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DOWN TO EARTH: A FRAMEWORK FOR EMPATHIZING WITH SCIENTIFIC DATA AND INVISIBLE THREATS

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Scientific research is the biggest contributor of knowledge and its engagement with the public is critical, not only for the purpose of democracy, but also for funding purposes. Space research is a domain of scientific research that has the additional challenge of working beyond the publicly visible sphere; although there are open and publicly available data about asteroids, terminology, scale and effects are incomprehensible to the public at large.

To tackle this issue, the authors developed “Down to Earth”, a digital platform that examines two possible approaches that could educate and familiarize citizens with space research. The first one is built on semantic theory to create meaningful representations of asteroid data tailored to the individual. The second part employs risk psychology theory to empathize users with asteroid hazards by providing a platform to create fictional scenarios of catastrophe on demand.

The project started with the goal to deal practically with the aforementioned issues and then ask questions about the social implications involved; this project also intends to question the means employed for engagement purposes, especially when the discussion comes to invisible threats and potential disasters. We stress the difficulty to make people (aka the taxpayers) empathize avoiding methods that cause terror.

AUTHOR KEYWORDS
asteroids; design; education; science; space communication; public engagement; empathize;

I.PROBLEM DEFINITION

In 2013, a near-earth object exploded over Chelyabinsk sky in Russia, injuring more than 1000 people. This event revealed the lack of mechanisms to deal with similar events. Despite this fact, public engagement with asteroid research remains low. Space research is mainly publicly funded and therefore the active engagement of people is critical. It is important to understand the factors that prevent engagement in order to create frameworks that encourage empathy with science and, more specifically, invisible threats.

Within this project we investigate the integration of science in popular culture and public engagement with science through accessible educational platforms. This work stresses the idea that the outreach of scientific research is struggling because of

1) inconceivable communications and

2) spectacles constructed by the media. In this context, we test the making process of digital communications. A prototype that examines the subject under the prism of space research was developed as a case study during the International Space Apps Challenge, a NASA incubator innovation program.

The audience of our research is the general public, as well as the design community, which lately drives the development of communication. A number of background factors informed our thinking during the project scoping. They are summarised and presented in the following sections.

I.I Space outreach and public engagement

To start examining the space popularization, we need to look at the factors that drive space communications of all kinds. First of all, it is a matter of democracy to communicate science advances to the public, according to Karen Bultitude; her opinion is that since science affects most of the decisions in society, people should be able to understand at least the very basics (Bultitude 2011). But apart from this purely societal motivation, a major purpose is to mobilize resources for space research. This practically means that the taxpayers need to be convinced of the necessity for government funding.

The discourse of what is worth paying for has been around for a while in the public realm and evidence can be traced back to the moon landing. In 1979, 53% of the Americans who participated in a survey concluded that the benefits of moon landing were not enough to justify its cost (The Gallup Poll Public Opinion, 1998 p.148) whereas in 1970, 81% of them, influenced by the communications of the time, answered that "nothing can equal seeing the astronauts land and walk on the moon as it happened live on TV" (Harris 1971 p.420).

Media and the entertainment industry play a major role in influencing public opinion; however, information is interwoven with spectacle and this dependence of space popularization on media very often leads to unnecessary catastrophe discourse (Weingart 1998). William T. Hartwell concludes that cinema could be very valuable in educating and familiarizing the public with research; popular cinema, nevertheless, usually distorts the role of science and presents the scientist as a mad persona. This results to considering science as "responsible for the world's ills"(Hartwell 2007).

It seems (Millstone and van Zwanenberg 2000) that the relationship between science and specifically, space communication and popular culture is very unstable and the position of the equilibrium varies between "not engaging at all" and contemporary pulp fiction. In terms of space as culture, it is clear that communication always happens in a specific political context, consequently, when designing the interaction of the general public with scientific research it is necessary to look at the broader context of popularization of ideas. When it comes to risk communication for example, the message transmitted by the media becomes either intensified or weakened on its way from the scientific community to the public; on the one hand, it is a very common phenomenon that design researchers, digital artists and makers do micromanagement of science popularization, making research findings entertaining, while on the other hand the traditional media adopt an aggressive attitude as if the only way to achieve public interest is to engross people or scare them to death. Consequently, public response to communicated risk can vary, between apathy and panic.

