Theoretical-empirical paper

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FutureCoast: A Climate Change Engagement Tool for Communicators and the Public

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Abstract

Climate change is one of the most difficult topics to communicate to the public. The causes, impacts and solutions are complex and multifaceted and therefore communicators require new methods and spaces to inform and exchange with the public. In this analysis, we examine how games and storytelling can engage people via the FutureCoast storytelling game. FutureCoast is an example of an innovative communication tool that creates an open, online space to explore climate change and its impacts. By asking players to envision climate changed futures, FutureCoast explores a type of engagement that promotes participation while also producing rich, qualitative information about their understanding. We observe that players can conceptualize a wide variety of concrete risks and solutions to climate change through the stories they create. From these stories, we as communicators gain context for common public perceptions of climate change.

Keywords

Climate education, climate communication, climate change, public engagement, public understanding of science, public perception, public participation, alternate reality gaming, envisioning, cli-fi

INTRODUCTION

The United States lags in public understanding of climate change impacts (Weber & Stern, 2011). Some studies have shown increasing numbers of people are becoming concerned about climate issues, yet despite indicating individual concern they do not conduct dialogue or act in a proportional manner (Leiserowitz, Maibach, Roser-Renouf, Rosenthal, & Cutler, 2017). A 2015 survey by Tyson & Langer documented that portions of the American public believe that there is significant disagreement amongst scientists that the climate is changing despite an overwhelming consensus in the scientific community. Such misinformation dissuades civic action that is needed to prepare for and mitigate climate change (Weber & Stern, 2011). That is why it is crucial that educators and communicators engage with the public in ways that will facilitate engagement and improve understanding with climate issues. New methods are necessary to inform the non-experts and create an encouraging space for discourse (National Research Council, 2010).

The FutureCoast storytelling game is an example of one such innovative method. It is a way for the public to engage with the climate topic regardless of current experience or knowledge, and is an opportunity for communicators to observe and gauge the public's current understanding and perceptions. These observations are a valuable step in creating effective climate change education initiatives in the future.

FutureCoast game was deployed in 2014 as a public, online/voicemail experience. Designed using best practices in online alternate reality education gaming (Squire & Jenkins, 2003), it is the first of its kind to invite the public to envision "possible climate-changed futures" (FutureCoast, 2014). Created and implemented under the Polar Learning and Responding (PoLAR) Climate Change Education Partnership with the intention of improving public engagement with climate change issues, FutureCoast made an open call to the public for their visions of what climate-changed futures may be like. The game created an engine for engaging people in "future-thinking" allowing them to visualize the impacts of a changing climate by establishing a player-created story-space and making the future seem real today.

In this article, we examine why we consider FutureCoast's unique use of playful future-focused storytelling an important component of our engagement model and how this model serves to widen participation in the climate change narrative and foster deeper engagement and understanding. We examine how the use of future-thinking provokes complex thought and how these thoughts in the form of players' stories provide communicators with a wellspring of data. From the data analyzed, we also find two communities player perceptions fall into and their general understanding of climate change and its impacts.

FutureCoast

FutureCoast (http://futurecoast.org) is an interactive storytelling game that encourages users to explore a future reality by leaving voicemails, that per the gameplay, have leaked through time to listeners in present day. By using voicemails as a form of expression, climate change and its impacts are no longer abstract concepts occurring in the remote future, but rather are visceral, first-person experiences for both the players and listeners.

Using this foresight narrative device, participants are encouraged to think concretely about the near-to-intermediate future (2020-2065) and what a climate-changed reality would be like. FutureCoast does not prescribe a certain degree of climate change or set of impacts occurring as a condition of the game, rather a variety of futures are built organically from the players' own existing knowledge and imagination.

FutureCoast was created by game and experience designer Ken Eklund as part of the Polar Learning and Responding (PoLAR) Climate Change Education Partnership. PoLAR works to inform understanding of and response to climate change through the creation of innovative educational approaches with a focus on the shifting polar environments that are increasingly linked to broader climate impacts such as rising sea levels and extreme weather around the globe.

The FutureCoast platform crowdsourced voicemails during an active period from early February through the end of May 2014. An open call was made via social media and press coverage for anyone to call-in to the toll-free FutureCoast hotline and leave a voicemail. In the fictional frame of the game, software of the future sprang a "space-time leak" in its voicemail system and audio artifacts manifested as physical objects called "chronofacts" (as pictured in Figure 1) during events called "chronofalls". In real-life, players engage through social media to find geocached chronofacts that could lead to new voicemails. This approach was designed to draw players into the story and out into the real world to learn about local places at risk of change. Online exists a growing library of player-created voicemails that leaked from the cloud of possible futures for inspiration or exploration, and were supplemented by blogs and in-character videos. All voicemails and supplemental media continue to be archived online to this date. FutureCoast's playful storyspace spurs players to engage on the topic of climate change and practice future-thinking. Overall, approximately 20,000 people, primarily in the United States, had direct interaction with the game during the Spring of 2014 via the game websites, social media, "chronofalls," and facilitated experiences.

