The nature, significance and influence of perceived personal experience of climate change

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Abstract

The authors review relevant research published or reported between January 2014 and midyear 2019 following a previous review of this research landscape in 2014. The review findings suggest that the nature, significance, and influence of perceived personal experience of natural environment changes, conditions, and events deemed to be likely consequences of global climate change have been problematically conceptualized, researched, reported, and understood by many climate change scientists and by reporters of climate change science and their audiences. The nature, *psychological* significance, and *psychological* adaptation and issue engagement influence of personal experience of perceived environmental manifestations of climate change are arguably central considerations with respect to the human dimensions of climate change. These matters encompass public understanding of climate change science, both internal and external adaptation processes, the psychological impacts of the ongoing stressor of climate change, and issue engagement and behavioral change. It is increasingly necessary that existing issues with discipline-based assumptive worlds, constructs and measures - and often unclear research and policy questions and objectives - be identified, clarified, and addressed. This particularly matters when researchers and policy makers are addressing public risk perceptions, understandings, and responses to global climate change, ideally to inform and enhance policies directed at climate change mitigation and adaptation, or alternatively framed, public issue engagement and ‘psychologically significant’ as well as ‘environmentally significant’ behavioral change.

Introduction

There has been an important discussion and debate about the nature, extent, significance, and influence of personal ‘experience of climate change’ over the past decade across the social and behavioral sciences and the humanities (e.g., ^{1–8}). This has reflected, in part, parallel debates about the extent and underpinnings of public acceptance or ‘belief’ regarding anthropogenic climate change, how best to communicate with and engage publics regarding climate change, the nature of environmental risk perception and response in the context of climate change, and the unfolding and increasingly dramatic local and global biophysical environmental changes, events, and conditions attributed to climate change (e.g., ^{8–19}). The nature, scientific status, and psychological and issue engagement *significance* and *influence* of individuals’ perceived exposure to and personal experience of ‘climate change’ have been underlying but often implicit considerations across this research endeavor (e.g., ^{6, 17, 20–29}).

The objectives and scope of this review were to examine a representative sample of research articles, published between 2014 and 2019, in which authors have examined the nature, extent, significance, and issue engagement influence of personal experience of environmental changes, conditions, or events considered to be probable consequences of climate change. A second major objective was to identify and address underlying considerations and issues which are arguably undercutting credible and crucial advancement and much-needed multidisciplinary alignments in this research landscape.

This review follows an earlier review of research with a similar focus across a comparable period of time ⁶. Our previous review was partly motivated by ongoing debate with respect to ‘seeing’ versus ‘believing’ in the context of climate change, and whether the seeming frequency of such reported experience was due to motivated reasoning rather than direct encounters and experience driving acceptance of the reality of climate change and issue engagement. This theoretical and conceptual debate had, and still has, strong political and policy implications. That review identified only four articles that assessed self-reported personal experience of perceived manifestations of climate change, and hence was a fine-grained examination of just these four articles, not a review of the broader literature that reports research into perceived experience of climate change at an individual level. From that review, little could be seen as *major findings* because of the diversity of, and other inherent concerns with, the reviewed studies. The current review thus examines a broader and more recent set of research studies which have been presented as, or would reasonably be understood to be, focusing on ‘personal experience of climate change’. This current status quo requires collective reflection, resolution, and some degree of cross-disciplinary

standardisation of language and methodologies to enhance research in this area and to ensure a fuller appreciation and application of research findings. In this article we are using the term ‘significance’ to refer to the individual level *psychological* significance and impact of personal encounters with perceived manifestations of climate change, i.e., the experienced meaningfulness, importance, and implied consequence of what has particularly caught one’s attention, and emotional and reflective engagement, while in and experiencing a natural environment setting change, condition, or event (e.g., unusual vegetation or wildlife presence or absence, phenological changes, strange weather, flood/drought severity). This use and meaning of the term is in contrast to statistical significance and behavioral ‘environmental significance’. We also refer to both personal experience and environmental transactions in what follows as these terms reflect a more accurate and encompassing environmental psychology, environment-behavior, framing of individual-environment dynamics and accords with geographers’ notion of ‘situated phenomena’ (e.g., ^{30–32}).

Research addressing and reporting personal experience of climate change-attributed environmental changes, conditions, events, and their impacts has been hampered by an often confusing, cross-disciplinary, discourse and language, and research practice. Reasons include:

- not situating the research, theory, and approaches advanced with respect to authors’ differing disciplinary perspectives and the language and constructs used,
- not clearly defining and operationalising core constructs and differing levels of analysis,
- the differing definitions of ‘climate change’ (Kyoto protocol/IPCC)
- the common treatment of extreme weather events as proxy manifestations of climate change,
- rarely clarified differentiation between *exposure* and *experience*,
- the problematic equating of residential location with both exposure and experience,
- the neglect and liminal status of *virtual* and *vicarious* exposure and experience,
- the often implicit or explicit dismissal of self-reports, perceptions, and phenomenological accounts generally, on ostensible ‘empirical’ grounds,
- the consequent questioned legitimacy, credibility, and scientific status of research respondent accounts of personal encounters with natural environment changes, conditions or events deemed to be probable manifestations of global climate change.

(e.g., ^{2, 6, 8, 33–36}).

In the review which follows we have examined those research articles and reports which are presented as, or would be understood by most readers as, studies and discussions of the nature and influence of direct personal experience of global climate change, or extreme weather changes, events, or conditions effectively treated as de facto manifestations of climate change, and the implications and putative influence of such experience on beliefs/acceptance, policy support, and/or overt behavioral engagement with respect to climate change. We use the phrase ‘perceived personal experience of climate change’ (PPEOCC), to refer to personal encounters with and experience of salient natural environment changes, conditions, or events deemed by research respondents to be likely manifestations of global climate change. While we have not included in our sample research studies focusing on the nature, significance, or influence of virtual or vicarious exposure to or experience of climate change, we briefly consider such experience, as indirect (e.g., multi-media) exposure and experience undoubtedly influences perceived personal experience of climate change (e.g., ^{37–40}).

Clearly there are many types of perceived personal encounters with, and reported experiences of, global climate change that are relevant to this paper. Two of the most obvious and prevalent of these are:

- individual (or small group) encounters in natural environment settings/contexts whether in backyard gardens, parks, rural settings, or protected areas in which a noteworthy feature, aspect, or event captures one’s attention, sense-making, and reflections/feelings;
- instances of extreme or unusual weather events, conditions, and/or regional impacts of such events and conditions, experienced by individuals resident in or spending time in affected areas.

Perceptions and ‘reality’

A fundamental philosophical, psychological, and cross-cutting ‘human dimension of climate change’ research which is rarely acknowledged or addressed is that of the conceptual and ‘hard science’ distinctions between, and the respective empirical and epistemological status of, an objectively real world of individual-natural environment transactions and encounters, as contrasted with individual level *perceptions*, *sense-making*, and *experiences* in natural environments. Also of central importance is the nature and status of ‘virtual’ exposure and experience via the ubiquitous new media ‘information environment’, continually reporting and *representing* both the phenomenon and risk domain of climate change and

associated natural environmental changes, conditions, events, and risks increasingly attributed to climate change (e.g., ^{41–46}). A further recurring issue is whether reported personal experiences of perceived climate change manifestations might be alternatively understood and conceptualized as instances of motivated reasoning/confirmation bias and/or prone to other ‘subjective’ limitations and heuristic biases (e.g., ^{2, 5–7, 47–49}). These discussions concerning the nature and importance of PPEOCC also reflect but largely ignore an extensive backdrop of natural history writings, environmental education research, environmental psychology perspectives, natural resource and human ecology restoration and management science, environmental risk perception research, place attachment and meaning research and writing, and philosophical and psychological studies of the nature of perception and experience (e.g., ^{50–61}).

