The Virtual Water Gallery: Art as a catalyst for transforming knowledge and behaviour in water and climate

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Abstract

Water is life. Water-related challenges, such as droughts, floods, water quality degradation, permafrost thaw and glacier melt, exacerbated by climate change, affect everyone. It is challenging, yet of critical importance, to communicate science on such difficult highly volatile topics. Art is a more approachable medium to traditional scientific outlets that has the potential to diversify voices at the table and to lead to more wholistic solutions to these complex challenges. Launched in 2020, the Virtual Water Gallery is a transdisciplinary science and art project of the Global Water Futures program, that aims to provide a collaborative space for dialogues between water experts, artists, and the wider public, to explore water challenges we all face. As part of this initiative, 14 artists or sci-artists representing women, men and Indigenous voices across Canada were paired with teams of Global Water Futures scientists to co-explore specific water challenges in various Canadian ecoregions and communities. These collaborations led to the co-creation of artworks exhibited online on the Virtual Water Gallery in 2021. In 2022, the Virtual Water Gallery came to life with an in-person exhibition in Canmore, Alberta, Canada. Surveys were developed to capture changes in knowledge, attitudes and water-related climate mitigation practices of visitors to this science and art online and in-person exhibition. Surveys were also developed to capture experiences of the SciArt collaboration participants. Results from the survey responses of 139 visitors hint to the significance of art in changing knowledge levels and intended behaviours related to water-related climate change mitigation, especially for visitors with low prior knowledge levels. This underscores the potential of SciArt to extend beyond communication, acting as a catalyst in the collaborative creation of new knowledge for the benefit of society. The insights gained from participant responses can serve as valuable guidance for shaping future initiatives.

Author summary

Water is essential for life, and challenges related to water, like droughts and floods, affect everyone. Climate change is worsening these challenges, affecting lives and livelihoods, and underscoring the need for effective communication for action. Art stands out as a compelling communication tool, more approachable than traditional scientific outlets, with the potential to make people care about important yet elusive facts. Launched in 2020, the Virtual Water Gallery is a project combining science and art to create a space for discussions among water experts, artists, and the public. Fourteen artists collaborated with scientists to explore specific water challenges in Canada, resulting in artworks displayed online during the pandemic. In 2022, the Virtual Water Gallery came to life with its first in-person exhibition in Canmore, Alberta. Surveys were distributed on the virtual gallery and at the in-person exhibition to gauge visitors' changes in knowledge and attitudes as a result of seeing the art. Results indicate art's potential to increase knowledge and influence behaviours related to water-related climate change mitigation, particularly for visitors with limited prior knowledge. This showcases the power of science-art to engage broad audiences and distill knowledge on intricate subjects.

Introduction

The United Nations has described climate change as "the defining crisis of our time" [1]. Changes in the Earth's energy balance as a result of anthropogenic climate change is driving changes in the hydrological cycle. Worldwide, there are already and projected shifts in the type, amounts, intensities, duration, and timing of precipitation events [2]. Many consequences manifest as water crises (e.g., [3, 4], as climate change worsens both water scarcity and water-related hazards, such as floods and droughts (IPCC 2021). The Paris Pact on Water and Adaptation to Climate Change (2015), led by the International Network of Basin Organizations (INBO) was signed at the 21st UN Conference on Climate Change (COP 21) in 2015, signaling the first time that freshwater was taken into account in relation to climate change. At COP 26 (Scotland, 2021), the first Water Pavilion exhibition space was established.

Water is an integral part of our daily lives and is essential for life. It underpins our economies, energy generation, food security, and our health and well-being. Water-related challenges, such as droughts, floods, and water quality degradation, have the capacity to impact everyone. However, not everyone is affected the same way and to the same degree, both by the events themselves and by the experiences [5]. Some people are more resilient than others on an individual basis. Some have access to resources that buffer them from impacts to greater or lesser degrees. The values that we place on water, and our relationships with it, are shaped by these lived experiences of, for example, floods and droughts. Additionally, these values are intricately tied to cultural and spiritual beliefs.

Research around the world is advancing progress in predicting these water challenges, understanding environmental impacts from climate change, and identifying plausible pathways to mitigation and living with Earth's carrying capacity. However, we cannot forget that impact requires implementation, which in turn relies on behaviour change, which in turn depends on motivation, capability, and opportunity [6]. Values shape peoples' attitudes, beliefs, and concerns, underpinning motivations towards behaviours and behaviour changes [7]. With respect to climate change, the United Nations Educational, Scientific and Cultural Organization (UNESCO) and the United Nations Framework Convention for Climate Change (UNFCCC) identified education as a way to change habits over the long term and public awareness as a mechanism for reaching diverse groups of people [8]. Further, [9] identified engaging in deliberative discussions and interacting with scientists as two of four ways to provide teachings on climate change.

Making science more accessible is fundamental to develop public understanding and promote open discussions with a broad audience (from experts to a non-specialist audience), to ultimately identify wholistic solutions to these challenges [10]. Science is often communicated with other scientists via scientific articles and conference presentations, using complicated graphics and terminology. Using more inclusive media, such as art, can help to generate dialogues with a wider non-expert audience and make science more accessible overall [11]. Art can also be a catalyst in the co-creation of new knowledge for the benefit of society. For example, artist and amateur meteorologist Luke Howard painted clouds in their beautiful uniqueness and facilitated the development of the cloud classification still widely used today [12]. Further, within the climate change context, artists have used their art to join voices calling for climate action at conferences on Climate Change, including at COP 26 [13]. Bringing together science and art (referred to as SciArt hereafter) is a topic that has received increasing attention in the last few years. The recent Geoscience Communication journal special issue on SciArt provides a collection of such initiatives [14].

As noted by [14], "the need for a collaborative space in which science and art can work together is imperative today". Given the public's trust in scientists as generators of information [15] and the varied impacts experienced due to climate change, a transdisciplinary approach to environmental challenges, where diverse voices have a space to be heard and the public can be better included in the scientific process, is becoming increasingly vital. In this context, art can appeal to the heart to reach the mind. By encouraging an emotional response to otherwise 'cold scientific facts', it can inspire curiosity from the audience, enriching the public discourse and rebuilding scientific trust. Further, [16] argues that art can help better cope with extreme events, before and after they occur, by promoting a better understanding of research and evidence (e.g., risks and probabilities), restoring trust in science, finding creative solutions for adaptation, and coping with past events and anxiety associated with possible future events through 'art-therapy'. As such, in place of looming facts and figures communicated by science, art can inspire hope that will in turn promote positive behaviour change [17].

Given the urgency of the water-climate crisis and the proven role of art in outreach, engagement, inspiration, and action, the overall aim of this article is to evaluate the impact of art specifically designed at the intersection of climate and water, as part of the Virtual Water Gallery SciArt initiative. As noted by [18], very few publicly available research articles report on the impacts of climate communication activities by scientists. However, such evaluation is critical to better understand the role of SciArt collaborations in enhancing knowledge and changing people's attitudes towards climate change and water-related mitigation. It also offers an opportunity to better understand how these activities affect the artists and the researchers engaged. In doing so, it is intended to further close the loop between scholarly and artistic works, demonstrating the role of art as a catalyst for change.

The Virtual Water Gallery

The Virtual Water Gallery (www.virtualwatergallery.ca) is a collaborative SciArt initiative. It was started with funding from Global Water Futures (GWF), a Canada First Research Excellence Fund program. The Virtual Water Gallery was set up to provide a safe, inclusive and collaborative space for fully open discussions between scientists, artists, and a wider public, to explore past, present and future water challenges. It is co-curated by a group of academics, artists and research communicators. This space promotes dialogue and catalyzes action around the climate-water urgency, following the 'dialogue model' for science communication, chracterized by a "science-directed two-way interaction between scientists or science communicators and the public" [10].

In establishing the Virtual Water Gallery, 12 artists were paired with teams of

Global Water Futures scientists in the summer of 2020 to co-explore specific water challenges in various Canadian ecoregions and river basins, including the Arctic, the mountains, boreal forests, prairies, farmlands, lakes, rivers, and communities. The water challenges tackled by these projects provide a cross-section of viewpoints on the value and meaning of water within the context of climate change, from international and Indigenous perspectives to the contrast between local Canadian "homeland" and industrial perspectives. These pilot collaborations led to the co-creation of science-art pieces that were then exhibited online in March 2021. Several other science-art collaborations and projects have since joined the Virtual Water Gallery.

Established in the context of the ongoing COVID-19 pandemic within an 'Emerging Asocial Society', where more people felt lonely and disconnected [19], the Virtual Water Gallery was created as a fully online space, using technology to enhance our social connectedness during times of social distancing. Artists and water experts engaged in online discussions to share their unique perspectives on water challenges. Only a few had the privilege of visiting the field sites where the scientists conducted their research.

Since the website launch in March 2021, close to 9400 visits from around the world have been recorded. Most visits (approximately 60% of all visits) originated in Canada, followed by the USA (approximately 17% of all visits), and the UK (approximately 4% of all visits) (Fig 1).

Fig 1. Virtual Water Gallery website visits. Virtual Water Gallery website visits between the website launch (April 2021) and the time of writing (February 2024). A: The timeline also indicates key Virtual Water Gallery events. B: The map shows visits by countries.

More recently (May-June 2022), we brought the Virtual Water Gallery to life in a series of physical gallery exhibitions. The first of these was hosted by the Canmore Fine Arts Council at artsPlace in Canmore (AB). Artists and scientists travelled to Canmore for the launch event (Fig 2). This consisted of a reception with speeches by several university, community and gallery representatives. Artists were then asked to introduce their art around the room. Following this, artists and scientists stood by their exhibits and mingled with participants, answering questions and engaging in discussions. Participants consisted of people from Canmore and the local research community. A 3D tour of the exhibition can be experienced at: www.virtualwatergallery.ca/3d-gallery-tour. In addition to the Virtual Water Gallery art pieces, art pieces created by participants of the Rockies Repeat Youth Climate Challenge (www.rockiesrepeatfilm.com/youthchallenge) were featured, with the aim of promoting a diversity of voices in art, namely youth voices.

Fig 2. Virtual Water Gallery first in-person exhibition. Photographs of artists and scientists presenting their collaborative art pieces at the Virtual Water Gallery Canmore exhibition. From top left to bottom right, clockwise: visitor enjoying art, Megan Leung (sci-artist), Rhian Brynjolson (artist), Patrick Cheechoo (artist), Tricia Stadnyk (scientist), Louise Arnal (sci-artist).

While the online Virtual Water Gallery had already proved to be an excellent venue for engaging a global public, it was recognized that the value of local connections and outreach cannot be ignored. This is the space where meaningful conversations can start, and impactful community-led changes can be achieved [20]. Canmore is a year-round tourist destination nestled in the Rocky Mountains, in western Canada. It is located in the Bow River Basin, which forms the headwaters of the Saskatchewan-Nelson River system (an arctic drainage basin). Canmore already experiences impacts of climate and environmental change, which provides a local context for these important water challenges. For example, large parts of Canmore were affected by a flood event in 2013 [21]. More recently, western Canada has experienced some of the worst fire seasons ever recorded, bringing home how vulnerable the community is to drought-related impacts [22]. Amidst these tangible impacts, Canmore exemplifies local leadership as the town declared a state of climate emergency in 2019 and has established a climate action plan [23].

The exhibitions (both online and in-person) aimed to capture the audience's imagination, as much as it was scientifically informative and inspired hope, by means of guiding balanced narratives throughout the gallery space. These narratives communicated the ongoing science behind each piece, where the 'ongoing' aspect invited the viewers to imagine sustainable futures and interact with the art in conscious action. For instance, the Virtual Water Gallery piece "When Water is Braided" by artists Patrick Cheechoo and Rebeka Ryvola inspires braiding together western and Indigenous views, highlighting strengths central to a two-eyed seeing approach to water science to tackle water management challenges we all face.

Methods

While creative methods such as art, music and serious games are increasingly being used for public outreach and educational purposes with respect to environmental topics and issues, evaluation has not necessarily progressed to the same degree [18]. In the absence of established methods for quantitatively analyzing the impact of science-art initiatives, a series of online surveys was developed. Ethical approval for the study was provided through the University of Saskatchewan Behavioural Research Ethics Board (certificate number BEH3421). All protocols on informed consent, data storage and management were implemented to protect participants and their personal information.