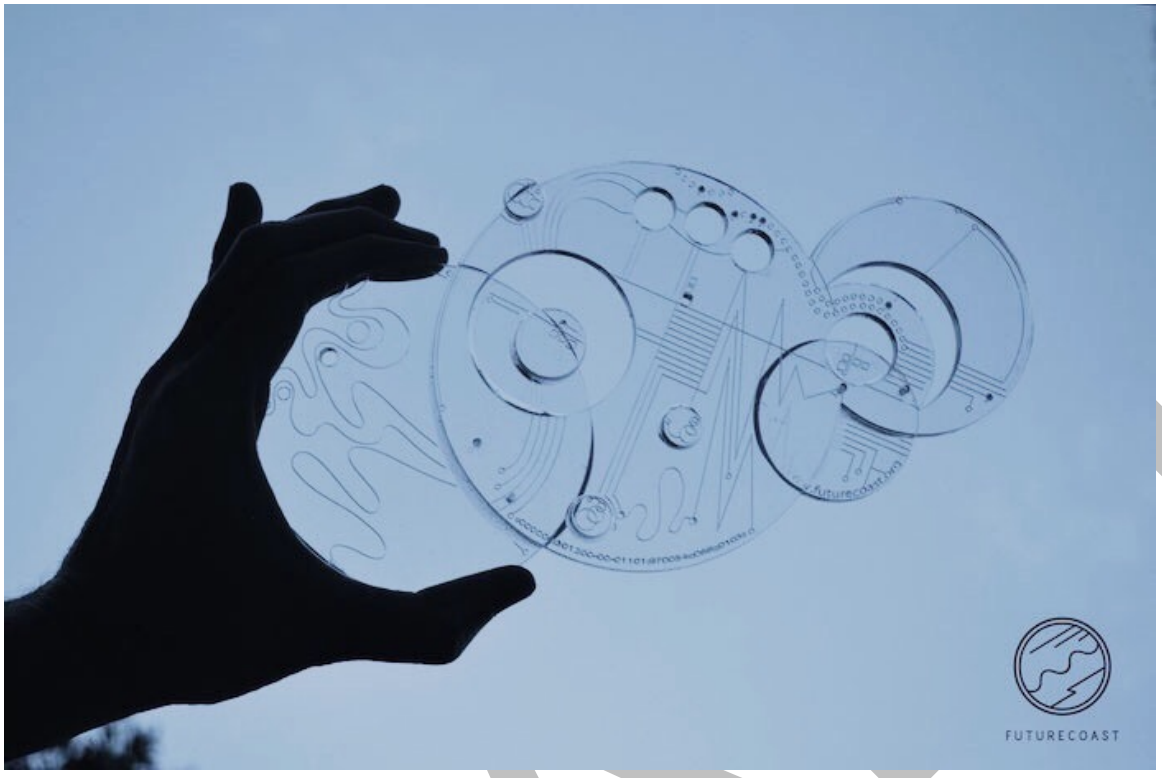

Figure 1: Image of a chronofact, a real-life object that enhanced authenticity of gameplay.

Gaming for Engagement

FutureCoast's storytelling game format strategically lends itself to the goal of engaging the public on the topic of climate change and its impacts. Games are a compelling way to captivate people; they are accessible, immersive, and encourage interaction and in this way create an open space for dialogue (Wu & Lee, 2015). Wu and Lee describe how games are natural tools for engagement that "allow for visioning - for example, being able to envision oneself in the future - and seeing consequences of actions at different points in time." FutureCoast's "stories from the future" framing requires a thoughtful engagement with the subject for players to generate narratives. Additionally, the foresight component of the game has the potential to raise an individual's consciousness of future climate impacts and encourage those who encounter FutureCoast to be conscious of climate change outside of the game.

Scholars contend that games allow players to connect to personal goals, connect to a community and create a meaningful story, all of which heightens engagement (Groh, 2012). The playful nature of FutureCoast gives players a space to enter an alternate reality of their creation based on their own impressions and start a peer-to-peer discourse about climate change issues concerning them. Climate change is infrequently discussed amongst the general public and since formal, classroom education is brief and un-sustained, for the vast majority of people there is a need for informal settings that promote climate literacy and normalize the reality of it amongst the public (Spitzer, 2012). Games can lessen the intimidating nature of climate change by serving as a non-political and non-expert venue for discourse on climate change, which may appeal to a

broader audience and allow them to engage with climate issues extending beyond their own current experiences and expertise (McGonigal, 2011). A study by Allen and Crowley (in press) shows that communication efforts which are relevant, participatory and interconnected are more likely to promote climate engagement. Storytelling games in particular, promote collaboration and the exchange of ideas, insights, and experiences among the contributors influencing their beliefs (CRED & ecoAmerica, 2014).
Relatable stories and personal experiences have been found to be more effective as communication strategies than presenting strictly statistical information to the public (Marx et al., 2007). In addition, people tend to depend more on experiential processing than analytical processing to understand climate change (van der Linden, 2015). And given that climate information is complex, based in science, and impacts occur over long time horizons, the human tendency to rely on experiential information is best used to promote understanding of this topic. FutureCoast's first-person narratives make the climate impacts directly relevant to players. The process of creating an in-character voicemail by the player serves as a proxy for actual experiences of climate impacts that can help them imagine the potential effects of climate change on their own lives (Marx et al., 2007).
Similarly, scientists are increasingly use scenarios and storylines as ways to explore the implications of environmental change and societal choices. The Intergovernmental Panel on Climate Change (IPCC) embedded impacts and response options into four different narrative storylines they developed as scenarios to describe the relationships between emission driving forces and impacts (Nakicenovic et al., 2000). Storytelling that employs future-thinking, much like the IPCC storylines and FutureCoast player stories, exits both the creator (e.g. the FutureCoast player) and observer (e.g. voicemail listener) from the hypothetical analysis and engages through experience, albeit of a speculative nature. By creating a first-person visceral experience, risks can be more clearly perceived and evaluated (Atance & O'Neill, 2001).
Alternate reality games, specifically story-focused foresight games, are used to explore possible scenarios of the future. They can explore both hypothetical situations and real concerns (Gordon, 2015). FutureCoast, like the forecasting games "World Without Oil" that encourages gamers to imagine how their lives would change at peak oil and "Superstruct" which calls players to design solutions for threats against mankind, adopted the "Play it, before you live it" philosophy (Groh, 2012). Games such as these encourage problem-solving, but rather than finding a single solution they involve imagining many possible narratives. Other research looking at exercises with integrated futurity and behavior change have shown that merely bringing future risks into a person's consciousness increases the likelihood that an individual will begin planning or make a change in lifestyle to prepare for or mitigate those risks (Spence et al., 2011). By engaging in future-thinking and creating stories for the game, players must deliberate on climate change and potential risks which requires recalling knowledge, comprehending it and applying it (Anderson, Krathwohl, & Bloom, 2001). Although we do not fully examine the impacts on behavior of this activity in this article, we anticipate that having a futures oriented dialogue about the risks of climate change makes it more salient for the public, and may promote conversation around the topic and more.

