Let's talk about climate change... but when do we start?

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Communicating climate change

Climate change poses numerous challenges to the environment and the survival of species, humans included. It has several negative impacts from local to global scales, with direct and indirect links to some of the most serious threats to human populations, such as the current COVID-19 pandemics (e.g. Newell and Dale, 2020) or the recent declaration of a severe food crisis driven by climate change in Madagascar by UN's World Food Programme (https://news.un.org/en/story/2021/06/1094632). Still, despite the scientific consensus about the influence of human activities on environmental imbalance, and the increase of civic mobilization demanding political action to address climate change (e.g. Caniglia, Brulle and Szasz, 2015), there are still important levels of resistance of public opinion to acknowledge the real impacts of the current climate crisis (e.g. Ballew *et al.*, 2019; Wong-Parodi and Feygina, 2020; Kulin, Johansson Sevä and Dunlap, 2021).

Science communication can be a powerful ally to raise awareness on these issues. One way to is by establishing collaborations between science communication and recent research results on the topic. This strategy was adopted in the scope of the ongoing research project "To Change or not to Change? The genetic basis and evolution of seasonal coat colour polymorphism". This project seeks to unravel the genetic basis of variation in the seasonal colour pelage - moulting between a winter-white and a summer-brown colour in species of weasels and hares. This characteristic is shared across several mammal species that inhabit regions of the globe with seasonal snow. Previous research has shown that animals that change to winter-white pelage can be more predated in snowless backgrounds (e.g. Zimova, Mills and Nowak, 2016), due to the colour mismatch with the surroundings (Fig. 1). Yet, many of these species also have animals that remain brown year-round, a characteristic that may be beneficial in the future, considering winter snow cover decreases caused by climate change (Mills *et al.*, 2018). Understanding the regulation (Ferreira *et al.*, 2020), the genetic basis and the evolution (Jones *et al.*, 2018; Giska *et al.*, 2019; Miranda *et al.*, 2021) of this variable characteristic can help to predict whether these species will be able to adapt to climate change (and consequent decrease in snow cover during the winter). These

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familiar species can be used as an example of the impacts of climate change on biodiversity, and can help amplifying the discussion to other examples of how climate change is impacting human and non-human populations in a constructive way, as suggested in the literature (e.g. O'Neill and Nicholson-Cole, 2009).

The activity "Coats for snow"

"Coats for snow" is an activity created within an ongoing research project, using the main research question and results to promote a discussion forum. Its main goal is to help communicating the impacts of climate change and foster new dialogues on the topic with a broader community. It was designed as a "consultative science communication" activity, where knowledge is exchanged iteratively from scientists to the non-scientific publics, and from the non-scientific publics to the scientists (Palmer and Schibeci, 2014), and inspired by the "AEIOU vowel analogy" of science communication (Burns, O'Connor and Stocklmayer, 2003): Awareness, Enjoyment Interest, Opinion-forming and Understanding. As such, the underlying objective is to raise Awareness on climate change and its impacts. To facilitate Interest and Understanding, we tell a story inspired on ongoing biodiversity research, studying how species adapted environments with winter snow can be affected by increasing global temperature and consequent decrease of snow cover, and how biological adaptation can foster their survival. To promote engagement and Enjoyment, we use a game that allows the active participation of the public. To contribute to informed Opinions and behavioural changes, we include a before-and-after debate, where different aspects of climate change can be addressed.

The activity is organized around four main stages. It starts with a general discussion about climate change, trying to elicit what children know about the topic. It then builds a debate about the nature and methods of science, with an emphasis on the importance of collaboration in the advance of our knowledge. The activity proceeds with the presentation of the research project. This was done by showing first a hare and a weasel with a winter-white coat in a snow-covered background. Afterwards, a hare and a weasel with the same winter-white coat but in an environment without snow were shown, highlighting the clear mismatch between the coat colour and the surrounding environment. The children were then invited to be part of the research project, and to advance hypotheses about the evolutionary history of these mismatched individuals if climate change decreases snow cover in their habitats. Their hypotheses were subsequently tested with a previously developed game that allows participants to actively test predictions of evolution by natural selection (Sá-Pinto and Campos, 2012; Campos and Sá-Pinto, 2013; Campos, Almeida and Araújo, 2018), which was adapted to this specific activity (Fig. 1). The results of the game prompt a final discussion, bringing to the debate the relations between climate change and species adaptation and survival, focusing both on the possible impacts of climate change on the studied species and on human populations.

Fig. 1: Stages of the activity “coats for snow”: the general discussion about climate change (top, left); introduction the case study, discussing the ongoing research, and posing hypotheses (top, right); testing the hypotheses with a game (bottom). Credits for the photographs of the activity: teacher N. C. Credits for the photograph of the weasel: R. Campos. Credits for the photograph of the arctic hare (public domain): U. S. Fish and Wildlife services.

The activity was first tested with a group of 25 children aged 9-10 years old in combination with a guided visit to the Natural History Gallery of the Science Museum from the University of Coimbra. It was later adapted to a session included in the outreach program “CES goes to School”, and implemented in several elementary schools. Within this program, the activity reached a total of 547 children aged 6 to 10 years old. It was also included in the “Ciência Viva at CES”, as a “Ciência in Loco” session (Campos *et al.*, in press), and used in a school-break activity camp, with a group of 15 children aged 6 to 12 years old. Some of the sessions were evaluated using a mix-methods approach: (participant) observation, audio recording and personal meaning maps (PMM; Falk, Coulson and Moussouri, 1998) (Fig. 2).

Fig. 2: Examples of Personal Meaning Maps made by the children that participated in the “coats for snow” activity, before and/or after the activity.

Preliminary results and further directions

As expected, both the game and the underlying story proved to be very attractive and engaging science communication strategies, encouraging highly interactive discussions around climate change and its impact on (human and non-human) biodiversity. It can be further used to spark discussions on a diverse array of topics, such as what can be consider as science(s), the different types of work scientist can do in different scientific areas, what is(are) the scientific method(s) and how it can help scientists to find answers (or new questions), and also debates on the Nature of Science, and the role of questioning, establishing collaborations and dealing with uncertainty.

However, from a preliminary analysis of the evaluation results, almost all children that participated in the activity declared that they have never heard of climate change. This stands in clear contrast to the observation that climate change is a widely mentioned topic in the media, and that many school students are adhering to climate strikes worldwide, and being active in social movements on climate change action (e.g. O'Brien, Selboe and Hayward, 2018; Han and Ahn, 2020). It thus led us to conclude that an extra effort to communicate and engage the public with climate change issues should include children as young as 5 years old. Science communication activities can be further included in climate change education strategies (e.g. a review of such strategies can be found in Monroe *et al.*, 2019), creating much needed synergies between research, communication and education. Even though climate change is a complex and somewhat dense scientific concept, results such as the ones from the “coats for snow” activity show that it is possible to create discussion forums on the topic with younger children, if appropriate and adapted strategies are used.

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