One survey (Appendix, File S2 File) was developed for the participating artists and researchers, asking them to reflect retrospectively on their knowledge gained, the experience and collaboration, what they would have done differently, and whether the experience had any changing effects. The survey included a section on background information in order to be able to differentiate experiences of artists, scientists, and sci-artists (i.e., individuals who are both artists and scientists). Participating artists and researchers were contacted directly with a link to the online survey. This link was the same for all respondents and ensured that responses were anonymous, recognizing that information provided may have allowed them to be identified by the team conducting the evaluation.

Another set of surveys (Appendix, File S2 File) was developed for visitors to both the virtual gallery and in-person Canmore exhibition. Respondents above 18 years of age were asked if they were willing to participate in a two-part survey. A short pre-survey (14 multiple choice questions) was designed to capture background information, lived experience, and baseline knowledge and attitudes towards the climate-water nexus and art. A longer post-survey (consisting of multiple choice and open-ended questions) was designed to capture experiences, what they enjoyed and did not enjoy, the role of art in research (and vice versa), and self-reported changes in knowledge and attitudes after having explored the exhibition. Respondents were asked to provide a pseudonym for the pre-survey and to re-enter this for the post-survey in order to connect both parts for the analysis. While both of these surveys were administered online, questions were specific to virtual or in-person participation. At the Canmore exhibition, a QR code and two electronic tablets were made available for people to access and complete the surveys. A pop-up on the Virtual Water Gallery website invited people to participate in the survey when accessing the content online. The survey was made available to respondents for the duration of the Canmore exhibition and for four months online, on the Virtual Water Gallery website. The Virtual Water Gallery and its evaluation were publicized through mailing lists, including HEPEX (https://hepex.org.au) and AboutHydrology mailing lists. Participation was incentivized through a prize draw for one of ten art prints provided by the artists.

Responses from participants (artists, sci-artists, and scientists) were coded thematically and analysed manually given the small number of respondents. Quantitative data and likert scale responses were summarised using counts. Pre- and post-survey responses from gallery visitors were connected using the pseudonyms provided. Incomplete surveys (i.e., only the pre- or the post-survey was completed) were removed. Multiple choice responses were coded numerically and open-ended responses were coded thematically into keywords that could be translated into numerical codes, in Excel. Questions that focused on experiences were categorized as positive or negative (Appendix, Table S1A Table). Visitor survey responses were analyzed using the Python programming language. Survey respondents' demographics and data exploration was performed using Python data analysis libraries like NumPy and Pandas.

To assess the associations between variables in the visitor surveys, Spearman's rank correlation coefficients were computed using the Pandas integrated correlation function. The statistical significance of these correlations was determined through two-sided permutation tests with 1000 resamples, using the Scipy library's scipy.stats module. This approach offers enhanced robustness when establishing statistical significance with limited sample sizes, as opposed to deriving p-values directly from the SciPy Python library's Spearman's rank correlation function. To assess whether distributions were significantly different, Mann-Whitney U rank tests were performed, using scipy.stats module.

Results

The following sections describe the experiences of the SciArt collaboration participants (Section) and the visitors to the art exhibitions, either online or in-person (Section). Complete response rates for participants (artists and scientists) was just over 60% (16 out of 25 participants), while 139 visitors took part in the evaluation (47 in-person and 92 online).

Participant experiences

A total of 11 artists and two sci-artists out of a total of 14, and three scientists out of 14 responded to the participant survey. Of these, 10 identified as men and five identified as women (the others did not respond to this optional question). The majority (13) were over the age of 45, with three over the age of 75. While the majority of participants reported strong knowledge of consequences of climate change and of processes for generating art (most respondents were artists), knowledge of impacts of climate change on water was less strong, again likely reflecting the distribution of respondent roles (Fig 3). Participants overwhelmingly reported lived flood (11) and drought (14) experience.

Fig 3. Participants knowledge. Self-reported existing knowledge of the consequences of climate change, of impacts of climate change on water, and of processes for generating art of participants of the Virtual Water Gallery.

With respect to the collaboration, the majority of participants rated their experiences as high (five very good; nine excellent). However, one participant rated their experience as poor and another as neutral. Both of these respondents spoke to a need for greater collaboration with the scientists and better guidance in the matching process, which may explain their lower ratings. The SciArt collaboration experience altered participants' attitudes in one of two ways. One was urgency - portraying climate urgency and change (two artists) and the urgency to act (three artists). Another was awareness - greater awareness of the climate-water nexus (one sci-artist, two artists) and recognizing that art can create greater awareness for others (four artists, one scientist).

When asked to speak to their learning experience throughout the Virtual Water Gallery collaboration process, one sci-artist and one artist commented on the power of community, the shared value and purpose, mutual encouragement, and shared visions between the team members. The reciprocity of knowledge was also identified, with two artists reporting increased scientific knowledge and one increased knowledge of research processes, the dedication of researchers, and the time and investments that research takes, while a scientist noted that they learned about the process of creating art. Two scientists and an artist spoke to the value of art, while another artist spoke to the influence of art. Reported learning experiences extended beyond the art-science connection to include the lack of media roles in increasing awareness (one artist) and learning about how politics impact climate mitigation (one artist). These collaborations blur the boundaries between science and art, as well as between scientists and artists. For example, a sci-artist and two artists spoke to learning more about the movement of water, a phrase that could refer to the art and beauty of water, and/or the science of water.

When asked about their most memorable experience, artists overwhelmingly described the opportunity to listen to science, access greater information, and engage in virtual and in-person discussions (seven artists, one sci-artist). A scientist enjoyed taking artists to field sites and four artists and a sci-artist enjoyed the engagement with scientists, other artists, or the public. When asked the best time to engage artists in research, the responses varied. The greatest number identified the start of the research process (six), while four respondents indicated that it did not matter. Only two identified the end of the research process and one the middle. This adds weight to the notion that art should not be seen as an add on, but rather integral to the research and knowledge mobilization process. Further, eleven artists found the process of producing art easier when working with a research project.

Overall, the collaborative experience was seen to be positive (Fig 4A), with 13 participants very likely to engage again and 15 participants stating that more scientists should collaborate with artists. Artists were overwhelmingly positive about engaging in the process again: *"One of the best experiences in my art career"* (Artist), *"I enjoyed the challenge of having to think outside the box to create art that has a message"* (Sci-Artist), *"It is compelling and important, so I will do this every chance I get"* (Artist), *"I have contacted a researcher and have begun [another project]"* (Artist). The only response from a scientist to this question was more neutral: *"We will see if an opportunity presents itself"* (Scientist). Despite the positive experiences, there were challenges faced as part of the process (Fig 4B). Steep learning curves and "initial ignorance" on both sides were identified by a sci-artist and an artist. Time was another challenge identified 13 times by artists, including time for developing relationships, time for the collaboration, and the fact that scientists are busy (this is further reinforced by the lack of survey responses from scientists). Two artists requested more time with students who were seen to be more willing to spend time with artists and translate the science than senior scientists, which may be a solution for another request, which was greater one on one time with scientists, especially in the field (three artists). Resources were identified as a challenge by an artist and a scientist. Resources were also identified when asked about the supports that artists require to participate in SciArt collaborations. Funding was identified by a sci-artist, three artists and a scientist. Translating the science and effective communication were identified as challenges by two sci-artists, three artists and two scientists. Similarly, converting science and conversation into art was another challenge identified by an artist. Other needs expressed by participants included: plain language science (sci-artist), media connections (artist), mutual willingness to share ideas (artist), collegial spirit (artist), desire of scientists (artist), access to documents, videos, and photos (artist), and defined commitments and expectations (artist).

Fig 4. Opportunities and challenges of SciArt collaboration. Keywords relating to A) opportunities and B) challenges of SciArt collaboration, extracted from participant survey responses.

One particularly poignant insight by an artist is: *"I'm not sure the scientists see their role as collaborators. I think they enjoy sharing their work and seeing what artists can make of it. Scientists just need time to be able to share and let the artists into their world."* (Artist).

Opinions on the effectiveness of art as science communication were more diverse, with one respondent indicating that it was neutral, six that it was very good and eight that it was excellent. When asked about the benefits of SciArt collaborations, some of the more frequently identified reasons included broader audiences for science (five artists, one scientist), growth and broader perspectives (one sci-artist, three artists) and mutual learning and sharing (three artists). Noteworthy individual artist responses spoke to science as providing accurate information to inform art and art as a dimension beyond science and not just the communication of science: *"Art adds a dimension that is beyond communication. It deepens engagement, activates emotion, and connects different ways of knowing and understanding. 'Communication' is too narrow a term"* (Artist).

When asked about their experiences at the in-person exhibit, everyone rated the experience as very good or excellent and all but one rated their engagement with the public at similarly high levels. This was supported by the emotions identified while participating in the event. Happy or elated was identified by four respondents, while 12 described the experience as empowering or uplifting. One respondent noted that participating in the event made them feel worried. However, 11 respondents indicated that they were very likely to participate in an in-person event again, and one artist highlighted the need for a travelling exhibit. Overall, several recommendations emerged for future SciArt collaborations (Table 1).

Ultimately, one artist's response encapsulates the aim of the project, the value of bringing science and art together, and the findings of this analysis: *"This is a very important project in order to unite the understanding of both scientists and artists and ordinary people who come to exhibitions or simply are not even interested in science or art, to make us begin to feel what is happening to us in the world and on the planet."* (Artist).

Visitor experiences

The 139 visitor responses were composed of 92 online (through the Virtual Water Gallery) and 47 in-person (i.e., survey respondents who visited the Canmore exhibition). Out of all of the visitor responses, 67 (or 48%) reported living in Canada (Fig 5A). However responses covered a wide geographical ranges, including visitors residing in the USA (27), and Brazil (1) on the American continents, Germany (6), Switzerland (4), France (3), The Netherlands (3), Greece (2), Italy (2), the UK (2), Iceland (1), Poland (1), and Sweden (1) in Europe, South Africa (2) and Ethiopia (1) in Africa, India (5), Jordan (1), and Pakistan (1) in Asia, and Australia (2) in Oceania. Similarly to the

Table 1. Setting up for success. Dos and don'ts of SciArt collaborations.

Dos	**Participants**
Invest sufficient time to develop strong collaborations, interact with scientists	13 Artists
Invest sufficient financial resources, incentives for strong collaborations	3 Artists, 1 Sci-Artist, 1 Scientist
Invest in time in the field with scientists	3 Artists
Engage artists at the start of the research process	6 Artists
Create an enabling environment for scientists to engage with artists (e.g., understand previous artistic works and how their research might fit the art style/medium)	2 Artists, 2 Sci-Artists
Approach partnerships and projects with an open mind	1 Artist, 1 Sci-Artist, 1 Scientist
Go ahead and get involved in the process	6 Artists
Learn as much as you can	4 Artists
Include more scientific information or data alongside art to better demonstrate what the art represents	3 Artists
Create meaningful engagement, documentary videos, and create opportunities to view them	3 Artists
Use larger spaces, more chairs, and live music at in-person events	4 Artists, 1 Sci-Artist
Give tenure and promotion credit for participating in art engagement	1 Artist
Connect artists to each other or to other researchers	2 Artists
Have patience	1 Artist
Step outside your comfort zone	1 Artist
Trust your art	1 Artist
Select research that you have some knowledge of	1 Artist
Provide research documents, photos, and videos to artists	1 Artist
Don'ts	
Force scientists to engage	1 Artist
Have lengthy speeches at events	1 Artist, 1 Sci-Artist

participants' responses (see Section), an overwhelming number of respondents had experienced a flood (91) or a drought (96).

Fig 5. Survey respondents' demographics. Survey respondents' A) country of residence, B) age, C) gender, and D) highest education.

Most respondents were in the 25 to 44 age categories (60%), with fewer respondents in the younger and older age categories (Fig 5B). Equally skewed, most respondents identified as women (60%), while 35% identified as men, and 4% identified as gender-fluid, non-binary and/or Two-Spirit (Fig 5C). The respondents' highest education was heavily skewed as well, with most respondents having a University degree (88%), 68% of which had a postgraduate degree (Fig 5D). In comparison, 7% of respondents had a college/trade degree, and only 5% were high school (non-) graduates. Overall, the demographics data are heavily skewed, reflecting biases in the sample of people who took part in the surveys.

From the survey responses, slightly more respondents had never seen a SciArt exhibition before (45), while 40 respondents had seen at least one other SciArt exhibition previously, 9 of which had seen more than four SciArt exhibitions in the past.

