BAMS In Box

NextGen TV and Advanced Emergency Alerting: The Future of TV Warnings and Alerts

Michael S. Michaud,[a] Jeannette Sutton,[a] Kodi L. Berry,[b] Holly B. Obermeier,[b,c] Heather Sheridan,[d] Gregory E. Cox,[d] Caroline M. Rafizadeh,[d] Savannah Olivas,[a] Nate Johnson,[e,f] Makenzie J. Krocak,[b,g] Joseph E. Trujillo-Falcón,[h,i] and Ling Ling Sun[j]

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ABSTRACT: The Advanced Television Systems Committee (ATSC) is introducing a new broadcast signal (ATSC 3.0), also called NextGen TV, that utilizes technology that can offer better-quality audio and video, a more user-focused experience including rich-format graphics, and location-based services. These technological advancements have great utility for improving the way weather warnings and other alerts are consumed by the public. To best utilize this opportunity, social scientists must work alongside broadcast professionals to assure that warning and alert information is displayed in a way that is user centric, targeted, and informative, while excluding extraneous information. This article outlines the importance of bringing together an interdisciplinary team from the academic, private, and government sectors to accomplish this goal. The team draws on literature on cognitive psychology, user interaction, and visual communication to show how the organization and presentation of risk information in a noisy environment can facilitate or impede effective decision-making. Preliminary analyses of current weather warning and information displays have shown variability between local and national networks. Future work using eye-tracking experiments and focus groups will be used to observe human interactions with various existing and proposed warning information displays is described. This research is the first step in designing effective warning systems that consider human behavior in addition to technology to utilize the full potential of NextGen TV.

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Corresponding author: Michael S. Michaud, michael.michaud@me.com
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AFFILIATIONS: [a] College of Emergency Preparedness, Homeland Security and Cybersecurity, University at Albany, State University of New York, Albany, New York; [b] NOAA/National Severe Storms Laboratory, Norman, Oklahoma; [c] Cooperative Institute for Severe and High-Impact Weather Research and Operations, The University of Oklahoma, Norman, Oklahoma; [d] Department of Psychology, University at Albany, State University of New York, Albany, New York; [e] NBCUniversal Local, New York City, New York; [f] Department of Marine, Earth, and Atmospheric Sciences, North Carolina State University, Raleigh, North Carolina; [g] School of Meteorology, The University of Oklahoma, Norman, Oklahoma; [h] Department of Climate, Meteorology, and Atmospheric Sciences, University of Illinois Urbana–Champaign, Urbana, Illinois; [i] Department of Communication, University of Illinois Urbana–Champaign, Urbana, Illinois; [j] Nebraska Public Media, Lincoln, Nebraska

1. Introduction

Technology is ever evolving, providing new ways to communicate with different audiences. This evolution is apparent in the ways people are alerted about the risk of severe weather. Some of the earliest alerts were as simple as using bells to signal when there were disruptions upstream in telegraph wires (Coleman and Pence 2009). Today, there is a vast alerting ecosystem, which utilizes channels including sirens, NOAA Weather Radio, Wireless Emergency Alerts (WEAs), notifications through phone applications and smart home devices like Alexa and Google Nest, social media, and more (Brotzge and Donner 2013; Krocak et al. 2024). While some technology has been created for the *purpose* of alerting people to danger, such as sirens or WEA, other channels have been adopted (such as social media) or adapted (such as smart home devices) to incorporate risk messaging using downloadable applications. A common theme that has emerged across all alerting technologies and channels is that they are based on the available technology and its different capabilities, and not how people use them. In many cases, alert and warning channels were designed first, while questions about how people attend to, interact with, and make use of those channels came after (van Manen et al. 2024).

NextGen TV is a new technology that is joining the airwaves across the United States, giving alerting organizations the opportunity to flip this common script. Instead of designing alerts around the capabilities that exist within the technology, they can be built based on the science of how people interact with the technology. Our interdisciplinary and cross-sector team of researchers and practitioners has come together to show this is possible. The capabilities of NextGen TV have the potential to significantly alter the way people get alert information through their televisions and handheld devices (Lehane 2024). We show that it is important to think about how alert information is presented *before* these channels are deployed. Decades of social and behavioral research have identified what kinds of information need to be included and how it should be presented (Mileti and Sorensen 1990; Sutton et al. 2024). Limited research has investigated how alerts and warnings should be presented visually (see Orton et al. 2025; Olivas et al. 2024; Sutton et al. 2021) finding that the style, including colors and fonts; structure, including placement and ordering of information; and content, what the message says, affect public perceptions and motivate behavior. Importantly, the visual design of messages affects not only visual attention (Sutton et al. 2021) but memory as well (Waugh et al. 2025). Our research starts a conversation about how weather alert information is best displayed visually for television.

