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Author(s):
Cologna, Viktoria; Berthold, Anne; Kreissel, Anna Lisa; Siegrist, Michael

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Attitudes towards technology and their relationship with pro-environmental behaviour: Development and validation of the GATT scale

Viktoria Cologna [a,b,*], Anne Berthold [a], Anna Lisa Kreissel [a], Michael Siegrist [a]

[a] Institute for Environmental Decisions, ETH Zurich, CH-8092, Zürich, Switzerland
[b] Department of the History of Science, Harvard University, Cambridge, USA

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ABSTRACT

Both behavioural changes and technological advances are needed to mitigate climate change and solve environmental issues. While optimistic attitudes towards technology can help to increase public support for these technological advances, they could also attenuate the perceived necessity for pro-environmental behaviour change. This is problematic, as an overreliance on technological solutions at the cost of behavioural changes could decrease the probability of meeting established climate change mitigation targets. Across three studies in Switzerland ($n_1 = 552$, $n_2 = 547$, $n_3 = 549$), we introduce and validate a 15-item survey instrument to measure general attitudes towards technology (GATT), namely techno-pessimistic, techno-optimistic, and techno-fix attitudes. Confirmatory factor analysis confirms the robustness of the instrument and models based on Item Response Theory indicate acceptable item fit indices. We then investigate how these different attitudes relate to pro-environmental behavioural intentions. Our results show that techno-fix attitudes are negatively associated with behavioural intentions, while techno-optimistic and techno-pessimistic attitudes are positively associated with behavioural intentions through an increase in climate change concern. To foster engagement in pro-environmental behaviour, we recommend strengthening techno-optimistic instead of techno-fix narratives, by highlighting the importance of individual behaviour changes for achieving climate change mitigation.

1. Introduction

Reducing the impact of human activities on the climate and the environment will require both changes in personal behaviour as well as technological advances. Indeed, technological advances are required across the spectrum to decarbonise our energy system, increase its efficiency, and allow for the removal of carbon dioxide from the atmosphere. Optimistic attitudes towards technology are important for the acceptance of these technological advances and developments (Ajzen, 2011). However, optimistic attitudes toward technologies have the potential to undermine the perceived potential of non-technical solutions and the uptake of personal behaviour changes (Byrne et al., 2016; Campbell-Arvai et al., 2017; Lorenzoni et al., 2007; Petersen et al., 2019; Soland, 2013). This could limit the ability to address climate change (York & Clark, 2010), especially so as energy efficiency gains achieved through technological advances often result in rebound effects, leading to an overall increase in energy consumption (Brockway et al., 2021). Techno-optimism can further catalyse psychological rebound effects by weakening individuals' feelings of moral obligation to show pro-environmental behaviour (Soland, 2013; see Santarius and Soland (2018) for a psychological theory of rebound effects). However, the extent to which techno-optimistic attitudes influence pro-environmental behaviour remains understudied. The aim of this article is to introduce and validate a survey instrument to measure different attitudes towards technology in general and to investigate how these attitudes affect pro-environmental behavioural intentions.

This analysis is pertinent as narratives of technological optimism continue to shape our socio-technical imaginaries (Stephens & Markusson, 2018) and climate mitigation assessments (Arvesen et al., 2011). Socio-technical imaginaries can be understood as visions of desirable futures available through technoscientific development (Levidow & Raman, 2020). Indeed, this optimism is reflected in most mitigation scenarios reported by the Intergovernmental Panel on Climate Change (IPCC) Special Report on 1.5 °C (SR1.5), which rely on the strong

* Corresponding author. Institute for Environmental Decisions, ETH Zurich, CH-8092, Zürich, Switzerland.
E-mail address: v.cologna@ikmz.uzh.ch (V. Cologna).

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deployment of negative emission technologies (NETs) to remove vast amounts of carbon dioxide from the atmosphere. However, the assumption of large-scale use of NETs in integrated assessment models (IAM) has been criticised for relying on controversial amounts of carbon dioxide removal and unprecedented technological changes (Anderson & Peters, 2016; Carton, 2020; Keyβer & Lenzen, 2021). Indeed, there is a substantial gap between modelling assumptions on the upscaling and rapid diffusion of NETs and the progress in actual innovation and deployment (Mander et al., 2017; Minx et al., 2018). IAMs have thus largely focused on the technical potential of different mitigation scenarios, but have overlooked the behavioural, cultural, and social factors that affect mitigation pathways (Nielsen et al., 2020).

Given these techno-optimistic modelling assumptions informing policymakers, techno-optimism perpetuates the climate policy discourse, where technological change is prioritised over social change (Stephens & Markusson, 2018) and solutions involving less technological input are considered less frequently (Heikkinen et al., 2019). Techno-optimistic narratives are also featured in the media (Asayama & Ishii, 2017). For example, a Japanese study that examined narratives of carbon capture and storage (CCS) technology in four major Japanese newspapers from 2006 to 2013, found that storylines fostered techno-optimism by viewing CCS as a technological silver bullet, while ignoring risks and uncertainties around it (Asayama & Ishii, 2017). This is considerable, as the media has the potential to influence attitudes towards climate change (Happer & Greg, 2015). Techno-optimistic attitudes are already present among the public, as was found in a poll by the Pew Research Center (Pew Research Center, 2016) showing that 55% of respondents in the US agree that new technology will probably, or definitely, have solved most of the problems caused by global climate change in the next 50 years.

Given the pervasiveness of techno-optimistic narratives, this paper seeks to determine how attitudes towards technology influence support for personal behaviour changes. In what follows, we review the literature on techno-optimism and how it relates to pro-environmental behaviour.

1.1. *Techno-optimism: a double-edged sword*

The effects of technology optimism on climate change mitigation and adaptation behavior are mixed. On the one hand, several studies find that more optimistic attitudes towards technology negatively affect behavioural intentions. For example, by examining data of nearly 5000 US farmers, Gardezi and Arbuckle (2020) found that greater techno-optimism can reduce farmers' support for climate change adaptation and increase their propensity to express a preference to delay adaptation-related actions. In his doctoral dissertation, Soland (2013) further observed that techno-optimism weakens individuals' feelings of moral obligation to act pro-environmentally by reducing both problem awareness and the awareness of the consequences of pro-environmental behaviours. However, they only found this effect for high-cost behaviours (e.g., environmentally friendly travel). Qualitative studies further corroborate the finding that reliance on technology exerts an individual barrier to engaging with climate change by serving as a justification for responsibility denial (Lorenzoni et al., 2007; Stoll-Kleemann et al., 2001). Further, learning about technological solutions to climate change can reduce climate risk perceptions, personal mitigation efforts and policy support. Studies have shown that being informed about technological solutions to climate change (e.g., geoengineering) reduces risk perception regarding climate change and, as a result, attenuates support for mitigation and adaptation policies or private engagement (Campbell-Arvai et al., 2017; Raimi et al., 2019; Wibeck et al., 2015). More generally, optimistic messages about progress on reducing emissions have been found to reduce mitigation motivation (Hornsey & Fielding, 2016).