Can art change knowledge levels?

Visitors to the gallery reported high prior knowledge levels of climate change consequences and of climate change impacts on water resources (Fig 6A and 6C). This is probably due to the skew in respondents' demographics described above. Despite the skewness of the data, an interesting finding (not statistically significant; Table S1B Table) is that virtual respondents reported lower prior knowledge levels.

Fig 6. Survey respondents' knowledge. Survey respondents' self-reported prior and post knowledge levels of climate change (CC) consequences (A and B respectively) and self-reported prior and post knowledge levels of CC impacts on water resources (C and D respectively), separated by virtual (full bars) and in-person (hashed bars) attendance.

While not statistically significant (Table S1B Table), we can observe shifts in the distributions of self-reported knowledge before and after seeing the exhibition (Fig 6B and 6D). Perhaps the most interesting shift occurred in the virtual exhibition for respondents' knowledge of climate change impacts on water resources (Fig 6D). More generally, in the post-survey, unlike in the pre-survey, all respondents were at least aware of climate change consequences and climate change impacts on water resources. While the sample size is small, the results hint that the exhibition increased knowledge levels of visitors with a low prior knowledge of climate change consequences and of climate change impacts on water resources.

Despite small differences in prior and post knowledge levels, 36 respondents reported that they felt that their knowledge level had changed as a result of the exhibition while 49 reported that they felt that their knowledge level had not changed. Out of these 36 respondents, 32 said that they had a better understanding of the links between climate change and water. A third reported that the exhibition changed their opinion regarding climate change, while slightly over 40% reported that the exhibition changed their sense of urgency regarding climate change. This suggests that, while levels of knowledge did not change significantly, the respondents' values around that knowledge changed. This is exemplified by the themes that emerged from the responses describing how their opinions had changed (Table 2). While only a few respondents who reported no change in knowledge also provided explanations, the themes that emerged are "connections" (2), "urgency" (1), and "solutions" (1).

Table 2. Survey respondents' values around knowledge. Themes identified by survey respondents regarding how the exhibition changed their opinion about climate change. The responses are divided into respondents who reported a change in knowledge and no change in knowledge.

Themes	Change in knowledge	No change in knowledge
Art as communication	3	-
Urgency	3	1
Connections	2	2
Art as education	1	-
Impact	1	-
Personal perspectives	1	-
Timescales	1	-
Struggle	1	-
Carbon footprint	1	-
Solutions	-	1

With respect to the types of participants who expressed knowledge changes, results of a Spearman rank correlation analysis with permutation tests show that the correlations between self-reported knowledge change and prior knowledge of climate change consequences, prior knowledge of climate change impacts on water resources, attendance type, and SciArt effectiveness in communicating the science behind the climate-water connection are statistically significantly associated with knowledge change

(Fig 7). Specifically, prior knowledge levels are negatively correlated with knowledge change, meaning that respondents with high prior knowledge levels were less likely to experience knowledge changes as a result of the exhibition. On the other hand, attendance type and SciArt effectiveness are both positively correlated with knowledge change, indicating that respondents who visited the exhibition in-person and who gave high ratings to the effectiveness of SciArt were most likely to report knowledge changes as a result of the exhibition.

Fig 7. Exploration of survey respondents' knowledge change. Spearman's rank correlation coefficients between respondents' self-reported knowledge change (0: no change; 1: change) and several variables (x-axis; see a detailed list in Table S1A Table). Results that are statistically significant (i.e., p-value < 0.05) are displayed in black. Exact values can be found in the Appendix, Table S1C Table.

While not statistically significant, it is interesting to note that respondents' feelings when completing the exhibition are positively correlated with knowledge change. This could suggest that respondents who had positive feelings were more likely to experience knowledge changes compared to respondents who had negative feelings from visiting the exhibition.

Can art change attitudes and behaviours?

Overall, when asked whether the exhibition changed their attitudes towards either climate change or water resources, most respondents answered "Not really" or "Somewhat" (Fig 8). While the distributions are not statistically different (Table S1B Table), more in-person respondents appear to have experienced changes in attitude.

Fig 8. Survey respondents' attitudes. Survey respondents' self-reported attitude change towards A) climate change and B) water resources, separated by virtual (full bars) and in-person (hashed bars) attendance.

The majority of respondents indicated that they already engaged in actions to reduce the impact of climate change (120), while 12 respondents said that they did not engage in any actions. Among those who reported engaging in actions, the types of actions they already engaged in are shown in Fig 9 ('pre' full bars) and are described in Table 3.

Fig 9. Survey respondents' climate mitigation actions. Types of actions respondents already engaged in ('pre' full bars) and they would like to engage in in the future ('post' hashed bars).

In the post-survey, 51 respondents reported that the exhibition caused them to reflect on their current behaviours regarding climate change mitigation, compared to 36 who said that it did not, and 4 who did not know. Regarding water-related climate change mitigation, 38 respondents reported that the exhibition caused them to reflect on their current behaviours, compared to 43 respondents who said that it did not, and 8 who did not know.

The types of actions respondents said they were likely to very likely to engage in as a result of the exhibition (and that they did not report in the pre-survey) are shown in Fig 9 ('post' hashed bars). It is important to note that 61 out of 139 respondents did not reply to this optional question in the post-survey. Interestingly, the actions that were most selected in the post-survey, listed in descending order, are: educating others on climate change and climate action, supporting conservation and biodiversity efforts,

Table 3. Climate mitigation actions. List of (water-related) climate mitigation actions available for survey respondents to choose from, and shown in Fig 9.

#	Actions
1	Energy conservation at home.
2	Energy conservation at work.
3	Water conservation at home.
4	Water conservation at work.
5	Composting.
6	Recycling.
7	Eating less meat.
8	Walking and biking as much as possible.
9	Using renewable energy.
10	Driving an electric vehicle.
11	Supporting conservation or biodiversity efforts.
12	Educating others on climate change and climate action.

and recycling. Conversely, the actions with fewer votes, listed in ascending order are: driving an electric vehicle, water conservation at work, and energy conservation at work.

Results of a Spearman rank correlation analysis with permutation tests show that the associations between self-reported reflections on current behaviours regarding water-related climate change mitigation and prior knowledge of climate change consequences, prior knowledge of climate change impacts on water resources, self-reported knowledge change, self-reported attitude changes towards either climate change or water resources, and self-reported reflections on current behaviours regarding climate change are statistically significant (Fig 10). Prior knowledge levels are negatively correlated with reflection on current behaviours, meaning that respondents with high prior knowledge levels were less likely to reflect on their current behaviours as a result of the exhibition. On the other hand, self-reported knowledge change, self-reported attitude changes towards either climate change or water resources, and self-reported reflections on current behaviours regarding climate change are all positively correlated with reflection on current behaviours. This indicates that respondents who also reported experiencing knowledge and attitude changes were most likely to reflect on their current behaviours as a result of the exhibition.

Fig 10. Exploration of survey respondents' reflection on their current behaviours. Spearman's rank correlation coefficients between respondents' reflection on their current behaviours regarding water-related climate change mitigation (0: no reflection; 1: reflection) and several variables (x-axis; see a detailed list in Table S1A Table). Results that are statistically significant (i.e., p-value < 0.05) are displayed in black. Values can be found in the Appendix, Table S1D Table.

How effective is art for communication?

When asked about the effectiveness of this exhibition in communicating the science behind the climate-water connection (SciComm in the figure), most responses ranged from ”Neutral” to ”Excellent” (Fig 11). While the distributions are not statistically significant (Table S1B Table), more in-person respondents appear to have thought that the exhibition's effectiveness was ”Excellent”. Respondents were also asked how effective art is at communicating science in general. The results are very similar and not shown. In addition, most respondents said that they were ”Likely” to ”Very likely” to attend similar future events (Fig 11). Out of all responses, 84 thought that more scientists should collaborate with artists, one did not think so, and eight did not know.

Fig 11. Survey respondents' ratings of SciArt. Respondents' ratings of A) the effectiveness of this exhibition in communicating the science behind the climate-water connection and B) their likelihood to attend another SciArt exhibition in the future.

After completing the exhibition, most respondents felt positive (62%), 21% of respondents felt negative, and 17% of respondents had neutral feelings (Fig. 12). A thematic analysis of respondents description of their feelings, categorized as positive, neutral or negative, is shown in Table 4. Out of all respondents who indicated having negative feelings, the majority were women (nine out of 13). Out of all respondents who indicated having positive feelings, there was an almost equal number of women (19) and men (20).

Fig 12. Survey respondents' feelings. Respondents' feelings when completing the exhibition, classified as positive, neutral, or negative.

Table 4. Feelings. List of feelings available for respondents to choose from, grouped into positive, neutral, and negative categories.

Categories	Feelings
Positive	Happy, excited, uplifted, empowered, connected, supported, inspired, interested, reflective, curious, appreciative, pleased, informed, enlightened, moved.
Neutral	Same as usual, uncertain.
Negative	Worried, anxious, overwhelmed, disempowered, sad, nostalgic.

With respect to the types of participants who highly rated the effectiveness of this exhibition in communicating the science behind the climate-water connection, results of a Spearman rank correlation analysis with permutation tests show that the correlations between the exhibition's effectiveness and SciArt effectiveness in general, self-reported knowledge change, self-reported attitude changes towards either climate change or water resources, and self-reported reflections on current behaviours regarding climate change are statistically significant (Fig 13). SciArt effectiveness, self-reported knowledge change, self-reported attitude changes towards either climate change or water resources, and self-reported reflections on current behaviours regarding climate change are all positively correlated with reported effectiveness of the exhibition. This indicates that respondents who rated the effectiveness of the exhibition as high also reported experiencing knowledge and attitude changes, reported reflecting on their current behaviours regarding climate change, and thought that SciArt is effective in general.

Fig 13. Exploration of survey respondents' ratings of the exhibition's effectiveness. Spearman's rank correlation coefficients between respondents' ratings of the exhibition's effectiveness (0: neutral to very poor; 1: very good to excellent) and several variables (x-axis; see a detailed list in Table S1A Table). Results that are statistically significant (i.e., p-value < 0.05) are displayed in black. Values can be found in the Appendix, Table S1E Table.

While not statistically significant, it is interesting to note that respondents' age, education and flood and drought experience are all negatively correlated with the exhibition's effectiveness. This could hint that younger respondents without a university degree, and who had experienced a flood or drought in the past, were more likely to gain benefit from the exhibition.

Discussion

Two key areas for discussion emerged from the analysis. The first is the potential for art to catalyse change and not simply another vehicle for communicating information. The second is how to maximize the potential of SciArt.

Beyond just a tool for communication: Art as a catalyst for knowledge, attitude and behaviour changes

[24] put forward a framework for guiding arts-based practices designed for diverse levels of engagement with specific target groups of participants and audiences. They describe three equally important depths of engagement in climate change that include:

1. *in* art, where art is used as a communication tool,
2. *with* art, where art serves as a medium to foster dialogues and learning, and
3. *through* art, which refers to art as a means of transformation.

These three levels are similar to [10]'s three engagement models (i.e., the 'deficit', 'dialogue' and 'participation' models). Our survey evaluation approach maps onto both of these approaches, where visitor experiences were analyzed based on whether art fostered changes in knowledge (2), and changes in attitudes and behaviours (3). While the first level of engagement (1), art as a tool for communication, has been prevailing and is an important application of SciArt collaborations, the higher levels of engagement reported by survey respondents indicate that we should move beyond the perception of the role of SciArt solely as a tool for communication towards harnessing more powerful roles of art as facilitating dialogues and change. This could, in turn, help scientists take a step back and rethink the complex scientific challenges they are tackling.

The artist's reference to art as connecting "different ways of knowing and understanding" (see results Section) may explain respondents' self-reported changes in the values around their knowledge, as opposed to adding to their knowledge - e.g., the sense of urgency and connections associated with climate change and water resources challenges. Arguably, these value shifts are as important as the factual knowledge itself. Indeed, [25] call to the importance of the social sciences and humanities to bring forward "nuance and additional substance to how knowledge on climate change is shaped", and highlight the role of interdisciplinary studies to "emphasize the human dimensions that complement techno-oriented approaches" to climate change mitigation.

