Final Report

Broadening the Accessibility of

Hawaiian Volcano Observatory Daily Updates

Contract # G15PC00059

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1. Executive Summary

This is an overview of a user-centered design study conducted by a team of social scientists at How To Health Literacy, LLC (H2HL) in cooperation with staff members from the Hawaii Volcanoes Observatory (HVO) and the Cascades Volcanoes Observatory (CVO). This report documents the findings of that study, the goal of which was to identify and explore the match between existing Hawaii Volcano Observatory (HVO) Daily Update texts and the needs, abilities and preferences of a select group of end users. This report also provides recommendations for future text-based communications that may be employed across USGS Volcano Hazards programs.

Study Description

The goal of this project was to employ user-centered design methods combined with task and health and science literacy analyses were to identify and explore the match between the existing HVO Daily Update texts and the needs, abilities and preferences of the end users. Thus, the aims of the study were as follows:

The present study was conducted during the Spring 2018 Kilauea Volcano eruption. This event presented the opportunity to review a broad range of HVO volcano hazard updates and messages. It also permitted analysis of how HVO messages were disseminated by media outlets.

Aim 1: Conduct a task analysis and a science and health literacy load analysis to identify the linguistic and processing demands (the "load") of a representative sample of existing Daily Updates (the "text"). This included science literacy and health literacy demands of the text.

Aim 2: Develop two alternate, experimental versions of the Daily Update based on findings from the task analysis and health literacy load analysis.

Aim 3: Identify user responses to an original version of the Daily Update and two alternate, experimental versions of the Daily Update through nine (9) one-on-one usability testing sessions.

Aim 4: Develop preliminary best practice guidelines for content and design of future text-based hazard communications.

The study focused on an audience of non-technical end-users (e.g. residents, tourists, media, local officials/emergency managers, and earth science professionals) who needed to quickly understand or translate science for lay audiences.

Below, we describe some of the key findings from the study:

Key Findings

- USGS HVO has broach reach and is the key source of information about volcanic activity in Hawaii.

Findings from the Task and Science and Health Literacy Load Analyses (Before Usability Testing)

Our analyses of representative HVO Daily Updates revealed the following:

- The writing style is characteristic of high quality "scientific writing" intended for scientists – earth scientists and others knowledgeable about volcanoes.
- Technical and scientific vocabulary and terms were ubiquitous and we determined that they would present obstacles to non-science audiences.
- Hard to read verb forms and sentences structure such as passive verbs and multiply embedded clauses/phrases were common.
- We did not find ample examples of explicit connection between sentences made through the use of cohesive ties such as pronouns and repetition. This added to the lack of flow and connection in the Update messages.
- The layout and design of the Updates did not make good use of information hierarchy nor graphic elements to assist scannability and quick retrieval of important information.

Findings from Usability Test Sessions

Findings from the usability sessions clearly showed all participants preferred the experimental versions of the texts which employed linguistic and design revisions informed by the task and science and health literacy load analyses.

- Local (Hawaii media) participants considered the HVO Daily Updates definitive and the *most scientifically accurate* information available. Participants emphasized how much they respected and relied on USGS information and personnel. These participants used HVO Updates to monitor situations, to quickly note status changes and, for those in communications, to understand and translate information for a non-science audience.
- All participants revealed scientific / technical language impedes understanding of the Updates, making it difficult to use and/or translate information for broader audiences.

- All participants want information arranged in a hierarchy—so they would be able to easily see the most important information by having this at the top of the page.
- Bulleted formats and shorter line length were generally preferred because they were easier to scan and read.
- All participants wanted the resources at the end of the updates organized into categories and most preferred hyperlinked resources.
- Most participants thought the icons/graphics enhanced readability for a more general audience.
- Most participants wanted additional clarification and context with respect to alert levels and warnings – e.g. what does 'orange' signify; what is the difference between a 'watch' and a 'warning'?

Final Recommendations

- Substitute more common words for science-specific words and terms.
- If scientific/technical words are critical for the understanding of the message they should be defined in some fashion._This can be done within parenthesis, the surrounding sentence/s or by including a SHORT glossary of terms regularly used in the Updates.
- Reduce sentence complexity and use a combination of simple and more complex sentences.
- Avoid front loading phrases that carry critical information. Front loaded sentences with important qualifiers can be easily misread.
- Make sentences and information cohere and flow better by using simple repetition and pronouns. Cohesion can be improved by not starting each sentence with new information, but rather carrying over some "old" information from a previous sentence.
- Activate verbs. Use the passive verb tense sparingly.
- Present some sections of text in bulleted lists to allow for easier scannability.
- Place information where people expect and want to see it.
- Think of multiple ways to better orient the reader to geographic locations you are talking about.
- Do not use overly long line length. Keep line length between 50-60 characters.

2. Introduction

2.1. Overview of the USGS Volcano Hazards Program (VHP), the Hawaiian Volcano Observatory (HVO), and the HVO Daily Updates

The mission of the USGS Volcano Hazards Program is to enhance public safety and minimize social and economic disruption from eruptions through delivery of effective forecasts, warnings, and information of volcano hazards based on scientific understanding of volcanic processes.

The **USGS Volcano Hazards Program (VHP)** monitors and studies active and potentially active volcanoes, assesses their hazards, and conducts research on how volcanoes work in order for the USGS to issue "timely warnings" of potential volcanic hazards to emergency-management professionals and the public. Thus, in addition to collecting and interpreting the best possible scientific information, the program works to effectively communicate its scientific findings and volcanic activity alerts to authorities and the public. The **Hawaiian Volcano Observatory (HVO)** is part of the VHP. HVO's mission is to monitor, investigate, and assess hazards from active volcanoes and earthquakes in Hawaii, and communicate results of this work to the public, emergency managers, and scientific community. One key activity performed by HVO staff is creating a **Daily Update** for the actively erupting Kīlauea Volcano. The Daily Update is a text-based message sent by email to subscribers and posted to the HVO website each day summarizing the status of actively erupting Kīlauea Volcano.

I ka nānā no a ʻike.

(By observing, one learns.)

ʻŌlelo Noʻeau: Hawaiian Proverbs and Poetical Sayings by Mary Kawena Pukui

2.2. Making HVO Daily Updates More Accessible to a Wider Audience

Community resilience is integral to several national directives, including the Federal Emergency Management Agency's "Whole of Community Planning" imperative and the Center for Disease Control and Prevention's public health emergency preparedness cooperative agreements. FEMA's and CDC's community-level recommendations for preparedness and mitigation advise determining local hazards, identifying socio-demographically vulnerable or at-risk populations and coordinating training to enhance engagement of lay persons in community resilience.

The growing complexity of health, environment, emergency preparedness and hazard information, as well as the changing demographics of the country, support the efforts of the USGS in its ongoing efforts to revise hazard messaging to broaden its usability and utility for a wide range of audiences. In order for communities to be resilient against disaster, citizens must have access to timely, understandable, and actionable information from trustworthy sources "for all populations" (Chandra et al., 2013).

Literacy and Accessibility of Information

The ability to educate and communicate risk information effectively to the public is a vital component of community resilience (Chandra et al., 2013) (see Fig. 1).

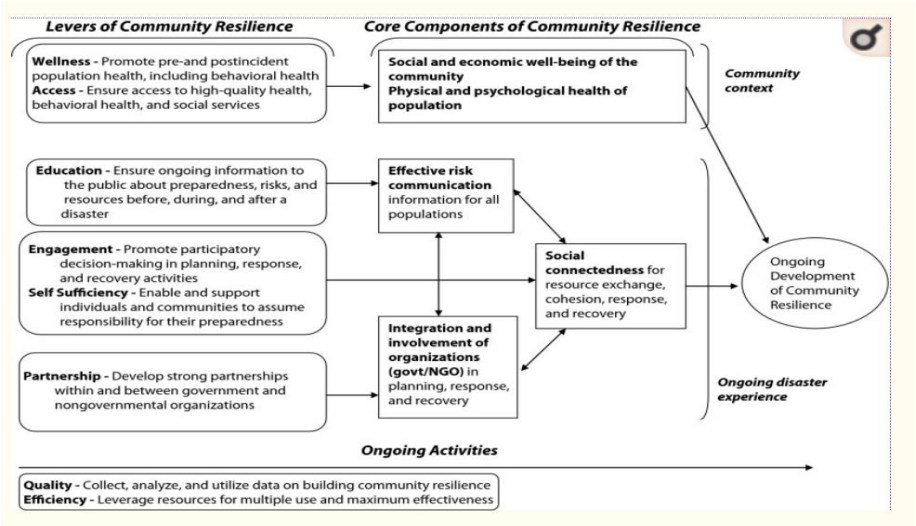


Figure 1. Core components and levels of community resilience from Chandra et al. (2013).

