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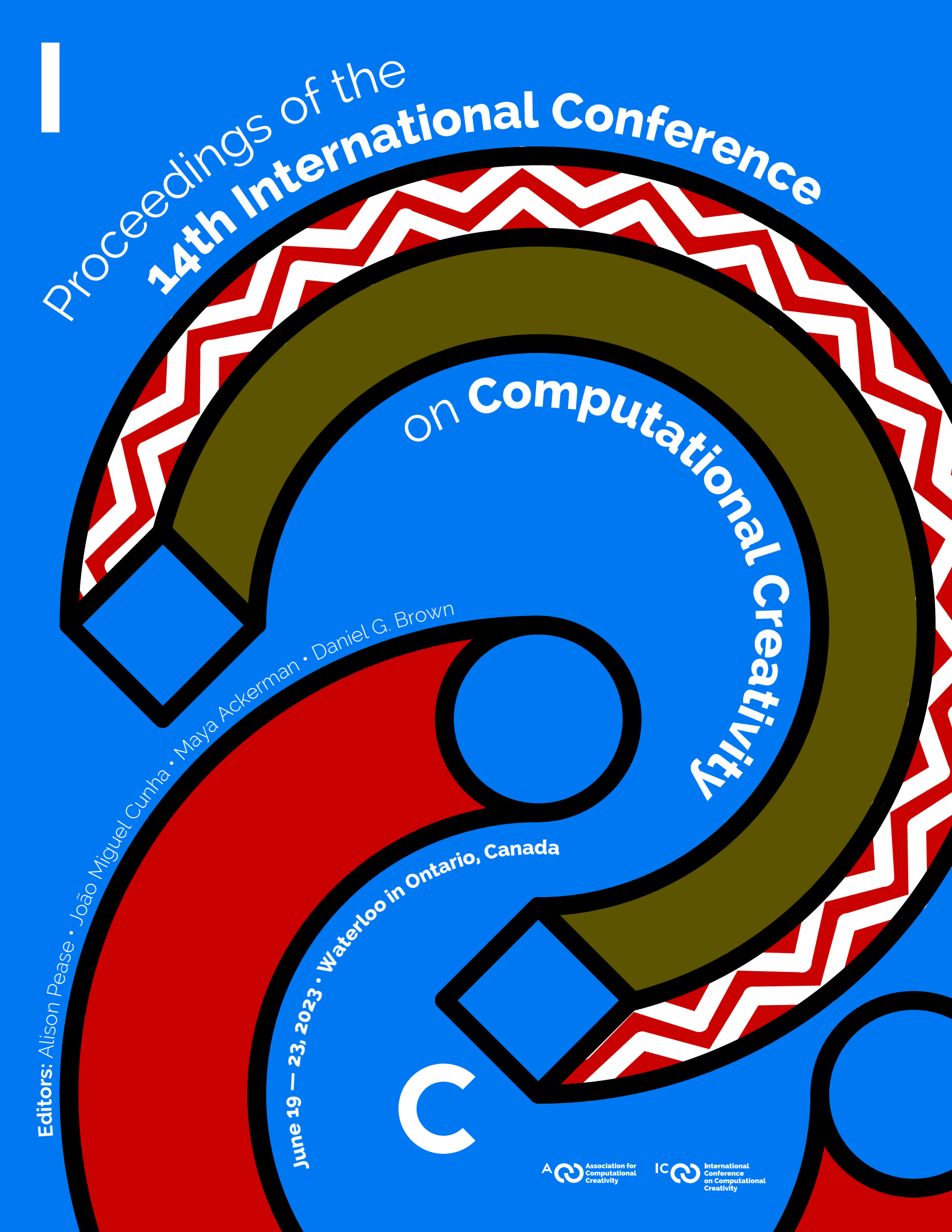
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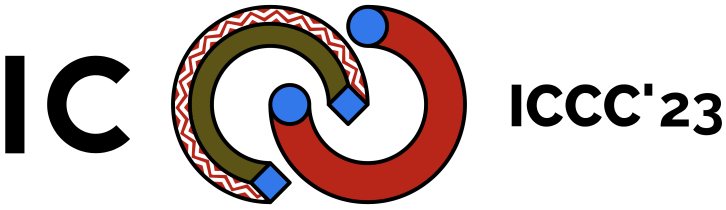

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Computational Creativity and the Climate Crisis

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Abstract

The latest IPCC report states that we must act now to avoid climate catastrophe within the lifetimes of our children. Although typically involved in knowledge production, we have a duty as academics to act. We propose two pathways for the CC community: (1) lead by example by cutting down our carbon footprint; and (2) use our strengths in creative thinking to contribute towards climate solutions, communicate the devastating impact, and help to effect a cultural shift.

