Carbon.to: improving the understanding of carbon dioxide information

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Abstract

We are nowadays increasingly presented with information about greenhouse gases in our everyday life. However there seems to be a gap between this increase in the exposure to carbon dioxide information and the understanding of how to interpret it, making behavioral change difficult. This article presents examples of how different applications have dealt with this problem by representing the carbon dioxide information in different ways. Based on the existing examples, an application called carbon.to was developed and released. This service tries to improve the understanding of carbon dioxide information by simulation in a playful way. Feedback from the users points towards that the gap in understanding existed and that carbon.to was successful in helping closing it.

1. Introduction

Starting as a research area in the scientific community, climate change and the effects of greenhouse gases have became a part of the public debate in the last years. This popularization can be said to reach its climax in 2007 when An Inconvenient Truth, a documentary about global warming starring Al Gore, won an Academy Award (Reuters, 2007), and again Al Gore and the Intergovernmental Panel on Climate Change shared the Nobel Peace Prize (Nobel Foundation, 2007). This popularization of climate change in the media can be seen reflected in the increased public knowledge about the subject. In the case of Sweden is estimated that hundred percent of the population knows what climate change and global warming is, and seventy percent wants to reduce their climate impact (Naturvårdsverket, 2008). Organizations and companies reacted to these needs and have started providing carbon information about products and activities. Individuals are now increasingly presented with information about greenhouse gases. Carbon dioxide, from a term mostly used in biology and chemistry, has become an everyday word.

However there seems to be a gap between this increase in the exposure to carbon dioxide information and the public understanding of how to interpret it. Even if individuals are familiar with the concepts of climate change and carbon dioxide emissions, when presented with quantitative carbon dioxide information we lack the knowledge to understand it and assess it in comparison with other activities. We lack carbon literacy.

Our hypothesis is that there is a lack of understanding carbon dioxide quantitative information and that this hinders behavioral change. The **aim** of this article is to get a better understanding in the ways to improve CO_2 quantitative information using a web interface.

This article follows a design-oriented method. Based on the problem area and existing solutions a real life intervention was designed, developed, and released to the public. The feedback from the users is gathered to contribute improving the next iteration of the application. This methodology finds its bases in design research in the context of learning (Brown, 1992; Hoadley, 2004; Barab and Squire, 2004). This article uses internet based feedback, using responses from social media streams as Twitter and custom built server logs as data for analysis. The users generated the feedback on their own in response to the released intervention without being asked nor controlled, allowing wider and more spontaneous responses.

The **objectives** of the article follow this design process and are to:

- Identify the problem area.
- Collect different examples about how carbon dioxide information is presented in real projects.
- Design and implement an intervention
- Test the intervention and gather feedback about its effect.

2. Existing representations of carbon dioxide

The first step in the design process was to explore existing examples of how carbon dioxide information has been represented in different contexts and projects. We looked at different efforts and strategies used for making the information easier to understand, as an alternative of just presenting quantitative information alone (see figure 1).

Figure 1. Max burger menu indicating 1.9kg CO_2 per meal (Max, 2010)

A common strategy is to put the quantitative information in context by using a baseline into which the data is compared. This baseline can be a way to improve the readability and have a sense of scale as for instance in Dopplr[1], where the emissions are presented graphically in bars so it is easier to see the scale differences. In figure 2 for instance the difference between train trips (short bars) and a long flight (long bar at bottom) can be seen.

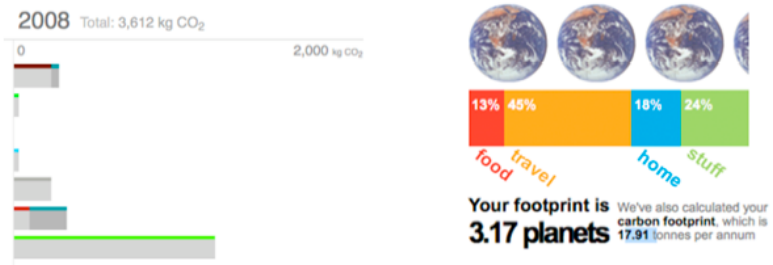


Figure 2. Dopplr (left) and WWF (right)

The baseline can also be normative, comparing the emissions with an ideal or recommended behavior. One example can be found in the WWF carbon calculator (WWF, 2010) where the result is presented in relation

[1] A service for travelers where the emissions of all your traveling can be calculated. See http://dopplr.com

of how many planets would be needed if everyone lived like you. There is a recommended goal (living under "one planet" footprint) and the carbon information is presented in relation to it.