A revealing example of confusion in these intersecting research literatures is that of the nature and conceptualisations of environmental *risk perception* as distinct from environmental *risk assessment*. ‘Risk perception’ is inherently about individuals’ phenomenological *perceptions, sense-making, and understandings*, with this ‘reality’ central to the contested credibility and validity of self-reports regarding such individual-environment encounters and experiences (e.g., ^{62, 63}). Environmental risk perception encompasses perceived human risks both *from* and *to* natural environments. ‘Environmental risk *assessment*’ is a more specialized, expert judgement-driven, formal process, often entirely divorced from a lay individual’s ‘subjective’ perceptions and understandings of the nature, extent, and seriousness of risks from and to one’s known and familiar natural environment (e.g., ^{23, 64–69}).

Importantly, even professionally-driven risk assessment processes ultimately rest on human judgements. Hence when academic discussion or research undertakings are addressing respondents’ perceived and reported personal experiences of global climate change, this is the data, the evidence, being considered, irrespective of whether the local incident or phenomenon would be judged by biophysical climate change science experts to be a substantive risk attributable to global climate change. Environmental risk perception is also, quite logically, an aspect and product of *sense-making* when encountering the changed, the anomalous, the disturbing in one’s known and familiar natural environment, with cognitive appraisals and causal attribution – rarely resolution – a core component of sense-making (e.g., ^{70–76}). Such sense-making in the context of personal encounters with environmental changes and events attributed to climate change can constitute particularly salient, personally significant, witnessing events, in this case of a grave, planet-altering, indeed existential risk

(e.g., ^{45, 77–83}). As Weber ⁸⁴ also notes, the U.S. National Science Foundation (NSF) Committee on the Human Dimensions of Climate Change, in its ground-breaking 1992 report, “divides human response to global changes into a hierarchical set of seven interacting systems, with the most fundamental system being ‘individual perception, judgement, and action’” (⁸⁴, p. 315; ⁸⁵, p. 5). The status and fundamental importance of individual level perceptions and personal experience of climate change has not altered in the interim following the NSF report (e.g., ^{8, 15, 83, 86}).

We argue that it is not possible to make progress in defining dangerous climate change, or in developing sustainable responses to this global problem, without recognising the central role played by social or individual perceptions (²³, p. 11).

Public versus climate change science understandings

Central to this consideration of the nature, significance, and influence of reported personal experience with seeming local evidence of climate change is the question of national and global publics’ general understandings of ‘climate change’, as compared to formally accepted climate change science accounts and definitions. It can be cogently argued that current public understandings of ‘climate change’ in most developed countries is that of global, anthropogenic, atmospheric system change – and societal, biodiversity, and ecosystem system consequences. This understanding corresponds, in essence, with the definition of ‘climate change’ by the United Nation’s Framework Convention on Climate Change, i.e., “a change of climate that is attributed directly or indirectly to human activity that is in addition to natural climate variability observed over comparable time periods” ^{87–89}. While most social and behavioral scientists, and science journalists and writers, along with the public, accept this Kyoto Protocol definition, many national and international physical and natural science bodies (e.g., ⁹⁰) fundamentally changed this Framework Convention definition to encompass and apply to *any* “natural internal processes or external forcings ... in the composition of the atmosphere” ⁹¹.

This definitional divide creates serious communication and policy problems – and research challenges - in that the phenomenon and risk domain of climate change, from a public understandings and public discourse perspective, and hence research survey consideration, includes this crucial human causal contribution or ‘forcing’ as the defining and differentiating feature of anthropogenic climate change (e.g., ^{6, 45, 59, 88, 92}). This important anthropogenic, ‘hybrid’, character of global climate change, along with the scope and multiple associated meanings which accrue to such a grave and global environmental risk (e.g., dread, stigma, the unknown, species and ecosystem loss, catastrophic human deaths) is

strongly evidenced by over three decades of environmental risk perception and meaning research (e.g., ^{57–59, 88, 93–97}).

What does the general public make of the global warming problem? How does the public view the risks entailed by greenhouse emissions? What is the correspondence, if any, between the scientific picture and the public view, between the professional assessment of risk and lay public's perception? While considerations of the social, ethical and cultural context for evaluating the long term risk of climate change are emerging, relatively little attention has been paid to psychological aspects (^{23, p. 104}).” (^{98, p. 1}).

The language and multiple labels being used to distinguish ‘human-influenced’ environmental risks, phenomena, and events/impacts from ‘natural’ environmental risks, phenomena, and events/impacts remains confusing and dynamic as we enter the Anthropocene. Reference to ‘extreme weather events’ is encompassing but reasonably clear, though the matter of attributed human causal influence is seldom or satisfactorily addressed or clarified in particular contexts ^{99, 100}. ‘Disaster’ labels include natural disasters, technological disasters, hybrid disasters, and natech disasters, with hybrid disasters being the most general descriptor for events or circumstances reflecting combined natural and human causation. Potentially adding confusion, extreme weather events are often simultaneously referred to as natural disasters in research contexts relating to personal experience and human impacts.

In a number of ways the phenomenon and risk domain of climate change differs dramatically from these descriptors and categories in that this is a global phenomenon and risk domain, existential in nature, planet system changing in consequence, likely now present for millennia, and constituting an ever-present environmental stressor. But ‘climate change’ also shares the emotional valences and meanings of numerous other hybrid risk domains, with respect to stigma, blame, catastrophic consequences, and interference with nature. When participants in research surveys respond to questions relating to equivalents of PPEOCC, this human causal attribution is a critical, sense-making, response-determining, ‘tampering with nature’, factor strongly differentiating climate change from other ‘natural’ environmental risk domains (e.g., ^{45, 72, 94, 96, 101, 102}). However, the most salient point in the context of researching perceived personal experience of climate change is that while many extreme weather events are likely to be influenced by climate change, they must be personally perceived as probable manifestations climate change to constitute ‘perceived personal experience of climate change’. This criterion has seldom been addressed or applied in the research we have

reviewed, previously and presently. It is noteworthy that, in multiple recent research surveys that include items addressing causal attributions for climate change, over 85% of respondents select options indicating the cause was either human activity mainly or entirely (e.g., ^{25, 88, 103–108}).

How is *personal experience of climate change* conceptualized, operationalized, and reported in social and behavioral sciences research contexts?

The motivational and psychological impact relevance of ‘personal experience’ in the context of climate change risk perceptions, understandings, and responses has been well recognized over the past decade (e.g., ^{1, 2, 5–7, 9, 20, 31, 109–115}). Yet definitional and operational specification of what is meant and encompassed by personal ‘experience’ remains a crucial matter in making sense of research reports and arguments. Although many studies have documented the important influence of ‘experience’ on risk perceptions, and the effect of risk perceptions on preparedness and mitigation behaviors ^{5, 116–118}, the linkages are complex, varying in strength and even direction in some cases (e.g., ¹¹⁹). The importance of experience depends in part on its location, intensity, duration, type, and how it is defined ^{120, 121}. For natural hazards for example, personal experience has often been limited to witnessing a specific event or, alternatively, to suffering substantial losses from it. ¹²².