However, there is ample evidence millions of adults in the US struggle to understand technical, scientific and medical information (Kindig, Panzer, & Nielsen-Bohlman, 2004). Three primary domains of skill contributing to a person's use of health and safety information are one's 1) **fundamental literacy**, 2) **health literacy**, and 3) **science literacy** (Zarcadoolas, Pleasant, & Greer, 2009). **Fundamental literacy** refers to a person's ability to read, comprehend and use written language/text. Americans' general fundamental literacy is low when compared to that of other industrialized nations. For example, in a recent survey by the Organization for Economic Co-operation and Development (OECD), the U.S. ranked 16th out of 23 countries in literacy, 21st in numeracy, and 14th in problem solving in technology-rich environments (Organisation for Economic Co-operation

Development, 2013). To put this into context, more than 50% of the adults in the US read at 8th grade level or lower (Kutner, Greenburg, Jin, & Paulsen, 2006). The NY Times is written at 10th grade level and much higher. Most municipal and federal health and safety websites are written and have concepts requiring much higher levels (Kher, Johnson, & Griffith, 2017).

Health literacy refers to the wide range of skills, and competencies that people have to seek out, comprehend, evaluate, and use information about health, and to make informed choices to reduce health risks, improve health outcomes and overall quality of life (Kindig et al., 2004; Nutbeam, 1999; Zarcadoolas et al., 2009). To varying degrees, a health literate person is able to participate in the ongoing public and private dialogues about the environment, health, science, policy and politics. Health literacy evolves over one's lifetime and is impacted by a range of educational, psychosocial and cultural factors, as well as type and kind of community networks. Health literacy is increasingly recognized as a critical factor affecting health consumers/patients. There is over 30 years of evidence showing that a significant portion of the US adult population has difficulty accessing, understanding and using information that may impact their health and safety. More than half of the adults in the US are low health literate (Kindig et al., 2004; Kirsch, 1993; Kutner et al., 2006). Reading graphs, charts, maps, understanding numbers, and working with percentages are the very foundation of most risk communication, yet they are the very things average and poor readers find challenging.

Science literacy is "the knowledge and understanding of scientific concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity" (National Research Council, 1996, p. 22). Among the many critical competencies involved in being scientifically literate are being able to "to describe, explain, and predict natural phenomena" and "evaluate the quality of scientific information on the basis of its source and the methods used to generate it." Americans have high levels of confidence in the scientific community, and more than 9 in 10 agree scientists help solve problems facing the world (National Science Board, 2018). However no more than 20% of American adults are "science literate". (NSF Public Understanding of Science 2008) Low science literacy is a major barrier to people engaging with environmental and health information (Zarcadoolas, Pleasant & Greer, 2006).

Significantly, Americans (54%) regularly get their science news from general news outlets—those that cover a range of different topics—and not from specialized or scientific sources (Funk, Gottfried, &

Mitchell, 2017). As a result, most news about science is reported by journalists who may not be well versed in the subject matter they are covering or who have difficulty taking sophisticated science concepts and accurately translating and writing about them in an accessible manner for broad readership. This can lead to misunderstandings and inaccuracies if reporters attempt to paraphrase complex scientific information. In the article, 'Scientists and Journalists Square Off Over Covering Science and 'Getting it Right',' Dana Smith noted; "science can be complicated, and a single word can change the meaning or implication of a finding" (Smith, 2018).

"If you want to stay safe and informed, there are no better resources than what the USGS's Hawaiian Volcano Observatory provides."

'The USGS Hawaiian Volcano Observatory Is A Trusted Source For The Kilauea Eruption' by Ethan Siegel

At least dating back to the 1990s, when environmental scientist Jane Lubchenko helped found COMPASS and the Leopold Leadership Program, a communications program for mid-career scientists, there has been a growing interest in the media's ability to make science more accessible to the general public. Programs inspired by this movement are American Association for the Advancement of Science (AAAS), and the Alan Alda Center for Communicating Science, at Stony Brook University in New York. The center focuses on improvisation and listening skills to help scientists and engineers be more relatable—a goal of its founder, Alan Alda, former host of the PBS show Scientific American Frontiers. The center has trained nearly 10,000 people across the country.[1] In sum, the media relies on trusted sources to assist in conveying complicated scientific information to the public with both efficiency and accuracy.

USGS Messages have Wide Reach

In the period after the most recent eruption of Kilauea (2018), the USGS HVO has emerged as **the** key source of information about volcanic activity on the Big Island of Hawaii. Due to the reach of HVO messaging, it is important for HVO to create widely accessible Daily Updates.

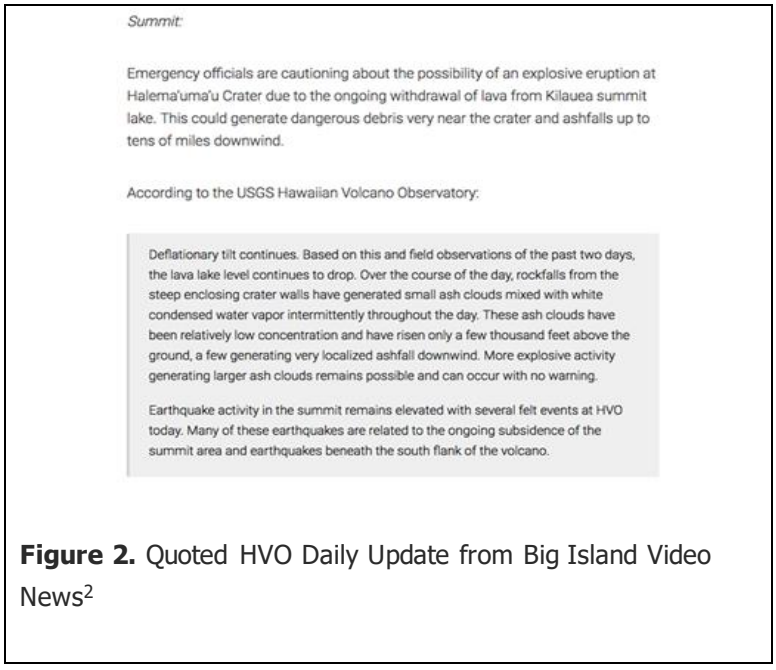
[1] For more information on COMPASS, the American American Association for the Advancement of Science (AAAS), and the Alan Alda Center for Communicating Science at Stony Brook University – please see: https://www.compassscicomm.org; https://www.aaas.org/Communicating-Science-Workshops; https://www.aldacenter.org/

Point #1 - By July 2018, over 60,000 news articles had been posted online by the media referencing USGS/HVO sources or sharing USGS/HVO links—and that does not include the thousands of print only/radio/broadcast television reports also utilizing the HVO as a source. USGS reach included local (Hawaii), national (U.S.), and international media – such *as Big Island Video News, Hawaii Tribune-Herald, CBS News, Newsweek, CNET, Daily Mail,* and *Reuters*, to name only a few examples.

Point #2 - Due to the complexity of the information, many reports quoted messaging from HVO verbatim to ensure accuracy (see Fig. 2).

One reporter from Hawaii noted:

"I would never dare to say; 'inflationary tilt continues at the summit,' but I would say, 'scientists say "inflationary tilt continues at the summit."'…I would preserve it as written. – HVO, Reporter



Summit:

Emergency officials are cautioning about the possibility of an explosive eruption at Halema'uma'u Crater due to the ongoing withdrawal of lava from Kilauea summit lake. This could generate dangerous debris very near the crater and ashfalls up to tens of miles downwind.

According to the USGS Hawaiian Volcano Observatory:

Deflationary tilt continues. Based on this and field observations of the past two days, the lava lake level continues to drop. Over the course of the day, rockfalls from the steep enclosing crater walls have generated small ash clouds mixed with white condensed water vapor intermittently throughout the day. These ash clouds have been relatively low concentration and have risen only a few thousand feet above the ground, a few generating very localized ashfall downwind. More explosive activity generating larger ash clouds remains possible and can occur with no warning.