Another way to make the information easier to grasp is translating it into the equivalent of another unit we can relate better to, e.g. the hours a light bulb have to be on for emitting such amount. A common representation is translating CO_2 information into the number of trees that would be needed to absorb it. Dopplr uses also translation in their yearly report sent to the users by email with aggregated information from their trips. It compares your carbon footprint with how much driving a Hummer during a year emits (See figure 3 left). Another example can be seen in the polemic around Google search energy use. The Times (2009) published that two searches using Google accounted for 7 grams of CO_2, as much as boiling water for a cup of tea. Google refuted the story, but the use of the analogy of the cup of tea was a success, making the information much easier to grasp that the sole 7 grams. This success can be seen in the proliferation afterward of stories such as *"A Google or a Cup of Tea: which warms the globe the most?"* (Treehugger, 2009) and it can be seen as representative of the power of translating abstract information into everyday concepts to which we can relate.

This strategy has been also adopted in marketing interventions. Volkswagen (2010) used an iPhone application for demonstrate how little their new eco-fuel model emitted. The user blows in the microphone and it calculates how many kilometers the car can travel emitting the same CO_2 as your breathing. *Jazzcalculator*[2] a web service also from Volkswagen follows the same concept. It compares the CO_2 emitted by traveling to the number of hours that a jazz band needs to play for emitting that (based on their breathing volume). For instance a trip of 200km emits 4,14kg of CO_2 that equals 6:56 hours of jazz jamming (see figure 3 right).

Figure 3. Dopplr Hummer (left) Volkswagen jazzcalculator (right)

These alternative representations can be seen as a way to get around the fact that most people have poor carbon literacy. By using representations that users can relate to – things and actions encountered in everyday life – a greater understanding of climate impact can be achieved.

[2] Available online at: http://www.jazzcalculator.com/

3. Concept and Implementation

Based on the problem area and the previously explored ways of making carbon information easier to understand, we designed and built an intervention to test our views in solving the problem and to get user feedback about them. We created a web service called Carbon.to[3] that allows users to improve their understanding of carbon emissions in a playful way by providing the possibility to convert and compare between different real world units. The idea is similar to the presented concepts transforming CO_2 information into equivalent representations, but enabling the user to choose the units and quantities for a more dynamic and personal experience. The application was programmed in Ruby on Rails[4] and the source code is available as open source[5].