This article showcases how the visual structure of alerts and warnings can be designed using social and behavioral science knowledge. First, NextGen TV and its technological capabilities are explained. Second, we briefly review the current knowledge about designing messages for alerts and warnings and how visual design can best enable cognitive processing of the information displayed. We then review how alerts and warnings are currently displayed in local, national, and cable broadcasts. Finally, we present a vision for social and behavioral research that can inform the future of alert and warning designs.

2. What is NextGen TV?

Since 2013, the Advanced Television Systems Committee (ATSC) has been developing and deploying a new television broadcast signal. This signal has been called the ATSC 3.0 standard, or NextGen TV. ATSC 3.0 uses Internet Protocol (IP) which allows for more efficient information coding over the air and can be combined with Internet service for an enhanced broadcast through television, handheld devices, and other digital platforms such as connected vehicles. For NextGen TV, some of the key features include increased sound and picture quality, the ability for viewers to customize the content they receive, and the ability for broadcasters to send different information based on user preferences and location (Lehane 2024).

With these new capabilities, ATSC has promoted the adoption of standards for Advanced Emergency Alerting (AEA) that will enable the display of important alerts and warnings for weather hazards and other threats (Czarnecki 2017). Broadcasters are currently designing ways to encode messages into the broadcast signal that will display based on a receiver's location and the user's personal preferences. AEA will also include the capability for a NextGen TV receiver to turn on a television to share an alert, such as a tornado warning or other high-risk message based on the user's preferences (Czarnecki 2017). For example, a viewer may set a preference to turn on their television when a tornado warning has been issued within 50 miles of their location. There are still many questions that need to be answered as NextGen TV is developed and is operationalized for the end user. Some questions are related to technological capability and policy, such as how broadcasters will change the areas that receive signals for a weather event as it is moving, or determining thresholds for interrupting programs or activating a sleeping device. We are most interested in the question: How should television displays be designed to provide viewers the information they need for decision-making, while reducing cognitive overload that can occur when viewing complex information under heightened emotional states? Using applied social and behavioral science can help to answer this question.

3. Why is warning design important?

Decades of research have been conducted to identify the content and style to optimize alerts and warnings for imminent threat events. Mileti and Sorensen (1990) cataloged the information most necessary to motivate protective action in response to a warning, finding that message receivers need to know 1) who, or what authoritative source, is sending the message; 2) the type of hazard and its potential impacts; 3) the population and area at risk; 4) the instructive guidance on how to protect themselves from the threat; and 5) the time by which to take protective actions. Warnings should also be complete, clear, and consistent in their presentation. Sutton and Fischer (2021) extended the research by Mileti and Sorensen when they conducted think-aloud interviews and eye-tracking studies on the structure of visual warnings issued by National Weather Service Weather Forecast Offices via Twitter (now X). Using example stimuli, recording eye movements, and asking participants what they were focusing on, the authors found that the structure of a message, where content is placed, and the visual elements, such as color, icons, maps, and text, affect visual attention and processing of information.

As further evidenced by an entire field dedicated to graphic and digital design, visual design is important. Images, text, and other graphical information can be interpreted in different ways; how information is presented can also affect how much, and how effectively, information is absorbed (Franconeri et al. 2021). When it comes to alerts and warnings for imminent threat events, optimal visual design can make a difference for information processing. For example, the use of color, which is one strategy to attract viewer attention and show gradients of risk and hazard type, is interpreted differently by populations due to cultural norms (Bitterman et al. 2023; Lupton and Phillips 2008; Ou et al. 2012; Evergreen and Metzner 2013; Sutton and Fischer 2021; Franconeri et al. 2021). Similarly, scholars have found that symbols and icons can direct attention to important content but are not universally understood by viewers (Caivano 1998). Furthermore, differences in typeface and font can call attention to different text (Lupton and Phillips 2008; Lidwell et al. 2010) or impact readability (Lupton and Phillips 2008). Additionally, the use of animation can direct attention to key elements of a message, while also showing dynamic movement of a hazard or threat. However, in some cases, animated content has been shown to increase cognitive load among viewers (Cook 2006). Commonly observed television elements, such as scrolling text, can result in a higher cognitive load among viewers, requiring additional effort to process information effectively (Harvey et al. 2019).