Recent overview articles relating to personal experience of climate change “consider ‘experience’ in a very broad locational sense – as ‘geographic’ exposure, for example, residing in an area where local climate conditions have changed over the past five years” (e.g., ^{2, 4, 123–126}). However, this take on ‘experience’ and underlying levels of analysis effectively ignore the nature and dynamics of individual level experience, risk perception, sense-making, and psychological responses and impacts. This locational, geographic exposure, consideration of ‘experience’ also encompasses experiences of perceived but more gradual climate change impacts that occur over seasons, years, and even decades (e.g., ^{69, 127}). Also routinely ignored is the very distinctive nature of this global, hybrid, and ongoing environmental stressor character of this climate change risk domain, its social constructions and representations ^{93, 96 128–31}, and the realities of virtual and vicarious exposure through a global ‘information environment’ (e.g., ^{45, 132}). Again, it is a widespread researcher view supported by ample evidence that understanding the anthropogenic causes of climate change is the strongest predictor of climate change risk perception (e.g., ^{6, 102, 133, 134}).

Much of the conventional logic of these many approaches to researching personal experience of climate change are captured in a reflective publication by Egan and Mullin ¹³⁵.

However, research about the effects of personal experience on attitude formation almost always suffers from two threats to inference. First individuals are usually exposed to experience – or in fact may select into these experiences – in non-random ways that are correlated with the attitudes hypothesized to be dependent on the experiences. Second, most research relies on survey respondent self-reports of experience. These reports are not only unreliable; they may also be the consequences of specific attitudes about politics and public affairs, rather than bias-free measures of their causes. ... Our research strategy is straightforward: we merge local weather records with geocoded data collected from five nationally representative sample surveys. ... In short, we exploit the fact that changes in local temperature assign individuals nearly at random to experiences that they may choose to interpret as evidence for or against global climate change (¹³⁵, p. 796).

There are many other more recent researchers who have basically adopted this strategy (e.g., ^{125, 136, 137}). This logic and accompanying operationalizations unfortunately simply misses the nature, meaning, and significance of *personal experience* generally and *PPEOCC*, and dramatically attenuates the encompassing spectrum of possible natural environment encounters and experiences.

The current climate change research landscape addressing personal experience.

To gain an overview of research published in the period from January 2014 to June 2019, we searched the literature for studies addressing personal experiences of climate change, or studies that link other kinds of personal experiences to climate change-related beliefs, attitudes, or behaviors. We uncovered almost 100 empirical studies, plus thirteen review papers that related to the topic of climate change-related experiences, and a small number of conceptual papers and monographs. From this set, we selected 36 papers reporting empirical research that seemingly represent the breadth and diversity of the research landscape, and we conducted a thorough critical review of these 36 studies. Selection of these papers was purposive, rather than exhaustive, with the aim of ensuring the availability for review of a cross-section of articles in terms of (a) outlets/journals. (b) countries of origin, (c) author(s) disciplinary background(s), (d) types of experience investigated and means of assessing these experiences, (e) dependent or outcome variables, and (f) research (data collection and analysis) methods. The online supplementary materials accompanying this paper contain tables summarising key aspects of the selected studies. Additional details relating to this review are available upon request from the second-named author. This section highlights key points from our review.

Description of the Studies

Most of the 36 studies were conducted in the USA, although nine other nations were represented, and one study ¹³⁸ included data from 24 nations. The studies were published in 18 different journals, and were authored by researchers from a range of disciplines. Theoretical and/or other conceptual foundations underlying the research were seldom stated, and none of the papers provided a detailed definition or discussion of the concepts of *experience or personal experience*.

Most studies used survey (questionnaire-based) methods, with one in three complementing these with data drawn from meteorological or similar databases. Other methods included interviews, experiments, and analyses of archival data. Three studies used mainly qualitative methods. No study fully captured both the qualitative and quantitative dimensions of experience. Sample sizes varied from 43 to almost 15,000 participants, with the two studies that used online users or messages as the unit of analysis having samples in excess of one million. Data analytic techniques varied with study aims and design, with regression-based techniques most commonly employed.

The studies are roughly divisible into three broad categories based on the means used to assess the core exposure or experience variable(s). In the first category, thirteen studies ^{4, 107, 125, 136, 137, 1391–146} used various meteorological databases (e.g., from the US National Oceanic and Atmospheric Administration, or the US National Climatic Data Center) to extract information pertaining to weather conditions, extreme weather events, natural disasters, and/or climatic patterns in participants' place (e.g., county or zip code) of residence. A further four studies adopted what might be termed a 'group comparative' approach that involved taking advantage of unusual weather patterns occurring at particular times in particular regions either to compare residents before and after these events, or to compare samples of residents of affected and unaffected areas. The remaining 19 studies assessed experience through self-reports. These reports were obtained either through face-to-face interviews ^{147–151}, telephone interviews ¹⁵², paper/postal questionnaires ^{153–156}, online questionnaires ^{104, 138, 157, 168, 169}, unspecified or mixed mode questionnaire administration ^{160–162}, or a life history writing exercise ¹⁶³. Five studies (four of which were primarily based on geo-coded data and one of which was primarily a self-report study) used elements of both the objective and self-report approaches to assess experience/exposure. Importantly, among the studies that assessed experience solely by way of self-reports, only five asked participants to report their experience of climate change manifestations or impacts, while the remaining 14 studies obtained self-reports of extreme weather events (especially, flooding).

Correlates of climate change, weather, or related experiences included beliefs in/acceptance of the reality of climate change, attributions as to the causes of climate change, risk perceptions/concerns over likely climate change impacts, and climate change policy endorsement.

Evaluation of the Studies

All 36 reviewed studies have strengths. In many, if not most studies, important issues were investigated, sampling was at least adequate, and approaches to analysis were appropriate. That said, all studies had weaknesses, with strengths of a minority often drawing attention to shortfalls in the majority. Key limitations of this body of research are highlighted below.

As noted, rather than asking participants to report their personal experiences, in 13 studies exposure was *inferred* from independent sources of weather, hazard, or similar information, with individuals grouped into geographically-defined, and presumably, meteorologically-homogenous, clusters. This approach captures the impacts of weather and environmental events at the regional, rather than individual, level. It thus addresses questions pertaining to weather/climate *exposure*, rather than questions pertaining to (subjective) climate change *experiences*. The approach potentially has operational strengths – most notably, the objectivity of its measures and its capacity to circumvent problems associated with participant response bias (see below). Limitations include the questionable validity of some approaches taken to identify geographical regions and/or assess extreme weather/natural disaster exposure.

Nearly all studies used self-report techniques, if not to assess experience, then at least to assess the correlates of experience. Self-reports are prone to two main sources of error: participants may misperceive reality (e.g., they may observe that temperatures are rising when in fact they are not), and they may misreport that which they perceive. The latter is often attributed not to intentional dishonesty, but to memory lapses and response biases including social desirability, acquiescence, and consistency/confirmation biases. Writers in this field (e.g., ^{2, 5, 24}) have drawn particular attention to the likelihood that self-reports of personal experience may be influenced by pre-existing beliefs or worldviews, coupled with respondent desires to insure consistency between their prior beliefs and reported experiences. Elsewhere in this paper, we argue that neither consistency and confirmation biases, nor ‘motivated reasoning’, invalidates self-reports of experience or related risk perceptions.