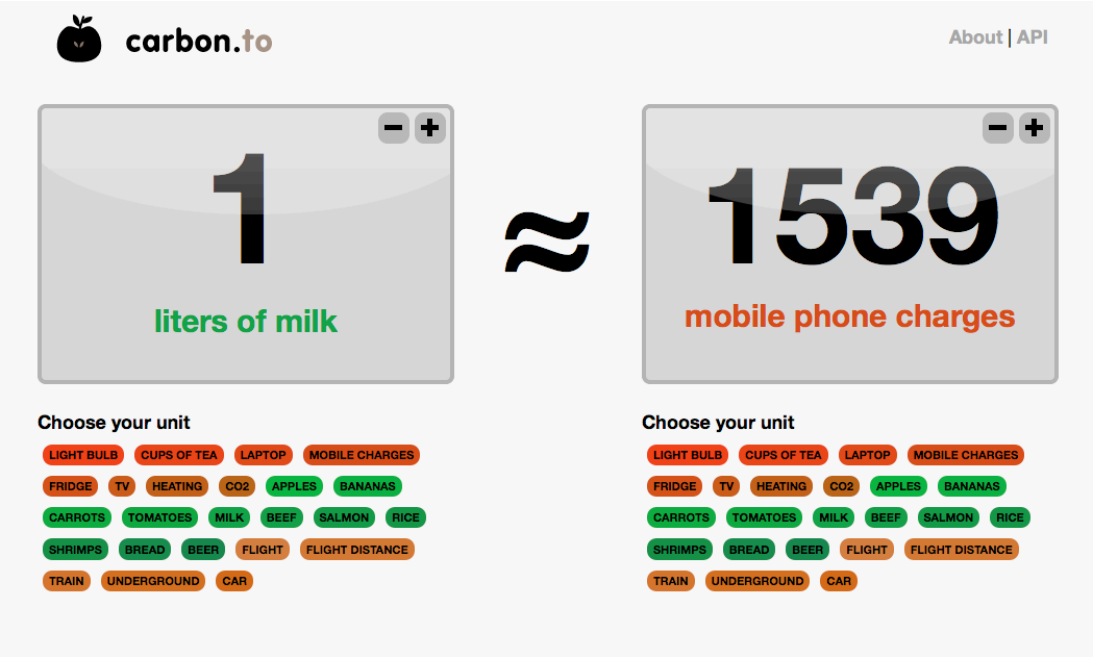


Figure 4. Screenshot from application

When the application starts, it displays 1 kg of CO_2 in a random unit (see fig 4). The user can add or subtract from the figures to explore the relation between the units. An important aspect is the possibility of comparing all units with each other, not just with CO_2. For example it's possible to see how many mobile charges are required to emit the same amount of CO_2 as flying for 5 hours. The application converts between 23 different units[6].

The application is also a tool for other services to translate their carbon dioxide figures into other units through an API (application programming interface). The API is simple with a few endpoints that provide data in XML and JSON format.

[3] Available online at: http://carbon.to

[4] More information at: http://rubyonrails.org

[5] Source code is available at: http://github.com/hinke/Carbon.to

[6] The references for the units are publicly available at: http://docs.google.com/View?id=dcqj9r34_206vr9hpqg8

The environmental information used in the application comes from different sources:

- *Food*: Food information as kg of beef or slices of bread comes from life cycle information published at Food and life cycle energy inputs (Carlsson-Kanyama et al, 2003). The data is specific for Swedish consumption.
- *Electricity and appliances*: Data such as watching television or warming cups of tea include the energy use during use (they do not include the rest of the life cycle) and are taken from AMEE[7]. The electricity carbon factor (for transforming energy in CO_2) is for Sweden and also from AMEE.
- *Transport*: Transportation data as km by plane or train is generic data from AMEE and not specific to any country, except the underground which is specific to the London underground and also from AMEE.

It is important to understand that there are many uncertainties in these calculations, some information that are from life cycle perspective, while others are limited to the use phase. The uncertainties are represented by the use of the symbol ≈ instead of equal.

The intent in carbon.to is to increase the understanding of carbon emissions through a learning process by simulation. The users compare different choices and different products by playing with the units. This helps to explore the cause-and-effect relationships and works as a simulation for the real moment of decision. The use of computers as simulation tools is one of the keys for using computers to change users behavior and attitudes (Fogg, 2003). Simulation is a powerful persuasion because it persuades in a subtle way, without seeming to preach. The persuasion effect is embedded in the design (Fogg, 2003). The main principles at work are:

- **Principle of Virtual Rehearsal:** The tool enables experimentation without consequences. Users can play comparing different footprints and behaviors while not emitting.
- **Principle of Cause and Effect:** The intervention is designed to show clearly the link between cause (behavior) and effect (CO_2).

4. User feedback

The intervention was released to the public on September 2009 and it was announced using social media tools. It has received more than 6000 visitors from 72 different countries, most of them coming from blogs[8] and social media streams as Twitter[9] and Facebook[10]. These channels provided a direct feedback connection, where the users wrote about their experience with the services and their opinions.

[7] More information at: http://amee.com

[8] For instance from: http://eco.microsiervos.com/practico/calculadora-equivalencias-emisiones-co2.html

[9] http://twitter.com

[10] http://facebook.com

4.1 Usage

A logging system was programmed to get detailed information of the usage of the site, saving each interaction (any time the numbers change, as when changing units or increasing and decreasing the values) in a SQL database.

The logging system is still running, getting more than thousand interactions per day. After one month running it had 43000 interactions from 1150 users. This can be seen as representative for the site normal traffic. The real time statistics can be accessed online[11].

The most compared units (after removing the initial comparison that is randomized) are shown in figure 5.