Earthquake activity in the summit remains elevated with several felt events at HVO today. Many of these earthquakes are related to the ongoing subsidence of the summit area and earthquakes beneath the south flank of the volcano.

Figure 2. Quoted HVO Daily Update from Big Island Video News[2]

CNN, among many others, produced the following report with language taken directly from one of the HVO-produced Status Updates (see Fig. 3):

[2] http://www.bigislandvideonews.com/2018/05/12/afternoon-eruption-update-new-fissure-lower-puna-vacation-rentals-pau/

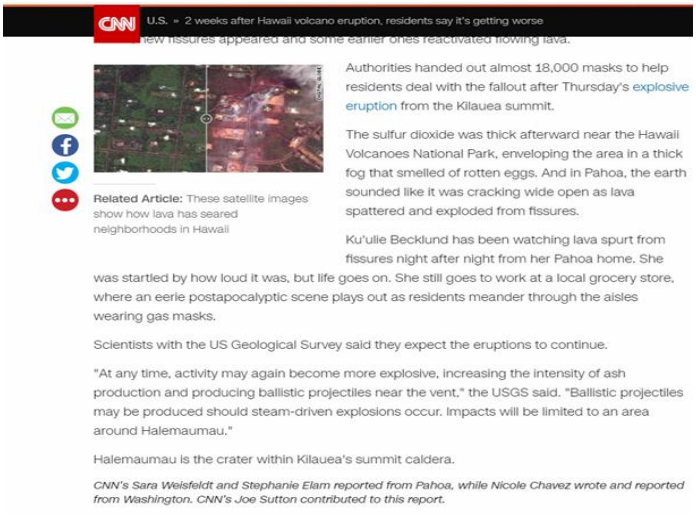


Figure 3. CNN Quoting USGS[3]

Point #3 – Media is the widest disseminator of HVO information, but the updates are also very important stand-alone sources of information for other groups of non-technical users. A resident of Pahoa, a community in the path of the current eruption, described reading the Updates regularly over the years. This resident also commented that since the most recent eruption; "*The USGS HVO does so much for all of us, especially now, to keep us safe. I sometimes access it several times a day, to keep abreast of what's going on with the Lower East Rift Zone eruption in Leilani Estates and at Halema`uma`u. The alerts and maps are especially helpful, and give me peace of mind."*

HVO has even been responsible for driving new users to social media (see Fig. 4)!

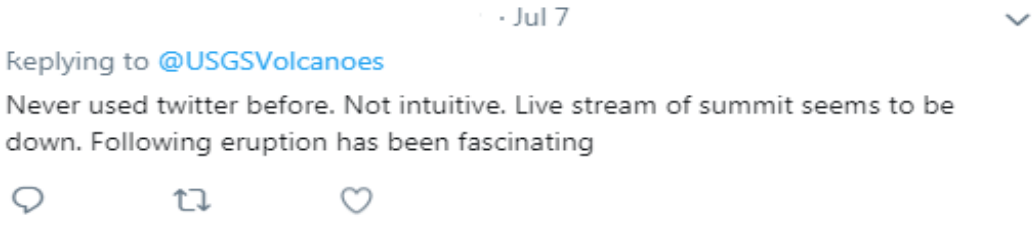


Figure 4. New Twitter User

[3] https://www.cnn.com/2018/05/18/us/hawaii-kilauea-volcano-leilani-estates/index.html

Hawaii state emergency managers and local officials also used HVO images and descriptive text in an application for federal disaster assistance (see Fig. 5).

Figure 5. Page 20 of the Hawaii application for federal disaster assistance[4]

These examples demonstrate the reach of USGS/HVO messaging.

2.3. Project Goal

The goal of this project was to conduct a small usability project in support of the USGS Science Application for Risk Reduction Program (SAFRR) in its ongoing efforts to revise hazard messaging to broaden its usability and utility for a wide range of audiences. To this end, user-centered design methods combined with health and science literacy analysis were employed to identify and explore the match between the existing HVO Daily Update texts and the needs, abilities and preferences of the end users.

2.4. Testing Aims

[4] https://governor.hawaii.gov/wp-content/uploads/2018/05/1805048-1Reduced.pdf

Aim 1: Conduct a **task analysis** and a **science** and **health literacy load analysis** to identify the linguistic and processing demands (the "load") of a representative sample of existing Daily Updates (the "text"). This included science literacy and health literacy demands of the text.

Aim 2: Develop two alternate, experimental versions of the Daily Update based on findings from the task analysis and health literacy load analysis.

Aim 3: Identify user responses to an original version of the Daily Update and two alternate, experimental versions of the Daily Update through one-on-one usability testing.

Aim 4: Develop preliminary best practice guidelines for content and design of future text-based hazard communications.

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3. Methodology

In order to understand the structure and function of the elements of the Daily Updates, we conducted a **task analysis** and a **science** and **health literacy load analysis** of selected HVO Daily Updates for Kilauea Volcano. These analyses revealed (a) typical users of the updates and common tasks those users may perform with the text; (b) linguistic and cognitive demands selected users may encounter when using the text to perform identified tasks. Taking into account the findings from these analyses and employing accepted readability and usability guidelines; we developed two alternate, experimental versions of the Daily Update. We designed these versions to be tested with selected users to determine their preferences and regarding how usable and useful the original version of the text was compared to the two experimental (rewritten) versions of the text. We then interviewed participants in a series of remote usability test sessions to identify types of information and specific text elements that readers said were difficult to understand or should be changed to improve readability and usefulness.

3.1. Task Analysis

Task analysis is a method commonly used by human factors specialists to decompose (identify and break down) the tasks a user likely has to perform with a product or system in order to understand and use it. Task analysis requires developing an understanding of users—their goals of use, what they need to accomplish, and the knowledge and experience they bring to the table. This process helps identify elements of the tool/text to focus on in usability testing sessions.

Findings from the Task Analysis

In discussion with the HVO and CVO team members, the following user audiences and user tasks were identified for the HVO Daily Update for Kilauea (audiences in **bold**):[5]

- **Local residents/visitors** – learn about the current (daily) status of Kilauea to inform household or vacation plans
- **Scientists** – (a) understand earth systems at work and advance the field of knowledge; (b) translate scientific information about volcanic processes for the lay public
- **Journalists/media** – get information about the status of Kilauea to disseminate to a wider audience
- **DOI/Parks Department employees** – review, print and post Daily Update at select locations within Hawaii Volcanoes National Park to inform staff and park users about current conditions
- **Aviation community –** review information to ensure safe operation of aircraft in/around possible volcano hazard areas
- **Emergency managers, local officials –** keep abreast of potential changing conditions, hazards to people or property

Of note was the particularly wide breadth of audiences served by the updates – and that each group had very specific tasks they may perform with the updates. Although all user groups were important to CVO, it was determined that the focus of this particular study would be on the use and utility of the daily updates for a non-technical audience (e.g. residents, tourists, as well as media, local officials/emergency managers, and earth science professionals who needed to quickly translate science for lay audiences.

3.2 Science & Health Literacy Load Analysis

Science and health literacy load analyses involve examining the text (message) to identify what are the likely linguistic and cognitive demands the material places on the reader. Depending on the type of text being analyzed this includes identifying the basic reading demands, as well as the science, health, or environmental concepts needed to comprehend the message. While the list of potential text elements

[5] It was beyond the scope of the present study to conduct a full analysis of who all of the users were and for what purposes they accessed the updates—this would require a more comprehensive study utilizing a different set of methods.

is theoretically infinite, the analyzer is constrained by the function of the text, how it's intended to be used, and the intended target reader- target audience.

These are the domains examined as part of the load analysis:

- Language –
    - Written Language (vocabulary and syntax, sentence structure)
        - Specialized Vocabulary and Phrases
        - Passive vs. Active Verbs
        - Complex Sentences
    - Discourse Analysis (cohesion)
- Design
    - Visual Line length
    - Visual Hierarchy
    - Other Design Elements

Findings from the Science and Health Literacy Load Analysis

In this study, we analyzed a selection of HVO Daily Updates crafted by different HVO writers. The following sections present findings in each of the domains mentioned above.