However, learning about new technologies can also amplify concerns about climate change or increase awareness of climate issues, known as the risk salience hypothesis. For example, Merk et al. (2016) found that providing participants information on stratospheric aerosol injection (SAI) significantly increased participants' purchase of emission offsets due to an increase in threat perception of SAI. This is in line with findings by Kahan et al. (2015) showing that participants exposed to information on geoengineering were more concerned about climate change risks. This could reflect pessimistic attitudes towards technology and their potential to mitigate climate change. Meyers et al. (2023) found that showing participants a video that explains how technologies can be part of the solution to mitigate climate change increased perceptions of hope which in turn positively affected climate policy support. Other studies did not find compelling evidence for the risk salience argument (Carrico et al., 2015) or the relationship between learning about a geoengineering technology and support for climate policy (Fairbrother, 2016). These contrasting findings in the literature could be related to individuals' general attitudes towards technologies. The lack of a scale to measure such attitudes thus presents an important limitation.

To sum up, techno-optimism can be considered a double-edged sword: on the one hand, optimistic attitudes towards technology can increase public support for technologies and climate policy. On the other hand, techno-optimism can crowd out personal behaviour changes and policy support by reducing perceptions of risk and responsibility. Our paper seeks to explore this ambiguous relationship by introducing and validating scales to measure General Attitudes Towards Technology (GATT) and assessing their relationship with pro-environmental behavioural intentions.

1.2. *The present research*

The literature acknowledges the existence and interplay of various attitudes towards technology. The most commonly discussed attitudes include techno-optimistic and techno-pessimistic (or sceptical) attitudes (Barry, 2016; Dentzman et al., 2016; Fletcher et al., 2021; Kerschner & Ehlers, 2016; see Kozinets (2008) for an overview of technology ideologies). To the best of our knowledge, no empirically validated scale exists that assesses different types of attitudes towards technology. Previous studies used to measure individual attitudes either relied on single items (Drews et al., 2019) or two-item scales (Fletcher et al., 2021), or were not published in peer-reviewed journals (Jakobs et al., 2005; Soland, 2013). We address this important gap in the literature by introducing and validating scales to measure techno-optimistic and techno-pessimistic attitudes and assessing how they relate to behavioural intentions. Attitudes can broadly be defined as favourable or unfavourable feelings towards a particular attitude object or behaviour (Ajzen & Fishbein, 2005). Attitudes are generally regarded as more or less stable personal dispositions, that successfully explain past behaviour and predict future behaviour (Kroesen & Chorus, 2018). We understand techno-optimistic attitudes to relate to benefit perceptions and techno-pessimistic attitudes to relate to risk perceptions of technologies. Indeed, risk and benefit perceptions of technologies have been found to influence attitudes towards technology (Sjöberg, 2002) as well as the uptake of and support for different technologies and related behaviours (Bearth & Siegrist, 2016; Jobin & Siegrist, 2020; Siegrist et al., 2000).

While previous studies analysed how information about specific NETs influences mitigation support, to the best of our knowledge no study has analysed whether and how underlying general attitudes towards technology influence pro-environmental behaviour. We believe that the assessment of attitudes towards technology in general, rather than specific technologies, fills an important gap in the literature. This approach further allows to overcome methodological challenges related to measuring attitudes towards specific technologies, such as NETs, and their influence on behavioural intentions. As familiarity with NETs is very low among the public (Carlisle et al., 2020), responses will be very sensitive to the wording of questions and the information on NETs provided in the surveys (Pidgeon et al., 2012). This might explain why some studies find that information about technologies leads to *decreased* mitigation support, while others find that information about technologies leads to *increased* mitigation support.

In exploratory Study 1, we review the literature to collect items that have been used to measure attitudes towards technology, analyse the reliability of the resulting survey instrument, and investigate the relationship between techno-optimistic and techno-pessimistic attitudes and behavioural intentions. In Study 2, we add a measure of techno-fix attitudes and assess how the three attitudes relate to behavioural intentions. In the pre-registered Study 3, we validate the survey instrument used to measure techno-optimistic, techno-pessimistic, and techno-fix attitudes with a confirmatory factor analysis and their association with behavioural intentions. Lastly, based on Item Response Theory (Hambleton et al., 1991), we use Graded Scale Response Models (Samejima, 2005) to assess the measurement precision of individual items of the three GATT sub-scales.

These studies significantly contribute to the literature by (1) introducing a robust and empirically validated survey instrument to measure general attitudes towards technology (GATT); (2) investigating how these attitudes towards technology influence behavioural intentions; and (3) providing recommendations for climate change communicators on how to avoid the elicitation and strengthening of techno-fix attitudes.

2. Study 1

2.1. Methods

2.1.1. Sample

In June 2020, we recruited $n = 552$ Swiss participants through a professional provider of consumer panels. We only invited participants from the German-speaking part of Switzerland and applied gender and age quotas to obtain a balanced sample. Overall, 50% of participants declared to be female (n = 277) and the mean age of our sample was 46 ($SD = 14.42$), which is close to the average age in Switzerland of 43 years (BFS, 2020). The data and code used to compute all analyses reported in the manuscript are available at: https://osf.io/76kyt/.

2.1.2. Questionnaire

We assessed *General Attitudes Towards Technology (GATT)* with 18 items that focused on the perceived risks and benefits of technology, technology's role for the national economy and the influence of technology on our lives (Table S1). We selected items based on a review of the literature. Nine items were taken from the European Commission for Special Eurobarometer 340: Science and Technology - European Union Open Data Portal, 2010. These double-barreled items relate to both science and technology, and we adapted these items so they would only refer to technology and not to science. One additional item was selected from Kerschner and Ehlers (2016) and one from Martínez-Córcoles et al. (2017). Two modified items were taken from Drews et al. (2019), whereby the term "economic growth" was substituted with "technological innovation". All English items were translated to German by the third author and retranslated by the first author, to compare the accuracy of translations. Where translations differed, the first and third author discussed until agreement on wording was reached. Lastly, we included five items from Jakobs et al. (2005), one of which we adapted from the German to the Swiss context. We assessed participants' agreement with the items on a six-point Likert scale from 1 = strongly disagree to 6 = strongly agree.

Willingness to adopt pro-environmental behaviours was assessed with eight items, six of which were originally developed by Tobler et al. (2012), for example "To what extent are you willing to offset CO_2 emissions (e.g., from flights)?" (Table 1). Intentions were measured on a 7-point scale from 1 = not at all willing to 6 = extremely willing and 7 = already doing so (Cronbach's α = 0.82).

Climate change concern was assessed with four items from Shi et al. (2016) on a scale from 1 = strongly disagree to 6 = strongly agree that have been validated in Switzerland, for example "I worry that the state of the climate is changing" (Cronbach's α = 0.92; Table 1). All data analysis was conducted in R Studio (Posit team, 2023).

Table 1
Survey items included in Study 1.

