. Although not included in this review, future analysis should consider the visual infrastructure and effectiveness of motion graphics, animation, and video.

Components

Components include layers of graphic variables representing various levels of information to create a macro-image and message. The macro-image for instructional and informational materials provided during the pandemic consisted mostly of illustration, shape, color, photography, and typography. These components include external and internal identification, level of organization, and consideration of length.

There are two levels of component identification: external and internal (Bertin, 1983). External identification includes elements outside the general intended content and may include things like headline bar graphics, sponsorship logos, and "for more information" tags (**fig. 6**). Internal identification includes elements relating to the intended goal of actionable instructions which can include instructional graphics and text (**fig. 7**). Understanding the relationship between external and internal identification will determine the level of competition for the reader's attention between these two levels of identification.

Fig. 5: Original Document **Fig. 6**: external identification components **Fig. 7**: internal identification components (State of California, 2021b)

Above, the external components (**fig. 6**) are dominant in the top level of visibility and therefore overshadow the more critical content of the internal, actionable content (**fig. 7**). More visibility has been given to the external components with the application of esthetic illustrations, color, and application of scale.

The level of organization and length of components are perceptible steps that can either present obstacles or help the reader understand the message (1983). Disaster psychology should influence the level of detail of instructions as distress increases or decreases for the reader. People under extreme distress will retain even less detailed information due to environmental risk factors and survivors' prioritization of immediate basic necessities. Bertin also suggests that if the visual elements outweigh the level of components, processing becomes "inefficient and necessitates the burdensome reading of several successive images" (1983, p. 35). **Fig. 8** compares three examples of the level of organization for face mask protocol.

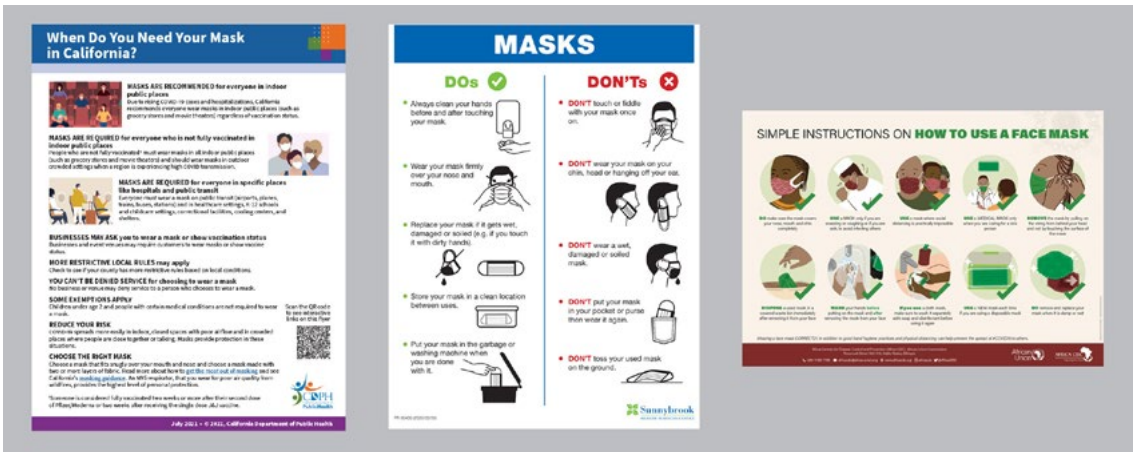

Fig. 8 (State of California, 2021a; Sunnybrook, 2020; Africa CDC, 2020)

Below is an illustration of page choreography, or the order of graphic density, hierarchy, and graphic variables, that can create obstacles for the reader, causing an unintended sequence in reading information.

