Your personal chatbot coach to change your CO2 footprint

Baptiste Jacquet
Laboratoire CHArt-UP8 RNSR
200515259U, Université Paris 8
Saint-Denis, France

Maxime Bourlier
Laboratoire CHArt-UP8 RNSR
200515259U, Université Paris 8
Saint-Denis, France

Laura Caravona
Università degli Studi di
Milano-Bicocca
Milano, Italy

Luis Martínez Izquierdo
Univesidad de Granada
Granada, Spain

Francisco Javier Jiménez Ríos
Univesidad de Granada
Granada, Spain

Frank Jamet
Laboratoire CHArt-UP8 RNSR
200515259U, CYU Cergy Paris
Université
Cergy-Pontoise, France

Joachim Engel
Paedagogische Hochschule
Ludwigsburg
Ludwigsburg, Germany

Laura Martignon
Paedagogische Hochschule
Ludwigsburg
Ludwigsburg, Germany

Laura Macchi
Università degli Studi di
Milano-Bicocca
Milano, Italy

Jean Baratgin*
Laboratoire CHArt-UP8 RNSR
200515259U, Université Paris 8
Saint-Denis, France
jean.baratgin@univ-paris8.fr

ABSTRACT

Limiting global warming to 1.5°C is a daunting task that requires the involvement of the global population and in particular of the population of the richest countries with the highest carbon footprint per capita. Changing behavior is a difficult task, but tools such as chatbots can be useful to help change habits and raise awareness of one's impact on the environment. In this paper, we discuss previous work related to behavior change from the point of view of cognitive psychology and with the use of chatbots, before suggesting a design for a chatbot aimed at reducing one's carbon footprint.

CCS CONCEPTS

• **Human-centered computing** → **HCI design and evaluation methods**; • **Applied computing** → **Psychology**.

KEYWORDS

human-machine interaction, behavior change, chatbot coach, chatbot design, pragmatics, climate change

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1 INTRODUCTION

As the world is attempting to keep global warming within 1.5°C compared to pre-industrial era [4], a drastic reduction of the global carbon footprint is required. While there are great disparities regarding CO_2 emissions between countries, and between high and low-income individuals, all of us must take our part in this reduction. Indeed, one area of interest regarding CO_2 reductions is the personal domain, i.e. what each individual emits because of their way of life [15].

This fundamental change in how we live our lives requires us to change our behavior on multiple fronts [63], yet, psychological evidence has shown that these changes are seldom effective and sustained without some external motivators, such as coaching. But having a personal human coach is not always possible. In this paper, we will discuss why changing behavior requires a sustained and multi-factorial approach before exploring the work which has already been carried out in the literature regarding using artificial agents as coaches in various domains. Using this knowledge, we will introduce a conversational agent design with the purpose of helping us change our behavior regarding climate change.

We suggest that chatbots can be relevant tools when used as coaches to promote behavior changes in favor of a decrease in CO_2 emissions.

2 HOW PSYCHOLOGY CAN HELP PEOPLE CHANGE THEIR BEHAVIOR

To make behavioral changes happen, legislation and monetary incentives can be useful tools but sometimes they are not enough, and that is where psychology can make a difference. The psychological research already started to tackle some important areas where there is a need for behavioral change such as improving donations to charities [14], following the recommendations of scientists against COVID-19 [7] and of course, in the fight against climate change [44, 59].

Nudging is the most commonly known technique used for behavioral change. Nudges consist of the modification of the environment that leads to an alternative behavior with a lower cognitive cost than the one it replaces. This principle has been used extensively in the public policy domain for example. Deliberate thinking can also have an impact on the choices we make, especially when these choices are loaded emotionally [48]. In cognitive psychology, dual-process theories tell us that there are two ways humans can reason [18, 23, 29, 30]. Either they use a fast, unconscious process labeled as *intuitive* or they rely on a slow, conscious, and costly process that is the deliberative type of thinking. Along the theories that support the idea of a dual process, one of them presents the interesting idea that deliberate thinking is engaged when two competing intuitions are activated with a similar strength to determine which one should remain [19]. If that is the case we could imagine ways to provoke a competition between two intuitions about some behavior which would lead to an engagement in deliberate thinking and therefore give the opportunity to consciously make changes.