Scale label	Items	Response options	Source	Cronbach's α
Pro-environmental behavioural intentions	*To what extent are you willing to engage in the following behaviours in the future?* Volunteering for a climate protection group (e.g., Greenpeace) Reducing meat consumption (max. 2 times a week) Setting your thermostat to 20 °C or lower during the cold season Avoiding flights for holidays Avoiding car use for commuting to work Donating money to climate protection projects Offsetting CO_2 emissions (e.g., from flights) Voting for politicians who support climate policies	1 = not willing at all to 6 = extremely willing 7 = already showing this behavior	First six items: Tobler et al. (2012)	0.82
Climate change concern	I worry that the state of the climate is changing. Climate change has severe consequences for humans and nature. Climate protection is important for our future. We must protect the climate's equilibrium.	1 = strongly disagree to 6 = strongly agree	Shi et al. (2016)	0.92

2.2. Results study 1

2.2.1. Exploratory factor analysis

Before conducting an exploratory factor analysis using all 18 GATT items, we verified sampling accuracy with the Kaiser-Meyer-Olkin (KMO) measure which resulted in a value of 0.86 (above the commonly recommended value of 0.60). Bartlett's test of sphericity further indicated sufficient significant correlation in the data for factor analysis ($\chi2$ (153) = 3303.673, $p < 0.001$). Q–Q plots and Mardia's test (skewness: $z_{1,18} = 3928.973$, $p < 0.001$; kurtosis: $z_{2,18} = 62.692$, $p < 0.001$) suggested that multivariate normality was very unlikely. Therefore, we used principal axis factoring (PAF) instead of maximum likelihood (ML) estimation since it is more robust to nonnormality (Beavers et al., 2019). We used oblique rotation using the Promax method given that our factors are likely correlated and oblique rotation controls for shared variance between the factors (Beavers et al., 2019). To estimate the number of factors to extract, we ran Parallel Analysis and Very Simple Structure (VSS) analysis. Parallel analysis suggests a number of factors by comparing eigenvalues of the real data with simulated data, while VSS analysis "determines the optimal number of factors by considering increasing levels of factor complexity, with the optimal number of factors being the solution where complexity one has the highest value" (Dima, 2018, p. 151). The parallel analysis suggested extracting five factors (Fig. S1), while results of the VSS analysis suggested a two-factor solution as optimal (Fig. S2). We therefore decided to first explore a five-factor solution in more detail (Table S2). Items measuring concern about the development of technologies and related uncertainties loaded on Factor 1. Items measuring the positive effects of technologies on the economy and development loaded on Factor 2. Items measuring positive views that technologies can solve problems, increase life satisfaction, and that the benefits are greater than potential harm loaded on Factor 3. Items assessing the negative effects of technologies on human rights and moral sense loaded on Factor 4. Lastly, Factor 5 captured two items measuring the positive view that technologies make our lives easier and expand our limits. Main factor loadings ranged from 0.30 to 0.93. Thus, the five factors measure different types of positive/optimistic and negative/pessimistic attitudes towards technology. Items measuring optimistic attitudes focus on the benefits of technologies, while items measuring pessimistic attitudes towards technologies focus on the risks of technologies. Given the theoretical soundness of distinguishing between perceived risks and benefits in the context of technologies (Jobin & Siegrist, 2020; Siegrist et al., 2000, 2007), the results of the VSS analysis suggesting a two-factor solution, and following the Kaiser Criterion which states that factors should be only retained if their eigenvalues are equal or larger than one (Beavers et al., 2019), we explored a two-factor solution (Table S3). To obtain a robust and unambiguous factor solution, we carefully reviewed our factor structure and excluded one item with cross loadings (GATT 9) and four items with the lowest factor loadings (GATT 2, GATT 10, GATT 12, GATT 18). Our final two-factor solution with 13 items explained 44% of variance (Factor 1 = 23%, Factor 2 = 21%). Main factor loadings ranged from 0.51 to 0.83 and communalities were between 0.30 and 0.66 (Table 2).

2.2.2. *Mediation analysis*

An inspection of the correlation table shows that techno-pessimistic attitudes correlate positively with behavioural intentions, while techno-optimistic attitudes show no correlation with behavioural intentions (Table 3).

Given the fact that previous studies found the perceived threat of climate change to mediate the relationship between information on NETs and mitigation support (Campbell-Arvai et al., 2017; Raimi et al., 2019), we conducted a mediation analysis to test whether climate change concern would mediate the relationship between techno-pessimistic and techno-optimistic attitudes and behavioural intentions. A post-hoc Monte Carlo power analysis for indirect effects with 20,000 coefficient draws per replication (Schoemann et al., 2017) showed that given the standardized effects found below and with a sample size of $n = 552$, our study has a power of >99% to detect the hypothesised indirect effects for techno-pessimistic and techno-optimistic attitudes.

Before running the mediation analysis, we centered the two independent variables techno-optimistic and techno-pessimsitic attitudes. We found a small significant indirect effect of techno-pessimistic attitudes on behavioural intentions through climate change concern, $b = 0.17$, $SE = 0.03$, 95% BCa CI [0.12, 0.23] (Fig. 1). The more pessimistic individuals were about technologies, the more concerned they were about climate change and the more likely they indicated to perform pro-environmental behaviour.

Similarly, we found a small significant indirect effect of techno-optimistic attitudes on behavioural intentions through climate change

Table 2
Results of the exploratory factor analysis for the final 13-item solution in Study 1.

% of total variance explained			Techno-optimism	Techno-pessimism	
			22.5	20.6	
Label	Item	*M* (SD)	λFactor 1	λFactor 2	h^2
GATT 1	Technology makes our lives easier and more comfortable.	4.53 (0.94)	0.66		0.45
GATT 3	Continued technological innovation is essential for improving people's life satisfaction.	3.60 (1.12)	0.57		0.38
GATT 4	Technology makes our way of life change too fast.a	4.21 (1.20)		0.58	0.33
GATT 5	Technology expands our limits.	4.44 (0.94)	0.68		0.45
GATT 6	Technology creates novel problems.[a]	4.44 (1.04)		0.68	0.45
GATT 7	Technology can sometimes damage people's moral sense.[a]	4.43 (1.04)		0.70	0.47
GATT 8	The applications of technology can threaten human rights.[a]	4.07 (1.21)		0.61	0.37
GATT 11	If a new technology poses risks that are uncertain and not yet fully understood, the development of this technology should be stopped even if benefits are expected.[a]	3.90 (1.18)		0.51	0.30
GATT 13	Limits need to be set for technological progress.[a]	3.99 (1.22)		0.61	0.38
GATT 14	I am worried about new technologies fraught with uncertainties.[a]	3.75 (1.23)		0.59	0.42
GATT 15	Without technological innovation the economy will become less stable.	3.97 (1.12)	0.55		0.31
GATT 16	Technology means progress.	4.41 (0.99)	0.80		0.64
GATT 17	The development of technologies is important for the Swiss economy.	4.53 (0.99)	0.83		0.66
Cronbach's α			0.83	0.80	

Note. $n = 552$. Extraction method: principal axis factoring. Rotation method: Promax. Loadings $\lambda < 0.20$ not displayed. [a] denotes recoded items. For the following analyses, the non-recoded values are used so that higher values correspond to more techno-pessimistic attitudes. R package used: psych 2.3.6 (Revelle, 2023).

Table 3
Pearson correlations for main variables in Study 1.

Variables	*M* (*SD*)	1	2	3
1. Techno-pessimistic attitudes	4.11 (0.79)			
2. Techno-optimistic attitudes	4.25 (0.75)	−18**		
3. Behavioural intentions	4.19 (1.19)	0.16**	0.02	
4. Climate change concern	4.80 (1.03)	0.25**	0.19**	0.57**

Note. $n = 552$. All scales were measured on a scale from 1 (= strongly disagree) to 6 (= strongly agree) with the exception of the behavioural intention scale, which was measured on a scale from 1 = not willing at all to 7 = already showing this behaviour. $^{*}p < 0.05$, $^{**}p < 0.01$.