The Data of Stories

FutureCoast engages the public in deliberation on climate impacts while simultaneously providing information to us as researchers' information about the public's understanding and attitudes toward climate change, what is considered the "knowledge-attitude interface" (Sturgis & Allum, 2004). Traditional deficit model based public understanding of science research assumes that a lack of information by the public is the driver for negative, skeptical, and/or biased risk perceptions (Bauer, Allum, & Miller, 2007). Under this model, polls and other quantitative methods of assessing public understanding that indicate a lack of public concern about climate change or skepticism about scientific consensus would imply a deficiency in their understanding of climate science. While this may be the case, continuing to provide more decontextualized information may not improve public understanding of climate change and its risks (Bauer et al., 2007). Furthermore, as Allen and Crowley (in press) argue public comprehension of climate science may not be the most relevant factor in inspiring the public to act on climate change and endorse meaningful public policy and program to prepare for it.

Individuals stories can communicate preconceived ideas about the impacts of and solutions to climate change (Marx et al., 2007). FutureCoast's "crowdsourced" climate futures provided us with insight on which topics are of importance to the players, what opportunities and challenges they foresee, and how those potential futures make them feel. We coded for content themes in the voicemails as well as the sentiments players expressed about specific climate impacts. These player stories produced a rich dataset from which we discovered their current state of knowledge, attitudes, priorities, and expectations.

Our analysis of the voicemail narratives show an opportunity for communicators to gain a deeper understanding of existing knowledge of climate change and its interaction with society. This added qualitative contextual information has been argued to be missing from traditional public understanding surveys and is essential to fully assessing public knowledge (Bauer et al., 2007). We demonstrate that innovative activities, such as the FutureCoast game, can identify existing knowledge and attitudes, as well as gaps in the public understanding of science. Researchers can build on this information to develop effective public education initiatives and at the same time engage the public in a climate change conversation.

METHODS

The FutureCoast project followed the design of an alternate reality game, incorporating both online and in-person interactions. The live period resulted in 251 voicemails that were analyzed with three types of codes: content, climate change response (CCR) and sentiment. Codes were evaluated for reliability with three independent coders.

Game Design

Voicemails used in this study were collected from the FutureCoast Hotline from February 6 to May 31, 2014. Participants called the Hotline and a prompt asked them to leave a voicemail from possibly climate changed future. Callers could then choose to listen to previously recorded voicemails as exemplars, or go directly on to leave their own. Players then choose a year from 2020 to 2065 and leave a voicemail up to 3 minutes long

from that time in the future. Online media components included two FutureCoast websites, player-created blogs, and social media feeds. The official FutureCoast websites include one in active gameplay with voicemails, and a second informational site that gave the context of the FutureCoast game as well as resources on climate change. Several characters were created by the game designers to heighten player experience. And players could also engage with the game in real-life by recovering chronofacts from chronofalls staged in major cities in the U.S. and Europe.

Dataset Development

A total of 265 voicemails were collected during the live period. Four were excluded from the dataset because they were duplicates or contained obscenities. Ten additional voicemails were excluded because they were in a foreign language or inaudible.
The final dataset consisted of 251 voicemails, with a URL to the audio file and a voice-to-text transcription for each. Voicemail transcriptions were manually reviewed, validated and re-transcribed if incorrect. Fourteen of the 251 usable voicemails had partial transcriptions due to one word or more being indecipherable, however the content of the voicemails was considered intact and the voicemail was included in our analysis. During the transcription process the duration of each voicemail was noted. The final data file also included the player selected year, as well as the chronofact ID number, where available.

Voicemail Coding

To analyze the composition of the voicemails, three types of codes were developed: content themes, sentiment groups, and climate change response codes. Each code received a binary code indicating the presence (1) or absence (0) of that theme in each voicemail.
Content themes were inductively created from the voicemails (Burnard, Gill, Stewart, Treasure, & Chadwick, 2008). These codes reveal the climate impacts a player envisions. For example, a voicemail describing weather events such as extreme temperature or changes in precipitation would be coded for the *Weather* content theme. Content code analysis consisted of detecting themes during the voicemail transcription process by a single researcher. After the initial coding framework was developed the content codes were further refined by the research group to reduce overlap while ensuring all major voicemail themes were represented. This process resulted in 14 unique content codes that are broad enough to encompass similar issues, but unique enough to minimize redundancy. Each voicemail was coded for a minimum of one content theme, but could be coded for an unlimited number of themes. Qualification for the code included direct mention of any themes or parts of the theme description (Table 1).
Sentiment codes were evaluated to understand the emotional response a player intended to convey via their character. Although the voicemails are fictional, the affect a player chooses to act out can indicate their attitude and perception of a specific climate issue. For instance, a climate impact that arouses negative sentiments may indicate the player perceives that impact as a threat. By comparison a demonstrated relaxed or happy disposition could be inferred as the opposite depending on the content of the voicemail.

During the first phase of coding, affect was determined by assessing the valence and arousal of the voicemail and speaker's voice. The valence indicates how attractive (positive), unattractive (negative) or neutral the context of the voicemail is to the player. The arousal is a measure of the voice itself and how activated, deactivated or neutral it is throughout the voicemail. A list of common sentiments was compiled (Table 1) and voicemails were coded for a minimum of one sentiment, but could be coded for an unlimited number of sentiments. Similar sentiment codes were then clustered into five groups and used during subsequent rounds of validation coding.