- Language
    - Written Language (vocabulary and syntax, sentence structure)

The initial science and health literacy load analysis of the selected HVO Daily Updates demonstrated a written high quality "scientific writing" intended for scientists – earth scientists and others knowledgeable about volcanoes. Scientific language is very precise and condensed language, characterized by: **specialized vocabulary and phrases**, **passive vs. active verbs**; and **complex sentences** (Gopen & Swan, 1990; Plavén-Sigray, Matheson, Schiffler, & Thompson, 2017).

Specialized Vocabulary - The science and health literacy analysis identified the following vocabulary and phrasing users may find difficult. They included:

- Bathymetry
- Tiltmeters
- Inflationary signal
- Deflationary signal

- Episode 61g

Passive vs. Active Verbs - The passive form of a verb (*was reported, is believed to have, is caused by, was inundated by…)* is ubiquitous in scientific writing and, for that matter, in most formal and technical writing. However its overuse presents comprehension difficulties for the reader. Passive verb sentences are generally harder to read than active verb sentences, especially when the sentences are longer. The passive verb conveys that X has been acted upon by Y. It objectifies the action and somewhat depersonalizes the voice. Writers use the passive verb form when they want to distinguish between two possible actors. Passive verbs however, can lead to confusion about who did what to whom?

For example:

A mother and grandmother are standing beside a child. The mother hugs the child. (Here, the writer wants to emphasize that the mother did the hugging, not the grandmother.)

The boy was hugged by the mother. (Passive verb form)

The mother hugged the boy. (Active verb form)

Writing in the passive verb form can result in content that is hard to read and comprehend. For example, the following sentence stacks two passive verb forms next to each other resulting in an unnecessarily convoluted sentence.

Such crimes may **be said** to **be found** in regions outside of New York City.

Vs.

You find such crimes outside of New York City.

The following text is an example of the passive verb form as typically used in the Daily Updates: (bold indicates the passive)

A collapse of the Puʻu ʻŌʻō crater floor Monday afternoon on Kīlauea Volcano's East Rift Zone **has prompted*** increases in seismicity and deformation along a large section of the rift zone, with seismicity currently occurring as far east as Hwy 130.

The above sentence is perfectly grammatical. But if the reader doesn't have the science literacy to know the causal relationship between a crater floor collapse and increases in seismicity, it's very

possible that a reader could interpret this sentence as the seismicity (ground shaking) caused the crater floor collapse.

To optimize comprehension, writing should use a combination of passive and active verbs. For more difficult concepts, it helps to activate verbs where possible.

Complex Sentences - Scientific writing is characterized by highly efficient, tightly packed sentences – sentences that pack a lot of information into **multipli-embedded** sentences. These sentences use qualifiers such as relative clauses and phrases to get more information into an utterance/sentence. The simplest sentences have a noun phrase and a verb phrase. For example:

> **The volcano / erupted.**
>
> Noun phrase / verb phrase

Generally, the longer the distance between the noun (subject) and the verb, the more complex the sentence. In the following example, there is a lot of information that comes between the noun phrase (the volcano) and the verb phrase (shows signs of reawakening).

> **The volcano**, which had been dormant for more than 10 years, and had lead scientists to believe that it would likely remain that way, has recently **shown signs of reawakening**.

To minimize the chance of confusion, this sentence could be re-written with fewer qualifiers, as in the following example:

> The volcano had been dormant for more than 10 years. Therefore, scientists believed that it would likely remain that way. However, the volcano has recently shown signs of reawakening.

Here is another example of a complex, tightly packed sentence, this time taken from the Daily Updates:

> Thermal images show an area of high temperature about 5-10 m (16-33 ft) from the edge of the sea cliff, with hot cracks running parallel to the sea cliff around the entry point, suggesting sea cliff instability. (Friday, January 27, 2017, 9:02 AM HST, HVO Daily Update for Kilauea Volcano)

When we **unpack** the sentence, it is easy to see that it is composed of at least four (4) simple sentences:

(1) Thermal images show an area of high temperature.

(2) The area is about 5-10m (16-33ft) from the edge of the sea cliff.

(3) Hot rocks are running parallel to the sea cliff, around the entry point.

(4) This suggests sea cliff instability.

If you wrote a text using only simple sentences the result would be boring, choppy, and lack **cohesion**. So the goal is to write a combination of well cohered sentences with a balance of simple and more complex sentences.

- **Discourse Analysis** (cohesion)

In a scientific text, each subsequent sentence continues to add new information. Scientists make inferences and see connections across familiar content and concepts, often without making the connections very explicit. Writing for other scientists there is no need. In contrast, prose starts with old information in the topic sentence and introduces new information, which becomes old as the writing unfolds in the paragraph. Think of reading a novel's description of a character, or reading a travel magazine. Rather than each sentence containing all new information, the information is connected by sentences referring back to information in previous sentences.

An example of descriptive language (prose):

"No one in your time could imagine a disaster of this magnitude. Little more than a billion people were alive in the 1840s. They were overwhelmingly agricultural, and few families needed more than two or three acres to survive. The American frontier was still wide open. And far away on continents to the south, up great rivers, beyond unclimbed mountain ranges, stretched unspoiled equatorial forests brimming with the maximum diversity of life."

- Excerpt from Edward O. Wilson, *The Future of Life*

Cohesion refers to how sentences and ideas hold together, or refer to each other, and create a logic and flow. Texts can have good or poor cohesion. Cohesion is central to reader comprehension (de Beaugrande, 1980; Grimes, 1975; van Dijk, 1977). Cohesion signals to the reader that they can look elsewhere in the text for the referent. The main way cohesion is achieved is by repetition and pronoun reference. New information in one sentence is repeated or referred to in a following sentence. Thus the new information becomes more familiar to the reader – becomes like 'old' information.

Writing with explicitly cohesive ties (repetition, pronouns) improves the readability of messages because the reader has to make fewer inferences across sentences and information.

Let's take a look at the way cohesion is used to positive effect in the following example from an HVO Status Report posted on July 10, 2018:

(1) Fissure 8 continues to erupt lava steadily into the perched channel leading northeastward from the vent. (2) **Disruptions** to the mid-channel occurred yesterday afternoon producing localized **overflows** along the margins of the flowfield, mostly atop earlier lavas. (3) **A significant overflow** north of the cinder quarry advancing yesterday and last night towards Cinder Rd. has stalled. (4) **An overflow** lobe moving around the west side of Kapoho Cone remains active this morning and small brushfires are reported along the margins. (5) Downstream, lava appears to be reoccupying the channel leading to the ocean entry were multiple fingers of lava are active. The southern margin of the ocean entry shows little sign of movement. (July 10, 2018 HVO Status Report)

✓ Sentences 2, 3 & 4 use the term 'overflow' that helps the reader see the connection (cohesion) between all of these sentences—this chunk of information is about overflows.

Sentence 2 introduces the new information – overflows. Sentence 3 makes this information old by starting with 'overflows' again. Reading is more fluent when information across sentences refers back to the information in previous sentences.

⚠ In contrast, the connection between sentences 1 & 2 is not as clear. There is poor cohesion between these sentences. Are both sentences talking about eruption? Or is 'disruption' unrelated to the eruption?

✓ Cohesion using simple repetition can help the readability of the information in the previous example. See the following example:

Fissure 8 continues to erupt lava steadily into the perched channel leading northeastward from the vent. This eruption caused disruptions to the mid-channel yesterday afternoon producing localized **overflows** along the margins of the flowfield, mostly atop earlier lava. (Rewritten example)

Here is another example of how good cohesion improves readability:

(1) Fissure 8 maintained **high fountains** through Wednesday with sustained heights exceeding 200 feet and the presence of multiple secondary fountains that reached to 60 feet. (2) **This fountaining** continued to feed a lava **flow that moved** downslope along Highway 132. (3) Advance rates were less than 100 yards/hour for the three lobes of the **flow**. (4) The **flow** moved north of Highway 132 in the vicinity of Noni Farms and Halekamahina roads, from which the two easternmost lobes advanced in a more east northeasterly direction while the westernmost lobe advanced in a northeasterly direction. (May 30, 2018 HVO Status Report)

✓ Again, sentences 1 & 2 have good cohesion. Fountain is new information in sentence 1 but it is repeated as the topic in sentence 2, becoming old information for the reader. This helps the reader build the connection between the two chunks of information. The 'flow' topic is continued throughout the paragraph.

Now, take a look at sentences 2 & 3. What should the writer do to make sentence 3 more cohesive using new – old information?