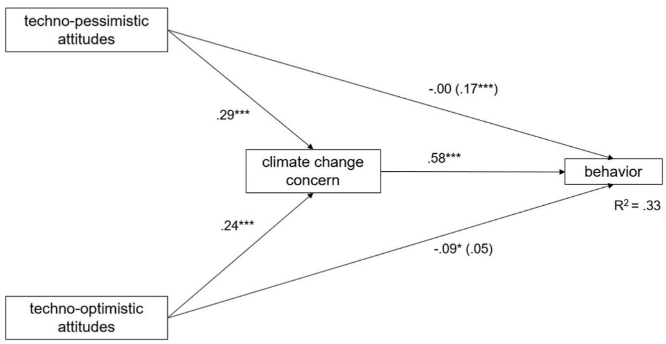

Fig. 1. Standardised regression coefficients for the relationship between techno-pessimistic attitudes and behavioural intentions as mediated by climate change concern.
Note. The total effect is presented in parentheses.

concern, $b = 0.14$, $SE = 0.03$, 95% BCa CI [0.08, 0.21]. Here, climate change concern acts as a suppressor, whereby its addition to the model leads to a negative direct effect of techno-optimistic attitudes on behavioural intentions. According to the correlation coefficients presented in Table 2, there was no significant linear relation between general techno-optimistic attitudes and behavioural intentions. However, when inspecting the relationship more closely, we observed a significant quadratic relationship ($\beta = -0.91$, $SE = 0.05$, $p < 0.001$). Specifically, we found that optimistic attitudes correlate positively with behavioural intentions up to a certain point, after which the data reveals a negative correlation (Fig. S3).

We therefore hypothesise that our techno-optimistic attitudes scale might have captured two attitudes instead of just one: techno-optimistic attitudes that positively correlate with behavioural intentions and techno-fix attitudes that negatively correlate with behavioural intentions. Individuals holding techno-fix attitudes might be so optimistic about technology that they do believe behavioural changes are unnecessary. We hypothesise that techno-fix attitudes might negatively influencing the uptake of pro-environmental behaviours, while techno-optimistic attitudes will positively influence their uptake.

We decided to conduct a follow-up study to examine whether techno-fix attitudes could be empirically distinguished from techno-optimistic attitudes, and if so, how they influence pro-environmental behavioural intentions.

3. Study 2

Given the findings of Study 1, we aimed to introduce and test a scale to measure techno-fix attitudes and to investigate whether it could be empirically distinguished from techno-optimistic attitudes. To the best of our knowledge, no scale has previously been empirically validated to measure techno-fix attitudes, though Drews et al. (2019) used a one-item measure to assess techno-fix attitudes. While an empirical assessment is lacking, techno-fix attitudes have conceptually been described in the literature. Since previous studies do not distinguish between techno-optimism and techno-fix attitudes, what we describe as techno-fix attitudes here is often referred to as techno-optimism in the literature. For example, York and Clark (2010, p. 481) describe such techno-fix attitudes as claims that "technological breakthroughs will serve as the means to address each and every environmental problem that arises, allowing society to overcome natural limits and all socio-ecological challenges". Relatedly, Barry (2016, p. 108) describes them as "exaggerated and unwarranted belief [s] in human technological abilities to solve problems of unsustainability while minimising or denying the need for large-scale social, economic, and political transformation". Based on these sources, we define techno-fix attitudes as highly optimistic attitudes towards technologies that lead individuals to believe that technologies can solve all problems thereby undermining the perceived need for individual behaviour changes. Thus, techno-fix attitudes present a different type of optimism than the one we assessed with our original techno-optimistic attitudes scale in Study 1, which was based on benefit perceptions of technologies. Given the results from Study 1 and the wider literature (Fletcher et al., 2021), we expect general techno-pessimistic attitudes to be positively related to behavioural intentions through a higher climate change concern. Further, we expect that stronger techno-fix attitudes should relate to weaker behavioural intentions through lower climate change concern.

3.1. Methods

3.1.1. Sample

To extend and validate our results from Study 1, we recruited $n = 547$ Swiss participants from the German-speaking part of Switzerland through a professional provider of consumer panels in March 2021. Overall, 52% of participants declared to be female ($n = 284$) with a mean age of 46 ($SD = 14.25$), which is close to the average age in Switzerland of 43 years (BFS, 2020). This study was approved by the ETH Zurich Ethics Commission (EK 2021-N-20).

3.1.2. Questionnaire

Techno-pessimistic and techno-optimistic attitudes were measured with three items each (Table S4), all but one taken from Study 1, and assessed agreement with the statements on a six-point Likert scale from 1 = strongly disagree to 6 = strongly agree. We further created three new items to measure techno-fix attitudes, e.g., "Individual behavioural changes are completely unnecessary, because technological innovations will solve all our problems".

Willingness to adopt pro-environmental behaviours was assessed with nine items, including "reducing food waste" and "switching to a sustainable diet", on a six-point Likert scale from 1 = strongly disagree to 6 = strongly agree (Cronbach's α = 0.78; Table 4). These items were taken from taken from Ivanova et al. (2020), Wynes et al. (2020), Wynes and

Table 4
Measure of pro-environmental behavioural intentions in Study 2.

Scale label	Items	Response options	Sources	Cronbach α
Pro-environmental behavioural intentions	*In the face of climate change, I am willing to do the following activities ….* Avoid one transatlantic flight a year (e.g., Zurich – New York) Buy only unpackaged food Save stand-by electricity (400 kWh/a) Install efficient light bulbs Reduce food waste Switch to a sustainable diet (less meat, more fruits and vegetables) Less car transport; Use public transport for shorter distances Switch from plastic to canvas bags Have one fewer child	1 = strongly disagree 6 = strongly agree	Ivanova et al. (2020); Wynes et al. (2020); Wynes and Nicholas (2017)	0.78

Nicholas (2017) and Grieβhammer et al. (2010). This scale reflects the recent call to include measures of high-impact behaviours in environmental psychology research (Lange et al., 2021; Nielsen et al., 2021). Climate change concerned was measured as in Study 1 (Cronbach α = 0.93). Other variables assessed in the questionnaire were used for a different study (Cologna, Berthold, & Siegrist, 2022).

3.2. Results study 2

3.2.1. Exploratory factor analysis

To explore the empirical soundness of a three-factor solution (techno-pessimism, techno-optimism, and techno-fix), we conducted an exploratory factor analysis. We first verified sampling accuracy with the Kaiser-Meyer-Olkin measure which resulted in an acceptable value of 0.70. Bartlett's test of sphericity further indicated sufficient significant correlation in the data for factor analysis ($\chi2$ (36) = 1354.533, $p <$ 0.001). Q–Q plots and Mardia's test (skewness: $z_{1,9}$ = 629.016, $p <$ 0.001; kurtosis: $z_{2,9}$ = 20.814, $p < 0.001$) suggested that multivariate normality was very unlikely. As in Study 1, we used principal axis factoring (PAF) and oblique rotation using the Promax method. The exploratory factor analysis confirmed the empirical soundness of distinguishing between the three factors. However, one of our techno-optimism items loaded on the techno-fix scale (Table S4), so we decided to remove this item from our analyses. Internal reliability for the three scales was good (Cronbach's α ≥ 0.69).

3.2.2. Mediation analysis

As in Study 1, techno-pessimistic attitudes correlated positively with pro-environmental behavioural intentions, while optimistic attitudes did not (Table S5). As hypothesised, our newly introduced techno-fix scale correlated negatively with behavioural intentions. A post-hoc Monte Carlo power analysis for indirect effects with 20,000 coefficient draws per replication (Schoemann et al., 2017) showed that given the standardised effects found below and with a sample size of $n = 547$, our study has a power of 80% to detect the hypothesised indirect effects for techno-pessimistic attitudes and a power of >99% to detect the hypothesised indirect effects for techno-optimistic and techno-fix attitudes.