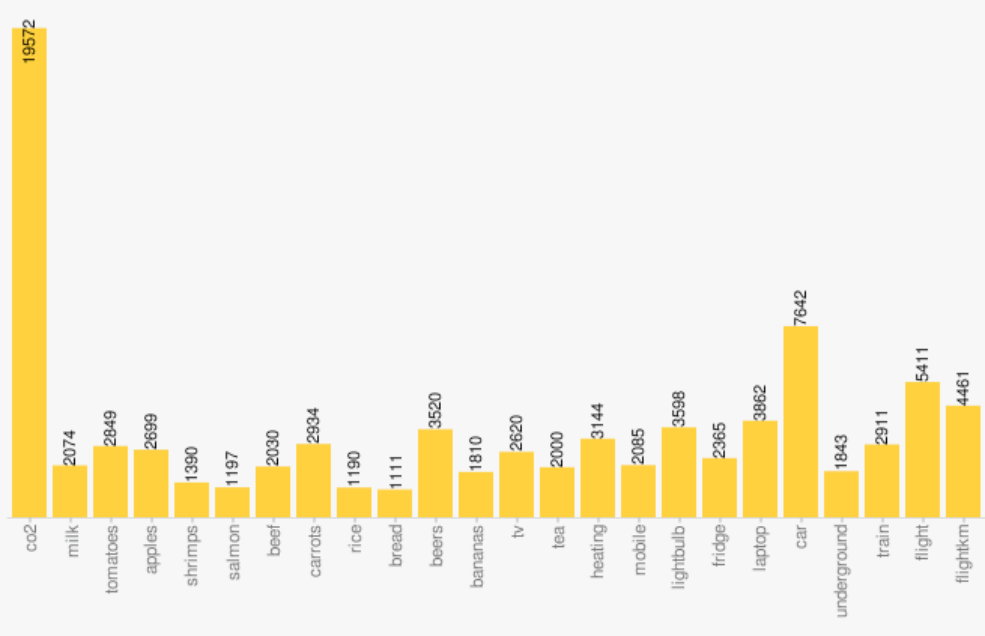


Figure 5. Logs from one month of usage.

From the logs we could get the following conclusions:

- Users were very active in the site, changing units and playing with the numbers. The average number of interactions is nearly 40 per user.
- Most interactions (roughly a third) were comparisons between CO_2 and something else, while comparisons between units were less popular.
- Transportation emissions are the most compared ones. Car was the most used unit.

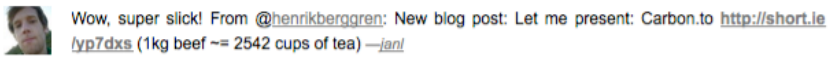
[11] Live statistics: http://carbon.to/showlog

4.2 Social media feedback

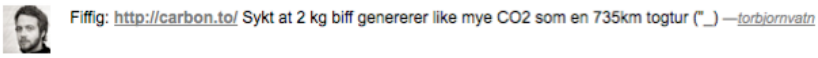
The feedback from real users is key for us both for evaluating the effectiveness of the effort and as an input for the next iteration of the design process. Most valuable were the reactions from Twitter[12]. Most responses including a link to the site were mainly a way of people to share the link with the followers, for instance:

fairandbare: "Here's an interesting app converting carbon into units you might actually understand…"

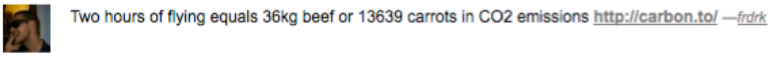
There were some comparisons that surprised the users because the unbalance in the impact. For instance beef is known to have a high climate impact, but it's when in comparison with another unit as traveling by train where the size of this impact can really be seen. Comments included the following:



jant: "1kg beef ≈ 2542 cups of tea"

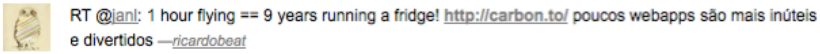


torbjornvatn: "2 kg beef generates as much CO_2 as 735 km in train"

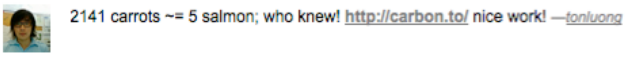


frdrk: "2 hours flying ≈ 36kg beef ≈ 13639 carrots"

Other activities that had the same effect were salmon and flying with tweets like:

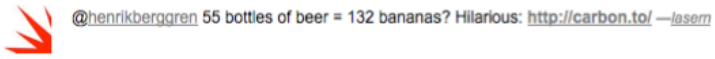


ricardobeat: "1 hour flying ≈ 9 years running a fridge!"



tonluong: "2141 carrots ≈ 5kg salmon, who knew!"