Despite the skewed responses to this study, art and art galleries are spaces that bring together people from various places and perspectives that might otherwise never meet. In this study, most visitors had a high level of education and very strong prior knowledge of climate change and water challenges, particularly amongst in-person respondents. Canmore, as a small community nestled in the Canadian Rocky Mountains, likely consists of a higher proportion of people with an appreciation of the environment and a basic understanding of environmental change through experience and observation as well as via scientific and academic mailing lists. Further, a national water conference organized by the Canadian Water Resources Association was held in the town during the exhibition, and conference attendees had a chance to visit the exhibition through an organized exclusive viewing. Reaching truly broad audiences with such small events is a challenge, and one that should be addressed in future work.

However, art can reach people who may not be able to access or internalize scientific outlets, such as scientific articles, numbers, and complicated graphics. The visitor survey results have shown that the online gallery reached people from a broad spectrum of identities (i.e., age, education level, lived experience) and knowledge of climate change and water challenges. In a world where the consequences of climate change are being differentially experienced across space, time and between population groups [5], the strength of merging art and science to reach a broader audience is multiplied. This further underscores the importance of accessibility to information to acknowledge, address, and uplift diversity and inclusion.

In a world where climate anxiety is pervasive, it is possible that these types of exhibits could amplify anxieties and lead to inaction, or actions with negative impacts. In a recent essay, [17] state: "Despair and hopelessness [...] have been documented to lead to 'climate anxiety' and to sap motivation to act". They continue by saying: "Any message of hopeful alarm should begin by emphasizing that people have agency, both individually and collectively, to shape the future". Indeed, feelings of being worried, anxious, or overwhelmed were reported by some visitors to the exhibit. However, the majority of visitor responses were of positive feelings. While not statistically significant, there is an indication that the art exhibited online and in the gallery fostered a positive environment that could in turn lead to knowledge changes, even given such a short exposure period. While there is uncertainty about whether knowledge change translates to behaviour changes, at least intended behaviour changes regarding (water-related) climate change mitigation result from increased knowledge and from positive interactions with the art as seen in the visitor experiences (see results Section). [26] call this "emotional predisposition". This is further supported by an analysis of 883 visitor responses to art displayed at the ArtCOP21 event that accompanied the 21st UN climate summit in Paris. [27] found that exposure to climate change-related artwork is linked, at least in the short-term, to heightened support for climate policies, and is primarily driven by emotional engagement. As such, a critical role and strength of art in climate research and in changing knowledge levels that could in turn inspire behaviour changes, may be its ability to ring a "hopeful alarm". This further reinforces the role of art and even more so the integration of art with the environmental and the social sciences. The sciences and arts communities need to, now more than ever, collaborate closely and, together, rewrite the narrative to inspire hope for knowledge changes and ultimately empower climate change adaptation and mitigation at the community level.

In addition to being a catalyst for knowledge, attitude, and behaviour changes, art is an undeniably powerful tool to foster imagination, thereby supporting identification of plausible pathways to climate action and living within Earth's resources [16, 19]. While superficially, imagination appears contradictory to communicating scientific facts, they are complementary. Indeed, it has been argued that effective climate adaptation must be imaginative and inclusive [28]. As the frequencies and magnitudes of water-related natural hazards are increasing around the world, some events are outside of the historical ranges in the collective memory [29]. Creative methods can help build community resilience to hazards [20], for example by enabling people to imagine future risk and possible preventive actions [30]. In the aftermath of the disastrous floods in western Europe in 2021, [31] wrote: "What is the use of a perfect forecast if the people it is supposed to warn cannot see the danger they are in? Effective flood warnings require people to be able to see into the future and imagine their house full of water, to assess the likelihood of that happening, and to see the multiple paths they could take to keep them, their family, and their property safe". Merging the rigor and knowledge of the sciences with the imaginative and creative power of the arts is key to empowering diverse audiences and to highlighting the possible adaptation pathways that can be followed towards a more desirable future, and ultimately to more inclusive climate change adaptation [25].

Palette of wisdom: Mastering lessons in the SciArt tapestry

This paper paints a portrait of the impact of the Virtual Water Gallery on the audience, scientists, and artists involved. In doing so, it aims to set a framework for evaluating the impact of such initiatives. This is critical because, while creative methods such as art, music and serious games are increasingly being used for public outreach and educational purposes with respect to environmental topics and issues, evaluation has not necessarily progressed to the same degree [18]. Through an analysis of 819 research articles about scientists' climate communication efforts, [18] found that only seven of these articles assessed the impact of the reported activities. They emphasize the significance of going beyond the conventional practice of tallying participant numbers or relying on informal conversations for impressions. Instead, they underscore the necessity of developing a comprehensive understanding of which aspects of science communication are effective or not and for which audiences.

In addition to developing an evaluation method that can be modified and built on by future researchers, several recommendations emerged from the participant experiences, that are invaluable to shape future SciArt collaborations and events (see results Section). One of those recommendations relates to the timing of including art in the scientific process. Most participants said that SciArt collaborations need time to flourish, that they should happen at the start or the middle of the research process, and that it is easier to produce art when working with a research project. This reinforces the notion that the art is not just an add-on to science projects or a tool for one-way communication once a research project is over (as discussed above, see Section). Instead, art should be seen as integral to the research and knowledge mobilization process. The norm is changing, albeit slowly, and "the arts are moving beyond raising awareness and entering the terrain of interdisciplinarity and knowledge co-creation" [26]. However, in many scientific initiatives, art is still all too often used solely as a tool to communicate scientific findings in an aesthetically pleasing form to a wider audience. This responds to grants that require outreach or public engagement, but as a box-ticking exercise, failing to create a dialogue between the artists and the scientists and therefore recognizing the value and harnessing the potential of merging science and art for innovation. As mentioned in a 2021 Nature Editorial: "The alliances are most valuable when scientists and artists have a shared stake in a project, are able to jointly design it and can critique each other's work. Such an approach can both prompt new research as well as result in powerful art" [32].

Participant experiences in the SciArt process additionally highlighted the limited involvement of established scientists and emphasized the more positive engagement with students. What are the reasons and what does this mean for the future of SciArt? We infer that it could be linked to the insufficient recognition of SciArt collaborations in academic development, when compared to, for example, the number of publications. This could lead established scientists, whose time is extremely limited, to not get involved in such collaborations as much as students. One of the participants identified the need for taking part in art engagement activities to count towards tenure and promotion credit. Assessment systems are currently being revisited in academia (e.g., through the San Francisco Declaration on Research Assessment; DORA; https://sfdora.org/). We venture to say that these transformative and generational changes are key to fostering better SciArt collaborations with scientists across all academic levels and roles.

The value of SciArt is undeniable (as highlighted in the discussion above, see Section) and is being increasingly recognized within the scientific sphere. There is a richness of SciArt, and more generally science communication (or SciComm) initiatives and activities at conferences such as the European and American Geophysical Union conferences (EGU and AGU respectively). Universities are also supportive of SciComm (e.g., social media presence, media interviews, three minute thesis (3MT) competitions, etc.). This shows the increasing appetite for SciArt as well as the growing knowledge and resources available. Yet, there is still a lack of formal training for researchers as science communicators and sci-artists and the tools for students (and staff) to do this properly are lacking [33]. This is perhaps symptomatic of the historic lack of legitimization of using creative methods to address scientific challenges that still prevails. As noted by artists, scientists and sci-artists in this study, resources, both in terms of time and money, and recognition are critical to the success of SciArt endeavours. As such, we strongly advocate for conference microcosms to help strengthen the role and centrality of creative methods at universities and in the development and communication of research. Supports can include dedicated conference sessions and SciArt workshops, student training, recognition of engagement of non-artists in the development of artistic works and of artists in the development of research and scholarly works, dedicated funds to engage artists and sci-artists in research and at conferences, and the establishment of a collection of resources to guide individuals wanting to create new SciArt activities or to participate in existing initiatives.

The results reported in this paper provide a snapshot of the immediate/short-term impacts of the Virtual Water Gallery on participants and visitors. However, the impacts of SciArt can sometimes take time to be realized. For example, the authors are aware of several projects and other opportunities that have presented themselves for participants in the Virtual Water Gallery process, such as additional SciArt projects in part as a result of this project. To address this gap in evaluation, [20] developed a version of the Ripple Effect Mapping (REM) evaluation approach [34] to uncover and document the naturally unfolding, community-wide impacts that resulted from their initial SciArt project. Such an approach could be used in the future to highlight long-term impacts, or ripple effects, of the Virtual Water Gallery.

Conclusion

This study proposes a method for evaluating SciArt initiatives in terms of how they might alter knowledge, attitudes and water-related climate mitigation practices of visitors to SciArt exhibitions. It presents results from an application of this evaluation method to the Virtual Water Gallery exhibitions. While a relatively small sample size (139 responses), results suggest that the exhibition increased knowledge levels of visitors with self-reported low prior knowledge of climate change consequences and of climate change impacts on water resources. In respondents who indicated high prior knowledge, values around knowledge (e.g., urgency, connections) were reported to have changed even when absolute knowledge was unchanged. Visitors who had low prior knowledge and who reported experiencing knowledge and attitude changes were most likely to reflect on their current behaviours as a result of the exhibition. The type of exhibition and the feelings evoked also played a role in self-reported knowledge or intended behaviour changes. Specifically, visitors of the in-person exhibition and leaving the exhibition feeling positive emotions (e.g., happiness, excitement) were most likely to report changes. Demographics and lived experience were also impactful in shaping visitors' experiences. Although not significant, younger visitors who reported lived experience with floods or droughts and did not hold a university degree, and who reported knowledge, attitude, and intended behaviour changes as a result of seeing the exhibition, were also most likely to rate the exhibition's effectiveness as high. Most visitors thought SciArt in general (and this Virtual Water Gallery exhibition) is an effective tool for communication, would like to see more SciArt collaborations, and are likely to visit similar exhibitions in the future.

These findings underscore the power of art. In co-creating art within the SciArt process and engaging artists, scientists, and diverse exhibition visitors in conversations around critical topics such as climate change through art, it is possible to move beyond art as one-way communication tool to SciArt as part of the research process, to foster dialogues, learning, and transformation. In evoking positive emotions, art can create environments for positive changes in knowledge, attitudes, and behaviours while perhaps minimizing the climate anxiety that can affect people engaging in other forms of climate change communications and conversations. Moving forward, it is important to capture these types of evaluations as part of the SciArt process. This will help to inform future training programs and SciArt initiatives as well as to advance our understanding of the nuances dimensions of art as more than just one-way communication. Finally, longer-term impact studies are needed to understand whether changes in knowledge and attitudes are sustained and whether self-reported intended changes in behaviour translate to actual changes.

Supporting information

S1A Table. Survey variables. Survey variables, their categories and the keywords used in figures and tables.

S1B Table. Mann-Whitney U tests.

S1C Table. Spearman rank correlations for survey respondents' knowledge change. Summary results of Spearman rank correlation calculations and permutation tests, where the predictand variable is respondents' knowledge change as a result of visiting the exhibition. The predictor variables are shown in the rows of the table. The results are based on 71 observations excluding missing values. Variables with statistically significant results (i.e., p-value < 0.05) are shown in italics.

S1D Table. Spearman rank correlations for survey respondents' reflection on their current behaviours. Summary results of Spearman rank correlation calculations and permutation tests, where the predictand variable is respondents' reflection on their current behaviours regarding water-related climate change mitigation as a result of visiting the exhibition. The predictor variables are shown in the rows of the table. The results are based on 62 observations excluding missing values. Variables with statistically significant results (i.e., p-value < 0.05) are shown in italics.

S1E Table. Spearman rank correlations for survey respondents' ratings of the exhibition's effectiveness. Summary results of Spearman rank correlation calculations and permutation tests, where the predictand variable is respondents' ratings of the exhibition's effectiveness in communicating the science behind the climate-water connection. The predictor variables are shown in the rows of the table. The results are based on 61 observations excluding missing values. Variables with statistically significant results (i.e., p-value < 0.05) are shown in italics.

S2 File. Surveys. Virtual Water Gallery participant survey and two-part visitor survey.

Author contributions

CSW, supported by LA, obtained the funding, conceptualized and designed the surveys. Both LA and CSW contributed to cleaning the data prior to its use for a formal analysis, and designed the methodology to analyze the results. CSW carried out the initial analysis of the participants' data and LA carried out the initial analysis of the visitors' data. Results were compiled and co-analysed by both LA and CSW. LA prepared visuals for the manuscript. Both LA and CSW wrote the manuscript.