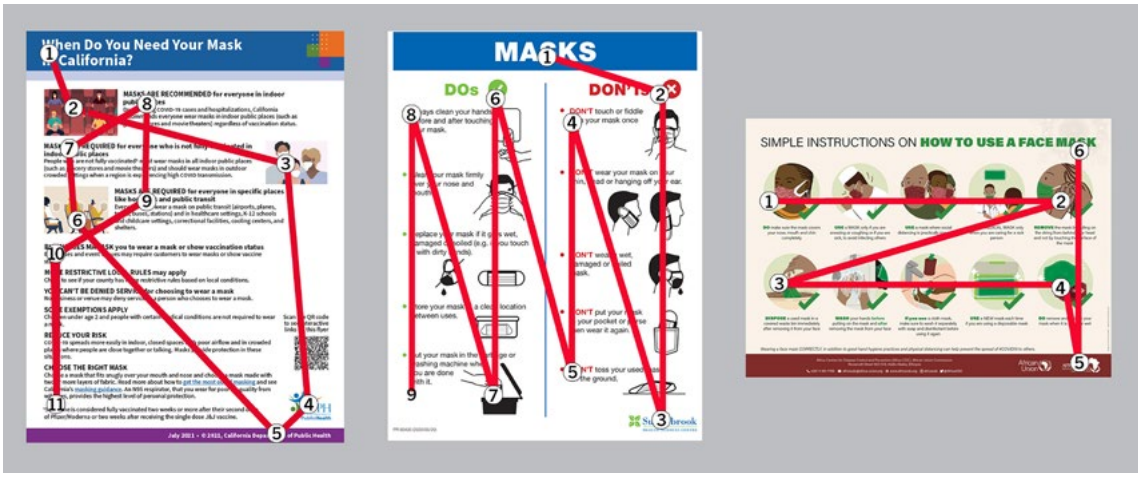

Fig. 9 (State of California, 2021a; Sunnybrook, 2020; Africa CDC, 2020)

Graphic Density

Graphic density affects a reader's speed and compartmentalization, which helps with recall, depending on how much or how little visual variables occupy the space. The denser the visual variables that occupy the space are, the less a reader can separate those variables (Bertin, 1983). Layouts are more successful when less information is presented and organized on the page (Jaenichen and Schandler, 2017). The level of contrast must also be sufficient to distinguish between foreground meaning and background noise, which Bertin would categorize as retinal legibility (1983). He advocates "predictable information," which can enable sufficient comprehension through elementary reading activity for a person in an urgent or emergency scenario. One of the most common errors of legibility is that background "noise" is either more visible than, or competes with, the main subject matter (Bertin, 1983). Retinal legibility is also affected by the quality of variable combinations. Bertin states: "when two or more variables are each associated with a different component, the combination is no longer redundant, it is 'meaningful'" (1983). In other words, visual intentionality along with messaging creates meaningful messages.

Below, **Fig. 10** demonstrates graphic density from highest (left) to lowest (right). The length of components, defined as the layering of graphic variables including scale, value, texture, color, orientation, shape, and white space, demonstrate the effect and relationship graphic variables have to one another influencing the overall macro image. The image on the far left has the highest graphic density with the most layers of graphic variables and least contrast between layers. The image on the far right has the lowest graphic density with enough contrast between graphic variables to aid in compartmentalization.

Fig. 10 (Centers for Disease Control and Prevention, 2021b)

Considering the relationship between foregrounding and backgrounding, **fig. 11** exemplifies how layers of graphic variables are embedded with minimal contrast between the levels of organization. The outcome is perceived as dense and requires more processing to identify and decode each layer.

Fig. 11 (Centers for Disease Control and Prevention, 2021b)

Maximum Visibility

Bertin also advises "maximum visibility" for messaging that is of the same kind. For pandemic messaging, the image may change depending on the target audience, demographic, timing of the pandemic, and protocols it represents (1983). The New Zealand Government's *Unite Against COVID-19* (2021) was a federal-level campaign that was branded and looked uniform in style, therefore presenting information as one voice. This strategy of visual communication provided an authoritative and credible visual voice for pandemic information (**fig. 12**). The campaign was presented in multiple languages, offered alternative formats such as audio descriptions for the visually-impaired, large print, Braille, sign language videos, and support and information for whānau, hapū, and iwi Māori communities that exists in one location. The visual campaign was consistent throughout, providing maximum visibility.

Fig. 12 (New Zealand Government, 2021)

The collection of materials from the California Department of Public Health (CDPH) (**fig. 13**) and CDC (**fig. 14**) was more inconsistent. CDPH material were more visually divergent than those of the federal content in its branding and density. It may be difficult for the public to recall credible information associated with a specific agency if there is a lack of consistency at the agency level.

Fig. 13
Material on COVID-19 prevention from the California Department of Public Health local campaigns (State of California, 2021c)

Fig. 14
Material on COVID-19 prevention from the CDC national campaign (Centers for Disease Control and Prevention, 2021c)

Conclusion

As the pandemic progresses, governments will need to continue sharing crucial health information with the public. Varied literacy levels (UNESCO, 2021) and a preference for mixed methods presentation when learning new information (Lujan and DiCarlo, 2006) necessitates the consideration of visual approaches in disaster communication. By using Bertin's principles of graphic analysis in combination with communication models, this international review provides interdisciplinary insight to identify growth and guideline opportunities in COVID-19 messaging.

Future research should expand on these findings to create evidence-based guidelines for visual communication about disasters. While Bertin's graphic analysis is effectively understood by interested cartographers (Palsky, 2018), it would be prudent to translate his work to make it accessible to government and emergency management authorities' visual communication plans. Simple solutions like reducing the complexity of graphic elements on the page and displaying information in a visual way can have positive implications on the comprehension of potentially lifesaving information (Jaenichen and Schandler, 2017).

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