Climate change response (CCR) codes were created by the researchers based on general climate science concepts that were included to assess the participants' knowledge and awareness of climate change effects and potential response strategies. They included: (1) *Adaptation*, (2) *Mitigation*, (3) *Challenges*, (4) *Opportunities*, (5) use of *Scientific Information*, (6) *Bottom-up strategies*, (7) *Top-down* response strategies, and (8) *Physical impacts*. Unlike the content themes and sentiment groups, for which all voicemails received at least one tag, CCR themes did not have a minimum requirement and were coded for only if mentioned. Voicemails qualified for the CCR codes frequently required an understanding of climate specific topics such as adaptation and mitigation. Some messages explicitly stated adaptation technologies or mitigation strategies, while others implied them. *Challenges* and *Opportunities* were often explicitly stated in voicemail messages or easily inferred based on the content of the voicemail. The use of *Scientific Information* was determined based on the use of relevant climate science references and terminology and *Physical Impacts* referred to physical changes that occurred due to climate change. *Bottom-up* strategies included voluntary individual or community responses, while *Top-down* strategies included government or industry responses. Detailed descriptions of CCR themes can be found in Table 1.

Code Category	Code	Description of Code	Prevalence Score
Content	Technology	Technological innovations or mainstream use of current technology; can include products, adaptive solutions, and geoengineering	0.33
Content	Weather	Extreme heat or cold, extreme weather events (e.g. flooding, drought, cyclones, etc.), weather pattern shifts, seasonal change; does not include acid rain	0.31
Content	Governance/Policy	Municipal/state/national government action, policy (e.g. carbon accounting policies); does not include informal community groups/actions	0.22
Content	Food	Agriculture, fishing, and general mentions of shortage/rationing	0.20

Content	Energy	Renewable energy or fossil fuel infrastructure, policy, technology, cost, availability etc.	0.16
Content	Health	Biotechnology, genetic modification, adverse health impacts (e.g. respiratory distress, heat stroke, etc.), healthcare costs	0.14
Content	Other*	Economic issues, infrastructure, industry & business, social issues, ecosystems & landscapes	0.14
Content	Water	Water shortages and rationing, water disputes, saltwater intrusion	0.13
Content	Conflict	Rebellions & protests, war	0.07
Content	Migration	Human migration, both largescale or individual	0.07
Climate Change Response	Challenge**	Negative effects of climate change (e.g. resource scarcity, energy & transportation interruptions, conflict, disasters)	0.60
Climate Change Response	Adaptation**	Adaptive responses to climate change – any change in behavior/lifestyle due to environmental factors (e.g. adaptive technology, adaptive policy, behavior change, migration, resilient infrastructure)	0.42
Climate Change Response	Opportunity	Positive outcomes due to climate change (e.g. agriculture & industry expansion, increase in jobs)	0.22
Climate Change Response	Mitigation	Technological or behavioral change that reduces emissions (e.g. sustainable transportation, carbon counting, lowering energy consumption, renewable energy)	0.16
Sentiment	Happy/ Excited	Happy, Pleased, Content, Excited, Enthused, Hopeful	0.31
Sentiment	Neutral/ Robotic	Neutral, Emotionless, Robotic, Calm, Relaxed, Peaceful	0.26

Sentiment	Scared/ Panicked	Scared, Concerned, Worried, Distressed, Panicked, Shocked	0.24
Sentiment	Sad/ Defeated	Defeated, Pessimistic, Resigned, Sad, Disappointed, Regret	0.19
Sentiment	Angry/ Annoyed	Angry, Irritated, Annoyed, Frustrated	0.14
Sentiment	Indeterminate*	Sentiment could not be determined	0.02

TABLE 1: Coding categories, code descriptions and prevalence of each voicemail code. Prevalence is a proportion of the frequency each code was found within its code category (*Includes content or sentiment codes that were originally coded for but did not reach intercoder agreement. **Indicates climate change response (CCR) codes that did not have sufficient intercoder reliability to carry out full statistical analysis in other parts of the study but was included here to demonstrate as a complementary pair to other CCR codes.)

Code Validation

After the initial coding and development of content, sentiment, and climate themes, two additional coders were trained to validate the theme definitions and results. Theme definitions were revised if a low agreement among coders occurred, and all three coders recoded the voicemails based on the revised definitions.

Additional steps were taken to validate the resulting codes in the form of an intercoder agreement analysis using the Reliability Calculation Program (ReCal). The agreement measure selected was Krippendorff's Alpha due to its ability to handle nominal data, to compare more than two coders at once, and to account for chance agreement. The agreement threshold required for themes to be included in further analyses was .667, as suggested by Krippendorff (2004) for exploratory data.

Two of the three coders met the agreement threshold for sixteen of the original twenty-seven themes. Nine themes were excluded due to low agreement coefficients. Two CCR themes with low agreement (*Adaptation* and *Challenge*) were included in our analysis because they formed complementary pairs with other CCR themes that did meet the agreement threshold (*Mitigation* and *Opportunity*). The third coder was used as a tiebreaker for disagreements between the first two coders, which is a common method for resolving coder disagreements in content analysis (Lombard, Snyder-Duch, & Bracken, 2002; Reis & Judd, 2000; Edwards & Lampert, 1993). Each voicemail was originally coded for at least one content theme and one sentiment group, however, because some codes did not meet intercoder agreement they were excluded from our analyses (Table 1). Thirty-four (34) voicemails did not receive a content code that met the threshold, and were therefore marked as "Other." Five (5) voicemails did not receive agreement for a sentiment code, and were marked as "Indeterminate." These codes were only used if no other content theme or sentiment group was coded for.