 Sentence 2 introduced new information – movement – 'flow that moved'.

To a scientist, the start of sentence 3 'advance rates' may imply 'rates of speed'. This may not be as likely with non-science readers. Therefore, the sentences could cohere more by rewriting to make new information about movement, old.

✓ Here is the previous example re-written with additional cohesion:

This fountaining continued to feed a lava flow that moved downslope along Highway 132. Advance rates of **movement** were less than 100 yards/hour for the three lobes of the flow. The flow moved north of Highway 132 in the vicinity of Noni Farms and Halekamahina roads. (Rewritten example)

Or simply:

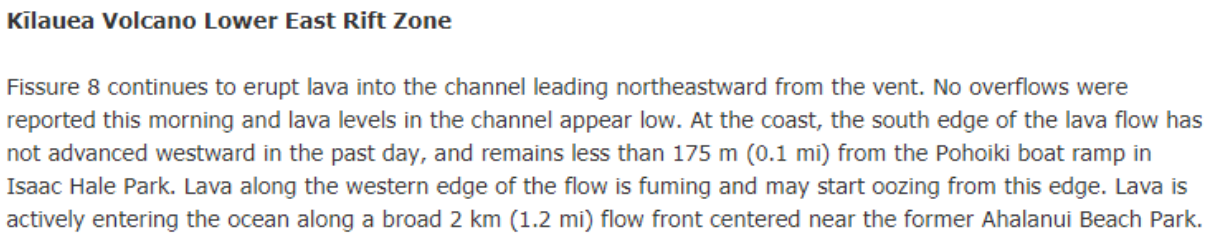
The flow moved at less than 100 yards per hour.

- **Design**

The design of a page (print or web) plays an important role in the readability of your message. Clean page layout, font, column width (line length) and text size are some of the basics that influence how a reader engages with and understands the content.

- **Line Length**

It is important to keep in mind that the visual length of a line from end to end does not equal sentence length (word/character count). Line length is the length in inches from margin to margin.



Kīlauea Volcano Lower East Rift Zone

Fissure 8 continues to erupt lava into the channel leading northeastward from the vent. No overflows were reported this morning and lava levels in the channel appear low. At the coast, the south edge of the lava flow has not advanced westward in the past day, and remains less than 175 m (0.1 mi) from the Pohoiki boat ramp in Isaac Hale Park. Lava along the western edge of the flow is fuming and may start oozing from this edge. Lava is actively entering the ocean along a broad 2 km (1.2 mi) flow front centered near the former Ahalanui Beach Park.

Figure 6. Sample line length for an Update/Status Report (July 30, 2018 HVO Status Report)

Sentence length is distance to the period. Visual line length greatly affects the scannability and readability of a text.[6] The average line length (margin to margin) in the Updates is 98 characters (without spaces) – this exceeds the typical recommended range of between 50-60 characters (see Fig. 6).

Visual Hierarchy and Organization

Hierarchy and organization of information is very important for comprehension (Williams, 2015). Content should be organized into a clear visual hierarchy, so that the most important and generalizable information comes before the less important or very detailed information. [7] Additionally, related items should be grouped visually—the more unrelated items are, the further apart they should be placed (proximity principle). Visually, techniques such as use of headers, bullets, bolded and/or highlighted text also improve readers' ability to scan and identify main points.[8] Ensuring content is appropriately grouped and organized is important to all users. According to a recent usability study by Hoa Loranger and Kate Moran, even highly educated readers "crave succinct information that is easy to scan".[9]

Analysis of the hierarchy and organization of the content of the Daily Updates suggested that using bullets and sub-headers would help condense and increase the scannability and readability of the texts. Further, grouping related information—such as in the resources section—could also enhance usability of the content.

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[6] http://www.humanfactors.com/newsletters/optimal_line_length.asp

[7] https://www.plainlanguage.gov/resources/artides/elements-of-plain-language/

[8] https://www.plainlanguage.gov/resources/artides/elements-of-plain-language/ and https://www.webdesignerdepot.com/2010/01/the-principle-of-proximity-in-web-design/

[9] https://www.nngroup.com/articles/writing-domain-experts/ and https://www.nngroup.com/articles/plain-language-experts/

Icons

Icons, when used appropriately, can help a reader to understand and quickly surmise content. Icons can also draw attention to important points. Visually, icons, along with judiciously used white-space can enhance scannability and readability. The caveat? Icons can be easily misinterpreted and should be user-tested to ensure users and designers similarly understand what the icons represent.

Font

Most users tend to prefer sans serif fonts (e.g. Arial), especially on web-based platforms. Optimal reading speed for most adults will be elicited with 12-point fonts, but when being used on a web page, the fonts should never be less than 10-points.[10] In general, no issues were found with respect to font use in the analyzed sample of Daily Updates.

Based on the items identified in the task analysis, in the science and health literacy load analysis, and in conversation with USGS personnel, two alternate versions of an original USGS Volcano Update were developed (Versions 2 and 3 - see Appendix A) to be usability tested alongside the original version (Version 1 - see Appendix A). These three (3) versions were the testing tools used in the usability sessions.

The rewrites addressed the following elements:

1. Revised some (but not all) scientific terms
2. Revised some sentences to be shorter, and less complex.
3. Used more cohesion
4. Added headers to sections
5. Added a quick summary in the form of "Quick Look" at top of pag.
6. Re-presented some paragraphs as bulleted lists
7. Condensed and categorized the additional resources
8. Inserted visual icons in Version 3

3.3. Development of Protocol

Description of User-Centered Design Method

[10] http://www.humanfactors.com/newsletters/more_about_fonts.asp

User-centered design is driven by principles that focus on the user experience as they use any kind of tools, including print information and visuals. It grew out of the need to design computer and other technological tools to be "user-friendly". A fundamental premise of design approach is that the developers can learn the most by collaborating with their target user/audience. Usability testing is the process of having users interact with a tool to perform various real world tasks. A testing protocol is developed usually comprising both open- and closed-ended questions to assess factors such as whether the information and tasks are intuitive, easy or difficult to understand, believable or not believable, and trustworthy or not trustworthy. A 'Think-Aloud' method is used. Participants receive instructions to articulate their preferences moving through the tool/text (Dumas, Dumas, & Redish, 1999, p. 121).

Finalizing Testing Protocol

Due to budget and time constraints associated with this project, it was determined that all usability interviews would be conducted remotely. Thus, the **testing protocol** (the 'script' of the scenarios and tasks participants would be asked to complete during the interview) was written to facilitate remote testing. The protocol for the usability interviews was developed by How To Health Literacy, LLC (H2HL) with assistance from HVO and CVO team members. This protocol was then pilot tested by two independent users to ensure the scenario, test questions, and protocol were understandable and appropriate.

3.4. Recruitment

HVO and CVO team members sent emails to partner contacts requesting a list of individuals interested in participating in testing sessions. H2HL interviewers sent emails to the individuals on the list providing information about the logistics of the usability test sessions and requesting availability and participation. Interested participants responded with an appropriate date and time.
To comply with Office of Management and Budget (OMB) Paperwork Reduction Act (PRA) regulations, interviews were limited to nine (9) non-federal government employees.

3.5. Participants

A total of nine individuals participated in formal user testing (*one participant provided feedback, but did not engage in a formal testing session – see Table 1). All participants were assured that their participation was voluntary and that their identities would not be publically disclosed in any formal reports.

Partner HVO/CVO	Role[11]
CVO	Communications Specialist (Federal)
CVO	Project Manager (Federal)
CVO	Public Affairs Specialist (Federal)
CVO	Warning Coordination Meteorologist (Federal)
CVO	Web and New Media Manager (Federal)
CVO	Education Ranger (Federal)
HVO	Radio Journalist
HVO	Journalist
HVO	Reporter
HVO	Local Resident*

**Full interview was not performed with this participant.*

Table 1. Participants, Partner VO, and their Roles (roles are participant self-identified)

3.6. Procedure

Two interviewers conducted remote usability tests with all participants using Go ToMeeting™. Go ToMeeting is web conferencing software that allows individuals to meet remotely via the internet in real time. Go ToMeeting was used to broadcast testing elements (3 versions of the HVO Daily Update – the original and 2 alternate versions) located on the desktop of the H2HL interviewers over the internet to participants. Participants were then able to manipulate the documents and text during the interviews.