The role of academics in the climate crisis

Scientists have issued a series of warnings to humanity that business-as-usual will result in the loss of ice sheets, tropical rainforests, and coral reefs, causing rising sea levels and increases in extreme weather that will make large areas of the planet uninhabitable and cause devastating human suffering (Gardner et al. 2021). The latest warning – in the Synthesis Report of the Intergovernmental Panel on Climate Change (IPCC), published in March 2023 – stresses that massive and immediate greenhouse gas emissions reductions *across all sectors this decade* are necessary if we are to avoid major inevitable and irreversible climate changes (IPCC 2023). Every living person and yet-to-be living person is a stakeholder in the protection of our world, and the prevention of climate chaos. It is vital, then, that the CC community, in concert with all academics: *(a)* ensure that we are not adding to the problem, and *(b)* do all we can to prevent climate catastrophe.

As the planetary emergency deepens, we need to reconsider the role of academics and universities, and expand our conception of how we contribute to the public good. In a world increasingly in crisis, all academic communities should urgently be asking themselves: *"What can we do?"* Along with our privileged education and lifestyle, our trusted position within society, our platform for sharing our views, and the fact that we are a part of the very institution that has identified the crisis – comes greater responsibility. As academics, we should strive to be pivotal change agents. This is especially the case since it is not clear who else can lead the way. As a society, we simply do not have the necessary channels and processes for a problem of this magnitude and urgency. Politicians are incentivised by lobbyists and short term cycles of power; corporations are focused on maximising profits; and the mass media is largely owned by self-interested conglomerates. Increasingly urgent recommendations from the world's climate scientists are routinely deprioritised by world leaders and promises on climate targets are routinely broken. Conferences such as COP - often seen as our best chance to make actionable global targets - are heavily sponsored by fossil fuel companies and private car companies, who ensure that their interests are protected. In short, the structures of power are the biggest challenge in climate action, because they have a stranglehold over us and they are strongly incentivised to perpetuate the status quo.

Our planet needs advocates, and academics are well placed to do this. We have access to data, education to understand it and structures to share it. We are a global community with a global platform, and we work within a system which gives us considerable independence. We have the power to legitimise the problem and to drive solutions. As a community we need to find ways to engage with the challenge; leading by example and capitalising on our strengths to implement meaningful and impactful climate action.

Climate-conscious approaches to academia

Climate-conscious approaches to academic practices are emerging, both at a general and discipline-specific level. Urai and Kelly (2023) speak to the power of collective action and point out that historically universities have been fertile ground for major social movements, such as the anti-nuclear weapons movement and the anti-war and civil rights movements in the US. They suggest steps that academics can take, such as speaking about the climate crisis to colleagues and students, and joining climate action groups (such as Scientists4Future, Scientist Rebellion, Faculty for a Future, ClimateActionNeuPsych, Doctors for XR). In order to envisage climate-conscious university practices, they propose an academic version of Raworth's "doughnut" model of economics (Raworth 2017) in which she reframes economics to aspire to living well within planetary and social boundaries.

Arguing that the extensive academic mobility involved in current conference travel is untenable in the context of climate catastrophe, Goebel et al. (2020) reflect on their experiences in creating virtual and hybrid spaces as an alternative model. They recommend that these spaces should not simply be conceptualised as (lesser) replacements for on-site conferences, rather seen as opportunities for new aca-

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demic practices. Pointing to work in the sociology of knowledge on the value-based, political and economic enterprise of academic knowledge production, they consider how virtual meetings can overcome hierarchical structures to create participatory and inclusive spaces for more horizontal and equal collaboration.

Aron (2019) and Aron et al. (2020) suggest actions for neuroscientists and cognitive scientists. These are of general applicability: flying less, using positions of responsibility to tackle the climate emergency, and drawing on the influence of funding bodies and people involved in grant review to include an emissions-counting component. They also describe ways to incorporate the topic into teaching and research, share resources and advocate within university and professional organisations.