Meanwhile, the digital revolution has catalyzed civic participation. Although, as we saw, this fact facilitates misinterpretation in certain cases, on the other hand, while the citizens become technologically literate and familiar with political and societal processes, they eliminate misinterpretation. Not only do they stay informed and distribute information, but they also show willingness to produce it and assist the researchers' work (e.g. citizen science).

I.II Risk perception of invisible threats

There has been extended research on how people perceive the risk of hazards, much of which conducted by Roger E. Kasperson. He has argued that risk, unlike danger, is a social (and institutional) mechanism because "hazards interact with psychological, social, institutional, and cultural processes" affecting the public response.

This discourse attempts to describe the inconsistency between what the scientific society communicates about the impact of a potential hazard and how the general public perceives it. There are several theories justifying this phenomenon, analyzed in "The Social Amplification of Risk a Conceptual Framework"; it is argued that the public can become tolerant with weak evidence, as long as the message is of high social value (Kasperson et al. 1988). It seems that our judgment about risk varies, depending on whether communications work on an emotional level, or a factual level. To put it in Paul Slovic's words, "any factor that makes a hazard highly memorable or imaginable – such as a recent disaster or a vivid film or lecture – could considerably increase the perceived risk of that hazard" (Bobrowsky and Rickman 2007). This is an idea we took into consideration when designing the interaction of our platform.

Another value we considered is the impact of lack of information regarding probability on risk perception. Amos Tversky and Daniel Kahneman conclude that people tend to "calculate" the probability of uncertain events based on simple heuristic operations, rather than statistical principles; consequently, the perception of probability is liable to cognitive biases (Tversky and Kahneman 1974). This part is very crucial for the communication of possible asteroid hazards, because it can question the way people can empathize with the subject (Zeckhauser and Sunstein 2010); the issue that arises is, how do communications make them perceive an invisible threat as something probable if they haven't experienced a similar hazard before? Slovic admits that it is difficult to convince people to take asteroid hazard seriously, as they have no experiential referent (Slovic 2007).

II. DOWN TO EARTH CONCEPT

There is no lack of asteroid data. On the contrary, there are publicly available databases (NEO 2003). What is still missing is data in a format that is commonly understood by the public; otherwise these datasets remain open to diverse interpretations (and misinterpretations). Down to Earth, a digital application of educational nature, aims to operate as a case study on designing online, open interactions that deal with invisible threats. Through the design process, we examined how the context described in the previous section facilitates the development of communications characterized by certain values; we aimed to bring to the surface the promising possibilities and the ethical questions that they create.

For the purposes of this project, the researchers used the numbers available and employed metaphors to provide a reference point for asteroid data, like diameters, weight or distance from Earth. In simple words, we compared the sizes of asteroids with those of iconic buildings near user's location; at its current realization, user selects an asteroid from a list and the application returns its height in comparison to the height of an iconic monument. Monuments selection is based on user's geolocation, offering personalized information. For example, if a user accesses the application from London and chooses to get to know the facts about the Near Earth Object "Apophis", he/she finds out that the asteroid is 2.03 times the size of the Shard.

The second part of the platform gives the option to smash the asteroid into the user's location. The application then measures the potential disaster mortality. For example, in the hypothetical scenario where Apophis crashes into Shard, the potential mortality according to the application would be 128368 deaths.