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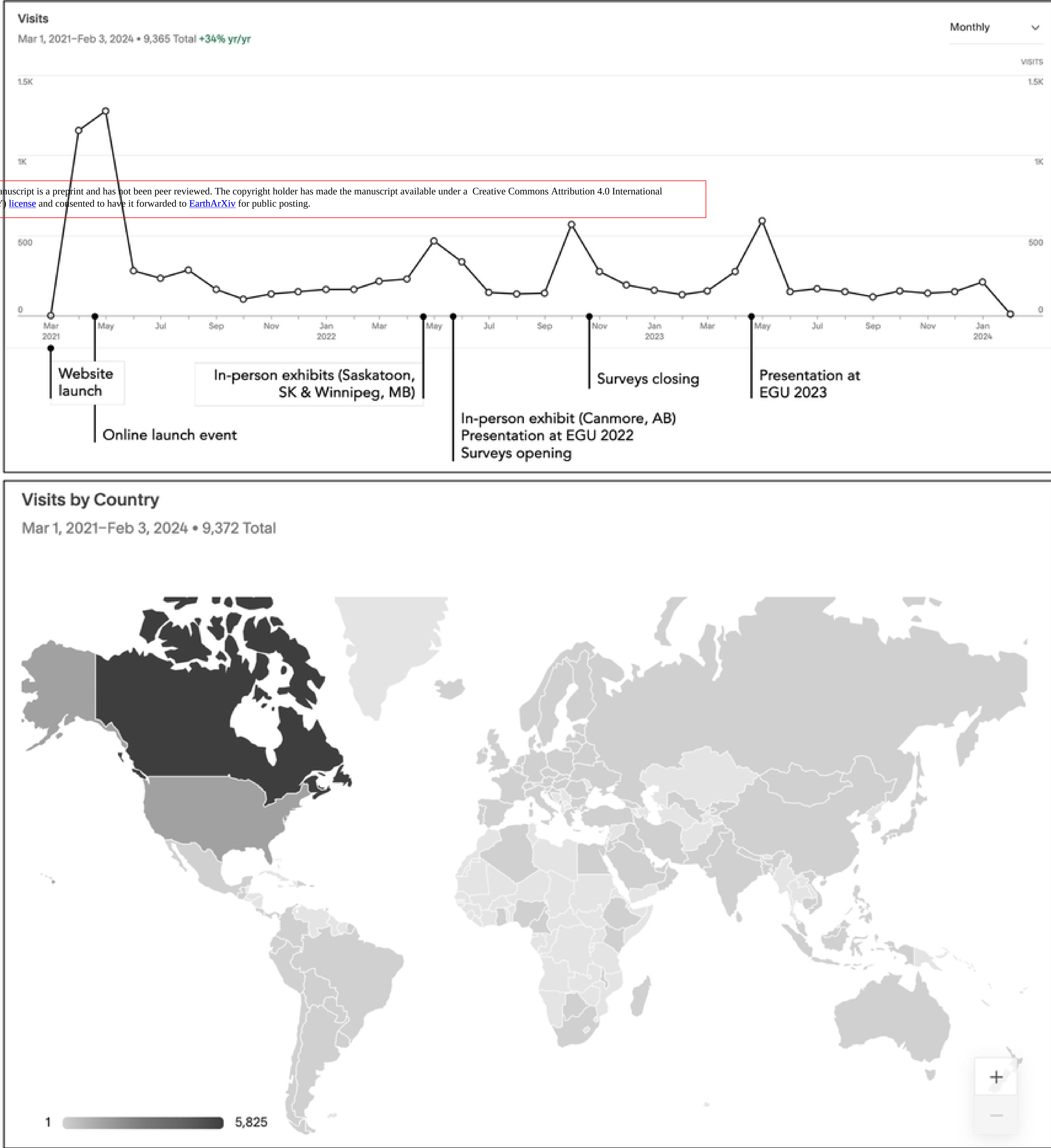
Visits
Mar 1, 2021–Feb 3, 2024 • 9,365 Total +34% yr/yr
Monthly
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Website launch
Online launch event
In-person exhibits (Saskatoon, SK & Winnipeg, MB)
In-person exhibit (Canmore, AB)
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Presentation at EGU 2023
Visits by Country
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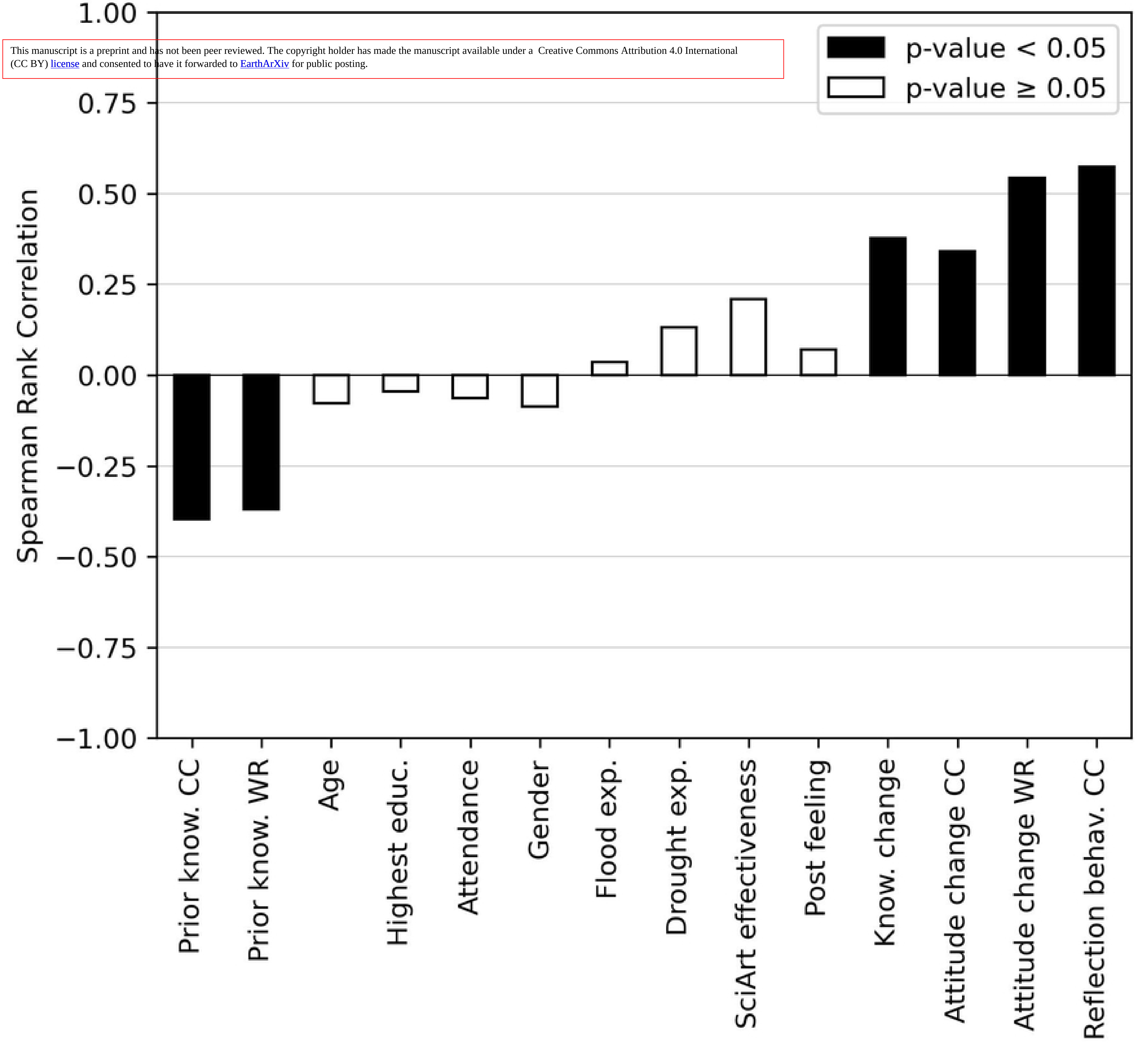