Notwithstanding our observation that many studies operationalized experience of climate change in terms of self-reported experience of (extreme) weather events, we argue

below that experiences of extreme weather cannot be equated with experiences of climate change. Various other potential limitations of this group of studies were identified: a failure to specify suitable time-frames or geographical locations for the experiences, the dubious practice of operationalising ‘experience’ in terms of injury or (financial or property) damage incurred, the lack of opportunity provided for research participants to elaborate on their responses, the use of untested, unreliable and/or single-item questionnaire ‘measures’, the lack of attention paid to indirect experiences, and the occasional inclusion of experiences of other individuals within putative measures of *personal* experience

In this set of 36 studies, for understandable reasons, true experiments are rare, meaning that causal conclusions could not be confidently drawn. Coming closest to this ideal, the two studies comparing groups of flood affected and non-affected individuals/areas could arguably be termed *natural* (but not true) experiments. Few studies used longitudinal research designs, with those of Gustafson et al.¹⁶⁴, Carlton et al.¹²⁷, Konisky et al.¹²⁵, Lang and Ryder¹⁴⁰, Palm et al.²⁴, and Sisco et al.¹⁴⁶ seemingly providing the strongest evidence of temporal ordering.

In terms of approaches to data analysis, some online surveys reported only univariate findings, while other studies reported mainly bivariate effects. Findings in most studies were strengthened by statistically controlling for demographic, belief/ideological, and other potentially confounding variables. However, few studies examined mediation and/or moderation effects, and even fewer assessed non-linear or multi-level (individuals nested within regions) effects.

Major Findings from the Studies

Findings from this set of post-2014 studies can be summarized in three parts.

Objectively Assessed Exposure to (Extreme) Weather Events/Conditions/Trends. As noted, 13 studies mainly used geo-mapping or similar techniques to identify regional and hence, by implication, resident exposure to (extreme) weather (events). Most of these studies used survey methods to examine the climate change-related correlates of this exposure. In general, this body of research shows that exposure (to local weather, natural disasters, or multiple extreme weather types) is positively, but not strongly, associated with climate change beliefs, risk perceptions, concerns, issue engagement, policy endorsement, and related outcomes. The obtained effects varied with attributes of the weather to which participants were exposed, although there was limited between-study consistency in this respect. In several studies (e.g., ^{141, 142, 145}), the effects of (extreme) weather exposure were small in comparison to those of pre-existing climate change beliefs, political ideology, and

demographic characteristics. Consistent with most studies in this group, Ray et al.¹³⁶ concluded that the effect of objectively-measured exposure to extreme weather events is “modest, inconsistent across specific adaptation policies, and diminishes with time” (p. 104).

Self-reported Experience of Extreme Weather Events/Conditions. Findings from this group of studies regarding impacts of exposure/experience were similar to those from the previous (objective exposure) category. Self-reported experience of flooding was shown to be associated with heightened climate change concern and risk perceptions^{1, 2, 45, 150, 155, 161}, preparedness to reduce energy use¹⁴⁹, increased climate change emotional responses and issue salience^{2, 161}, and non-flooding adaptation intentions². Zaval et al.¹⁶² found that present temperature abnormalities were associated with increasing levels of climate change belief and concern. However, many studies^{127, 139, 141 154, 156, 165} did not demonstrate clear links between self-reported experiences of extreme weather or disaster events and climate change-related outcomes, and/or did not demonstrate links that were consistent across different types of experiences or climate change outcomes. Several of the obtained effects were mediated and/or moderated by other factors. As is the case for objectively-assessed weather indices, political orientation and prior climate change beliefs tended to overshadow weather experiences in predicting climate change-related beliefs and behaviors.

Self-reported Experiences of Climate Change Manifestation and Impacts. This category of research studies was the focus of our 2014 review⁶, when we identified only four studies in this category. Somewhat surprisingly, research with this focus is still quite rare, with only five of the present set of 36 studies directly operationalizing ‘personal experience’ of events, conditions and/or changes that respondents perceived to be manifestations of global climate change. Three of the five studies reported the percentage of their respondents who claimed to have had direct personal experiences of climate change, its manifestations, or impacts. These studies and the associated percentages of respondents were: Babutsidze et al.¹⁵⁷: 55%; Capstick et al.¹⁰³: 76%; Leiserowitz et al.¹⁰⁴: 46%. Discrepancies in these figures presumably reflect differences in study setting, timing, sampling, question wording, questionnaire context, and other factors. In general, these 2014-2019 estimates of the population prevalence of climate change experiences are higher than are estimates obtained in previous years⁶. Studies in this group seldom reported tests of the associations between experiences of climate change and related beliefs, attitudes, or behaviors. An exception is Broomell et al.¹³⁸ who found that climate change experience was more strongly associated with willingness to engage in specific mitigation acts than with general intentions to act. The relative neglect of the correlates of direct personal experience in this set of five studies stands

in contrast to the four studies reviewed in 2014 ⁶, in which a range of cognitive (e.g., belief certainty, risk perception) and behavioral correlates were investigated.

Summary of the Findings. Based on our reading and assessment of this arguably representative selection of recent studies of this topic, we offer the following three propositions as a summary of the findings:

1. The majority of recent studies have relied on either objective evidence of exposure to extreme weather or natural disasters, and/or self-report evidence of these experiences. These studies have yielded mixed, seldom strong, and often qualified, evidence of associations between exposure to/experience of these events and climate change related beliefs, attitudes, and behaviors, with most research suggesting that these outcomes are better predicted by pre-existing political, environmental, and ideological values and beliefs.
2. Few recent studies have obtained self-reports of personal experiences of climate change. From the research that has been conducted, it seems that the incidence of perceived direct climate change experiences has increased in recent years, but limited evidence has recently been published as to the antecedents, significance, or issue engagement influence of these experiences.
3. The effects of experience may ultimately be found to be indirect, conditional, and nonlinear, but until the conceptual, measurement, methodological, and analytic shortcomings of the recent research are addressed, clear conclusions will continue to be elusive.

DISCUSSION

When addressing such topics as environmental risk perceptions, understandings, or personal experience of climate change, language and meanings matter, and terms and construct specification and clarity particularly matter, whether communicating with research respondents, the public, policy makers, or fellow scientists. When the subject being discussed or researched encompasses global phenomena, issues, and implications, these matters become even more critical. This has all been challenging in the context of global climate change, a grave global threat, a very salient environmental stressor, a complex phenomenon requiring the expertise of very different areas of the biophysical sciences, the social and behavioral sciences, and the humanities - all contextualized within often very different assumptive worlds, involving differing research and problem approaches, and respective languages and argument and evidence-based criteria.

In the context of this review, an important focus and challenge has been the language used when referring to *global climate change*, *experience*, *exposure*, *significance*, and *influence*, and the cross-disciplinary translation and operationalization of these external and internal environmental processes, considerations, constructs, and parameters in the research examined. Clearly global climate change involves two very different formal definitions and a spectrum of public understandings. In our review we have acknowledged these differences, but have subscribed to the Kyoto Protocol specification of anthropogenic climate, in large part because this both corresponds to what is arguably everyday use and meaning, and because this matters greatly with respect to the nature of the hybrid environmental risk domain and environmental stressor status of climate change.

A further challenge has been the nature and meaning of *experience*, and in particular perceived personal experience of environmental changes, conditions, or events deemed to be probable manifestations of climate change. Any encompassing consideration of the *human dimensions* of climate change can founder on what such individual and collective experience encompasses. The research focus we have addressed narrows the compass of the challenge to a considerable extent as we are dealing with individual level, natural environment contexts, perceptions, encounters, and experiences, and more specifically the nature and extent, and the psychological significance, and issue engagement influence, of such perceived environmental encounters. While researchers addressing the personal experience of climate change are largely aware of many of these considerations, they have not been very clear about how and why they have framed their research questions or devised their research methods, procedures, operationalizations, and ‘measures’ as they have, nor have they often *situated* their research with respect to this broader multidisciplinary space, or their own disciplinary perspectives and assumptions. This, in our view, has led to considerable confusion about what was actually being researched, what these research findings, overall, might suggest, what conclusions might be drawn and communicated to policy makers and government bodies addressing the immense challenges of unfolding climate change, and what corrective research and public risk communication and issue-engagement measures might be undertaken. In the discussion which follows we examine a number of these overarching issues in the context of the research studies we have considered.