During the session, the interviewer explained the test session. Participants were directed through a series of tasks by the interviewer. Participants received instructions to articulate their preferences moving through the original and then 2 rewritten versions of the Daily Update and to use the Think

[11] CVO participants are all quoted as CVO, Science/Media to ensure they remain anonymous (not identifiable through their job titles); HVO role descriptions are listed based on participant self-description.

Aloud process where possible. The moderator asked questions based on user comments and probed to better understand the reader's response to the content. To view the full protocol, see Appendix B.

At the conclusion of each session, participants were given the opportunity to discuss any topics that they did not feel had been covered prior to concluding the interview.

All sessions lasted approximately one hour and occurred between April and May 2018.

We used a grounded theory approach to analyze the data (Glaser, Strauss, & Strutzel, 1968). Each interview was recorded and quick notes were completed immediately after the session. Researchers iteratively reviewed the recordings, coding statements. Codes were grouped based on similarity to develop initial themes. Through discussion both researchers came to an agreement on major and minor themes and chose representative quotes to stand for these themes in the written report.

4. Findings

4.1. User Response to HVO Daily Updates

HVO Daily Updates are a Trusted Source of Information

Once they've said it, it's good to go (HVO, reporter)

Local (Hawaii media) participants considered the HVO Daily Updates definitive and the *most scientifically accurate* information available. Participants emphasized how much they respected and relied on USGS information and personnel.

- *There are all sorts of images and information coming in but they [USGS] are the subject matter experts…sometimes we'll see something and we'll hold it until that official statement comes out from USGS. (HVO, Radio Journalist.)*

However, the technical nature of the text in the updates sometimes required discussion with a specific person at HVO to get clarification.

How participants use the Update[12]

[12] Descriptions of Daily Update use were limited to HVO participants (see Fig. 1). A wider analysis of all user applications of the Daily User beyond the report of these participants was beyond the scope of the present study.

- *I usually print out the front page with the activity summary and the update for the area I'm interested in. Usually 1 page. I underline the sentences of what's happening. So I can focus on the phrases I don't understand so I can call Janet. (HVO, Journalist)*
- *Monitor two levels of information. Quickly determine – Safe – Not Safe. (CVO, Science/Media)*
- *My primary task is to translate and communicate to a wider audience. (CVO, Science/Media)*
- *I do a lot of copying and pasting, if I'm in a hurry, especially if a lava flow is coming to the town, I was turning out the updates almost as fast as they were coming in. [I write]-here's what the USGS says and I just copy and paste … I appreciate that these aren't line breaks….and the Hawaiian diacritical markings. (HVO, Reporter)*
- *I'm always monitoring through the USGS Updates…(currently) "I'm watching the deformation like a hawk" (HVO, reporter)*

4.2. Language Findings

Vocabulary/language

All participants recognized many parts of the Updates are intended for scientists – geologists and volcano experts. They commented on the scientific terms, complex sentences and sophisticated measurements to demonstrate this. However, even highly educated, science-literate participants commented that some of the terms were unfamiliar and challenging.

Participants pointed out complex sentences and scientific terms that were typical for scientists, *"but hard for the general public"* or people who are not scientists and some described challenges translating this into language that could be shared with different, less-technical audiences.

- *"The trickiest thing for me is the technical, scientific language." (HVO, Journalist)*

After reviewing the original version of the Update, almost all participants pointed out the technical/scientific language was a barrier to understanding the information. After reviewing the test

texts, participants noted that the Updates included "complicated language" that either posed difficulties to their own understanding of the content of the Updates or needed to be "translated" for the ultimate target audience.

- *[bathymetry]– We wouldn't expect our audience or viewers to know what that means right off the bat … [the technical terms] are "Not meant for a broad "average bear" audience … I don't have the background to understand this [inflationary tilt] or [bathymetry] … [Reading aloud] "Very steep bathymetry" (laughs) "What it could mean is…where the lava is entering the ocean…where it's deep there. The lava is not building up that fast… Maybe the water is deep where it's falling off into the ocean so new land is not forming very fast" "But I'd have to check with the scientists to see if that's the case. (HVO, Journalist)*

- *[It's] fine for scientists – I understand they have to do that – it's an efficient way for them to get their info across. (HVO, Reporter)*

- *I call Janet – "What does that mean?" I would have to call and ask what "delta development" means. I'm concerned, in layman's terms, what matters. (HVO, Journalist)*

Some suggested that USGS create a short glossary of frequently used terms at the bottom of the Update page.

- *I can Google 'inflationary tilt' – but I wouldn't know if I've got the definition correct without the right context. (HVO, Radio Journalist + Journalist)*

Surprising themselves, one or two participants noticed a url for a glossary of terms.

- *Oh look at that, there's a definition of terms …. If I thought I could find out what "inflationary tilt" was then I'd definitely go there. [But] I have to understand the definition (HVO, Radio Journalist + Journalist)*

However, not all participants thought they would use the link to a glossary. They suggested the USGS could define terms in context of the sentence/paragraph or at the bottom of the page, in a 'Frequently Used Terms' section, for example.

How participants want the Update organized

- I would urge USGS to use *"the most important, easily understood language"*
    - As one reporter said, *"One thing I think is really helpful is the lava viewing information [link] because I feel like with the county, things keep changing. The challenge – the lava keeps moving….As a reporter I need to know where it is and what does it look like now. It's great to have a place I can quickly go to."*
- *And for me a map – even if it's at the bottom of the daily update to show where the flow [goes]* (but participant acknowledged that can be time consuming)

Alert Level and Color Code

Participants consistently pointed out that the color-coded warning systems needed context and more description of the levels and codes. Some of the questions raised included:

- *What is the scale? CVO, Science/Media and HVO, Media*
- *People still don't understand all the alert levels for the weather service, and that is information people see all the time (explaining why it is challenging) CVO, Science/Media*
- *How does this affect me? Is it bad or good? - CVO, Science/Media*
- *What is Watch compared to Warning? How does that correspond to the color system (for aviation)? Watch… Orange - what do these mean**?** Is orange only for aviation. What about any health warnings - respiration? - CVO, Science/Media*

Additional Sources of Information

Most participants had not used the websites at the bottom of the Update. Some said they never noticed them before.

- *I've never noticed the links before. I'm usually on time constraints and maybe I never scrolled down as far. HVO, Media*

- *Make the additional resources list shorter and more relevant—to avoid being a "link farm" CVO, Science/Media*

While they thought they were good, they wanted "hyperlinks" in an electronic format and as long as it were kept up to date.

Changing communication methods

Several users organically brought up the ubiquity of electronic and mobile devices today and asked about how mobile-ready the Updates were. This was mentioned most often when discussing:

- the problem they have when trying to identify specific geographic locations cited in the Updates
- how people would access the information going about their daily business
- the urls in additional resources – and a request for hyperlinks

4.3 Format/Organizational Findings

Quick Look

All participants said the new (Versions 2 and 3) 'Quick Look' section was a good and useful addition.

- *I can see how the 'Quick Look' could be helpful. I'm thinking, especially when the lava flow is threatening a town and we're watching the lava flow on a daily, hourly basis….this would be a way to find out really fast. Really useful. (HVO, Radio Journalist)*

Line Length

Most participants agreed that the bulleted formats, utilizing shorter lines of text, were easier to *scan* and that this enhanced readability.

- *[This] version is easier on the eyes…to scan through and to skim. Especially if you're …doing it very fast. (HVO, Reporter)*

The only hesitation about the bullets came from reporters and publishers of web content who are pressed for time and cut and paste USGS technical statements right into their copy. However, they endorsed the bulleted text, even though it might take them more time to incorporate into their reporting.

Icons

Most participants thought the icons/graphics enhanced readability for a more general audience. They did not think the icons would be of particular interest to scientists reading the report.

- *I think more for the general public – they would be helpful. Especially the hazard sign…A lot of tourists treat Hawaii like Disneyland. [Tourists say] Ah…this is so great…They jump in the ocean….they go to the volcano…"Oh the lava's so pretty." [without minding cautions]*

Geographic Location

Participants said they were not familiar with many of the specific locations (e.g. Kamokuna) mentioned in the Updates and would like USGS to help by perhaps adding a map or the number of miles from a known landmark.

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5. Recommendations

"If the reader is to grasp what the writer means, the writer must understand what the reader needs (Gopen & Swan, 1990)."