p-value < 0.05
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Spearman Rank Correlation
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0.00
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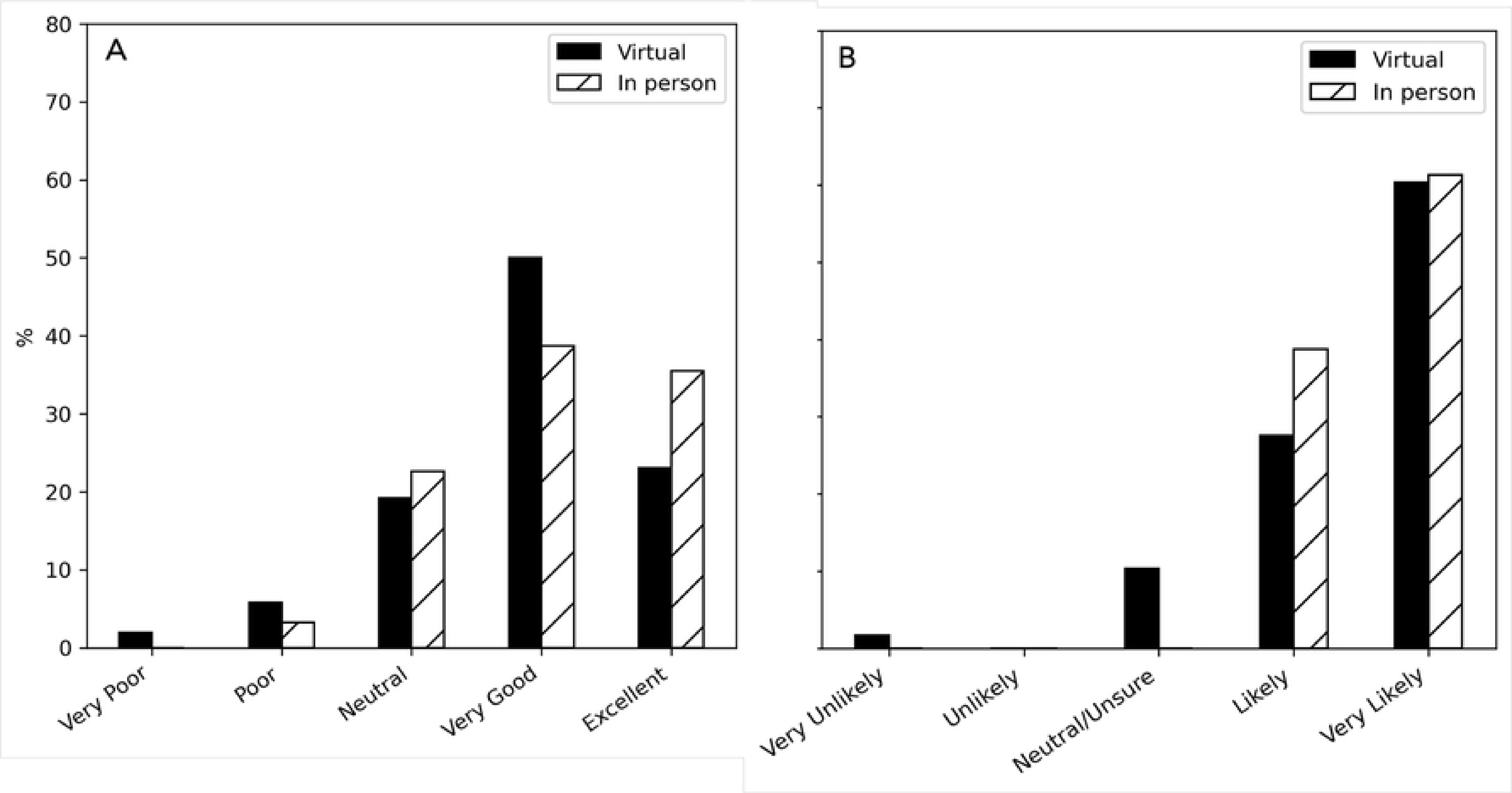
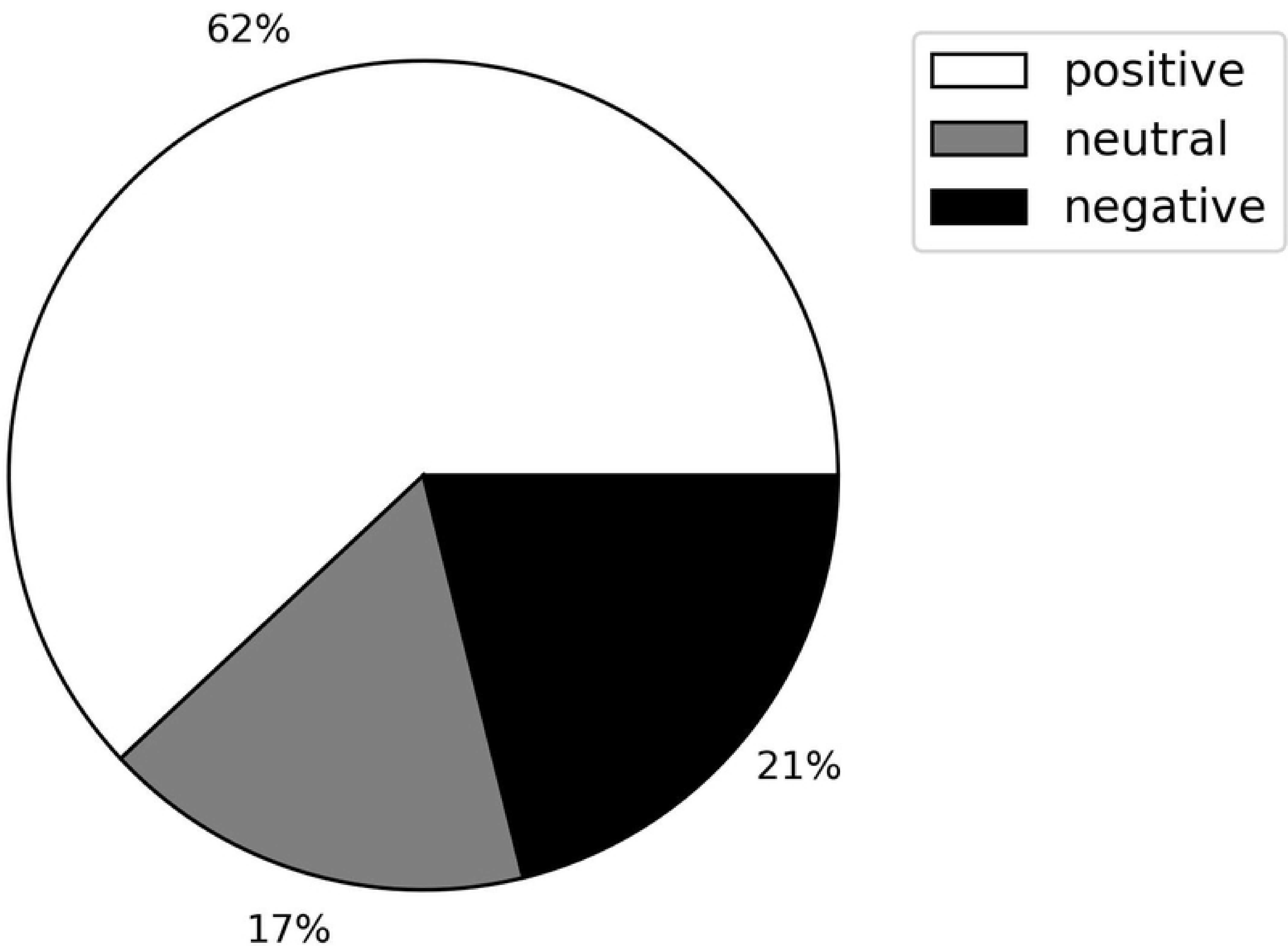
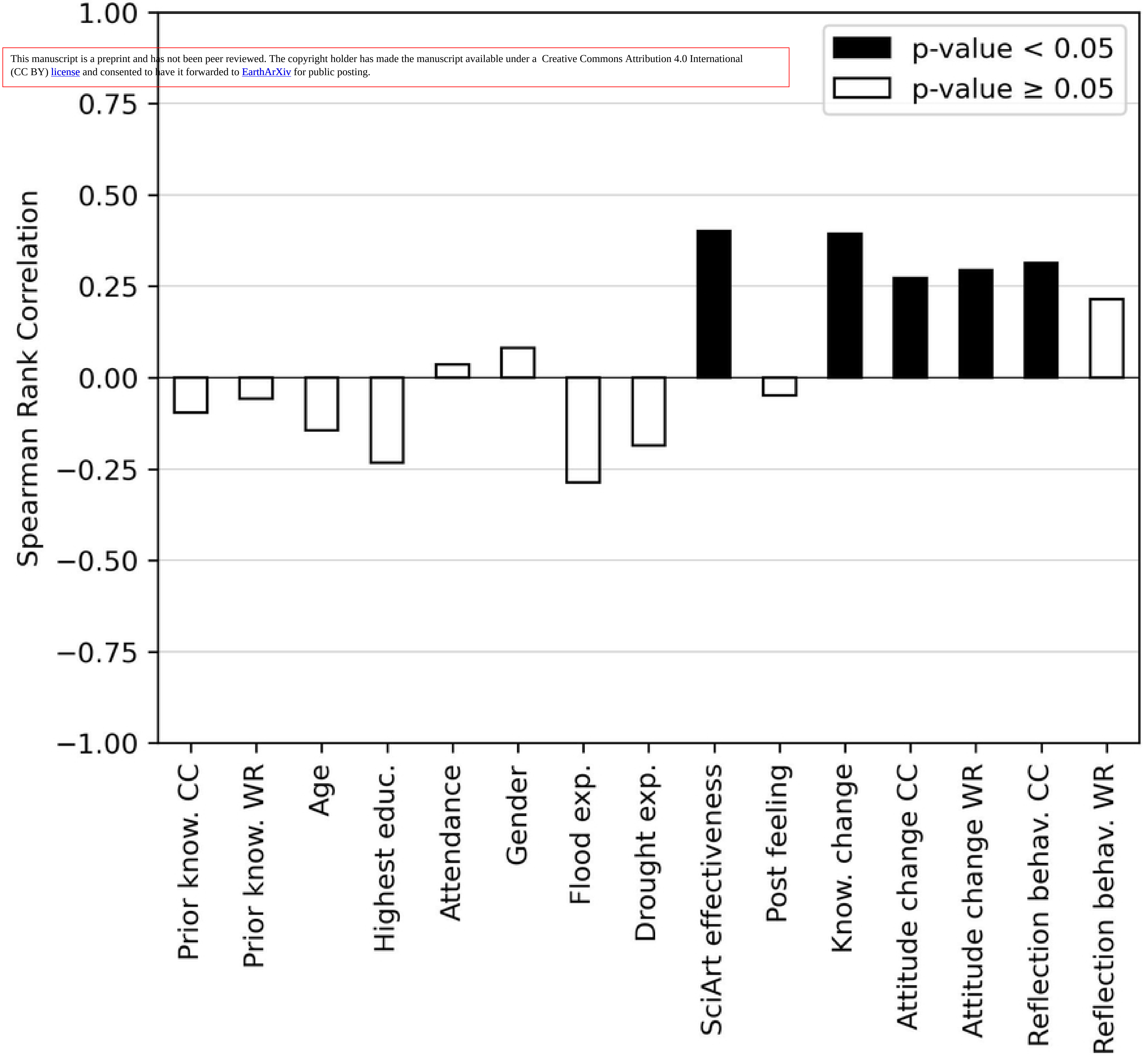
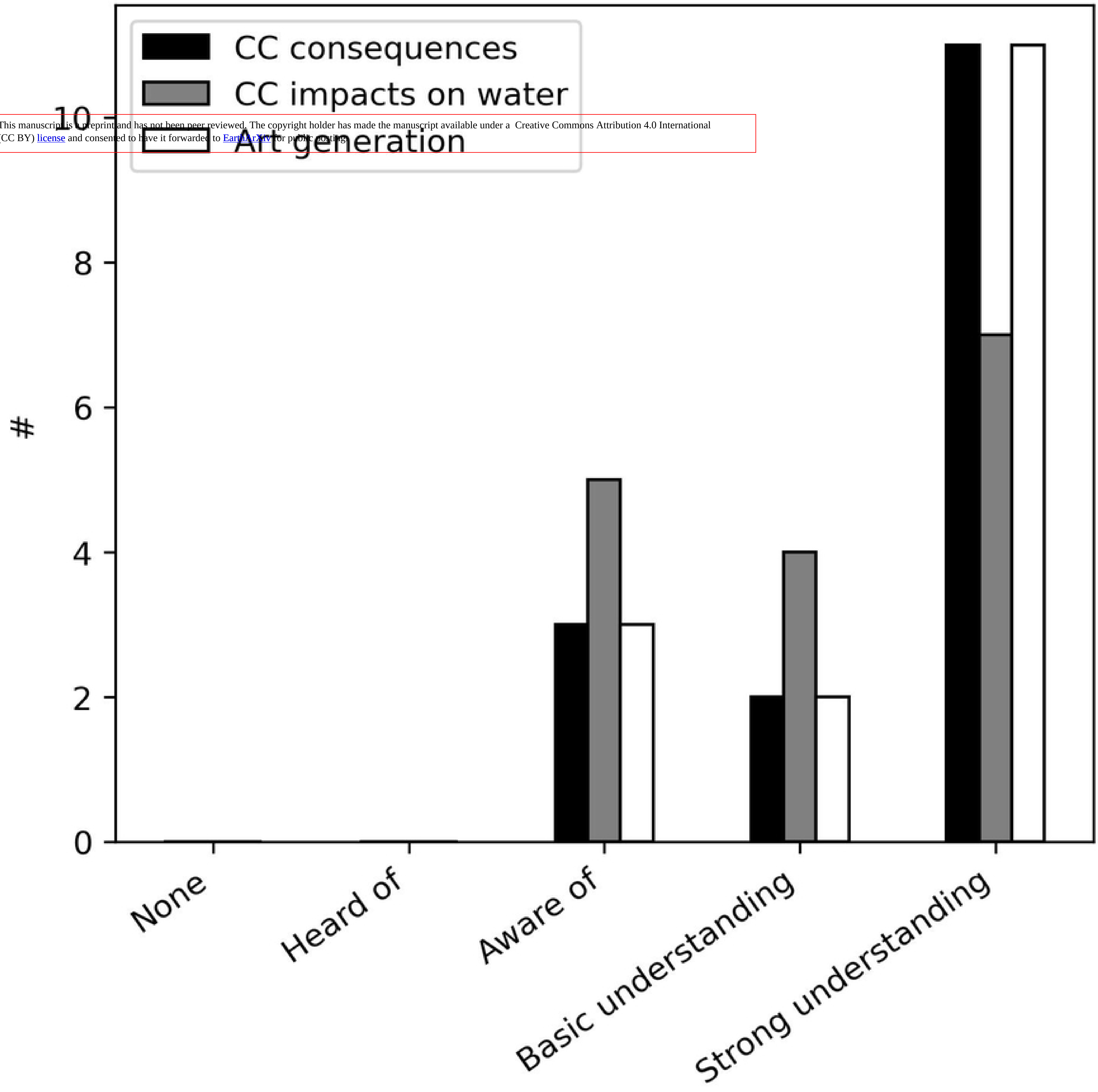
−0.50
−0.75
−1.00
Prior know. CC
Prior know. WR
Age
Highest educ.
Attendance
Gender
Flood exp.
Drought exp.
SciArt effectiveness
Post feeling
Know. change
Attitude change CC
Attitude change WR
Reflection behav. CC