The carbon footprint of the CC community

Academic disciplines jostle for position in much the same way as individual academics, especially young disciplines such as CC. Under good leadership, CC has established itself and carved out a niche specialism; albeit still lacking a high impact journal and reliable funding streams. Much of this has been done via community building through a series of international annual conferences, held in locations where it is hoped to maximise our global reach. The twelve annual CC conferences held so far have been highly successful in terms of building a global community, and many of us count as friends, as well as colleagues, people who we have met at these conferences. However, as a collective, our biggest carbon footprint lies in our travelling habits and it is simply not tenable to ignore the impacts of this.

Academics fall into the tiny minority of very high emitters of CO_2 – the 1% of the world's population that emits 50 per cent of CO_2 from commercial aviation (Gössling and Humpe 2020). Studies such as (Jäckle 2022; Klöwer et al. 2020) have estimated the carbon footprint of scientific conferences; finding individual attendee emissions of 1.7–3.4 tons (for North American conferences), or 0.5–1.4 tons CO_2-eq (for European conferences) (Jäckle 2022). Here, an average conference had about the same carbon footprint (just from the travel-induced emissions) as 120–310 average British people for an entire year. It is impossible to justify these levels when climate experts insist that we must limit our annual emissions to 2.5 t CO_2-eq at most, by 2030, going down to 0.7 t by 2050. Clearly, we need to develop a new model of green and sustainable CC conferences.

By studying the data to calculate where we might make the biggest savings, (Jäckle 2022) recommends a mixture of (1) selecting a centrally located conference venue; (2) promoting low-emission land-bound travel options; and (3) holding hybrid conferences, enabling online participation particularly for colleagues from far away. (Klöwer et al. 2020) further proposes (4) switching to biennial conferences; and (5) having regional hubs which are virtually connected, where delegates can travel to their nearest hub rather than to a single global conference host city. These actions can reduce conference travel emissions by up to 90%.[1]

We must talk about which measures would work best for us in CC, given the strong and close-knit community that has been carefully nurtured over the last decade or so. Together, via the Steering Committee, the Annual Meeting, the Annual Conference and other mechanisms, we need to collectively identify and then implement pathways towards a more sustainable academic model, while at the same time protecting our strengths as a community. In doing so we hope to answer the question: *How can we conduct responsible research in CC in the time of the climate crisis, while maintaining global significance?*

A further concern is the carbon impact of the computational infrastructure in CC. Vanderbauwhede (2023) argues that while computational resources are often effectively been treated as infinite, computing emissions already account for more than emissions from the airline industry (at almost 4% of the world total). Even more alarming is the fact that by 2040 they are set to rise to more than half of the total emissions budget needed to keep global warming below 1.5°C (*ibid.*). In order for the world to meet its climate targets, therefore, the global use of computational resources will need to be transformed radically. Vanderbauwhede sets out his vision for low-carbon and sustainable computing – "frugal computing" – in which the carbon cost of both production and operation of computational devices is considerably reduced. In order to build sustainable practices, CC urgently needs to engage with this vision.

The CC community should also consider what kinds of organisations CC research is contributing to. For instance, research in this and related fields is often sponsored (directly or indirectly) by large corporations or the military, both of which are large contributors to the carbon crisis.

Opportunities for computational creativity

Creative thinking will be essential in addressing climate change, and a field as diverse and inter-disciplinary as CC has much to contribute. CC-driven data visualisations, decision-making, scenario planning, problem solving, enhancement of human creativity as well as scientific and artistic creativity can all play a role. Other applications will emerge, especially given the special topic on CC and climate change at this year's ICCC (which we hope will be continued in future conferences).

CC researchers have shown how CC techniques can be used – to support and enhance decision-making in areas where novelty and value are useful (Jändel 2013); to explore a scenario, actions and outcomes (*ibid.*); to automatically generate creative scenarios (Tan and Kwok 2009); and to improve the resourcefulness of AI systems in the context of creative problem solving (Gizzi et al. 2020). Work such as this has clear applications to climate change. Chang and Ackerman (2020) are the only people so far to explicitly work in the area of CC and climate change. Their system, EarthMood, provides an interactive learning experience into climate change by inviting a user to vary projected levels of CO2 ppm, ocean pollution, global temperature, species di-

[1] Note that Jäckle cautions that other measures, such as eliminating printed conference programmes or switching the catering to vegetarian or vegan would have little impact (Jäckle 2022).

versity and so on, and then creating an artistic data visualisation based on the projections. Their aim is to educate people on climate change by using creative representation of data to evoke emotion, and to "elicit a sense of kinship between the viewer and the earth" (*ibid.*, p3). We can easily see how this sort of goal could form the basis of a programme of work in co-creative systems and the climate crisis.