Unfortunately, most of the time, relying only on nudges or deliberate thinking is not quite enough [46]. This is because of the strength of habits. Part of the research has therefore been focused on understanding them as well as the way to overcome them and replace them with chosen, more appropriate habits.

A habit is formed by the repetition of a specific behavior in a stable situation (we will see next why this matters) in the pursuit of a goal as it reaches automation when confronted with the associated situation [1, 56, 57]. As they are automated, habits are really difficult to override, but psychology gives us some insight into how to do so.

First, there are *implementation intentions*. They are detailed action plans that specify where, when, and how one is supposed to act in a specific situation so that one achieves their goal. They take the form of if-then conditionals. The antecedent gives the information about where and when the desired action should take place and the consequent presents how the goal is obtained. This way a precise and easily identifiable situation gets linked with precise instructions toward the desired behavior. They have been created to overcome the *intention-behavior gap* [61]. The linkage with well-identifiable opportunities eases the override of the former habit and by repetition, it sets a new habit that will get triggered automatically. This method has proven to be efficient for snack eating [2] or even self-speed limitation [10]. However, the impact of implementation intentions is sometimes limited. Some studies have yielded the conclusion that it could be efficient in some cases of smoking [6] but not with the strongest smokers [62]. Lastly, there are conflicting meta-analyses about its impact on eating habits with some positive results [3] and others with small to no effect [55, 60]. Overall implementation intervention seems to be pretty effective in some cases but fails to override the old habit when the latter is too strong. This is why some authors [12] recommend that we focus on altering the environment instead (which is related to our next point). Nevertheless, there are case implementations in which intentions can be very effective, and even more so knowing how easy it is to set up as it has a low cognitive cost and does not require any change in the environment.

Regarding changes in the environment, the literature suggests that it is a good idea to try to change some habits in the context of changing environments such as moving into a new house or when starting a new job. This is called *habit discontinuities* and the reasoning behind it is that habits are triggered in a stable environment and with a new context, old habits might not be activated and therefore could be overwritten more easily by new ones [58].

Of course, the best way to proceed would be to use all the tools at our disposal. Once old habits are broken, nudges and engagement in deliberate thinking can indeed be powerful leverages for change. We would need new tools that could incorporate all of those, and chatbots might just be one of them.

3 CHATBOTS AS AN EFFICIENT COACHING TOOL

The use of chatbots as tools to change behavior is getting increasingly popular in the literature in recent years. Multiple approaches have been tested and now constitute an important basis to inform us on the design of a coaching chatbot. We detail some of them below.

Coaching chatbot have been extensively used to provide help with mental health with promising results. NESTORE is one of those virtual coaches [21]. It is designed as a virtual coach with the purpose of improving the general well-being of seniors, including physical, nutritional, cognitive, social, and emotional well-being. It provides the user with personalized recommendations, notifications, and training exercises throughout the day. NESTORE has many components as it is a complete system architecture, but one of its main elements is the conversational virtual agent. NESTORE has been designed following the Health Action Process Approach (HAPA [50]) which takes into account the gap between the intention of changing one's behavior and the actual behavior change [5].

Unfortunately, there is, to our knowledge, no study showing the effectiveness of this virtual coach. Other chatbot coaches have been developed for different target groups, such as adolescents. CRI (or CRIS) for example has been developed to promote life-skills and mental well-being of adolescents, in particular regarding cyberbullying [26]. While the study had a small sample size, the chatbot was well received by the adolescents, 76% of them finding the chatbot useful and 81% considering it to be innovative. 95% of them mentioned they would recommend it to a friend.

Multiple chatbots have been developed to help people cope with depression and anxiety. One of them is TESS, a behavioral coaching chatbot [53]. One advantage of this chatbot is that it can converse through usual communication channels, including text messaging and Facebook Messenger, making integration of the chatbot in the daily routine much easier and seamless. Integrated in a behavioral

counseling of adolescent patients coping with weight management and prediabetes symptoms, its task was to promote treatment adherence, behavior change, and overall wellness. During this study, the chatbot had generally positive reviews. Participants reported positive progress toward their goals 81% of the time and considered it useful 96% of the time. A particularly interesting aspect of Tess is its ability to learn continuously and as a result to improve over time.