Scholars have also found that visual layouts can provide structure, allowing viewers to more easily identify important information (Tversky 2013). If structures are used in a consistent way, this can help viewers to create a mental "schema" of information that makes processing easier (Hegarty 2011). Each of these elements is necessary to consider when designing for the future of NextGen TV. This wealth of knowledge should be leveraged when considering the design for warning information. Since current designs are created by television stations and companies, it is unknown how many have tapped into this established and growing field of study.

4. What do current designs look like?

To better understand how television alerts can be designed to address the needs of the viewer, and to serve as a basis for future experiments, we first examined how weather alerts are currently presented (Michaud et al. 2024). We collected 59 static images of warning information displayed during severe and tropical weather television broadcasts from four different kinds of broadcasts: local news broadcasts ($n = 33$), weather cable networks ($n = 20$), cable news networks ($n = 4$), and national news networks ($n = 2$). We then conducted a quantitative content analysis where we coded for information structure (how the warning was presented within the screen), warning content (what the message said), and style (use of colors, animations, and other graphics). We also made notes about the volume of information contained on a screen, which could lead to a cluttered appearance and be perceived by viewers as distracting. (See the appendix for additional method information.)

Two screen structures were identified. The first structure is described as a "warning overlay" (see Fig. 1), where scrolling content was placed over existing content at the top or bottom of the screen, most commonly seen in local broadcasts. The second structure shrinks the broadcast to facilitate content visible on the right and left sides and across the bottom of the screen. This structure was most common in the weather networks, using an "L bar" or "J bar" presentation (see Fig. 2).

Warning content varied across broadcast types. The majority (56%) of the broadcasts we examined included some kind of warning content (hazard, impact, and/or protective action guidance). This type of content was primarily found in content delivered by local stations. Nonwarning content was also included, such as current conditions (47%) and forecast information (34%), primarily by weather networks.

Fig. 1. A local television station warning design with a text crawl and a graphic overlay.

We also examined the way information was presented stylistically. The sample included some kind of graphic 63% of the time, primarily showing radar, satellite images, and county warning maps. While the images we examined were static, there was evidence that some stations rotated their use of visual imagery, such as alternating between the display of a warning map and radar images, which were sometimes animated. Weather networks included more visual elements to display different types of weather information, but local stations were more likely to use visual elements to convey warning information. For example, 61% of the screens reviewed included "crawls," or text that is scrolling across the screen. The majority of crawls included warning content and were posted on local stations. Interestingly, a few stations simultaneously showed multiple crawls; these generally included warning information and news headlines at the same time.

Fig. 2. A weather network warning design with an L-bar structure.

Fig. 3. An example of a cluttered warning design.

Next, we identified visual characteristics that could be perceived to be distracting or cluttered to viewers, such as layers of text and imagery that were incongruent or could require additional attention to interpret. For example, in Fig. 3, we find a screen that includes very small graphics and text, which can be difficult to read. We also find a county warning map that is difficult to view due to the text that is placed directly over the background. We also find that the use of colors found in the warning map and the logo are identical (logo removed from image to preserve anonymity), preventing easy visual access. Finally, we find multiple text crawls, where warning content is included at the top and local headlines continue to scroll on the bottom. Both crawls are on transparent backgrounds, making them difficult to read.

The content analysis was a first step to design effective warning displays like those proposed for NextGen TV. We were able to identify aspects of current designs that are likely to be problematic. In addition, by identifying common design features, our analyses enable future research to focus on how best to use these features. This is important for practical purposes, as designers need not invent new display elements. It is also important for cognitive purposes, as viewers' familiarity with these design features may have led them to form a schema for how to interpret them. We therefore set the stage for social and behavioral scientists to consider, in a rigorous and methodological way, how message recipients interact with various screen displays and evaluate their effectiveness for cognitive processing and decision-making under stress.

5. How can we make warning designs better?

Understanding cognitive processing of screen designs requires research methods that are targeted at understanding what information people can extract from a display, what strategies they use to search for desired information in a display, how well they can remember that information, and how they use that information to guide their decisions about what actions to take. Cognitive psychology has developed a variety of research methods for answering these kinds of questions. As such, to better understand how warning information can be designed for the purpose of motivating appropriate and effective protective action, our research team has devised additional studies that take a multimodal approach, using eye-tracking technology, qualitative interviews, and focus groups.