While scientific and mathematical creativity have typically been under-represented within the CC community (Pease et al. 2019; Loughran and O'Neill 2017), CC-related work is being carried out in other AI research contexts, such as automated reasoning and automated scientific discovery – often couched in different terminology with different methodologies. Building bridges to these areas and collaborating on the problem in an interdisciplinary way could very well be fruitful.

Perhaps the most obvious route for CC to contribute is as an arts community with a unique perspective. As an artistic movement, climate art is growing: the last decade in particular has seen an increasing number of artworks, projects and networks on climate-related arts, with most works in literature, theatre, film and installations (other areas include climate music, video games and data art). Most are interdisciplinary, co-creative works, involving artists, scientists, practitioners and communities. The arts will be essential in effecting a cultural transformation, because they can drive social learning, cultural innovation and knowledge integration (Galafassi et al. 2018).

The computational creativity community are well positioned to play a pivotal role here, via our unique place in the arts world and the interest that society has in our systems and their outputs. This is particularly true given the recent massive increase in popularity of, and research effort into, generative AI. Systems which generate images from prompts, such as Midjourney[2], Stable Diffusion[3] and DALL-E[4], are now in the public consciousness, with high profile uses (eg the front cover of The Economist), controversies (eg Boris Eldagsen's AI-generated photograph winning the Sony world photography awards) and deep fakes (eg the pope in a puffer jacket). These build on the popularity of generative AI system ChatGPT, with 100 million monthly active users, and sets the stage for CC climate art to make a powerful cultural contribution.

There is precedent in CC for artistic representations of current affairs. Krzeczkowska et al. (2010) enabled the CC artist The Painting Fool to access and select news stories and generate a piece of visual artwork which depicted the story. Such systems, enhanced to reflect developments in CC such as automatically producing aesthetic, framing or explanatory information, could have a unique and influential voice in the discussion.

CC artists still have a novelty value and are newsworthy in themselves, so we benefit from opportunities to raise awareness and reach new audiences. Many of us are already working in outreach and public performance spaces, such as gallery exhibitions, interactive performances and so on, so we already have a powerful platform to introduce climate art to the public. Additionally, (Sommer and Kløckner 2021) showed that people's perception of climate art and openness to the message is affected by their perception of the artist. How this would translate to a computational artist has yet to be seen, but one could imagine people saying: "even the AI artists are worrying about the climate!". With this in mind, we look further at various roles that the arts can play in the climate crisis in the section below.

[2]midjourney.com

[3]stablediffusionweb.com

[4]openai.com/product/dall-e-2

The role of the arts in the climate crisis

Art for climate communication Art is necessary to enrich and complement science communication on climate change. Psychological findings by Roosen, Klöckner, and Swim (2018) show that limitations of purely factual messaging can lead to discrepancies between knowledge and behaviour, and that art can overcome these psychological barriers. For instance, art can create a moment of reflection, which might be needed to detach from everyday routines and engage with existential questions. Furthermore, artworks are often deliberately ambiguous, requiring the viewer to do their own creative work to interpret it. This meaning-making activity can trigger creative thinking, which may equip viewers to visualise climate solutions, as well as relating climate change to their own experience, values and knowledge. Likewise metaphors and storytelling can be more compelling, persuasive and memorable than literal modes of expression, as these involve the listener and can increase their sense of personal relevance, with listeners actively searching for meaning and applying the general thread of the story to their own lives (Roosen, Klöckner, and Swim 2018). As well as linking to a large body of work in CC on metaphors and storytelling, this also connects to CC ideas on the value of obfuscation in framing, in order to increase the amount of interpretation required by audience members (Cook et al. 2019).

Art for activism Artists have played a key role in historical societal transformations by heralding shifts in mindsets. Art has confronted humanity's greatest challenges, such as war, inequality and disease, providing social spaces for grief and reconciliation and the renewal of human consciousness (Galafassi et al. 2018). For instance, the anti-slavery poster 'The Brookes Slave Ship', went viral and played a pivotal role in publicising and galvanising the movement against the slave trade (Krznaric 2021). This relates to Smiths's work, in which she paves the way for CC to become a platform for activism in her discussion of how we can use CC to advance the ideals of social justice (Smith 2017).