What is ‘experience’ and what is its status?

It is interesting and instructive that the primary and secondary definitions of ‘experience’ in the Oxford English Dictionary are “a procedure carried out to test or demonstrate something: an experiment” and “proof by actual trial: practical demonstration”. The tertiary

definitions of ‘experience’ are “actual observation of or practical acquaintance with facts or events, considered as a source of knowledge” and “a state, condition, or event that consciously affects one; the fact or process of being so affected.” A further definition in this source is “knowledge resulting from actual observation or from practical acquaintance or from what one has undergone” (¹⁶⁶, p. 894).

Experience is without question an encompassing term and expression. Clearly ‘everyone knows’ at some levels what ‘experience’ means and covers, but its etymology, history, use, and meanings in philosophy and the human sciences underscore the polysemous nature of this vital term and multileveled construct. It is worrying that throughout this past decade of social and behavioral science research addressing the nature, significance, and influence of personal experience of climate change, the fundamental meanings and empirical status of perceived and subjective ‘experience’ would appear to have been largely ignored or dismissed. This unfortunately reflects the multidisciplinary character of the research, preferred levels of analysis, and a physical science ‘positivism’ that finds expression in a strong focus on the physical, the ‘objective’, the observable and measurable. This is so despite a firm conviction that “One thing which all sciences show in common is an insistence that in the last analysis they are founded upon human experience.” (¹⁶⁷, p. 520). Indeed, empiricism itself is defined by many in terms of experience.

In all its forms, empiricism stresses the fundamental role of experience. As a doctrine in epistemology it holds that all knowledge is ultimately based on experience. (¹⁶⁸, pp. 239–240).

There are clearly multiple language and meaning issues when discussing or researching personal experience of climate change. ‘Personal’ or ‘individual’ implies an individual level of analysis and an arguable need for some level of self-report. While one can collect and/or examine locational data relating to individual residence and extreme weather events or environmental changes, and infer exposure, this is a considerable remove from direct self-report of personal encounters with and experience of perceived manifestations of global climate change. Similarly, ‘experience’ can be viewed and defined from an observer or analytic perspective as an incident, occurrence, or event, but this is not what is generally inferred or implied when discussing the nature, significance, or influence of direct, personal experience. This distinction reflects both differing levels of analysis and the substantive nature of individual level, subjective, personal experience, particularly when researching the nature of what occurred and was perceived and experienced from the respondent’s vantage point. One must approach the definition and specification of global climate change from the

respondent's perspective, as well as conceptually and operationally. This circumstance takes as read that the environmental change, condition, or event encountered and made sense of as a probable manifestation of climate change encompasses one's environmental risk perception, internal experience, and individual-setting 'transaction' with this circumstance, in the broader context of whatever activity one has been involved in. It would be very difficult to ascertain or examine almost any aspects of individuals' personal *experiences* of perceived manifestations of climate change without obtaining individual level accounts of the incident or situation and individuals' perceptions and subjective experience in and of this situation.

Whether one takes an *environmental perception* perspective, an *environmental risk perception* perspective, an environmental psychology *transactional perspective*, a *causal attribution* perspective, or a *sense-making* perspective (e.g., ^{56, 58, 59, 72, 169–172}), an individual's perceived personal encounter with and experience of an environmental change, condition or event perceived to be a probable manifestation or consequence of global climate change is an important psychological reality. This is so irrespective of whether IPCC atmospheric or biophysical scientists would judge such an environmental change, condition, or event to have been caused or otherwise influenced by anthropogenic global climate change. Indeed, many such scientists would confirm that in the current context virtually *all* weather events are influenced to some extent by global climate change (e.g., ¹⁰⁰). It is also useful to appreciate that from an 'objective', environmental psychological or environmental perception perspective what is being considered is an individual encounter and *transaction* with an anomalous or noteworthy aspect of a natural environment (e.g., ^{173–175}). The 'personal experience' of this encompassing transactional encounter in the context of responding to a survey or interview question, concerning the recalled encounter and experience - further nuanced by one's intervening reflections, possible conversations, and information-seeking about such an experience - are all important considerations.

Standing back from such considerations, it is remarkable that many researchers would intentionally exclude self-reports of research respondents' encounters with and experience of perceived climate change manifestations or consequences. The expressed rationale for such procedures is typically that this ensures that factors such as motivated reasoning, confirmation bias, protection motivation, and a spectrum of other 'subjective' and heuristic 'biases' do not detract from a credible research focus on the 'objective' influence of an empirically confirmed environmental event on 'objectively measured' behavioral responses (e.g., ²). However, such procedures unfortunately disregard the very nature of environmental perceptions, the noun and verb status of experience, the inherent subjective nature of

experience and experiencing, and the nature and cognitive, affective, and symbolic meanings of an environmental risk domain such as anthropogenic climate change (e.g., ^{58, 95, 176}). Such procedures also preclude the possible psychological significance and personal importance of such an experience, and the nature of subsequent *psychological adaptation* and *issue engagement* responses to the experience that are not overtly behavioral.

The centrality and human dimensions of experience are universally accepted in psychology, philosophy, literature, and the arts and humanities generally (e.g., ^{62; 177–182}), but so unquestioningly accepted that the importance of experience across many behavioral science research domains has been, paradoxically, both taken for granted and/or intentionally set aside, as it has in more ‘behavioral’ psychological research, or in social science disciplines in which individual or experiential levels of analyses are exceptional rather than mainstream. This is not to suggest that one’s disciplinary vantage point necessarily precludes more ‘psychological’, ‘internal environment’ considerations. Phenomenological geography perspectives, for example, have made crucial contributions to understanding the human dimensions of climate change (e.g., ^{3, 55, 159, 183–185}).

Why might perceived personal experience of climate change be particularly salient and psychologically significant?

One might well argue that those spending time in natural settings often have salient and out-of-the-ordinary environmental encounters. But personal environmental encounters with the perceived consequences of climate change, particularly initial such experiences, are arguably quite different. Such encounters are typically with respect to unusual environmental changes or incidents, often by way of deteriorating or otherwise alarming circumstance or changes in one’s own familiar setting, and possibly reflecting a particular mindfulness, and felt connection with one’s familiar natural environment. Such perceived climate change influences and consequences are by definition anthropogenic or human-forced, underscoring both human agency and impacts and accompanying associations, including the stigma and consequences of a societal or science/technology-based ‘tampering with nature’ (e.g., ^{96, 101}). Others have written about such experiences as a ‘bringing of climate change home’ (e.g., ^{3, 61}), whether by chance encounter, or in the context of genuinely appreciating, and realizing, what global climate change means and portends in one’s known home environment. This itself can be a powerful and personal ‘witnessing’ of this altering ‘state of the planetary environment’. It is also likely that such personal encounters make one’s virtual exposure to and experience of global climate change more real, immediate, and disturbing. The thoughts and emotions that can accompany such personal experience can range from concern, to

apprehension, to anger, to guilt, to felt helplessness, to loss (e.g., ^{25, 26, 186–189}). There can also be countering emotions and motivations relating to confirmation, realisation and resolve with respect to what has been a disputed and *seemingly* distant, temporally and geographically, phenomenon and threat.