ATENA is a psychoeducational chatbot for behavioral therapy, positive psychology, and mindfulness techniques [25]. In a study on young adults who were tasked to use the chatbot for 8 sessions over four weeks, participants reported a decrease in anxiety symptoms when they initially had extreme Generalized Anxiety Disorder (GAD-7) score ranges, a decrease in stress symptoms, and improved on some aspects of mindfulness (describing, e.g. being able to describe one's own feelings, and nonjudging, e.g. not criticizing oneself for having irrational or inappropriate emotions).

Another study attempted to compare two self-help psychological intervention types: one using a chatbot, and one using bibliotherapy (a directed type of reading used in medicine and psychiatry) [38]. The main interest of this study is that it is a controlled experiment with an accepted intervention type regarding patient care. This study shows that participants had, on average, lower scores on the Patient Health Questionnaire (PHQ-9, which measures depression) and GAD-7 scores. Participants using the chatbot also had higher Work Alliance Inventory (WAI-SR) scores than those following the bibliotherapy, indicating that participants could build a therapeutic alliance with the chatbot. The authors of this study also describe some limitations. One of them is the repetitiveness of the chatbot. Indeed, the interventions of the chatbot had to be approved by professionals which limited the range of possible interactions with the participant.

Similarly, the effectiveness of an increasingly popular chatbot, Woebot [24], has been tested against bibliotherapy. Participants could either follow interventions with a chatbot for 2 weeks or were instead directed to an e-book: National Institute of Mental Health ebook, "Depression in College Students." The results indicate that anxiety significantly decreased in both groups (GAD-7), but only in the chatbot group did the participant's depression score decrease (PHQ-9).

Beyond mental health changes, other chatbots have been developed to change people's lifestyles and habits. Among them, a Food Diary Coaching chatbot was designed to help people who wish to improve their food lifestyle [13]. While most people did not complete their challenges with the chatbot (only 11% of the challenges were successful), users still managed to improve their diet in 65% of cases.

A study comparing an embodied conversational agent, which in this case differs from a chatbot only in the aspect that an avatar is displayed on the screen representing the virtual agent, to the combined use of education sheets and meditation audio files showed that participants interacting with the conversational agent after one month significantly decreased their consumption of alcohol to reduce stress and increased daily fruit consumption by an average of 2 servings compared to the group with the education sheets [27].

Overweight people seeking to reduce their weight also seem to benefit from the use of a chatbot (Lark Weight Loss Health Coach AI, or HCAI) [52]. Indeed participants partaking in a weight loss program with the chatbot lost weight over the year, with an average of 2.4kg lost (2.38% of their initial weight) which could be attributed to the chatbot. This is similar to transnational diabetes prevention programs [20]. Even though there was no control group in this study, it indicates a potentially interesting link between the use of the chatbot and the change in dietary behavior.

Perhaps even more telling, chatbots also seem to be efficient on a full-on addiction: tobacco smoking [47]. In a randomized clinical trial with a control group consisting of participants following interventions recommended by the services portfolio of the Madrid Health System, and an intervention group with an adapted version of the same interventions on a chatbot. Post-treatment, participants in the intervention group had significantly higher cessation of smoking odds than participants in the control group, likely due to the more frequent interactions with the chatbot as they could access it at will compared to access to a professional in the control group.

In consequence, we believe that, if used appropriately, a chatbot could be a beneficial tool to help coach people regarding climate change and help them reduce their environmental impact. To our knowledge, no chatbot has been developed in the domain of climate change except for ClimeBot [54] but this chatbot does not aim at changing behaviors, instead, it is a conversational agent designed to answer questions about climate change.

4 DESIGN OF A CHATBOT FOR ENVIRONMENTAL LITERACY AND BEHAVIOR CHANGE

4.1 AI or Script based

When it comes to developing a chatbot, one of the main interrogations is whether to use Artificial Intelligence (AI) or a Script-based approach to user interaction. Both have advantages and problems.