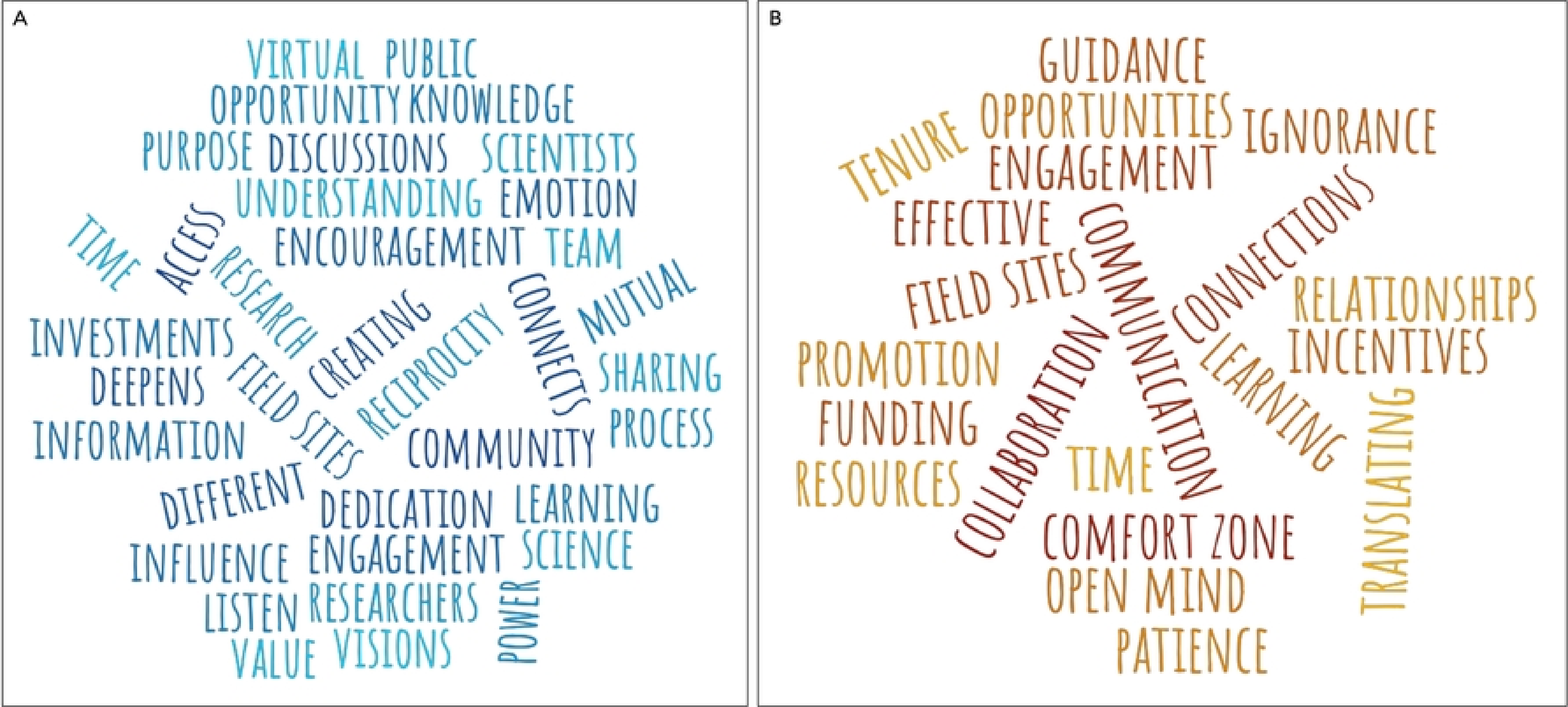

A
B
Virtual
In person
%
0
10
20
30
40
50
60
70
80
Very Poor
Poor
Neutral
Very Good
Excellent
Very Unlikely
Unlikely
Neutral/Unsure
Likely
Very Likely

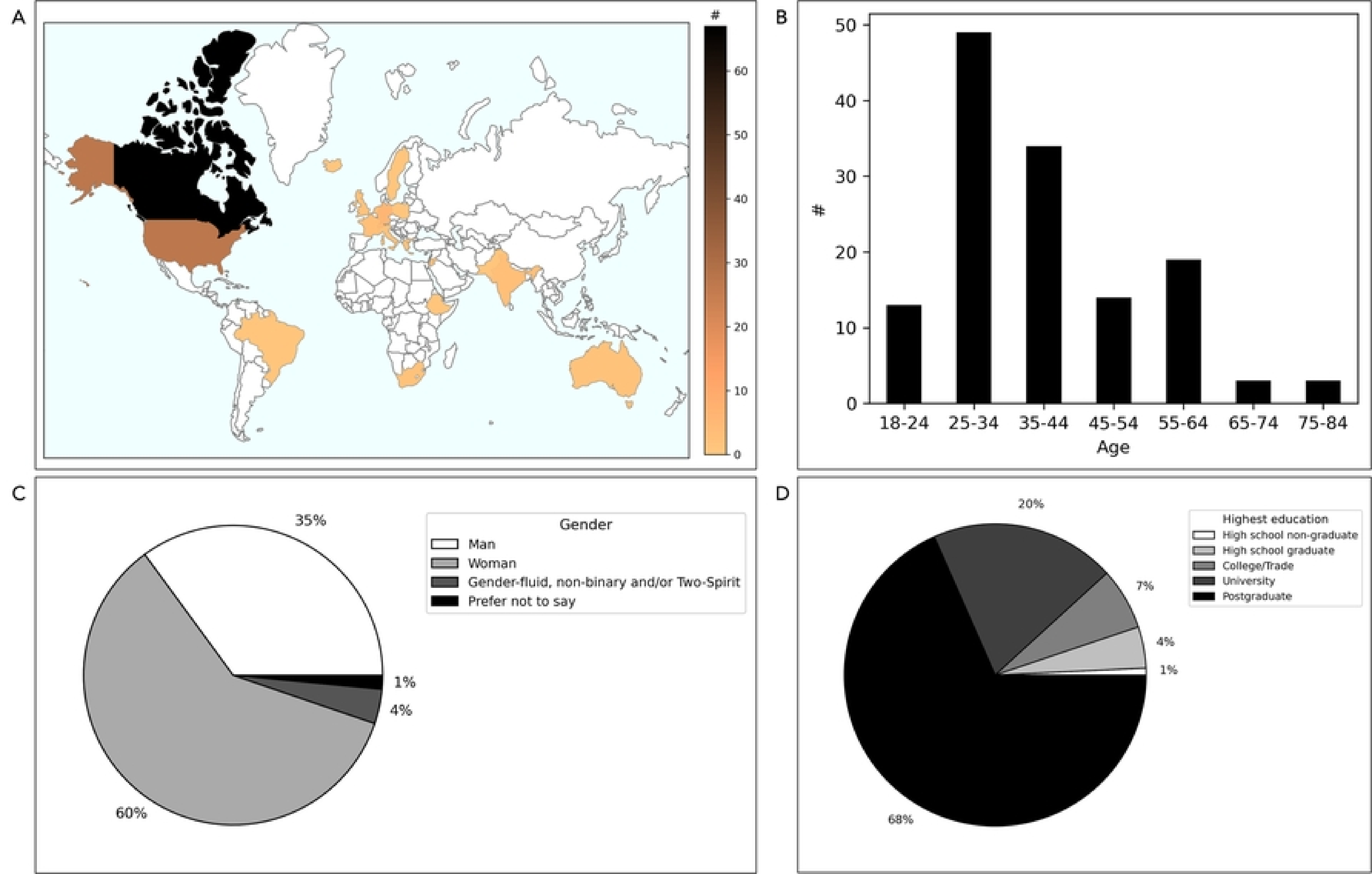

62%
17%
21%
positive
neutral
negative

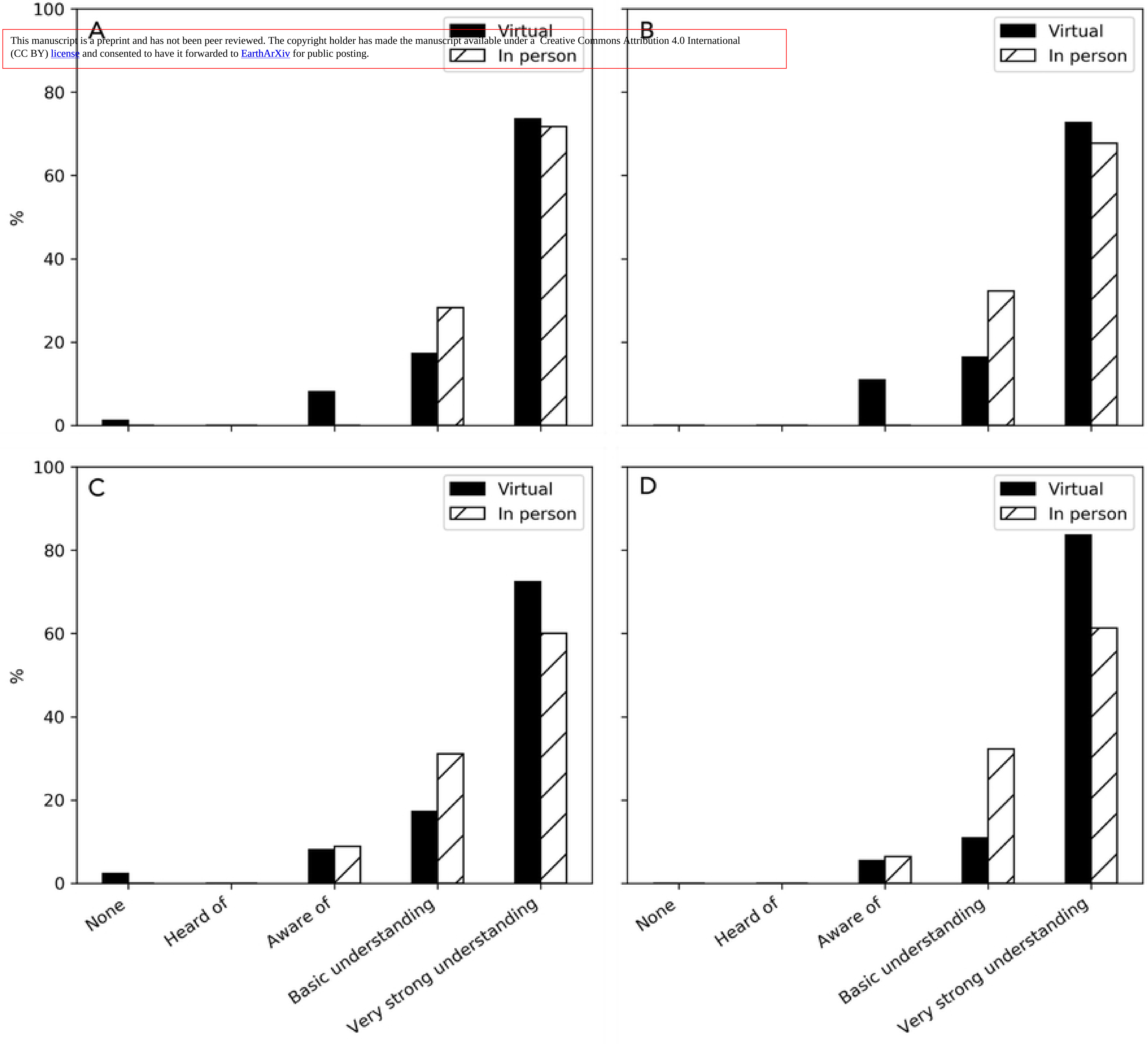

1.00
0.75
0.50
0.25
0.00
−0.25
−0.50
−0.75
−1.00
Spearman Rank Correlation
p-value < 0.05
p-value ≥ 0.05
Prior know. CC
Prior know. WR
Age
Highest educ.
Attendance
Gender
Flood exp.
Drought exp.
SciArt effectiveness
Post feeling
Know. change
Attitude change CC
Attitude change WR
Reflection behav. CC
Reflection behav. WR