The grave risk of climate change, its ubiquitous media coverage, its environmental stressor character, and perceived impacts in one's own immediate natural environment, all make a personal encounter with a perceived, probable, manifestation of climate change very salient and psychologically significant for many individuals. This *psychological significance* is in many ways as important as *environmental significance* (e.g., ^{190, 191}), and arguably a *sine qua non* for both issue engagement and psychological adaptation as well as behavioral change (e.g., ^{6, 25, 192–195}).

Sense-making, causal attribution, and survey questions and response options

Clearly, individuals' perceived personal experience with environmental changes or incidents which they deem to be likely manifestations of climate change (PPEOCC) reflect some form of causal attribution and sense-making, and de facto environmental risk perception ^{100, 133}. This personal meaning-making in the context of transacting with one's natural environment is, again, quite different from the scientific detection and attribution of noteworthy environmental changes or extreme events (e.g., ^{100, 196, 197}). The question of whether climate change scientists would regard the environmental change, condition, or event as attributable to global climate change is again irrelevant to the question of the nature and psychological significance and influence of such perceived and experienced encounters on the part of an individual. Hence it is important to distinguish between these two very different circumstances, that of a science-based 'expert' judgment and causal attribution assessment, and that of an individual's encounter with an environmental event or condition perceived by she/he/group to be a likely consequence of climate change. Yet much of the research which has been addressing the nature and role of 'personal experience' in the context of climate change has taken a research design stance in which extreme environmental events, not necessarily linked to global climate change, are linked to 'geocoded' residence and a locational risk analysis of survey respondents (e.g., ^{123, 198, 199}), without reference to, and typically in the absence of, individual reports or informative first-hand accounts of personal experience with environmental events or conditions which respondents deemed to be probable manifestations of climate change. Alternatively, in other 'experience of climate change' research contexts, extreme weather events and natural disasters are simply and

routinely treated as concrete and credible proxies for climate change (e.g., ^{2, 125, 136, 149, 150, 152, 160, 200}).

The problematic equating of extreme weather events and their impacts with global climate change

An extreme weather event, or extreme weather generally, arguably does not equate with or serve as an acceptable proxy for global, anthropogenic, climate change, a human-forced alteration of planetary atmospheric systems and global weather and climate regimes, and its myriad and devastating ecosystem and human life and societal system impacts. What is central to the nature, significance, and influence of direct personal experience of an extreme weather event in the context of climate change is whether research respondents' personal experience and environmental risk perceptions and attributions are such that the event is perceived and experienced as a probable manifestation of climate change (e.g., ^{6, 102, 103}). Yet in most of the reported research presented as addressing the salience and influence of perceived encounters with climate change-related events, neither the methodology nor the data include or report on individual accounts or responses or reflections, by way of open survey response options or similar interview prompts for expanding a response. Research respondents are seldom directly asked whether they have ever directly experienced an environmental change, condition, or event which they deemed to be a probable manifestation or consequence of climate change (e.g., ⁴). Indeed, in the present sample of articles reviewed, only five of 36 studies included such an item in their survey, interview, or other data collection procedure.

The counter-argument which has been more recently made is that individual level reports/accounts of personal experience of environmental changes, condition, or events are prone to multiple biases (e.g., motivated reasoning, the availability heuristic, memory accuracy) and an absence of objective evidence. In contrast (this argument goes), personal reporting of documented extreme weather event effects and their material impacts, such as damage due to flooding, are far more reliable and empirically credible and defensible than individuals' environmental perceptions and sense-making with respect to reported environmental encounters (e.g., ^{2, 4, 103}). What again is missed in such arguments and accompanying methods is that the subject matter and focus of either stated or implicit central importance, i.e., the interrelated environmental risk *perceptions, understandings, sense-making*, and related internal and external *psychological processes, responses, and impacts of an attributed climate change event*, are neither really addressed or assessed, other than in rare instances, by post event interviews related to a severe flooding event. This is in a context in

which everything is really about the natural disaster event, and physical and often financial impacts, during which matters of climate change attribution and concerns are raised. In contrast, in a survey or interview about possible personal encounters with perceived climate change manifestations or consequences, the context and questions are much more directly about this experience itself, with survey or interview items relating to attribution, concern, distress, issue engagement, commitment, and pro-environmental lifestyle changes.

It has been compellingly argued and increasingly evidenced that climate change is a dramatically unfolding existential risk, both objectively and subjectively, for ecosystems, biodiversity, and human societies, and a rapidly altering planetary condition that may well be with us for millennia^{201, 202}. Specific extreme weather events are, in contrast, time and region specific, and natural and known phenomena, with century and millennial old culturally informed adaptation wisdom, and however damaging and devastating, are part and parcel of the landscapes and lives of all countries and cultures (e.g.,^{203, 204}). Australia, ‘land of drought and flooding rain’²⁰⁵, is arguably the most currently exposed inhabited continent to the ravages of climate change. The present authors’ own Australian research program^{26, 206}, mandated to address public risk perceptions, understandings, and responses to both extreme weather events *and* global climate change, found that the psychological significance and influence of reported direct extreme weather event/condition experiences were remarkably modest when compared with reported, perceived, direct experience of environmental changes, conditions, and events attributed to climate change^{26, 206, 207}.

Perhaps the strongest argument against the use of extreme weather events as documented, empirical events and conditions representing climate change is that considerable convergent, cumulative, research evidence indicates that the contribution of assumed or established personal experience of extreme weather events to acceptance of, issue engagement with, or overt behavioral influence relating to climate change is very modest, with this finding and conclusion being stated in many of the research reports reviewed in the online supplemental materials and elsewhere (e.g.,^{4, 47, 115, 116, 124, 125, 127, 133, 135, 138, 158, 160, 161, 208–215}). These findings throw into serious question the current methodologies and wisdom of approaching the nature, significance and influence of personal experience of climate change through the examination of geo-referenced exposure to or more directly assessed personal experience of extreme weather events, not assessed as attributed to global climate change by survey respondents at the time of their occurrence.

This is not to suggest that the human dimensions and impacts of natural disaster events are not very powerful and often devastating (e.g.,^{216–219}). But such experience has historically

and culturally been largely attributed to natural causation. Indeed, other than in some traditional subsistence cultures, all countries and cultures make sense of and come to terms with naturally occurring extreme weather events and ‘natural’ disasters in culturally congruent and adaptive ways, with culture itself being a formidable adaptation process and agent (e.g., ^{177, 178, 220, 221}). However, and again cross-culturally, when dramatic, exceptional, and out-of-historical-context environmental events and conditions appear, such phenomena can constitute very different and troubling environmental risk domains and narratives (e.g., ^{73, 203, 221}). The ‘story of climate change’ itself has become a powerful, global, narrative, nuanced by regions and cultures and social representations, and interwoven with differing takes on adaptation and mitigation responsibilities and possibilities (e.g., ^{222–226}).

It is extraordinary that ‘social and behavioral science’ based climate change research over the past decade which has been expressly addressing the nature and putative significance and issue engagement influence of personal experience of climate change would intentionally, ‘strategically’, and operationally *not* seek, or examine the actual perceptions, experiences, understandings and responses of individual research participants. This is despite the pressing need and call for more basic, primary, research on the more qualitative, phenomenological, psychological, nature of such perceptions, experience, impacts, and ‘human dimensions’ of climate change (^{8, 182, 189}). Similarly, there would appear to be limited appreciation that *adaptation*, a fundamental construct within psychology for well over a century (e.g., ^{71, 194, 227, 228}), encompasses a fundamental suite of *internal environment* emotional and cognitive processes arguably integral to individuals’ coming to terms with/adjusting to the stark and escalating threat and challenges of climate change (e.g., ^{25, 229}).