As noted in the previous section, findings from the usability sessions suggested users would prefer Daily Updates that employed the linguistic and design changes tested in the experimental versions of

the texts. The following recommendations are a synthesis of the findings from the usability sessions as well as the linguistic and processing analysis done by the research team.

5.1. Language Recommendations

You don't have to define every difficult/new word. Let the text do the heavy lifting.

A universal (and very handy) strategy that readers and listeners use when they come upon a difficult or new word is to 'skip and guess' (infer).

For example, NBC interviews a scientist about the eruption; the scientist states:

> "Very few volcanoes are monitored as extensively as Kilauea. It's one of the most heavily **instrumented**."[13]

Most readers will use their understanding of monitored (my doctor monitors my high blood pressure; the store has monitors watching for shoplifters) to then guess that 'instrumented' has to do with the tools experts use to watch/track the volcano.

Thus, inference helps people make sense of complex information.

However, if difficult words are critical for the understanding of the message they should be defined in some fashion. This can be done within the surrounding sentence/s or by including a SHORT glossary of terms that you use regularly in the Updates.

The following is an example from Update 5/26/18 that would be improved by defining key terms. For example, defining the terms in bold (bolding is ours) would improve understanding of the following text.

> Fissures 7 and 21 are feeding a **perched lava pond and pāhoehoe flow** that has advanced northeastward covering most of the area between Kaupili and Mohala Streets. The **flow front** has become an **'A'ā flow** and is advancing slowly toward Pahoa Pohoiki Road. The latest observations indicate the flow front is about 150 yards from the road. On the west side of Fissure 7 a perched pāhoehoe flow (near Makamae St) broke out around 04:00am feeding short flows to the west. Overnight, flaming and vigorous spatter was observed from a cone on Fissure 8, while Fissure 17 was the source of multiple booming gas emissions. Sensors in the LERZ indicated that the lava ocean entries remained active overnight.

[13] https://www.nbcnews.com/mach/science/volcano-expert-explains-science-behind-kilauea-s-ongoing-eruption-ncna876741

Vocabulary – substitute more common words:

 Here's an example from an Update with more difficult vocabulary:

> **The ocean entry is a hazardous area. Venturing** too close to an ocean entry on land or the ocean exposes you to flying debris from sudden explosive **interaction** between lava and water. Also, the lava delta is unstable because it is built on **unconsolidated** lava fragments and sand. This loose material can easily be eroded away by surf, causing the new land to become unsupported and slide into the sea. Additionally, the interaction of lava with the ocean creates "laze", a **corrosive** seawater plume **laden with** hydrochloric acid and fine volcanic particles that can irritate the skin, eyes, and lungs.

✓ In this example, more common language has been substituted for the complex terms used in the previous paragraph.

The ocean entry is a hazardous area. Getting too close to an ocean entry on land or the ocean exposes you to flying debris from sudden explosive **contact** between lava and water. Also, the lava delta is unstable because it is built on **loose** lava fragments and sand. **This loose material** can easily be eroded away by surf, causing the new land to become unsupported and slide into the sea. Additionally, the interaction of lava with the ocean creates "laze", a seawater plume **containing** hydrochloric acid and fine volcanic particles that can irritate the skin, eyes, and lungs.

Reduce sentence complexity.

Try to keep subjects and their verbs closer together. This is most important when a number of complex science concepts are involved in the utterance.

- Long sentences are not necessarily complex sentences. Complex sentences are multipli-embedded.
- Avoid front-loading phrases that carry critical information. Front loaded sentences with important qualifiers can be easily misread.

Compare the complex sentences (indicated using the 'Caution' sign with the ones that follow):

 In the following sentence **emissions** (bolding is ours), is the front-loading word to avoid:

Due to high sulfur dioxide **emissions**, all media escorts near the fissures are postponed until further notice for safety.

Due to the laze hazard at the lava ocean entry stay out of the plume.

✓ Revised:

All media escorts near the fissures are postponed until further notice because of high sulfur dioxide emissions that are a health hazard.

Stay out of the plume at the lava ocean entry because laze is a health hazard.

✓ **Long sentences don't have to be complex sentences.**

The following long sentences use the simple connector "and" or "but" and therefore are not overly complex to comprehend.

Earthquake activity continues, but earthquake locations have not moved farther downrift in the past few days and the number of located earthquakes remains low.

An explosion was detected from the summit Overlook Crater just after 6:00 pm that produced an ash cloud that rose to 10,000 feet above sea level and carried slightly more ash than most recent explosions. (Update 5/24-25/18)[14]

✓ <u>Try rewriting one long sentence as two.</u>

⚠ An explosion was detected from the summit Overlook Crater just after 6:00 pm that produced an ash cloud that rose to 10,000 feet above sea level and carried slightly more ash than most recent explosions.

✓ An explosion was detected from the summit Overlook Crater just after 6:oo pm that produced an ash cloud that rose to 10,00 feet above sea level. The cloud carried slightly more ash than most.

[14] Incidentally the "slightly more ash" was used verbatim by CNN that day – "Small eruptions are continuing at the summit of Kilauea. An explosion reported Thursday produced an ash plume that rose up to 10,000 feet and "carried slightly more ash" than other recent ones, the USGS said." https://www.cnn.com/2018/05/24/us/hawaii-kilauea-volcano/index.html

⚠ This loose material can easily be eroded away by surf, causing the new land to become unsupported and slide into the sea. Additionally, the interaction of lava with the ocean creates "laze", a seawater plume containing hydrochloric acid and fine volcanic particles that can irritate the skin, eyes, and lungs.

✓ **This loose material** can easily be eroded away by surf. This can cause the new land to become unsupported and it can slide into the sea. Additionally, the interaction of lava with the ocean creates "laze", a seawater plume **containing** hydrochloric acid and fine volcanic particles that can irritate the skin, eyes, and lungs.

Connect sentences using cohesion.

As we have discussed earlier, scientific writing is tightly packed often contains a lot of new information that assumes the reader can make the needed connections between this information. Making these connections more explicit is helpful to non-science readers

- Repeat key nouns across sentences or refer back to them by using pronouns.
- Avoid starting each sentence with NEW Information.
- Create more cohesive, readable content by starting some sentences with OLD Information (information from the previous sentence).
- Place backward linking old information at the beginning as a topic sentence.

✓ In the following example, the *'new land' is old information from previous sentence and creates a stronger coherence between sentences, especially if the science concepts are not universally understood.

You can be hit by dangerous flying debris if you go too close to an ocean entry. When lava and water combine debris forms new land. This new land* is made of lava and sand and is unstable. Walking on or near any new land is **very dangerous.**

✓ Here, '**fountains**' (bolding is ours), old information from first sentence, also begins sentence two, creating tighter cohesion and increases readability, especially if the science concepts are not universally understood.

Fissure 7 activity is very active, producing a large spatter rampart over 100 feet tall from **fountains** reaching 150-200 feet. The fountains* fed two perched channels--the north channel fed a lava flow that advanced toward pad E of the PGV property and the south channel a flow

that was advancing to the southeast along the west border of the fissure 22 flow. (May 27, 2018 HVO Status Report)

Activate Passive Sentences

Use more active verbs

 This example includes a number of passive verbs making it hard to read. See the bolded text below:

Ash continued to erupt intermittently from the vent within Halema'uma'u crater, at Kīlauea's summit. At 1:56 AM HST, there was a small explosion that sent ash to 15,000' above sea level. The ash cloud rose vertically above the summit and drifted only slightly to the northwest owing to calm winds. The **explosion was reported felt** by a number of residents in the Volcano area, and it resulted in the **emplacement** of some incandescent blocks on the east floor/wall of Halema'uma'u crater.

✓ The last sentence could be activated as follows:

Residents in the volcano area reported they felt the explosion, which deposited some large incandescent blocks on the east floor/wall of Halema'uma'u crater.

 Again, see the passive verb form in bold in this example:

An explosion was detected from the summit Overlook Crater just after 6:00 pm that produced an ash cloud that rose to 10,000 feet above sea level and carried slightly more ash than most recent explosions.

✓ And, as re-written:

Scientists detected an explosion from the summit Overlook Crater just after 6:00 pm that produced an ash cloud that rose to 10,000 feet above sea level and carried slightly more ash than most recent explosions.

 Passive

HVO was prevented from flying over the activity or seeing details of the activity in our web cameras on site by poor weather.