Some comparisons were appreciated just as entertainment, for instance:



lasern "55 Bottles of beer ≈ 132 bananas? Hilarious"

[12] All the "tweets" linking to carbon.to were found at: http://www.backtype.com/domain/carbon.to/conversations

Even if this feedback is not from a controlled source it provides with several interesting ideas for future development:

- In general people liked the application and thought it was **fun to use**. This "fun" factor was one of the things we tried to generate from the design process. The different representations explored in the preview review are often tongue-in-cheek, like the Hummer representation of the Dopplr Personal annual report. This quality makes the figures less intimidating and more fun, which contributes to making carbon impact less abstract. We tried to include this quality in carbon.to, including units as bottles of beer.
- The users were **surprised by the relationships between different emissions**, for instance the high impact of beef. We think that this have a positive impact in the users understanding of carbon dioxide information. Not only did they learn or confirmed that beef has a high carbon footprint, but they learned it through their own interaction, not only by reading but as an embodied experience of trying and playing.

Some criticism can be point out from our method. There feedback was uncontrolled and subjected to the specific demographics of Twitter usage and the distribution patterns around technology-savvy circles. We must be aware of that fact but we can argue that this method of getting feedback showed to be successful both in providing data but also in the candid characteristic of the responses.

It is also important to mention the values embedded in the intervention. In the presented existing examples there are persuasive qualities implied in the comparisons. They have normative values embedded and can make the emissions look bigger or smaller. For instance when the Jazzcalculator from Volkswagen[13] compares your emissions with breathing, there is an intention of showing that the car emissions are small. In carbon.to, even if not that obvious, there are also values in the choices of different footprints shown as they were chosen personally and with the persuasive goal in mind.

4.3 Future work

We believe that a powerful use of Carbon.to that we have not yet explored fully is as a data source for other services that present climate impact data to their users. The API is simple to use and abstracts away the carbon dioxide translation from services that use it. The aim of Carbon.to is to become a source of carbon information that spreads that information through other services. It could be included in services that we mentioned as Dopplr[14] to allow translating the CO_2 results in several different units and between different transport means. It could be used in other contexts, for instance in a mobile phone for grocery comparison when in a supermarket. Games could be generated using the information from the API, users would be challenged to estimate the carbon dioxide of a number of different actions and products, and their carbon knowledge score would be calculated.

We see also the opportunity for more extensive user studies. There is a need for a better understanding of the impact of different representations in the users, their understanding of the data and its influence in their behavior. Polls, focus groups and deep interviews could be used in the future for completing knowledge about the effect of different representation in the understanding of CO_2 and the impact of carbon.to on it.

[13] http://www.jazzcalculator.com/

[14] http://dopplr.com

5. Conclusions

The aim of this article was to get a better understanding in the ways to improve carbon literacy (the understanding of carbon dioxide information). As global warming importance in society has grown rapidly, there is a gap between the public awareness and the skills needed to act in accordance. Carbon dioxide information is difficult to understand as it is presented through several layers of abstraction. This article explored different strategies that have been used to overcome these difficulties such as having a baseline and comparing or translating with other units.

From this problem domain and the existing strategies we developed carbon.to as an intervention to improve carbon literacy, a tool to help people to improve the understanding of carbon dioxide information through a process of play and simulation. Following a design approach we developed the service and released it in an early stage, getting feedback from real users through social media. In the feedback we could seen that the users found the application entertaining and they got surprised by many of the results.

In terms of impact, the intervention can be seen as a success with already several thousand visitors coming from seventy different countries, and activity around it in social media channels. In terms of increasing carbon literacy we can hint from the feedback presented that it was effective in increasing the knowledge and awareness in the area. We would however need to explore deeper the real effect in their understanding of carbon dioxide.

More studies are needed in the connection between the exposure and availability of CO_2 information, the users understanding of this information, and the impact of the strategies for increasing it. From our intervention we can see that there are great possibilities for applications to help both the users understanding and our own comprehension of this process.

6. Literature

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