Virtual and vicarious exposure and experience

The ‘new media’ *information environment* is a very real, ubiquitous, immersive, ‘environment’ taking up a dramatically increasing amount of experiential engagement and time globally. Extensive Pew Research Center findings provide compelling U.S. statistics.

“As smartphones and other mobile devices have become more widespread, 26% of American adults now report that they go online “almost constantly”, up from 21% in 2015, according to a Pew Research Center survey conducted in January 2018. Overall 77% of Americans go online on a daily basis.” ²³⁰

One need only look at ‘where the public is at’ when walking down the street or taking any form of mass transit, in most countries in the world, with an expert assessment in 2014 finding that people around the world spend an average of 485 minutes a day consuming media ²³¹. From a ‘virtual’ natural environment experience perspective this new ‘reality’

clearly needs to be taken into account. Such media coverage reflects and is accompanied by the image-focussed ‘landscape’ of **climate change**-themed commercial films, documentaries, and YouTube vignettes (e.g., ²³²). Paradoxically, this itself makes direct personal experience of perceived climate change manifestations in known natural environments even more arresting and alarming, conferring ‘reality’ and catalysing realisation - and, for many, resolve - concerning this clearly global but increasingly ‘backyard’ and alarming environmental threat and unfolding reality ^{6, 45}.

It is very likely the case that initial personal encounters with perceived manifestations of climate change have been preceded by considerable exposure to and vicarious experience of climate change through extensive multi-media and other popular culture coverage. There would be few individuals in internet-connected modern societies who have not had such exposure. This foreshadowing of a person’s initial encounter(s) with perceived local manifestations of climate change can make climate change very real and proximate in a powerful way for many. A plausible reason for this might be that such first-hand experience can validate and confer reality to a global phenomenon, risk, and change which has been *virtually* communicated, contested, extensively media-portrayed and covered, and a background source of unease, and for many felt distress. This is not to dismiss the probable and simultaneous psychological reality that concerned individuals might be particularly ‘attentive’, when in natural settings, to the state of their known natural environment, and whether there might be local evidence of global climate change. But this is arguably a far cry from the motivated reasoning, ‘believing is seeing’, counter explanations for quite genuine perceived personal encounters with ‘climate change’, and the accompanying psychological significance and influence of such experiences (e.g., ^{49, 233}). A parallel dynamic occurring in the context of such personal encounters is that such experiences become an integral part of *psychological adaptation* processes, the ‘coming to terms with’ the reality and reach of this global alteration and risk domain, and what it means and portends (e.g., ^{6, 25}). Such enhanced validation, acceptance, and realisation is likely an ubiquitous aspect of climate change adaptation occurring across the world, yet does not seem to be on the radar of climate change science or policy consideration and formulation.

The matter of psychological distance

An argument which continues to be made, across disciplines, is that of the ‘psychological distance’ of global climate change, emphasizing geographic and temporal ‘distance’ considerations, uncertainty and social distance, phenomenon and issue global scale and complexity, and convergent protection motivation responses to a salient and grave threat

(e.g., ^{28, 31, 234–240}). In a somewhat different vein, a number of authors and researchers argue that it makes little sense to speak of individuals' *experiencing* 'climate change', given the global, atmospheric system, wicked problem nature of climate change, its largely future threat status, and the inability of any individual to accurately ascertain causal attribution of any specific environmental event or condition (e.g., ²⁴¹). Clearly these arguments are relevant to the issue of direct, personal experience of climate change, although they lose some currency given that this latter consideration and focus is a matter of environmental *perceptions* and *sense-making*, and given the affect heuristic relevance of the climate change risk domain (e.g., ⁵⁹).

While it is self-evident that the physical science-based nature and scope of climate change is intrinsically difficult to understand ^{28, 242}, and indeed a worrying and ongoing environmental stressor ^{130, 243}, the aspects of climate change which can certainly elicit psychological defense mechanisms, also reflect the pervasive salience and 'presence' of climate change, ensuring that it is not 'out of mind'. While the cases for both the power and the limitations of personal experience in understanding climate change can be persuasively made (e.g., ²⁴²), an individual's sense-making and environmental risk perceptions in the case of personally encountering an anomalous environmental change or condition are both hard-wired by biological history and sensitized by the 'availability' of ongoing and extensive media coverage of global climate change ^{244–246}. And while there is no question that the profound risk of global climate change can initiate understandable and extensively-researched 'protection motivation' mechanisms (e.g., ^{118, 247}), and the reality that global climate change constitutes a formidable convergence of complex issues, this general psychological distance argument is very much at odds with the ubiquitous multimedia coverage of climate change, the very high percentages of reported direct personal experience of perceived 'climate change' related environmental encounters, and the visibility and availability of climate change in social representations, popular culture, and everyday conversations. The current global extinction rebellion, as a social movement, social representation, and collective response, is a compelling case in point.

The sheer quantum of virtual, vicarious, and direct personal exposure and experience – and indeed the increasingly dramatic unfolding of global climate change environmental impacts across the planet - does render the nature and level of the psychological distance argument rather moot. Thorough review of research addressing the nature, dynamics, and influence of putative psychological distance, and the effectiveness of countering 'proximizing' strategies, would strongly suggest that such psychological distance in the

context of climate change is far less pervasive than theoretical arguments might indicate, and that when and where it might exist, it may well have very modest influence on either issue engagement or behavior change.

Issue engagement and behavior change: psychological significance and environmental significance

Considerable confusion exists with respect to the language and terms being used when addressing climate change communication, issue engagement, and behavior and lifestyle change in the context of climate change. The nature of personal experience, and the roles it might play are clearly seen as important research foci. Two particularly frequent terms which permeate this communication and persuasion aspect of the human dimensions of climate change are ‘environmentally significant’ behavior change and ‘issue engagement’ when speaking of fostering or promoting pro-environmental behavior. Environmental significance, in the contexts of promoting pro-environmental behavior and climate change adaptation, refers to decisions and overt behavioral actions which result in materially reduced individuals’ or households’ carbon footprints (e.g., ^{191, 248, 249}). The phrase also has specific meaning in environmental protection legislation around the world relating to substantive environmental impact(s). In the United States this requires that “a person who proposes to take an action that will have, or is likely to have, a significant impact on a matter or environmental significance must refer the action to the minister for a decision as to whether assessment and approval is required by the EPBC Act” ⁸⁵. This ‘environmental significance’ is an expression which, in everyday discussion, is used to clarify and emphasize that environmental issue engagement has ‘real’, consequent, outcomes and dividends for the natural environment, whether in terms of environmental conservation, restoration, or protection. However, in environmental social science this expression has taken on a more specific ‘behavioral’ and ‘scientifically measurable’ meaning with respect to ‘making a difference’, and is effectively code for quantifiable or otherwise empirically demonstrable behavior change or altered environmental impact.

Unfortunately, this more formal ‘evidence-based’ meaning has become de rigueur in the environmental sustainability and climate change sciences generally, associated with acceptable evidence ‘confidence levels’ (e.g., ^{201, 250, 251}) for credible reporting, while the more encompassing meanings of personal importance and *psychological* significance have been largely ignored, as have more ‘psychological’, evidence-based, research criteria generally (e.g., ²⁵²). Much research addressing the significance of exposure to or experience of extreme weather events, for example, has used a ‘scientific’ and very behavioral and

‘behaviorist’ gloss of this phrase, again excluding the relevance of personal importance or meaningfulness connected to a reaction or response to an environmental issue or concern, or issue engagement which is largely internal, motivational, and psychological. This language and meaning issue is rather crucial in the context of personal experience of perceived climate change, as demonstrable empirical evidence is the sole evidential criterion for much research in this area. This is so despite the public engagement objective of much social science climate change research being enhanced awareness, changed understandings, and personal *issue engagement*, which can encompass much more than overt behavioral actions or change. The research that we have examined in this review has reflected some exceptionally strong views on what would and would not be considered credible research when addressing personal experience of perceived climate change, again with self-report of one’s own environmental encounters, environmental perceptions, sense-making, and personal responses seemingly viewed as too prone to subjective bias, heuristics, and memory lapses to be considered as credible data or evidence.