✓ Active

Poor weather prevented HVO from flying over the activity or seeing details of the activity in our web cameras on site.

⚠ Passive

No shallowing of earthquakes has been detected. HVO's GPS station in the area continues to show motion related to ground deformation in response to the ongoing intrusion.

✓ Active

Scientists have not detected any shallowing of earthquakes. Our GPS station in the area is continuing to show motion and ground deformation because of the ongoing intrusion.

5.2. Format/Organizational Recommendations

Place information where people expect to find it.

Organization – the introductory statement should function as an "advance organizer" – allowing the reader to anticipate what this section/paragraph will be talking about.

Each sentence logically adds to the introduction.

⚠ The middle portion of the fissure system continues to produce the most robust eruptive activity in the Lower East Rift Zone. The fountains from Fissure 22 feed a single lava channel that reaches the coast just north of MacKenzie State Park. The actual point of entry has continued shifting to the west. Fountains erupted from Fissures 5, 6, 13, and 19 continued to feed a lava flow advancing to the south along the west side of Fissure 22 flows that reached the ocean late this afternoon. **There are now two ocean entry points that produce occasional small explosions.** (Wednesday, May 23, 2018, 10:46 PM HST)

✓ The middle portion of the fissure system continues to produce the most robust eruptive activity in the Lower East Rift Zone. **Lava is entering the ocean at two ocean points and is producing occasional small explosions**. The fountains from Fissure 22 feed a single lava channel that reaches the coast just north of MacKenzie State Park. The actual point of entry has continued shifting to the west. Fountains erupted from Fissures 5, 6, 13, and 19 continued to feed a lava flow advancing to the

south along the west side of Fissure 22 that also reached the ocean (geographic location xxx) late this afternoon.

Likewise, interview respondents appreciated that they could quickly get a synopsis of the key information in the form of the "Quick Summary".

✓ **Orient to geography/place**

Incorporate a way to clarify the geographic locations named in the Updates.

Suggestions from users were:

- Name landmarks familiar to people.
- *"And for me, a map – even if it's at the bottom of the daily update to show where the flow is."*

Reference landmarks so that readers can identify the areas named in the Update. For example (see our addition in **bold):**

Lava continues to enter the ocean at Kamokuna **(the Kamokuna ocean entry is X miles towards the ocean from Pu'u O'o Vent and y miles from the County's lava viewing access road)** and surface flows remain active within 2.4 km (1.5 mi) of the vent at Pu'u 'Ō'ō. These lava flows currently pose no threat to nearby communities. The surface height of the lava lake in the Halema'uma'u Overlook crater was roughly 13 m (43 ft) below the floor of Halema'uma'u crater when measured this morning.

✓ **Use bulleted text to help organize content.**

✓ **Ensure information is arranged in a hierarchy.**

The following example from our testing versions demonstrates both of these points. The addition of bullets assisted readers in scanning the document quickly. Also, the most important information for most people – that the flow posed no threat to nearby communities (see yellow box) was moved to the top of the section, so that an information hierarchy was created – with the most important information at the top.

Original Version	Experimental Version
Lava Flow Observations: The episode 61g flow is still active and entering the ocean at Kamokuna. Significant delta development was not observed by HVO scientists on a helicopter overflight conducted Wednesday. Very steep bathymetry may be inhibiting reformation since the New Year's Eve collapse event. Thermal images show an area of high temperature about 5-10 m (16-33 ft) from the edge of the sea cliff, with hot cracks running parallell to the sea cliff around the entry point, suggesting sea cliff instability. Scattered surface flows from a small breakout that occurred on January 22 are still active close to the 61g vent, as are surface flows on a secondary branch of the 61g flow. All surface flows are occurring close to Pu'u 'Ō'ō, within about 2.4 km (1.5 mi) of the 61g vent. The episode 61g flows pose no threat to nearby communities at this time.	**Lava Flow:** • Scattered surface flows pose no threat to nearby communities at this time. • Episode 61g flow still active and entering ocean at Kamokuna. No significant delta development observed by HVO scientists on Wednesday's overflight. Steep bathymetry may be inhibiting reformation since the New Year's Eve collapse event. • All surface flows are close to Pu'u 'Ō'ō, within about 2.4 km (1.5 mi) of the 61g vent. These surface flows are from the small January 22 breakout and from a secondary branch of the 61g flow.

✓ Be Mindful of Line Length

Pay attention to line length. Recall, in the initial analyses of the Daily Updates, the average Daily Update line length was approximately 98 characters. Line length should be kept between 50-60 characters.

5.3. Applying the Recommendations

In this section, all of the rules discussed earlier will be demonstrated using an example taken from an HVO Status Report from June 9, 2018.[15]

⚠ **Original text uses vocabulary that could be easily simplified.**

The ocean entry is a hazardous area. **Venturing** too close to an ocean entry on land or the ocean exposes you to flying debris from sudden explosive **interaction** between lava and water. Also, the **lava delta** is unstable because it is built on **unconsolidated** lava fragments and sand. This loose material can easily be eroded away by surf, causing the new land to become unsupported and slide into the sea. Additionally, the interaction of lava with the ocean creates "laze", a **corrosive** seawater plume **laden with** hydrochloric acid and fine volcanic particles that can irritate the skin, eyes, and lungs.

✓ **Rewrite #1 – Use more familiar vocabulary. When you use complex/technical words & phrases provide elaborating information to help reader figure out what the word means.**

The ocean entry is a hazardous area. **Getting** too close to an ocean entry on land or the ocean exposes you to flying debris from sudden explosive **contact** between lava and water. Also, the **place where the lava and ocean meet**, the lava delta, is unstable because it is built on **loose** lava fragments and sand. This loose material can easily be eroded away by **ocean surf,** causing the new land to become **weak and** unsupported and slide into the sea. **Also, when lava comes in contact with the ocean water it** creates "laze", a **corrosive*** seawater plume **containing** hydrochloric acid and fine volcanic particles that can irritate the skin, eyes, and lungs.

* For readers who are not sure of what "corrosive" means, they can read on to see what is in the plume and what hard it can do to humans.

✓ **Rewrite #2 – Repeat information. Make new information old where useful to create cohesion between sentences.**

The ocean entry is a hazardous area. Getting too close to an ocean entry on land or the ocean exposes you to flying debris from sudden explosive contact between lava and ocean water. Also, the place where the lava and ocean meet, the lava delta, is unstable because it is built on loose lava fragments and sand. This loose material can easily be eroded away by ocean surf, causing the new land to

[15] HAWAIIAN VOLCANO OBSERVATORY STATUS REPORT - U.S. Geological Survey; Saturday, June 9, 2018, 10:37 PM HST (Sunday, June 10, 2018, 08:37 UTC)

become weak and unsupported and slide into the sea. Also, when lava comes in contact with the ocean water it creates "laze", a corrosive seawater plume containing hydrochloric acid and fine volcanic particles that can irritate the skin, eyes, and lungs.

✓**Rewrite #3 – Activate verbs.**

This text does not overly use the passive verb.

✓**Rewrite #4 – Simplify overly complex sentences.**

The ocean entry is a hazardous area. Getting too close to an ocean entry on land or the ocean exposes you to flying debris from sudden explosive contact between lava and ocean water. Also, the place where the lava and ocean meet, the lava delta, is unstable because it is built on loose lava fragments and sand. This loose material can easily be eroded away by ocean surf. The weak and unsupported land can slide into the sea. Also, when the lava comes in contact with the ocean water it creates "laze", a corrosive seawater plume containing hydrochloric acid and fine volcanic particles. Laze can irritate the skin, eyes, and lungs.

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6. Limitations

There were several limitations to the current study. First, there were considerable differences in participants' prior experience with HVO Daily Updates and Status Reports. Some participants were accustomed to reviewing the information due to proximity to Kilauea or due to their professional duties (e.g. local media). For others, this was the first time they had seen the texts. We did not quantify exposure to or experience with previous versions of the texts. Finally, the increased eruption hazards associated with Kilauea during the study period limited our ability to connect with some local (Hawaii-based) participants.

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7. Conclusions

This user-centered design study exemplified the high level of trust and broad reach of HVO communications. Addressing identified issues by implementing the recommendations and continuing to

work with real users will improve usability and enhance accessibility of crucial hazard information by a wider range of potential users.

8. Appendices

9. References

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