Even though general techno-optimistic attitudes and behavioural intentions were initially not correlated, when analysing the relationships of the different variables together within one mediation model we found a significant indirect effect of techno-optimistic attitudes towards technology on behavioural intentions through climate change concern, $b = 0.11$, 95% BCa CI [0.06, 0.16] (Fig. 2).

As in Study 1, we found a small significant indirect effect of techno-pessimistic attitudes on behavioural intentions through climate change concern, $b = 0.06$, 95% BCa CI [0.02, 0.10]. Thus, according to the data, both techno-optimistic and techno-pessimistic attitudes are positively associated with behavioural intentions, and this effect is fully mediated by climate change concern. Regarding techno-fix attitudes, we found a small significant indirect effect of behavioural intentions through climate change concern, $b = -0.12$, 95% BCa CI [-0.17, −0.08]. Techno-fix attitudes are therefore negatively associated with behavioural intentions through a decrease in climate change concern. As expected from the literature, concern was strongly positively associated with behavioral intentions. Overall, our model explained $R^2 = 28\%$ of the variance in behavioural intentions.

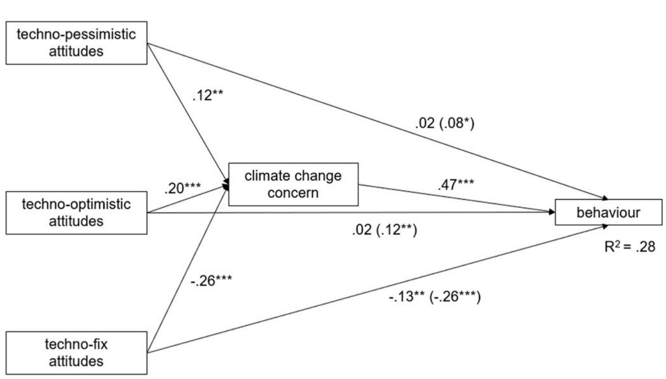

Fig. 2. Standardised regression coefficients for the relationships between techno-optimistic attitudes, techno-pessimistic attitudes and techno-fix attitudes and behavioural intentions as mediated by climate change concern.
Note. The total effects are presented in parentheses. Independent variables were centered.

4. Study 3

The aim of Study 3 was to validate the findings of Study 2 and to propose a robust survey instrument that can be used to assess technology-related attitudes. To this end, we pre-registered the following hypotheses based on Study 2 (https://osf.io/ahtyj).

H1a. Techno-fix attitudes will negatively affect pro-environmental behaviour.

H1b. The effect of techno-fix attitudes on behaviour will be partly mediated by climate change concern.

H2a. Techno-optimistic attitudes will positively affect pro-environmental behaviour.

H2b. The effect of techno-optimistic attitudes on behaviour will be fully mediated by climate change concern.

H3a. Techno-pessimistic attitudes will positively affect pro-environmental behaviour.

H3b. The effect of techno-pessimistic attitudes on behaviour will be fully mediated by climate change concern.

H4. Climate change concern will positively affect pro-environmental behaviour.

4.1. Methods

4.1.1. Sample

We recruited $n = 549$ Swiss participants from the German-speaking part of Switzerland through a professional provider of consumer panels in May 2023. Overall, 49.6 % of participants declared to be female ($n = 272$), 50.4% declared to be male ($n = 276$), and one person selected the response option "I prefer to self-describe", with a mean age of 45 ($SD = 15.30$), which is close to the average age in Switzerland of 43 years (BFS, 2020). This study was considered exempt from full IRB review by the Harvard University-Area Committee on the Use of Human Subjects (protocol # IRB23-0501) and approved by the ETH Zurich Ethics Commission (EK 2023-N-104).

4.1.2. Questionnaire

We measured techno-pessimistic and techno-optimistic attitudes with six items each, all taken from Study 1 (four of which have also been used in Study 2) and developed three new items on top of our three-item techno-fix scale used in Study 2 (Table S4) to assess six items for each scale. The level of agreement with the statements was measured as in Study 1 and 2 with a six-point Likert scale from 1 = strongly disagree to 6 = strongly agree.

We assessed the willingness to adopt pro-environmental behaviours with seven out of nine items previously used in Study 2 on a six-point Likert scale from 1 = strongly disagree to 6 = strongly agree (Cronbach's α = 0.78; Table S6). We decided not to include the item "have one fewer child" used in Study 2, as this item was likely of little relevance to a large proportion of our sample. Climate change concern was measured as in Study 1 and Study 2 (Cronbach α = 0.93).

4.2. Methods

4.2.1. Confirmatory factor analysis

Following our pre-registration, we conducted a confirmatory factor analysis by specifying three latent factors (techno-pessimism, techno-optimism, and techno-fix) and six indicators for each factor. Model 1 did not meet established cut-off criteria: comparative fit index (CFI) = 0.873, Tucker–Lewis index (TLI) = 0.852, root mean square error of approximation (RMSEA) = 0.080, standardized root mean square residual (SRMR) = 0.078 (Hu & Bentler, 1999). This can be explained by the fact that three items – one on each scale – had significant cross-loadings (Tpess 3, Topt 2, and Tfix 6; Table S7). After a careful inspection of the items in question, we decided to remove these items and run a confirmatory factor analysis (CFA) with three latent factors (techno-pessimism, techno-optimism, and techno-fix) and five indicators for each factor (Model 2). CFA results revealed that fit indices for Model 2 met established cutoff criteria: CFI = 0.992, TLI = 0.905, RMSEA = 0.067, SRMR = 0.060 (Hu & Bentler, 1999). A comparison of the Akaike Information Criterion (AIC) and Expected Cross Validation Index (ECVI) between Model 1 (AIC = 28067.70, ECVI = 1.223) and Model 2 (AIC = 23602.86, ECVI = 0.667) further confirms the better model quality of Model 2 (AIC) as well as the higher likelihood that Model 2 will replicate with the same sample size and population than Model 1 (ECVI). Our final three-factor solution with 15 items explained 48.2% of variance, main factor loadings ranged from 0.55 to 0.82, communalities were between 0.33 and 0.59, and Cronbach's α was very good for all three scales (≥ 0.78) (Table 5).

As in Study 2, we find that techno-pessimistic attitudes correlate positively with behavioural intentions and that techno-fix attitudes correlate negatively with behavioural intentions (Table S8). As opposed to Study 1 and Study 2, we now find a direct positive correlation between techno-optimistic attitudes and behavioural intentions.

4.2.2. Mediation analysis

A post-hoc Monte Carlo power analysis for indirect effects with 20,000 coefficient draws per replication (Schoemann et al., 2017) showed that given the standardised effects found below and with a sample size of $n = 549$, our study has a power of >99% to detect the hypothesised indirect effects for techno-pessimistic and techno-optimistic attitudes and given the non-significant relationship between techno-fix attitudes and climate change concern insufficient power (47%) detect the hypothesised indirect effects for techno-fix attitudes.

Our mediation analysis in Study 3 reveals a similar pattern as the mediation analysis in Study 2 (Fig. 3). We find significant indirect effects of techno-pessimistic attitudes ($b = 0.11$, 95% BCa CI [0.06, 0.15]) and techno-optimistic attitudes ($b = 0.16$, 95% BCa CI [0.11, 0.21]) on behavioural intentions through concern, even if, against our pre-registered hypotheses, these effects were only partially, and not fully, mediated by climate change concern. Therefore, people with techno-pessimistic attitudes and those with techno-optimistic attitudes, are more likely to report pro-environmental behavioural intentions due in part to an increased level of climate change concern.