Eye tracking is a common method used in cognitive psychology to measure visual attention (Rayner 1998, 2009). It uses specialized equipment that allows researchers to measure where a participant is looking, often with millisecond-level precision. Through the use of this technology, research participants can view examples of different warning screen designs while eye movements are measured, thereby capturing the dynamics of how they deploy attention to different elements of the display across time (Rayner 1998). It is therefore possible to determine which parts of a display tend to deploy attention, which may depend on the presence of text, colors, icons, animations, or other design elements. Eye tracking also grants insight into the strategies people may use when searching a display for relevant information, which can inform how best to structure the layout of warning displays. Eye tracking has been used in various weather contexts, such as forecaster attention on radar (Wilson et al. 2018) and situational awareness (Argyle et al. 2020), public understanding of weather graphics and warnings (Gedminas 2011; Sutton and Fischer 2021; Millet et al. 2024), forecast maps (Catala et al. 2018; Hegarty et al. 2010; Popelka et al. 2019), and broadcaster gestures (Drost et al. 2015). Only one other study has investigated the presentation of warning messages on televisions but was focused on the benefits of audio-only warnings, visual warnings, and animated warning messages (Drost et al. 2016), rather than the design of the warning information. Given the power of eye tracking, existing research has only scratched the surface when it comes to understanding how people deploy attention to find and make use of critical information in visual warnings. Such an understanding is essential to ensure visual warnings are designed to enable effective cognition and allow the public to make decisions with the most useful information. For additional details about the eye-tracking study for this project, see Rafizadeh et al. (2025, manuscript submitted to *Wea. Climate Soc.*).

While eye tracking provides a noninvasive way to measure the deployment of covert attention, focus groups provide a way to collect feedback regarding qualitative aspects of how members of the public engage with different design elements. Using focus groups is a common method for collecting user feedback and has been useful in examining perceptions of warning message design (Sutton and Woods 2016). This method allows participants to make direct, explicit observations about different types of designs and discuss preferences for design elements with peers. This is a valuable method because participants can discuss what they like and do not like and build ideas on the opinions of others. Designs for these focus groups are based on NextGen prototypes and other television designs to facilitate discussions around design preferences. This work is ongoing.

By coordinating multiple methods, we can scientifically examine what makes the most efficient warning designs that can be used operationally. Rather than designing warnings and expecting the public to adapt to these new designs, as what has been done in the past, we are starting with an understanding of human cognition and building around it. To give threatened populations the information they need to make decisions, we need to provide the most useful information in an easily digestible format. NextGen TV will only be its best when we combine knowledge gained from social and behavioral science with advanced technology. Future work will require iterative user-centered design to determine the best designs and information to include utilizing multiple methods like focus groups and eye tracking. Social scientists can work alongside technology experts to integrate what is best with what is possible. We hope this interdisciplinary process serves as an example of how to create and improve warning channels in the future.

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Data availability statement. These data are available from Jeannette Sutton (jsutton@albany.edu) at the University at Albany.

APPENDIX
Content Analysis Methodology

To examine current television warning information designs, we conducted a brief content analysis across various types of hazards and media. We observed live television broadcasts from Hurricane Idalia, Hurricane Lee, and Tropical Storm Ophelia during fall 2023, on local media stations, weather networks, cable news networks, and national news networks. Baron Weather provided additional video footage from 38 severe weather outbreak broadcasts, six tropical cyclones, and one winter storm between 2021 and 2023, from local television stations.

During coverage, we watched each broadcast for 5 min. These exemplars were collected to inform static stimuli for eye-tracking experiments; therefore, static images were captured of every screen configuration of the 5-min broadcast. When there were dynamic elements that changed, additional screenshots were recorded to show how the information on the screen changed. Notes were also recorded to capture how the information changed.

For the analysis, two researchers coded each image for several variables. First was contextual information, including the type of hazard, the broadcast source, and the broadcast type. Next, we examined how information was presented on the screen, such as how information was presented in relation to the live video broadcast, and where on the screen the information was presented. We also examined the way information was presented, such as textual and graphical information, the kinds of information they included, and where they were located within the screen. The type of content was also coded based on if it was warning information, forecast information, or other kinds of information, such as advertising or traffic reports. The use of color within textual information and graphics was also coded, along with the use of jargon within the text. Each of these elements was coded individually by each coder, who then worked together to adjudicate any differences to come to a final dataset.

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