Code Communities

As part of obtaining useful information for communicators we performed a network analysis on all code types that reached intercoder agreement. This analysis revealed 2 primary communities in our codes, those of optimists and those of pessimists which we will discuss further in this section.
We used a *fast greedy* modularity maximization algorithm (Newman, 2006) to detect communities, or subgroups, within the network that were used in extracting additional information about public knowledge from the voicemails. Using a weighted co-occurrence matrix of the voicemail codes we conducted a principal components analysis to determine optimal number of groups to use in the analysis. The algorithm split the codes into two communities. We determined that the division is primarily driven by greater association with positive or negative sentiments. We selected names communities based on the sentiment codes included, coupled with presence of the *Opportunity* or *Challenge* CCR codes. The "pessimistic" or challenge focused community includes all the negative sentiment groups such as *Scared/Panicked*, *Angry/Annoyed* and *Sad/Defeated*. As well, *Challenge*, *Conflict*, *Weather*, *Migration*, and *Adaptation* which generally have negatively connotated impacts in the context of climate change fell into this community. The "optimistic" community included the *Happy/Excited* and *Neutral* sentiments and the content and CCR codes of *Opportunity, Energy, Technology and Mitigation.*

FINDINGS

Our findings show that FutureCoast's playful exercise of future-thinking can indeed draw out data that provides insights on individual's knowledge and attitudes. Voicemail content, and the choices players made in how they presented their stories created ample information on their understanding of climate impacts and the future. Players understanding encompassed a broad range of climate change topics and demonstrated a high level of thinking. The voicemail data also revealed misconceptions about climate change that otherwise could have gone unnoticed in a traditional survey or analysis.

Temporal Setting

As part of the gameplay players could choose when the voicemail they recorded took place. Their choice could be any year between 2020 and 2065, and they could then give further details on the time they described within the voicemail content, for example by mentioning a season or holiday to contrast with expected weather events. Analysis of the years chosen revealed interesting characteristics in player choices. Peaks on the extreme ends of the period, years 2020 and 2065, are artificial in that they include all voicemails with earlier and later dates as seen in Figure 2. Peaks at years 2024 and 2059 are explained by the game prompt having used them which indicated the importance of what information is introduced to the public in exercises such as this. 2034 was 20 years after 2014 when the program ran. The years 2025, 2030, and 2050 are round years that experienced peaks in voicemails, these also happen to be common years scientists use to make projections which could indicate the use or knowledge of such information by

players. Aside from these peaks, the general even distribution of voicemails indicates that players could engage broadly and envision across a time period that spans two generations.

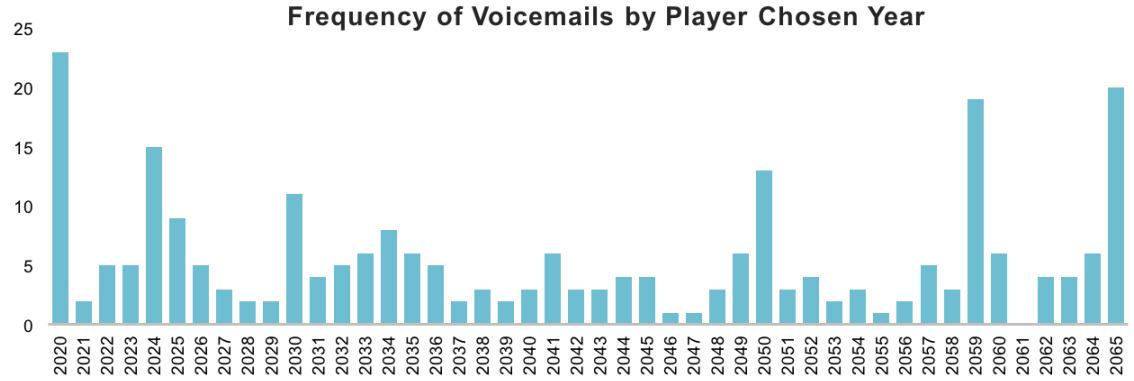

FIGURE 2: Frequency of voicemail setting year chosen by player. Part of the player experience is choosing a year in which one's voicemail comes from, this graph demonstrates frequency of voicemails by year over the period.

Codes and Content

Voicemail coding resulted in ten content codes were included in our analyses. The prevalence of each theme was calculated as a proportion of the number of voicemails the theme was mentioned in out of the total number of voicemails (Table 1). 13.5% of voicemails were coded as *Other* because the themes for which they were originally coded were excluded due to low intercoder agreement. Six sentiment groups were analyzed. *Happy/Excited* had the highest prevalence, appearing in 30.7% of the voicemails. The least prevalent group was *Angry/Annoyed*, appearing in 13.5% of voicemails. Five of the voicemails (2%) were coded as "Indeterminate" due to low intercoder agreement. Four climate change response (CCR) themes were included in the analyses: *Opportunity*, *Challenge, Adaptation,* and *Mitigation*. These themes form two groups of complementary, but not mutually exclusive, CCR pairs: (1) *Opportunities* and *Challenge*, and (2) *Adaptation* and *Mitigation*. Two of the four CCR codes did not meet the intercoder agreement threshold (*Challenge* and *Adaptation*) but were included in analyses because they formed complementary pairs with other CCR themes that did meet the agreement threshold.

Some of the more prevalent content themes reveal shared risk perceptions amongst players. More frequently occurring codes could indicate more salient climate topics for people and when coupled with the expressed sentiment and CCR code a clear picture is formed. For example, our results often showed technology, which was the most frequently occurring content theme appearing in over 33% of voicemails, correlated to optimistic sentiments as demonstrated in the following voicemail:

"Hi, Bro. It's me. Welcome back to San Francisco. You won't recognize it though by the time you get here. We've hired this bunch of Dutch experts, you know, building dams and dikes along ocean beach and stuff like that. They've been doing a great job but on the