However, in Study 3 we did not find the significant indirect effect of techno-fix attitudes on behavioural intentions through concern as we found in Study 2. However, people with techno-fix attitudes appear to be less likely to indicate pro-environmental behavioural intentions irrespective of their levels of climate change concern.

5. Measurement precision of scales and individual items

Next to establishing the internal robustness and reliability of our three GATT sub-scales techno-optimism, techno-pessimism, and techno-fix, we estimated the measurement precision of our survey scales at the scale- and item-level based on Item Response Theory (Hambleton et al., 1991). Item Response Theory describes the relationship between individuals' latent traits (in our case: attitudes towards technology) and the properties of items measuring these traits (in our case: the precision of the GATT items) with the use of "functions that give the probabilities of each possible item response for a randomly selected subject with a given latent trait" (Uttaro & Lehman, 1999, p. 1). It therefore provides information on how well the scales measure our latent traits. Given the ordered polytomous structure of our data with response categories ranging from 1 = strongly disagree to 6 = strongly agree, we examined

Table 5
Final three-factor solution of general attitudes towards technology (GATT) items.

% of total variance explained		Techno-fix	Techno-optimism	Techno-pessimism	
		18.1	15.8	14.3	
Label	**Item**	λFactor 1	λFactor 2	λFactor 3	h^2
Tpess 1	Technology makes our way of life change too fast.			0.58	0.33
Tpess 2	Technology creates novel problems.			0.64	0.48
Tpess 4	The use of technology can threaten human rights.			0.69	0.48
Tpess 5	Limits need to be set for technological progress.			0.70	0.49
Tpess 6	I am worried about new technologies fraught with uncertainties.			0.64	0.42
Topt 1	Technology makes our lives easier and more comfortable.		0.65		0.46
Topt 3	Technology expands our limits.		0.70		0.46
Topt 4	Without technological innovation the economy will become less stable.		0.55		0.36
Topt 5	Technology means progress.		0.67		0.50
Topt 6	The development of technologies is important for the Swiss economy.		0.75		0.53
Tfix 1	Technological innovations will allow us to carry on with our current lifestyles without any limitations.	0.64			0.49
Tfix 2	Thanks to technological progress we do not need to change our behavior at all.	0.82			0.58
Tfix 3	Technological solutions can solve all our problems.	0.79			0.59
Tfix 4	Technological solutions are the most effective way of solving society's problems.	0.69			0.57
Tfix 5	Technological innovations are more effective at solving society's problems than individual behavioral changes.	0.67			0.52
	Cronbach's α	*0.85*	*0.80*	*0.78*	

Note. $n = 549$. Analysis based on Study 3 data. Items measured using 6-point Likert scales with higher values indicating stronger agreement. Table shows translated items. Loadings $\lambda < 0.20$ not displayed. Three factors extracted with parallel analysis. Extraction method: Principal Axis Factoring. Rotation method: Promax. R package used: psych 2.3.6 (Revelle, 2023).

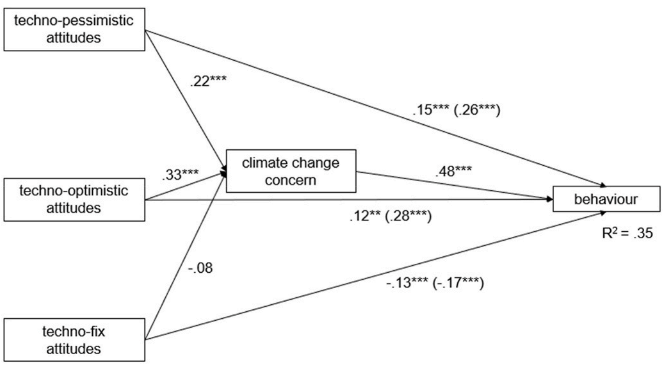

Fig. 3. Standardised regression coefficients for the relationships between techno-optimistic attitudes, techno-pessimistic attitudes and techno-fix attitudes and behavioural intentions as mediated by climate change concern.
Note. The total effects are presented in parentheses. Independent variables were centered.

Graded Scale Response Models (Samejima, 2005) with the mIRT package in R (Chalmers, 2012).

First, we inspect scale information functions and compute conditional standard errors (Fig. 4). Scale information functions provide a summary of the extent to which items, overall, provide information about individual differences along the latent trait ($I\theta$). Unlike scale reliability in classical test theory, IRT scale and item information varies as a function of the latent variable; for example, certain items may only provide information about individual differences at low (or high) levels of the trait. Standard errors, which are inversely related to scale information, indicate the precision with which scores can be estimated across values of θ. For the techno-optimism and techno-pessimism scales, conditional standard errors increased with higher levels of θ, indicating that our scales measure lower and moderate levels of these latent traits more accurately than higher levels. Conversely, for our techno-fix scale, conditional standard errors increased with lower levels of θ, showing that our scale measures moderate and higher levels of this latent trait more accurately.

Second, we examine the relative contribution of each item for each of our scales by breaking down our scale information function into individual item functions (Fig. 5). For the techno-pessimism scale, we find that items Tpess4 and Tpess5 are most informative (i.e., higher levels of I θ), meaning that they best discriminate individuals across different levels of the latent construct. This can also be observed in Table 6 which shows that these items have higher discrimination values a. Higher levels of a indicate steeper parameter slopes and therefore better discrimination of θ. The category thresholds (or location parameters) indicate the location on the latent variable at which a respondent has a 50% probability of endorsing that particular response category or one that is higher. Given that we have six response categories, five category thresholds are modelled (b1-b5; the probability of endorsing the first category or higher is 1). For the techno-pessimism scale, we find that responses covered a wide range of the latent trait (individual item probability functions can be found in the Supplementary Material). For the techno-optimism scale, we find that items Topt 5 and Topt6 have the highest discrimination values, and that these values are higher than for the techno-pessimism scale. Overall, the items of the techno-fix scale have the highest discrimination values, even though responses covered a smaller range of the latent trait compared to the other scales. We conclude that our scales provide a good foundation for assessing different attitudes towards technology, even though they are slightly limited in their assessment of more extreme attitudes. We encourage future research to investigate the cross-cultural validity of our scales and to potentially add individual items that increase item information functions.