On the one hand, AI-based chatbots can offer more flexibility and varied responses. Natural language understanding (NLU) is commonly used to detect the intent of users who typed their questions before giving predefined replies based on the detected intent. Another application is natural language generation (NLG) used to generate new replies based on a communicative intent. This technique is used less often in Chatbots, but there are notable examples like the now well-known ChatGPT[1].

The main problem with such chatbots is the amount of data required to train them. To be competent these conversational agents need to be trained on thousands of examples of conversations. This quickly becomes an issue for very domain-specific chatbots as a sufficiently detailed corpus of conversations sometimes simply does not exist.

Another problem with such a design is the validity of the information given by the chatbot, which cannot always be verified. Such a chatbot could generate a sentence conveying a high amount of confidence in the information given despite this information being based on thin air.

Finally, chatbots trained on examples of previous conversations often lack the ability to maintain contextual information during a

[1] https://chat.openai.com/chat

conversation. While notable advances have been made in recent years (thanks, not in small part, to the increasing accessibility of conversation logs), human users are very sensitive to a lack of conversational pragmatics in conversations [33–35]. People have expectations of what a conversation should feel like [51], and violating these expectations can quickly give rise to frustration and, eventually, to dismissing the chatbot entirely. Even the popular ChatGPT is not immune to this.

Script-based chatbots, on the other hand, are notoriously inflexible and usually give very predictable responses. Indeed, they rely on pre-defined scripts of conversations and in these conversations the chatbot is usually a bit more directive in order to keep the user within a specific conversational zone in which the chatbot will be relevant. This can even go to the point of drastically decreasing the user's ability to communicate by only using buttons instead of letting them type their own sentences. Perhaps surprisingly, in a coaching situation the use of this simplified dialog system is not at all detrimental to the work alliance[2] [40]. Users can indeed prefer simpler forms of interaction during their first conversations with the coaching chatbot as they get to know it.

These chatbots are much easier to program and control than AI-based chatbots, and the credibility of the information they provide depends on the credibility of the people designing the scripts. This gives the information provided by these chatbots much clearer sources and much greater credibility and validity. It is indeed possible to have professionals certify the content of the chatbot's scripts. This is the most common method used for sensitive domains like health coaching [21, 24–26, for examples].

The main problem with this approach is how limited the chatbots quickly become. Due to the lack of generative sentences, there is a lot of repetitiveness in these chatbots which can also be the cause of user frustration or disinterest.

The ideal coaching chatbot is therefore likely a mixed model mainly centered around script-based chatbots, initially interacting with their users with simple buttons, slowly progressing towards a more customized interaction with the user using intent recognition elements within scripts, and finally with a module allowing the chatbot to participate in small-talk, possibly with generative AI to build up trust [37].

To avoid repetitiveness in conversations, the chatbot should provide activities to help users improve their awareness of their own carbon footprint and of their impact on the environment instead of simply giving users information directly.

4.2 Activities

The chatbot will suggest activities to the user. These activities will consist in making the user play an active role while discovering information by experience instead of simply being told [41].

One such activity consists in developing critical thinking based on data [42]. The chatbot will invite the user to play with datasets, such as exploring the link between temperature variations and CO_2 variations, or the melting rate of glaciers around the world and its consequences [36]. Critical thinking in reasoning is also necessary to be able to reason and argue, evaluate the structure of reasoning, and distinguish between facts and opinions. The ability to approve and reject arguments will be promoted, rendering participants more adept at uncovering fallacies, rhetorical tricks, and false reasoning in arguments on climate change and environmental issues[3] [11, 39].

Understanding risk is also of great importance. Users will be shown different situations and see the consequences of their decisions in the long run (for example the risk of vaccination compared to the risk of contracting a disease) [17, 22]. Understanding and assessing risks can also be fostered through adequate activities. A game that leads the user to choose between alternatives, being informed about the expected outcomes of their choices in the long run, develops risk literacy through experience rather than through explicit description [for the advantages of such an approach see 31]. An example of this activity can be choosing between allowances or deciding about vaccinations. The chatbot we envisage would propose such games.