positive, we're now breeding saltwater plants for hydroponic farms. And we're even breeding salmon and other fish in rice ponds and catchment basins for salt water. But what's really exciting to me is that the most important is that our Pacific Reservoir. We've begun desalinization plants all along the coast, and we're supplying fresh water now not only to farms, but also to all the people around here. So, thankfully they have that breakthrough in science and technology to reduce the cost of desalinization. Chat with you with when you land. Let me know. Bye-bye."
(Chronofact C 65599-70920792)
The topic of weather which was mentioned in over 30% of voicemails was viewed much more pessimistically, and can demonstrate a depth of understanding of potential future risks:
"Hey mom. Just wanted to let you know that Brody, Dad and I are heading back early. We thought maybe the heat would break, but they're saying it will stay like this at least until late next week. It wouldn't be so bad if we could still swim in the lake. The algae's back again. Oh, and the bugs up here have seriously taken over. I think next time we should bring mosquito nets. It was bad. I'm all bit up. You wouldn't believe what the cabin looked like when we got here. It was like a horror movie, I swear. Bugs everywhere. And no, I'm not exaggerating. Brody took pictures. Anyway, we should be back by tomorrow afternoon. We're gonna try to find a hotel with AC for tonight. Love you."
(Chronofact ID 94217-05124361)
In an auxiliary analysis, we compared the sectors found in the 2014 National Climate Assessment (NCA) from the US Global Change Research Program to the FutureCoast content themes (Figure 3). Voicemail themes had a greater emphasis on social issues while the NCA sectors had greater focus on scientific themes, natural systems, and specific communities. These findings show players have a broad understanding of climate change impacts on par with the priorities of experts, yet imply that social impacts are more salient for them. While our analysis found differences in the risks non-experts found when compared to experts, we also noted the aptitude of players to comment on an equally wide range of themes.

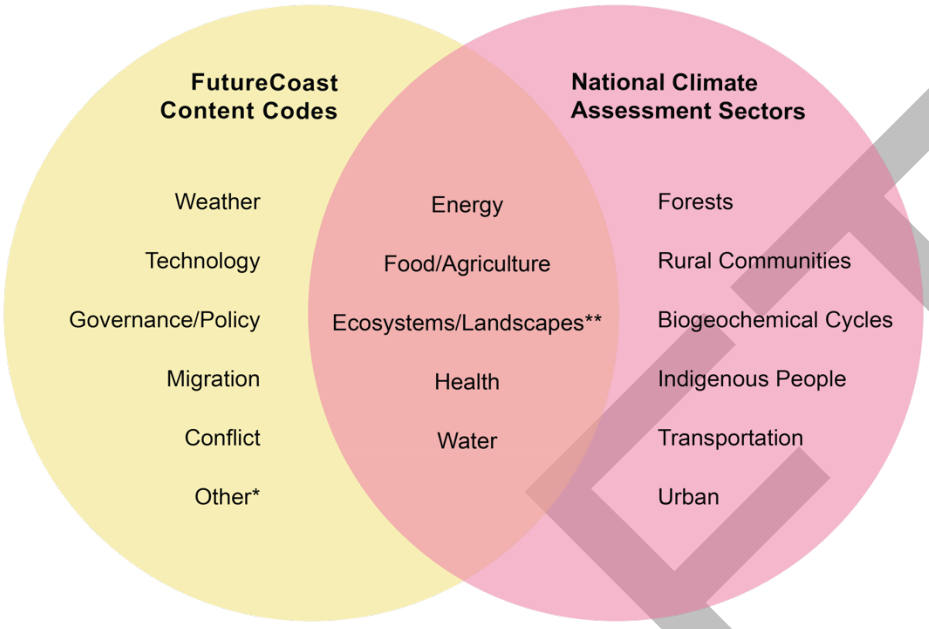

FIGURE 3: 2014 US National Climate Assessment and FutureCoast Theme versus Sector Comparative Analysis. (*Includes voicemail content codes/themes that did not have sufficient intercoder reliability nor did they correspond to a NCA sector (i.e. Economy, Infrastructure, Industry/Business, and Society). **Ecosystems/Landscapes did not have sufficient intercoder reliability to carry out full statistical analysis in other parts of the study but was included here to demonstrate an overlap with the NCA sectors.)

Communities - Optimists and Pessimists

Codes fall into one of two communities, that of codes that indicate optimism or that of pessimism about the future in the wake of climate change. These groups are a result of the statistical analysis we conducted examining the relationship between the voicemail codes. The following pessimistic and challenge focused voicemail was coded as *Water*, *Energy*, *Governance/Policy*, *adaptation* and *challenge* as well as sentiment groups *Scared/Panicked* and *Sad/Defeated*:

"Hi, it's me. Listen, besides the scheduled brownout, the city just declared an emergency and turned off the water. To all of the city. If you've got water, bring home as much as you can. Get back to me if you can, I have no idea when it's coming back on. Take care. Love you. Bye."

(Chronofact ID 168453-87112905)

The "optimistic" community (solutions-oriented) includes the more positive sentiment groups, as well as Opportunity, Mitigation, Energy, and Technology. For example, the following voicemail demonstrated an optimistic sentiment (*Happy/Excited*) and was solution-oriented containing the content themes of *Food*, *Health*, *Energy* and *Technology* as well as both the *adaptation* and *mitigation* CCR themes:

"Hey Kelly, this is Sheila. Just wondering how you are. I have to say, I just had the best workout. In 10 minutes, I generated 15 kilowatts. I wanna see you beat that feat.

Whoever wins gets to treat the other to some fat-grown beef on Friday. So, let's see if you beat me. Hope your day was better than mine. But I don't think that's possible! Bye." (Chronofact ID 23585-77019284)

Climate Misconceptions

The playful narrative style of participation allowed us to obtain an unencumbered view of misconceptions held by players. For example, one prominent misconception was a scientifically unfounded relationship between climate change and earthquakes and other non-climate related risks (e.g. tectonic shifts, meteor showers, etc.):

"Hi, Jack. This is Tony, we are scheduled to plan, to correct the issues with the tectonic plates of California. If not taken care of the massive Earthquakes will split California into 5 islands. One of which will drift up north killing thousands in Alaska. As you know the other four islands will become under chaos with dictators that will destroy the world starting with the US. We need the tectonic arrangement device. Please get in touch with me as soon as possible. Thanks, Jack, for joining the initiative."
(Chronofact ID 90750-88391460)

A more nuanced misconception we encountered was the exaggeration of near-term impacts of climate change. For example, the following voicemail which is supposed to occur in 2062 the player indicates that sea level rise (SLR) has inundated a large portion of the state of California and coastlines have reached Nevada, an impact not projected by even the most aggressive sea level rise models within the next century:

"Ah... hello sweets. Been awhile since we've talked. Yeah we just got done moving to Nevada it's so awesome we haven't been this close to the ocean since uh, since we lost our home in Santa Cruz. But it's great to be here, your mother loves to Reno and I sure hope you decide to come and join us one of these days. Well, talk to you soon. Take care, and don't forget to eat your greens! Bye."
(Chronofact ID 85471-07987160, year 2062)

The complexity of climate change makes it difficult to know how to evaluate existing public knowledge, but stories provide an opportunity to see just how information is constructed in players' mind and where there are disconnects in between perception and fact are.