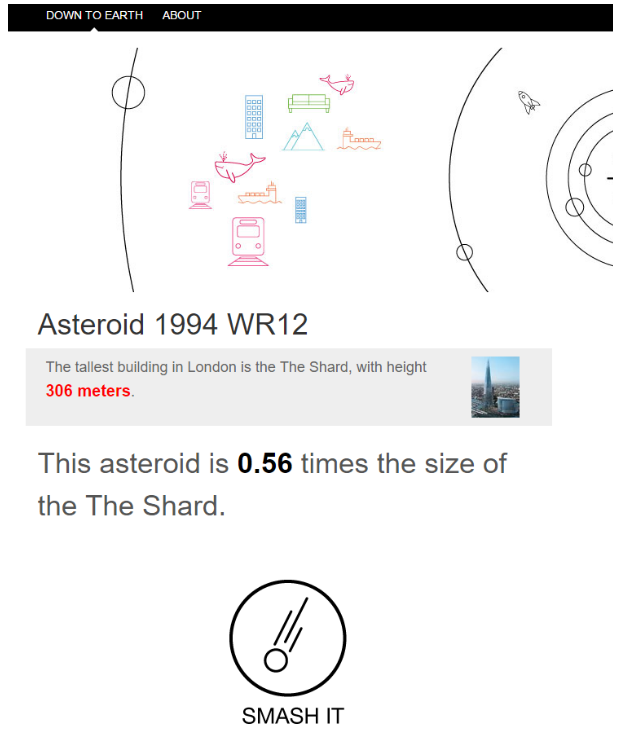


Fig. 1: Example of a comparison of an asteroid with London's Shard

II.I Familiar Metaphors of Asteroid Data

Asteroids are objects of the outer space and therefore don't have a perceptible impact on any one of the senses of the "receiver". This prevents people from understanding asteroid data. For example, is hard to perceive the size of a 20-meter asteroid. People are natural comparators and therefore, a known reference point would be utile in grounding the scales of the asteroid data. As described above, Down to Earth compares asteroid data with known references and specifically iconic buildings.

This approach builds on semiotic theory. Katie Salen and Eric Zimmerman denote that "semiotics is the study of how meanings are constructed" (Salen and Zimmerman 2004). Semantics is the branch of semiotics examining the relation between signs and the things to which they refer (Semiotics, History of Graphic Design 2004). The semantic approach is fundamental in design. Phillip Ross explains that "the semantic approach relies on the basic idea that we use our knowledge and experience to interpret signs of products. Products use metaphors in which the functionality and expression of the new product is compared to an existing concept or product that the user is familiar with" (Koskinen et al. 2011). A metaphor consists of the projection of one schema (the source domain of the metaphor) onto another schema (the target domain of the metaphor (Moser 2000)). The target domain enables people to create a mental model of the source domain. Mental models "are personal, internal representations of external reality" (Jones et al. 2011). Understanding the models people have of how systems work can be important in public engagement with science, health, democracy, and environmental issues (Phillips et al. 2013).

In our platform Iconic monuments were selected as target domain. What makes buildings iconic is their unique design, their symbolic value and their history – the impact they have had on the city where they were built ("Constructing Great Reputations: What Makes a Building Iconic" 2014). For these reasons people pay attention to monuments and "in paying attention to things, people make these things noticeable and sometimes memorable" (Koskinen et al. 2011). Therefore, we can assume that for the specific realization, iconic buildings provide a well perceived and intuitive reference point. Especially the latter is critical when it comes to public engagement, as it turns education into a seamless experience.

II.II Fictional Scenarios for Public Engagement

Tversky and Kahneman (Tversky and Kahneman 1974) propose that people are using heuristics to estimate probability and frequency of catastrophic events. These estimations are what triggers the alertness and make people engage with future risks. One such heuristic is what the authors call availability, which is defined as the quantity of the relevant examples that one can imagine or retrieve from memory. Availability is influenced by recency and emotional saliency. However, asteroid blasts are low probable high-impact events, therefore we need to stimulate the emotional response given that these events are rare and local (e.g. someone in US will not experience the Chelyabinsk event).

In our app we address this issue by generating an on-demand fictional scenario where an asteroid hits user's current location and reports the number of deaths of this what-if scenario.

One reason why we visualize the impact of the blast and not the probability of the event is because the effect of "probability neglect"; that is people's sense danger of a low probable but high impact threats is invariant to the probability (Loewenstein et al. 2001). However, reporting statistics like aggregate numbers of massive consequences can lead to an effect called "psychic numbing" (Slovic et al. 2011) according to which, one is more difficult to empathize with a tragedy when the reported effect involves a high number of people. However, reporting a percentage for the impact, rather than the absolute number, has a stronger effect (Slovic and Peters 2006). In our platform we choose to present both statistics (absolute number of deaths and as a percentage of your city's population).

The location of the user and the personalization of the catastrophic scenario adds an experiential effect; the user will feel part of the fictional event and will therefore have a stronger empathy effect. This approach tackles the issue of the absurdity of science communications, when they are meant to address massive tragedies. The application adds black humor and a twist of horror.