While individual change can seem small, it is important for the user to understand their impact in combination with all the other people who have similar motives. This can be experienced with a game on the Tragedy of commons. Participants will for example be given the opportunity to set the target of fish they wish to catch for the year (their profit increasing with the number of fish caught), and other players making similar decisions will be simulated. As people try to increase their profit by catching more fish, the profits will instead eventually start going down as the number of fish available for everyone to share declines.

Changes in behavior sometimes imply moral decisions. This is especially the case when talking about climate change. Acting by trying to maximize the greater good known as the utilitarian position and acting by a set of predetermined principles known as the deontological position, have both failed to be exclusively linked to one of the two reasoning processes (intuitive and deliberate) [9, 28]. Nevertheless, We could expect our chatbot to raise the strength of some intuitions about the impact of our behavior on climate change[see 8, for an example of moral dilemmas with a chatbot]. We intend to present the users with moral dilemmas that could create competing intuitions about the impact of our behavior on climate change by opposing utilitarian and deontic choices and therefore trigger the activation of the deliberation. By doing so we expect to give the user more awareness and control over their own behavior on the matter.

Understanding one's own impact on carbon emissions is an important step to realizing how much effort will be required to reach the global target of CO_2 emissions. The participant will thus be invited to calculate their own footprint and will create a CO_2 budget for the year and for the month, setting goals and getting feedback on whether they were able to reach their emission goals.

With the demand for electricity increasing and the progressive shift away from fossil fuel sources for energy production, it is important to understand how this electricity is produced and that not every country's electricity has the same carbon footprint. To this effect users will be invited to explore the real-time electricity footprint of various countries and what kind of facility produced it (wind turbines, nuclear, gas, coal, etc...).

[2]The cooperation between two agents to achieve a certain goal. Similar to the therapeutic alliance in patient care.

[3]e.g., verifying if from certain premises a conclusion follows: "premise 1: if there are waves of frost, then there is no global warming; premise 2: there are waves of frost; conclusion: so, there is no global warming"

An important way of reducing one's carbon footprint is to understand that it is linked to what one eats. The chatbot will suggest dietary recommendations based on the carbon footprint of meals, and ask for feedback to personalize the suggestions.

Individual change is a first step, but its impact will be greater if this change is shared with others. Group activities will be suggested by the chatbot, such as inviting friends or family to a vegetarian meal, cooking such a meal together, biking or walking with friends, organizing discussions on climate change, or on ways of saving energy.

With transport being responsible for an important amount of one's personal CO_2 emissions, the chatbot will also track the user's use of transportation to analyze it locally and provide feedback to the user, as well as alternative options to avoid using a car or a plane whenever possible.

4.3 Motivations

To improve the engagement of users, the chatbot should also regularly send users notifications. This can simply be to invite the user to catch up with the chatbot, to provide new information which might be of interest to them based on their current situation, to inform them of their CO_2 budget, or to compliment them when the chatbot notices actions taken to reduce their carbon footprint, as compliments have been shown to be an intrinsic reward and motivator in conversations with chatbots [49].

The chatbot's attitude should also be positive and encouraging to avoid putting its users in a state of eco-anxiety [16] and have scripts ready to help people cope with this type of anxiety.

5 CONCLUSION

The literature indicates that a chatbot that could foster environmental literacy through experience would be beneficial for tackling the difficult task of conducting people to change their behavior calibrating their impact on the environment. In this paper, we have discussed other attempts at developing chatbots as coaching tools in other domains of application and we have suggested a general design of such a chatbot to fight against climate change. We believe such a chatbot could prove very useful, not only for the people using it but also for the people they interact with as the information and habit changes they would gain from using the app would potentially propagate over time to people close to them [63]. This could also potentially change how students are educated in schools, as evidence indicates that educational strategies are an effective means of bringing about changes in behavior related to climate change [32, 45]. Similarly, this type of tool can be of great use in teacher training, in which climate change education is an emerging topic [43]. Once completed, it will be necessary to measure the effectiveness of this chatbot in a controlled study.

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