DISCUSSION

Climate change is one of the most difficult communication issues of our time because the causes, impacts and solutions are complex and multifaceted. New methods to both inform the public and create an encouraging space for discourse are needed to help the public take the best actions to address climate issues (National Research Council, 2010). FutureCoast is an example of an innovative way to address the scarcity of public spaces to engage with climate change. By asking players to envision climate changed futures, FutureCoast explores a type of climate change engagement that goes beyond the information deficit model toward a more participatory approach that also produces panoramic, data on public perceptions.

We observe that through the game players consider a wide variety of risks and solutions and personally engage with climate change. By analyzing the stories FutureCoast

participants told, we gained a deeper understanding of players' knowledge, attitudes, priorities, and expectations. This added qualitative and contextual information has been argued to be missing from traditional public understanding surveys and is essential to fully assessing public knowledge (Bauer et al., 2007). Traditional climate change engagement models could benefit from innovative approaches that both activate the public and glean exiting knowledge and perceptions.

Public Engagement

What makes FutureCoast a unique engagement experience is the accessibility that comes with being online, anonymous, and playful. Participants could envision a future free of judgement and restraint and consider the implications of climate change through stories in a concrete, realistic and arguably memorable way. The voluntariness indicates a receptiveness to the material as well as quality in their responses.

As Matthew Nisbet found in his 2009 study, storytelling can be used to "bring diverse audiences together on common ground, shape personal behavior, or mobilize collective action." Our research shows that by allowing players to envision a possibly climate changed future, they gain a proxy for experiential knowledge that enables them to think more deeply and potentially perceive risks more accurately than they might outside of the game. In an external evaluation of the game (Goodman Research Group) surveyed participants on their experience. One respondent notably said, "I'm paying more attention, I know I need to/want to do more research, climate change has ratcheted several levels up my level up my ladder of issues that I find personally important and pressing." Others responded similarly, indicating the games ability to engage players in the climate change discourse.

Player self-selection is an important component of the FutureCoast game design. A wholehearted participant is "self-motivated, self-directed, intensely interested and genuinely enthusiastic," all of which are essential in future-thinking games and indicates that the player is fully participating (McGonigal, 2011). In the case of FutureCoast, the premise that a player must opt-in contributes to the quality of content generated and genuineness of their expressed perceptions and attitudes.

Contextual Understanding

Communicators possessing a contextual understanding of public perceptions of climate change, such as attitudes and the perceived workings of systems and impacts, have the potential to help develop more informed and effective climate change communication strategies. Activities like FutureCoast and the subsequent analysis of the data they produce also reveal where there are deficiencies in public understanding beyond what can be obtained through the traditional question-answer format of most polls and surveys.

We found that overall players had a broad and diverse understanding of expected climate change impacts and societal implications. Content spanned over 10 unique codes and were comparable in scope to the sectors presented in the 2014 US National Climate assessment. Voicemails discussed topics that covered resource availability, physical environmental impacts, economic and political ramifications and the psychological effects of climate change. We found that the majority of codes co-occurred with one or

more other codes of the same category (Stovall et al., in press). This demonstrates that players were aware of the interconnectedness of social and/or environmental systems when considering future climate impacts.

Our data also shows that visions of the future fall into two communities: challenge-focused with negative sentiments (*pessimistic*), or solutions-focused with positive or neutral sentiments (*optimistic*). The appearance of some content codes such as *Food*, *Water*, and *Health* with predominantly negative sentiments may indicate a lack of perceived solutions for these issues. Pessimism about food and water resources in the context of climate change may reflect a general public expectation of resource scarcity. On the other hand, *Energy* and *Technology* were more commonly associated with positive sentiments and optimism, much like the so called "technological optimist" described by Robert Costanza (2000) as one with a worldview "in which technological progress is assumed to be able to solve all current and future social problems."