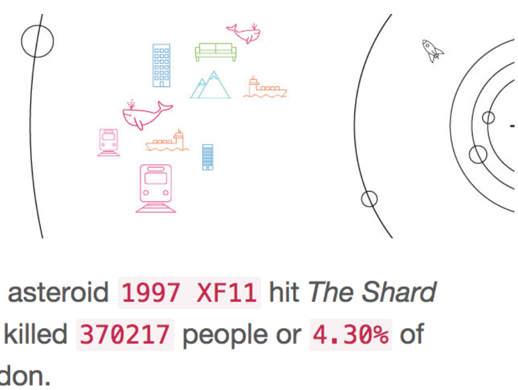


Fig. 2: Example of a fictional asteroid blast in London

II.III Technical Implementation

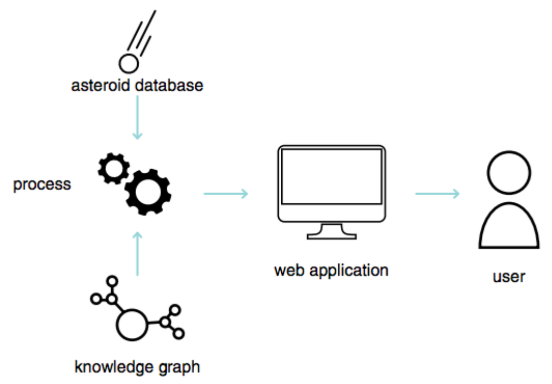
Focusing on asteroid data, Down to Earth takes numbers and uses metaphors to return personalized visual interpretations. Based on the ideas discussed in *section II.II.I* our implementation uses the location of the user to retrieve familiar examples to compare the scientific data with. The familiar examples are extracted from an open and collaborative human knowledge database freebase (Bollacker et al. 2008) and compare asteroid data to buildings and monuments nearby.

Using the sample knowledge database, down to earth allows the user to generate a personalized version of a fictional scenario of catastrophe. By choosing the option to smash an asteroid to its current location, the system retrieves the population density of the user and by computing the blast impact of the asteroid of choice it estimates the number of people that would have died in such event. That way we cultivate awareness and engage people with this invisible threat.

Data

In our application we used open data provided by NASA for Near Earth Objects (NEO 2003). This database contains entries of asteroids or objects that have been identified as potential threats, mainly due to their proximity from Earth, that the JPL Sentry System has detected based on currently available observations. The database contains scientific features of these objects, such as impact probability, size of asteroids, etc.

Overview of the system



Retrieval of familiar examples

As we mentioned, in our application we use collaborative knowledge database freebase for the retrieval of familiar examples. Freebase consists of entities (nodes) and their relations between them (edges) which are represented in a graph like structure. For example, the entity "London" of type ***/location/location*** is connected with the entity "Shard" which is of type ***/architecture/structure.*** As we can see, we can retrieve all the architecture structures in London by traversing the graph.

To interface with the database and retrieve examples we used Freebase API and Metaweb Query Language (MQL) (Flanagan 2007). For example, to retrieve the tallest building in London, the MQL query would be:

```
[{
   "name":null,
   "/location/location/area":null,
   "/architecture/structure/height":null,
   "/architecture/structure/height<":asteroid_size,
   "/location/location/geolocation":{
      "latitude":null,
      "longitude":null
   },
   "/location/location/containedby|=":[
      "london"
   ],
   "sort":"-/architecture/structure/height",
   "limit":1
}]
```

To extract the location of the user, we used the HTML5 geolocation provider (Holdener 2011).

Creation of scenario of catastrophic event

The last part of our application consists of an on-demand scenario of asteroid blast according which the user chooses to smash the asteroid on his location. Our application estimates then the number of people that would have been killed on such event. To compute this, we build on top of existing research (Collins, Melosh, and Marcus 2005) to estimate the radius of the impact of the asteroid blast given asteroid's features and assumptions regarding atmosphere, impact angle and target's features. Please note that the blast impact is an approximation and it's not of our intention to provide a good approximation. As far as our purpose is concerned, this is acceptable since we are mostly interested in creating an emotional reaction and a better approximation would not make much of a difference.

III. SUMMARY

The first section illustrates the points that we took into consideration to work on our case study and the general context, which dictates communication design in regards to space research. A good synopsis is a statement made by Roger E. Kasperson, that public perceptions are "the product of intuitive biases and economic interests".

The designed application is enabled by scientific data and puts them to use in a scientific manner to create metaphors. However, the use of the personalized catastrophic scenario and the mortality percentages, not only intend to engage the public but, in a sense, deceive the user and give the impression that he/she is part of the affected group. Down to Earth, as an educational tool, attempts to make the scale of asteroids more conceivable and to inform about near-Earth object threats. At the same time, the whole concept of the application stands somewhere between black humor and horrifying scenarios, an idea that employs design as a medium to discuss about propaganda and the absurdity of science communication, that occurs very often.

The proposed framework can be applied to other scientific domains that deal with invisible threats and user experience of fictional scenarios.

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