6. General discussion

To reduce human impacts on the environment, both behavioural changes and technological advances and uptakes are needed. Yet, theoretical arguments and empirical evidence indicate that optimistic attitudes towards technologies have the potential to undermine the perceived necessity for personal behaviour changes. This is problematic, as an overreliance on technological solutions to climate change at the expense of potential behavioural changes significantly decreases the chances of achieving net zero emissions by mid-century (Keyβer & Lenzen, 2021). This study makes an important contribution to the environmental psychology literature by developing and validating a robust survey instrument to measure techno-pessimistic, techno-optimistic, and techno-fix attitudes and investigating how these attitudes

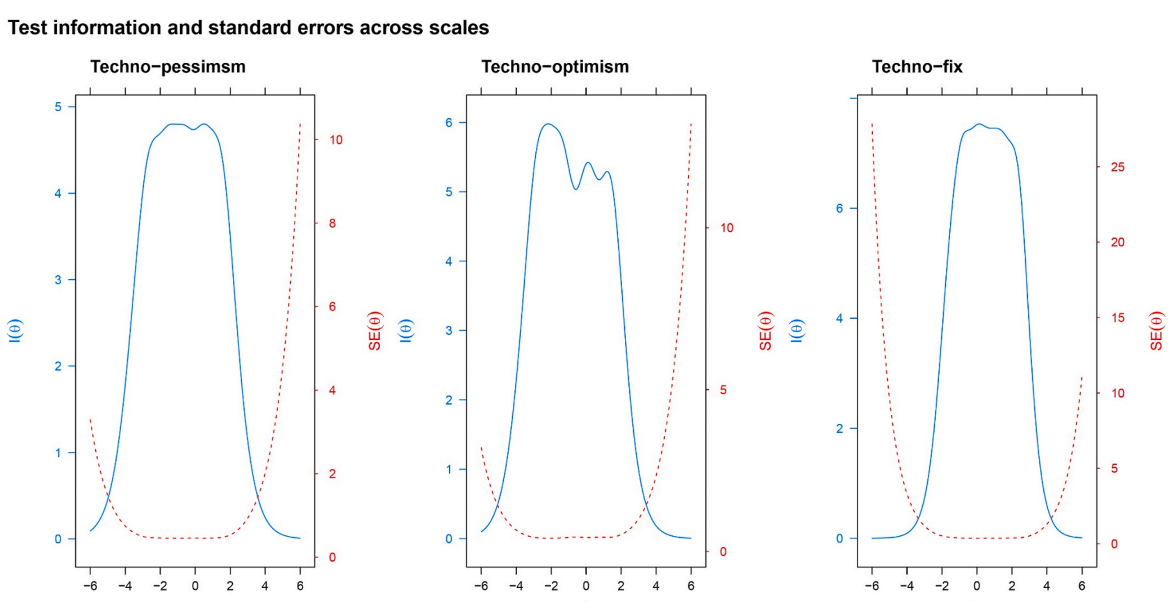

Fig. 4. Test information and conditional standard errors for final three GATT sub-scales based on data from Study 3.
Note. I θ = Information, θ = latent trait, SE = standard errors.

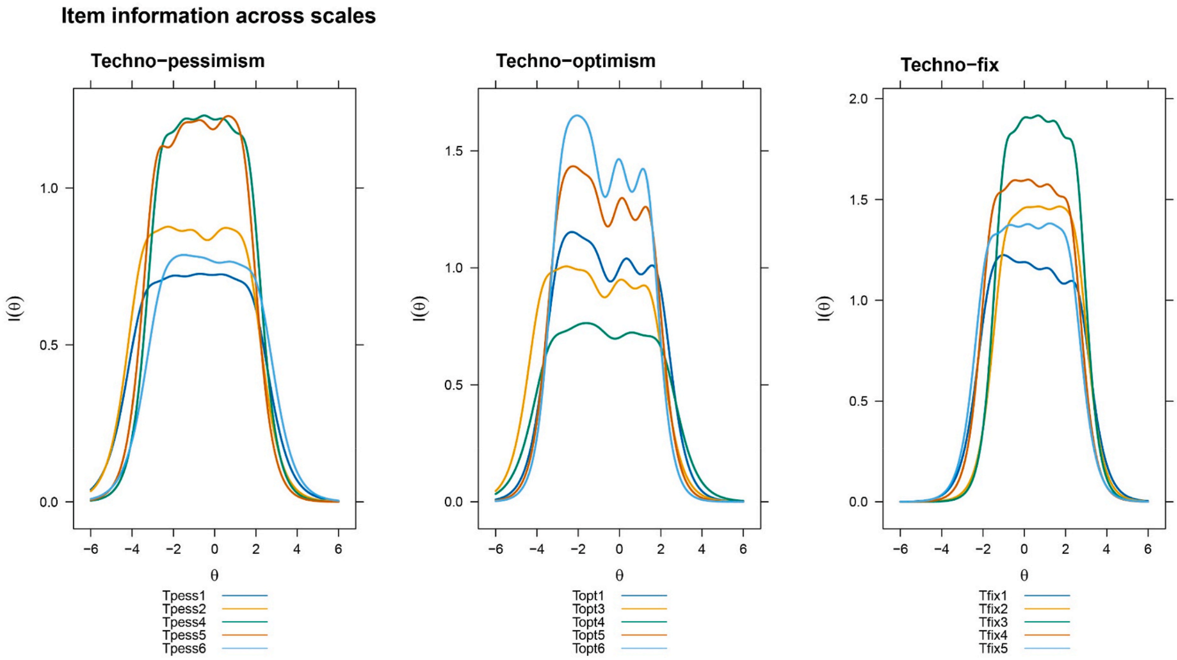

Fig. 5. Item information for the three final GATT sub-scales based on data from Study 3
Note. I θ = Information, θ = latent trait, SE = standard errors.

Table 6
Discrimination parameters and category thresholds for the final three GATT sub-scales.

Item	Discrimination	Category thresholds				
	a	b1	b2	b3	b4	b5
Tpess1	1.56	−3.37	−2.04	−0.78	0.45	1.75
Tpess2	1.73	−3.43	−2.24	−1.03	0.33	1.48
Tpess4	2.04	−2.58	−1.49	−0.51	0.48	1.56
Tpess5	2.03	−2.79	−1.59	−0.61	0.46	1.35
Tpess6	1.61	−2.50	−1.51	−0.45	0.77	1.99
Topt1	1.95	−2.93	−2.16	−1.20	0.32	1.74
Topt3	1.85	−3.68	−2.59	−1.49	0.03	1.42
Topt4	1.59	−3.30	−2.00	−1.01	0.51	1.90
Topt5	2.18	−2.87	−2.12	−1.25	0.11	1.41
Topt6	2.33	−2.77	−2.07	−1.36	−0.04	1.25
Tfix1	2.01	−1.61	−0.84	0.15	1.24	2.51
Tfix2	2.21	−0.90	−0.01	0.80	1.65	2.44
Tfix3	2.55	−0.92	−0.05	0.72	1.53	2.43
Tfix4	2.33	−1.50	−0.57	0.28	1.19	2.17
Tfix5	2.17	−1.75	−0.75	0.21	1.18	2.11

relate to pro-environmental behavioural intentions.

Overall, our data shows that techno-fix attitudes can lead to a reduced willingness to engage in pro-environmental behaviour, while both techno-optimistic and techno-pessimistic attitudes are positively related to behavioural intentions through an increase in climate change concern. This is in line with a previous study that found general techno-optimism to positively correlate with climate change concern (Fletcher et al., 2021). Given these differences in techno-optimistic attitudes and techno-fix attitudes, we recommend further empirical work on technology-related attitudes to consider these different types of optimism. While these two types of optimism correlate (Study 2: $r = 0.16$ $p > 0.01$; Study 3: $r = 0.51$ $p > 0.01$), they affect climate change concern and behavioural intentions very differently.

The concepts of "false" and "constructivist" hope as defined by Marlon et al. (2019) can help to explain why techno-fix attitudes lead to reduced pro-environmental behavioural intentions while techno-optimistic attitudes based on perceived benefit perceptions of technologies do not. "False hope" can be considered "a coping mechanism that refers to the hope that things will improve on their own accord" (Marlon et al., 2019, p. 2). False hope can lead to the perception that climate change is not a serious issue, or that something else, e.g., technology, will fix the problem. In their qualitative study, Stoll-Kleemann et al. (2001, p. 114) made a similar observation: "The faith in some form of managerial fix is always a comfortable zone for denial. […] From the evidence of the focus groups, this perspective was widespread, both as a hope and as an expectation". Thus, techno-fix attitudes and false hope might emerge as a reaction to feelings of dissonance, which are then reduced by trusting that technologies can solve all problems without the need for behavioural changes. It is therefore unsurprising that false hope has been found to negatively affect pro-environmental behavioural intentions (Marlon et al., 2019; Ojala, 2012). Soland (2013) further empirically supported this claim by showing that what they termed "greentech-optimism" can negatively affect behavioural intentions via reduced problem awareness.