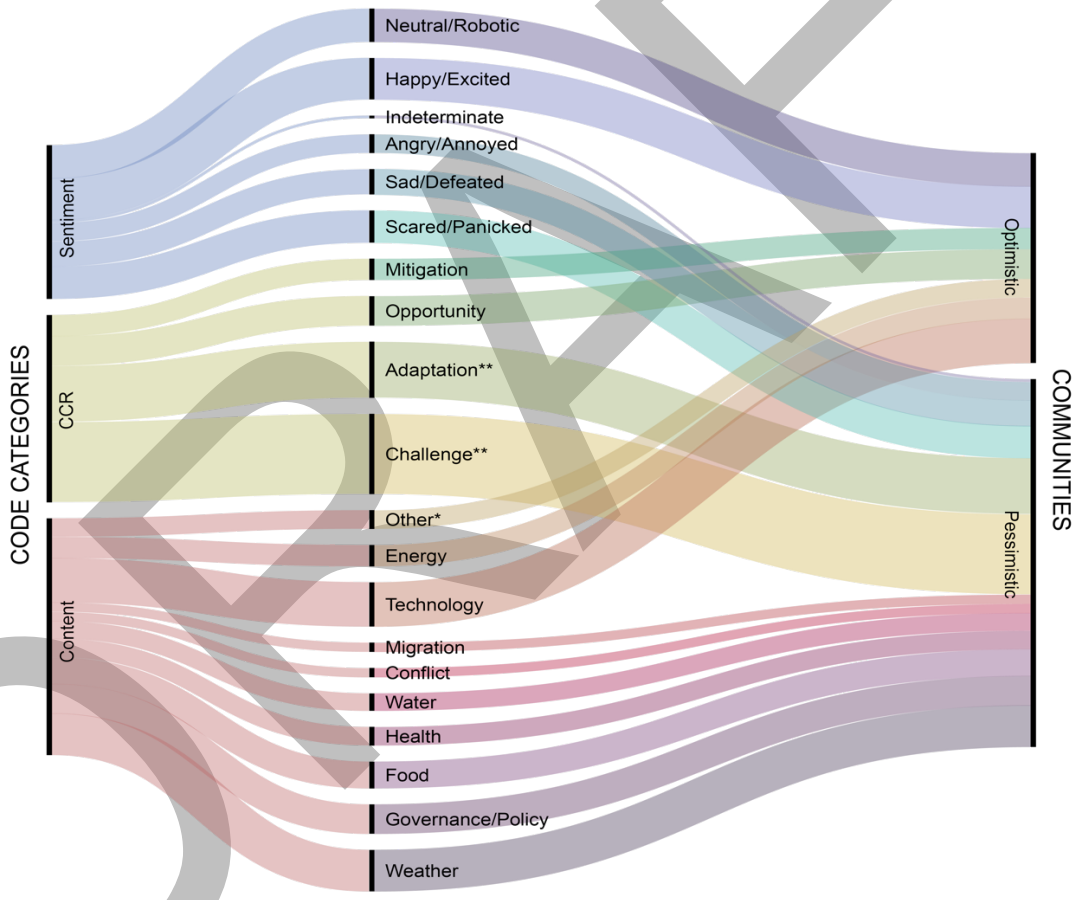

FIGURE 4: Alluvial diagram showing the relationships between code types, codes and communities. All codes considered in our analyses are found down the center of the diagram. The thickness of each band indicated relative code prevalence within its code category. The code category each code belongs to is indicated on the left of the diagram, and the community each code fell into is indicated to the right. (*Includes content codes that did not meet intercoder agreement. **Indicates climate change response (CCR)

codes that did not have sufficient intercoder reliability to carry out full statistical analysis in other parts of the study but was included here to demonstrate as a complementary pair to other CCR codes.)

Finally, we found misconceptions persist such as crediting climate change to unrelated geophysical threats and an accelerated expected timeline for some impacts. With this information, climate communicators can educate and rectify any misunderstandings held by the public.

CONCLUSION

The Frameworks Institute's 2015 Message Memo, *How to Talk About Climate Change and Oceans* states, "the greatest communication challenge for climate scientists and other translators is not a war between cognition and emotion, but rather the lack of consistent and complete storytelling." Storytelling is key for compelling climate communication. We argue that stories from all sides of the climate change discourse (both expert and non-expert) should be heard to increase public engagement and improve communication. Climate change communication needs innovative tools like FutureCoast that activate the public on climate change, disseminate information, and to gain perspective on existing narratives present in the public consciousness.

Games, stories and envisioning act as mechanisms that help enhance engagement with the public. The FutureCoast storyspace creates a place for players to visualize climate changed futures in first person, creating a realistic experience for players and listeners. They engage personally with climate change and comprehend a wide variety of interconnected impacts within a community of other non-experts. The availability of other crowdsourced narratives serve to peak players' interests in a range of climate change issues, as well as a space to brainstorm solutions. The visceral stories they create and listen to are memorable and encourage prolonged interest in, and possible action on, climate issues.

In addition to making the public more aware of climate change, FutureCoast helps communicators gauge existing public understanding and attitudes. Communicators aim to educate the public, but to do it effectively they must understand what the public knows and how they interact with the issues. Part of the innovation in FutureCoast is the analysis of the rich, player-created narratives that uncovers complex thinking about a climate changed future. By crowdsourcing futures from players, we as researchers discover the most salient topics on their minds while igniting a discourse around these topics. From the voicemails, we deduced thematic information and attitudes, and assigned climate change responses themes. From the coding analysis, we extracted commonly held misconceptions and dominant themes. We also identified two types of perceptions, optimist and pessimist, that exist when discussing specific climate issues. These discoveries are invaluable to communicators in framing climate outreach and education initiatives.

Communication and engagement are essential to improving the public's understanding of climate change. Communicator's must move past the information deficit model by which they simply provide more and more information, but instead engage the public in innovative, playful ways that promote public engagement.

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The authors declare no competing interests.

Notes: Methodological Considerations

We recognize that due to the way in which our data was collected and the methods by which we chose to analyze it there are some considerations to be accounted for when drawing conclusions from our analysis. Specifically, we would like to point out the representativeness of our participants when compared to random samples, the effects of gameplay on the content players produced, and methods by which we analyzed codes and developed communities.

Unlike traditional public understanding of science surveys, players were self-selected, not a random sample of the public. This is an inherent component of the game and could introduce a sample bias if our participants are assumed to be a representative sample of the public, therefore we do not purport this. We do consider self-selection, or voluntary participation as essential to the game format as it encourages wholehearted (i.e. voluntary and committed) participation and thus a higher level of engagement as discussed previously in this paper.

The content of the voicemails may not be representative of what participants truly think could happen in the future, the effects of acting out voicemail in a game setting could possibly cause an exaggeration of narratives. The voicemail content could have also been affected by other aspects of the activity. Participants who listened to other voicemails before leaving their own could have been influenced by them and framed their voicemail similarly or used similar themes. Likewise, misconceptions identified via voicemail content may have been exaggerated or generated as part of the playfulness of the game. That is why we focus this analysis within the context of the game and take into consideration the fictional aspects of gameplay.

There are many ways this data could be analyzed We excluded codes that did not meet the intercoder agreement threshold, and the categories that were created to include those voicemails were only present when all others were absent. There is the potential that relationships between codes that were included and those that were excluded were removed from our analysis.

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