Art for overcoming cognitive biases We are cognitively ill-equipped to handle the climate crisis. It is very hard to worry about problems in the future, to act now thinking of the consequences in 50 years time. Krznaric (2021) suggests ways that art can help us to stretch our "temporal imaginations" and prioritise long term over short term gains. For instance, the "Clock of The Long Now", by the Long Now Foundation, is designed to stay accurate for ten millenia, and on each of the 6,652,500 days, a unique sequence of

10 bells (created by Brian Eno) will chime. Other works include John Cage's composition "As Slow As Possible", which began a church organ performance in 2001, and is due to finish in 2640; Yoshiyuki Mikami's gradually fading photos of disappearing species, where each pixel represents one remaining animal left in the wild; and Superlux's pollution machine, that allowed viewers to breathe air that represented the air quality in the UAE in 1934 if current pollution rates continue.

Science fiction and speculative fiction can also help us to think long term, by exploring possible futures. These go back to the writing of Jules Verne and H. G. Wells, with the 2021 film "Don't Look Up" being a recent example. These works can help us to visualise and connect with an abstract future. While they don't all represent climate issues, by enabling us to envisage and question our relationship with the future, they can help us to overcome cognitive barriers to climate action (Krznaric 2021). This may be of particular interest to CC scholars. Manjavacas et al. (2017) developed a co-creative text generation system applied to a science fiction setting, which was used to good effect by an established novelist. Additionally, work on authenticity in CC highlights that CC might be particularly effective in speculative fiction, or science fiction, since it may be easier to avoid charges of inauthenticity if writing in domains which are not intended to resemble real life, believable settings and characters (Colton, Pease, and Saunders 2018).

Art for connecting with nature As well as communicating climate change, art can reconnect people to nature, emphasise our interdependence, and build empathy towards the natural world. Curtis (2011) found that work which celebrates the natural environment, such as nature writing and poetry, or artworks and performances which are actually situated in the natural environment, are effective in building empathy for climate action work. While this is a less direct approach to climate action, Curtis showed that emotional affinity with nature correlates with pro-environmental behaviour. The work by (Chang and Ackerman 2020) discussed earlier fits perfectly into this role, explicitly aiming to reconnect people to nature by eliciting a sense of kinship.

Evaluating impact of climate art The goals of climate art and communication are varied, and may be only loosely defined, so it is extremely difficult to measure any impact. Goals might include: informing and educating; increasing awareness; effecting individual behaviour change; and facilitating acceptance of climate policies (Sommer et al. 2019; Sommer and Kløckner 2021). Some of these goals come with evaluation metrics, but the relationship between these goals is complex: success in one area may well not translate to success in another. Methods from empirical aesthetics, such as questionnaires, interviews and behaviour change studies, can be used to try to evaluate impact. Lessons learned can then be implemented when designing new pieces. CC scholars have a long history of grappling with complex issues of evaluation, and are well placed to adapt methods from the climate art domain to CC.

CC and climate art These various roles of the arts in the climate crisis can guide programmes of CC work. Cultural transformation is often slow and unpredictable, but if we employ our unique skills and use our place in the art world to communicate climate change, then the collective voice and expertise of the CC community could provide a powerful conduit for climate engagement and action.

Summary and Conclusion

As Gardner argues; "the traditional academic roles of research and teaching are not sufficient to drive transformative change in a time of rapidly accelerating global crises, so those with the greatest knowledge and understanding of these crises have a moral obligation to provide leadership, and engage in advocacy and activism." (Gardner et al. 2021, p4-5). This applies to all academics, regardless of disciplinary specialism. We have a duty to lead by example, to help to spread the message through the population and denormalise current ways of living which are unsustainable. Here, we have proposed concrete actions (summarised below), but how we can best do that within CC is a matter for discussion, research and trial and error. We must be careful not to invest in activities which feel meaningful but have little real world impact, and we must guard against greenwashing our community, intentionally or unintentionally. Yet we cannot simply continue with business as usual. Our main goal in this paper is to spark debate and to inspire the whole CC community to urgently engage with the issue. The IPCC warns that there is a "rapidly closing window of opportunity to secure a liveable and sustainable future for all" (IPCC 2023, p.53). Let's ensure that we use our collective influence to act now.

Climate Actions for the Computational Creativity Community

1. Raise the climate crisis as a matter of urgency – start a community discussion with the Steering Committee, the Annual Meeting, the Annual Conference and other channels, and identify concrete actions.
2. Lower our carbon footprint – find a new green and sustainable conference model which will enable us to maintain our strengths as a community; reduce carbon impacts of the computational infrastructure in CC.
3. Apply our CC systems to the climate crisis – develop CC-driven problem-solving tools; produce CC artworks to raise awareness and help to effect a cultural shift.

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