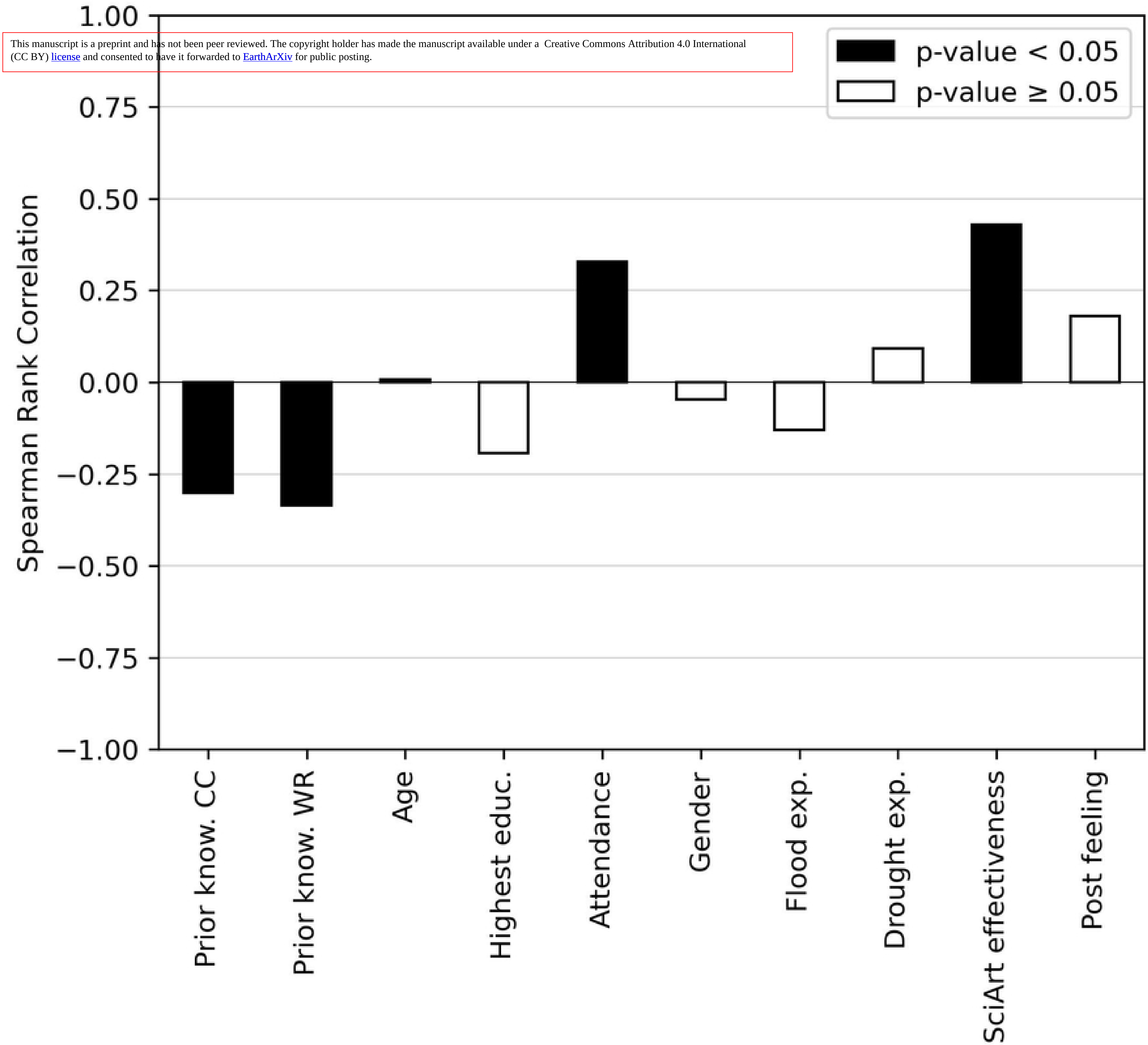

BOREAL FORESTS

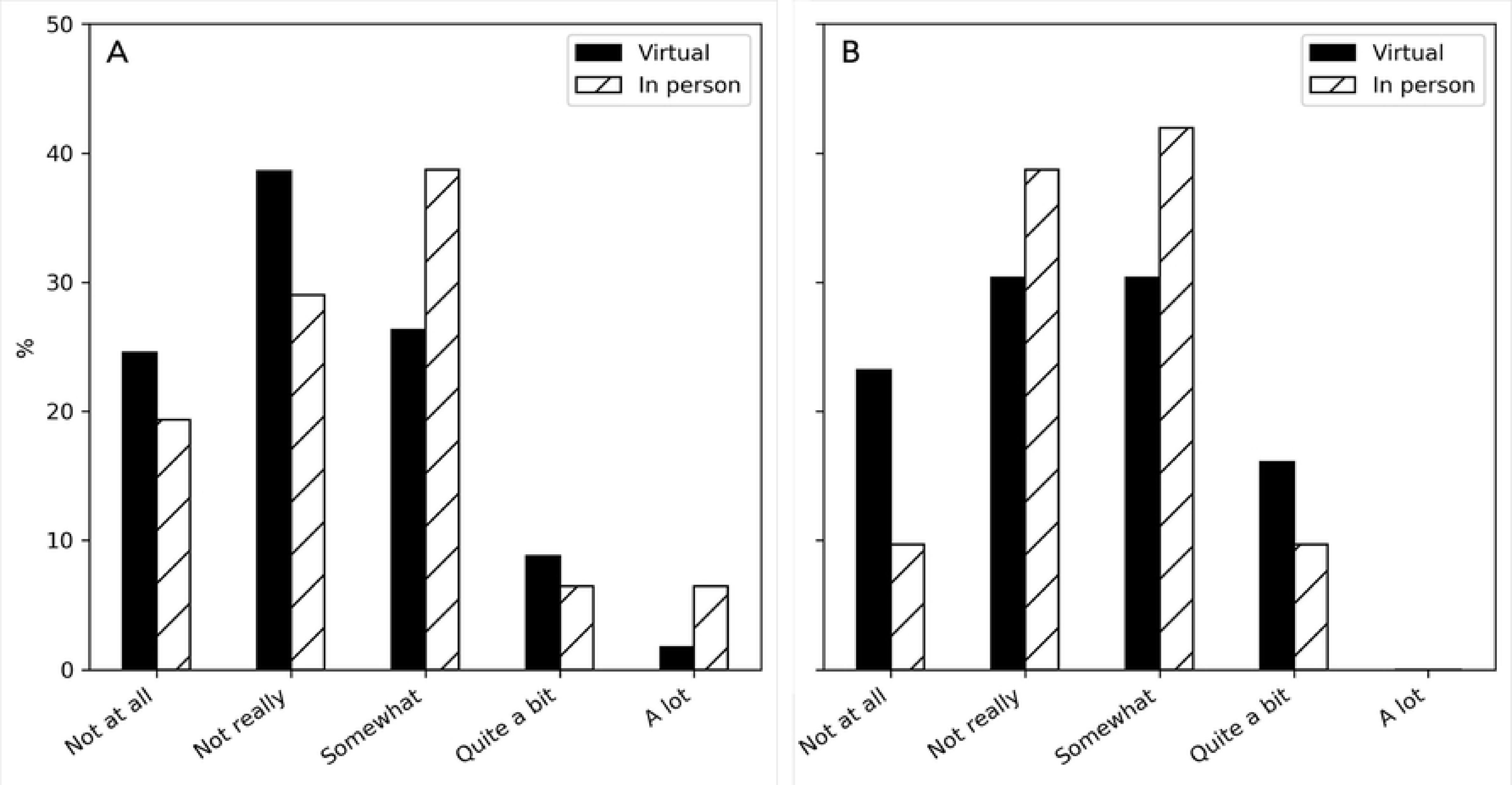

CC consequences
CC impacts on water
Art generation
#
0
2
4
6
8
10
None
Heard of
Aware of
Basic understanding
Strong understanding

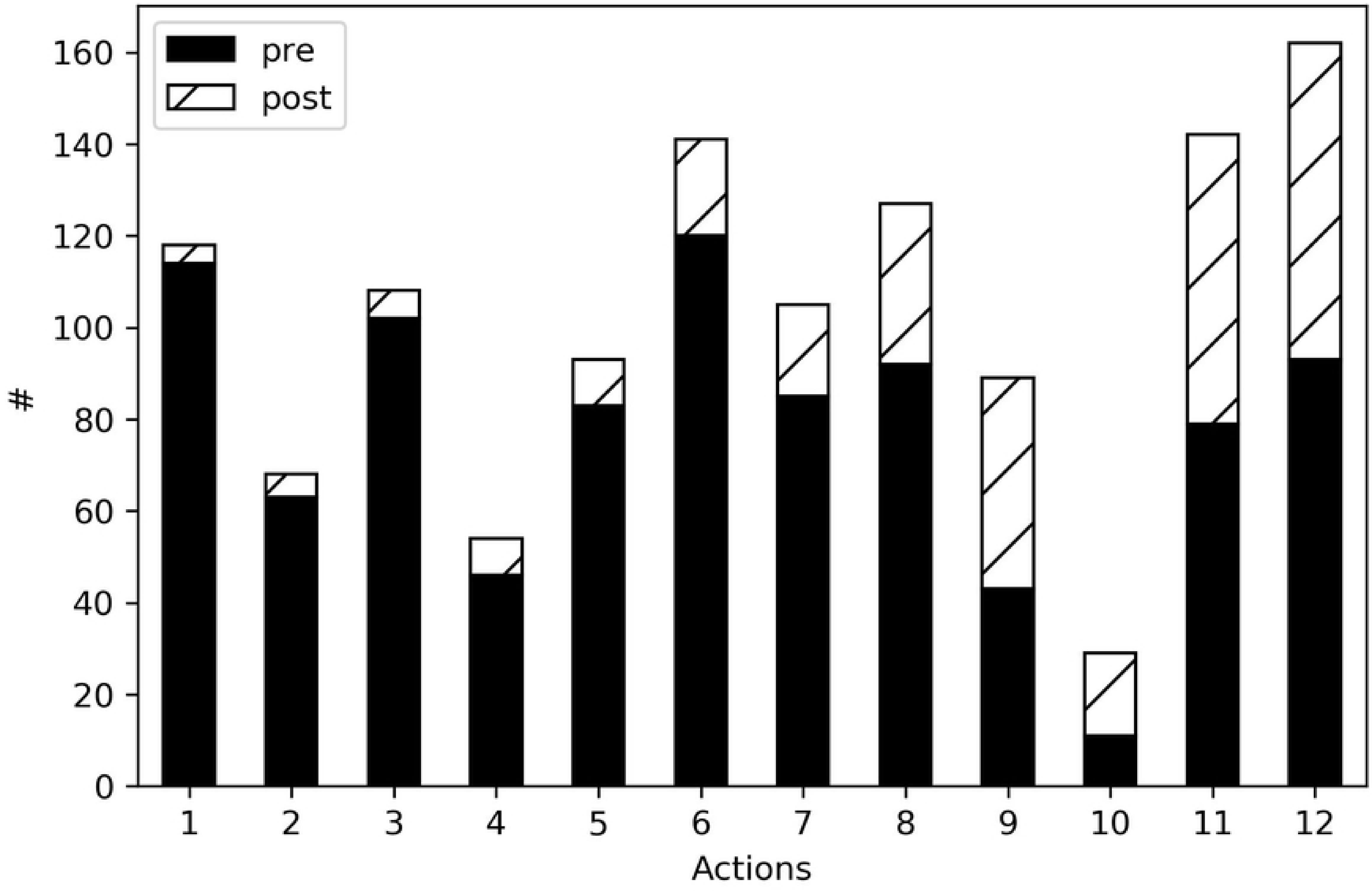

A
VIRTUAL PUBLIC
OPPORTUNITY KNOWLEDGE
PURPOSE DISCUSSIONS SCIENTISTS
UNDERSTANDING EMOTION
ENCOURAGEMENT TEAM
TIME ACCESS RESEARCH
INVESTMENTS CREATING RECIPROCITY CONNECTS MUTUAL
DEEPENS FIELD SITES SHARING
INFORMATION COMMUNITY PROCESS
DIFFERENT DEDICATION LEARNING
INFLUENCE ENGAGEMENT SCIENCE
LISTEN RESEARCHERS POWER
VALUE VISIONS
B
GUIDANCE
OPPORTUNITIES IGNORANCE
TENURE ENGAGEMENT
EFFECTIVE COMMUNICATION CONNECTIONS
FIELD SITES RELATIONSHIPS
INCENTIVES
PROMOTION LEARNING
FUNDING COLLABORATION TRANSLATING
RESOURCES TIME
COMFORT ZONE
OPEN MIND
PATIENCE


A
#
60
50
40
30
20
10
0
B
50
40
30
20
10
0
#
18-24
25-34
35-44
45-54
55-64
65-74
75-84
Age
C
35%
60%
1%
4%
Gender
Man
Woman
Gender-fluid, non-binary and/or Two-Spirit
Prefer not to say
D
20%
7%
4%
1%
68%
Highest education
High school non-graduate
High school graduate
College/Trade
University
Postgraduate


A
B
C
D
Virtual
In person
%
0
20
40
60
80
100
None
Heard of
Aware of
Basic understanding
Very strong understanding


Spearman Rank Correlation
1.00
0.75
0.50
0.25
0.00
−0.25
−0.50
−0.75
−1.00
p-value < 0.05
p-value ≥ 0.05
Prior know. CC
Prior know. WR
Age
Highest educ.
Attendance
Gender
Flood exp.
Drought exp.
SciArt effectiveness
Post feeling


A
Virtual
In person
%
50
40
30
20
10
0
Not at all
Not really
Somewhat
Quite a bit
A lot
B
Virtual
In person
Not at all
Not really
Somewhat
Quite a bit
A lot


pre
post
#
Actions
0
20
40
60
80
100
120
140
160
1
2
3
4
5
6
7
8
9
10
11
12