Conversely, techno-optimistic attitudes might relate to a sense of constructivist hope or the belief that one (or someone else) has the ability to overcome obstacles (Marlon et al., 2019, p. 2). In this case, the belief that technology is an additional factor that can help to address climate change next to personal behaviour changes. In her study on the role of hope for pro-environmental behaviour, Ojala (2012) conducted a factor analysis to differentiate between constructivist hope and hope based on denial and found that optimistic beliefs about technical solutions to climate change loaded more strongly on the "constructivist hope" scale rather than on the "hope based on denial" scale. This provides some further evidence that techno-optimistic attitudes relate to constructivist hope. This explanation is also in line with the finding that showing participants a video which presents (renewable energy) technology as a solution for climate change increased perceptions of hope and in turn climate policy support (Myers et al., 2023). However, it is unclear whether techno-optimistic attitudes are part of a more general positive and hopeful outlook on the future or whether being optimistic about technologies specifically, instead of a broader optimistic outlook matters for engagement in pro-environmental behavior. Fletcher et al. (2021) provide some first insights by finding only a weak correlation between technology optimism and general optimistic outlooks about the future ($r = 0.274$, $p < 0.001$). We encourage future studies to analyse how our investigated different attitudes towards technology relate to different types of hope and optimism in the context of climate change. Given the importance of climate policy support for climate change mitigation beyond individual pro-environmental engagement, we recommend future studies to consider how different attitudes towards technology influence support for climate policy.

Our study supports conceptualisations of techno-optimism as a multi-faceted construct which can result in reduced pro-environmental behavioural intentions under certain circumstances. Empirically differentiating between techno-optimistic and techno-fix attitude thus provides an important contribution to the literature and we advise future research to consider this differentiation. Future research efforts should study attitudes towards climate-friendly technologies to investigate to what extent general and climate-specific attitudes toward technology differ in their influence on behavioural intentions.

Regarding techno-pessimistic attitudes, we found that they lead to stronger behavioural intentions through an increase in concern about climate change. This finding can be interpreted following the risk salience argument, where greater risk perception of technology leads to greater perception of climate change risks and in turn to stronger behavioural intentions (Carrico et al., 2015; Kahan et al., 2015; Merk et al., 2016). As past research has mostly focused on techno-optimistic attitudes, we encourage future research to investigate techno-pessimistic attitudes and its determinants.

6.1. Implications for climate change communication

To increase technology acceptance without undermining the perceived need for behavioural changes, we recommend communicators to focus on the benefits of technologies. To foster feelings of constructivist hope, communicators are encouraged to mention technology as (only) one (key) element in addressing climate change next to behavioural changes. As advised by Marlon et al. (2019), elements of constructivist hope should be coupled with elements of constructivist doubt (e.g., the need for more action beyond technological solutions) to mobilise behaviour change. In order not to strengthen techno-fix attitudes, negative consequences of a sole reliance on technological solutions should be mentioned. Namely, overreliance on technological solutions without demand-side solutions (e.g., efficiency improvements and changes in personal consumption) can lead to rebound effects (Brockway et al., 2021) and significantly decreases the technological feasibility of keeping global warming to well below 2 °C (Keyβer & Lenzen, 2021). Communicators could further refer to evidence showing that demand-side solutions entail fewer environmental risks than many supply-side technologies (von Stechow et al., 2016). Indeed, communication research has shown that framing geoengineering as a small piece to solving a bigger problem can be effective at educating the public about this technology without losing support for mitigation (Raimi, 2021; Raimi et al., 2019).

6.2. Limitations and future research

It should be noted that the effect sizes reported in these three studies are small. Therefore, while we show that techno-related attitudes consistently relate to pro-environmental behavior across three studies, their overall magnitude in affecting pro-environmental behavioural intentions is likely limited. Given the cross-sectional nature of our data, we cannot make conclusions about the causality of our proposed model. For example, it could be plausible that climate change concern influences attitudes towards technology or that a bidirectional relationship between the technology attitudes and concern exists. We therefore encourage future research to experimentally test the proposed relationships.

While we distinguish between techno-optimistic, techno-pessimistic and techno-fix attitudes, we acknowledge that many more nuanced attitudes towards technologies may exist (Kerschner & Ehlers, 2016). For example, within technology enthusiasts, Kerschner and Ehlers (2016) further conceptually differentiate between technophiles (technological change is always to the better), technocrats (decision-makers should be selected based on their specialised, technological knowledge) and entropy optimists (any unfavourable outcome of human activity can be reversed through technological fix). We encourage future research to assess the differences between general and domain-specific attitudes towards technologies and their effect on behaviours across different contested domains, such as biotechnology and geoengineering. The assessment of domain-specific attitudes will likely also result in larger effect sizes than reported in our three studies which investigate general attitudes towards technology. As our study relied on samples of the Swiss German-speaking population, future studies should use our survey instrument in other countries to explore its cross-cultural validity.

Further, future research should be dedicated to studying the antecedents of different attitudes towards technology and deploying experimental designs to investigate if and how attitudes towards technology can be manipulated (Soland, 2013). We are only aware of two master theses (Gerteis, 2014; Speck, 2014) that attempted to change attitudes towards technology through experimental manipulations and more peer-reviewed literature on this topic is needed. We also recommend future investigations to differentiate between different types of behaviours (low-cost vs high-cost, low-impact vs high-impact) as the effect of techno-optimistic attitudes on different behaviours might vary. For example, Soland (2013) found that greentech optimism weakens individuals' feelings of moral obligation to act pro-environmentally by reducing both problem awareness and the awareness of the consequences of pro-environmental behaviours, but only for high-cost behaviours (e.g., environmentally friendly travel).

7. Conclusion

As humanity grapples with drastically reducing emissions, both technological advances and behavioural changes are needed to limit global warming to well below 2 °C and reduce human impacts on the environment (Creutzig et al., 2018; Stephens & Markusson, 2018). However, techno-fix narratives perpetuate the climate policy discourse (Stephens & Markusson, 2018) and the media (Asayama & Ishii, 2017), which can limit engagement in pro-environmental behaviour. In this research, we investigate this hypothesis by introducing and validating the GATT scale and analysing how different attitudes towards technology affect pro-environmental behavioural intentions. We find that techno-fix attitudes negatively affect behavioural intentions. However, optimistic attitudes towards technology can increase behavioural intentions through an increase in climate change concern. We thus advise communicators to be cautious when reporting about the benefits of technologies without mentioning the necessity for demand-side solutions to increase the chances of keeping global warming to well below 2 °C.

CRediT authorship contribution statement

Viktoria Cologna: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Writing – original draft. **Anne Berthold:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Supervision, Validation, Writing – review & editing. **Anna Lisa Kreissel:** Conceptualization, Data curation, Formal analysis, Writing – review & editing. **Michael Siegrist:** Methodology, Supervision, Validation, Writing – review & editing.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jenvp.2024.102258.

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