Challenges in documenting psychologically significant and influential environmental risk perceptions and personal experiences through current research strategies

The problems and challenges of research addressing public risk perceptions, understandings and responses to climate change are many (e.g., ^{26, 33, 115, 163, 193, 206}). They include credible sampling, mode of administration, time constraints, longitudinal research challenges including continuing research programs and funding, respondent identification, attrition, credible and standardized items and scales, capturing qualitative accounts, etc. The need for longitudinal monitoring and documentation of change and impacts, and the often necessary use of panel survey service providers for cost and administrative reasons, has led to the widespread use of questionnaire-based surveys as the predominant research strategy when individual respondents and their views are desired or required (e.g., ^{1, 253}). However the nature of this ongoing, global, phenomenon of climate change, and its dramatic, unfolding, environmental changes and impacts, clearly require strategic and ideally longitudinal research monitoring programs, and survey items and response options that provide credible measures of individual level environmental perceptions, understandings, and responses. Where closed-ended questions are used, a standard set of items is needed to permit valid comparisons across studies, times, and nations. There is also a crucial need to supplement such research platforms and programs with parallel qualitative research with the capacity and sensitivity needed to more adequately ascertain, document, and explore changing individual level

experience of, responses to, and psychological and broader health and well-being impacts of, climate change^{6, 8, 21, 27, 163}.

The distillation of objectives and operationalizations of personal experience of climate change in the online supplemental materials clearly illustrate the problems and underlying issues in how researchers from differing disciplines have approached questions pertaining to the nature, extent, and influence of personal experience ‘of climate change’, with extreme weather events, conditions, or consequences serving as a presumed, de facto, face of climate change. Many of these studies do not investigate self-reported, perceived, personal experience of natural environmental changes, conditions, and events deemed to be probable manifestations of global climate. As noted, only five of the reviewed studies involved the presentation of one or more transparent question(s), whether by survey or face-to-face interview, to individual respondents about whether they might have had such an experience, and, if so, the nature and significance, and self-reported influence, of this perceived climate change experience/encounter. In many ways the statements of purpose and methodology employed in these studies tell us more than the reported findings do about what can be concluded regarding respondents’ personal experience of climate change. We are presented in these research articles with very different constructions and operationalizations of personal experience, along with an effective dismissal of the validity and value of environmental risk perceptions, psychological significance and impacts, and psychological adaptation and issue engagement responses - as contrasted with possible but very problematically ‘measured’ environmentally significant overt behavioral responses. Researchers need to identify individual and contextual variables that moderate the effects of self-reported personal experience, and they need to examine possible nonlinear, reciprocal, and multi-level effects of experience on diverse internal, individual, and collective states and processes.

Concluding commentary

What observations can be made, and/or conclusions drawn, from this very diverse picture of research objectives, assumptions, methods, and operationalizations? There is no doubt that research on personal experience is both important and strategic. While the authors’ 2014 review identified few relevant articles, this current, broader, review identified and considered 36 articles of comparable relevance. In the context of their own research, other authors have also reviewed research findings addressing the nature, extent, and influence of ‘personal experience of climate change’ (e.g.,^{1, 7, 113, 126, 133, 212, 235, 254}). A paradigmatic example of issues addressed in these reviews has been that of ‘seeing’ versus ‘believing’ in explaining research findings relating to the nature and role of personal experience of climate change

(e.g., ^{5, 6, 47}). A parallel rationale has been that a better understanding of climate change experience might well provide needed insight into not only how such knowledge of personal experience can be strategically used (e.g. ²⁵⁵), but, equally importantly, how these ‘internal environment’ processes are mediating and moderating both successful psychological and behavioral adaptation, and the psychological, social, and environmental impacts of climate change (e.g., ^{130, 243})..

What becomes very apparent in reviewing this research landscape is what is largely absent. Missing elements include:

- a common, cross-disciplinary, climate change research-specific, language for those working in this arena;
- a standardized glossary of core terms, constructs, and research methodology and procedure-reporting terminology;
- an accurate and encompassing gloss of *experience* in the context of climate change, reflecting perspectives of both the humanities and the social and behavioral sciences, which identifies and differentiates the multiple ways in which personal experience of climate change has been operationalized in this research area, and what is lost and gained in each such operationalization;
- an addressing of and clear differentiation between exposure and experience, and direct personal experience and virtual and vicarious experience, in the context of the research being reported;
- a common understanding and appreciation of differing disciplinary research approaches and assumptions, and their respective advantages and disadvantages, when addressing subjects such as environmental risk perception and personal experience of perceived climate change;
- a more informed knowledge and appreciation of the research undertaken across the social and behavioral sciences over the past several decades relevant to the nature and putative psychological significance, and issue-engagement influence, of perceived personal experience of climate change;
- a situating by authors of where and how their research sits within this emergent field of research, and with respect to what is common to and what differs from previously published research.

- an acknowledgement of the philosophical, conceptual, and methodological issues involved, and how these were addressed and navigated in the research undertaken and being reported.

An addressing of these missing elements would give readers and fellow researchers confidence that the studies undertaken were well-considered and informed by current research and prior reviews.

As discussed, a further and embedded matter relating to the scientific status of constructs, theories, methods and ‘evidence’ looms large in the context of climate change research and IPCC/USGCRP criteria relating to ‘confidence’ in findings. Scientific status and relevant assumptive world issues also continue to reflect the strong ‘behavioral’ focus of the work of many researchers working in areas of environmental social science, with the promotion of *environmentally significant* behavior change being a principal target^{192, 256}. But the nature and more challenging status of ‘internal environment’ psychological processes relating to cognitive, emotional, adaptive, and motivational processes, and constructs such as personal importance, psychological significance, concern, self-efficacy, and psychological impacts generally, have tended to have lesser status and climate change science credibility, with research findings relating to these constructs and processes rarely meeting natural and physical climate change science ‘confidence’ criteria, for example in IPCC and USGCRP scientific assessment reports (e.g.,^{250, 257}).

While all of the studies examined have individual strengths, and together provide an increasingly detailed picture of some specific kinds of climate change-related ‘experience’, the selection of the events and conditions researched has meant that this emergent picture has many blank but crucial spaces. That flooding events were the single major focus of 11 of the 36 studies reviewed (and one of several foci of a further 15 studies), and the absence of any self-report by individual research respondents characterized the research of a further nine of these studies, is again extraordinary given the ostensible focus of each of these studies on personal experience of climate change. The seeming limited interest in, and in some cases the provided rationales for not examining, individual level accounts, and indeed the phenomenology of such personal experience, are not entirely inexplicable, but are disappointing. Importantly, effects vary with the psychological processes (e.g., appraisals, attributions) and states (e.g., distress, resolve) elicited by the experience, yet these processes and states, as mediating variables, have seldom been adequately studied. This is where more research is most needed. Simply conducting more studies of the relationship between *exposure* to EWEs/NDs and CC understandings and responses will produce more

(inconsistent) evidence of weak effects. Such currently favored and widely adopted approaches miss the nature, psychological significance, and issue-engagement influence of personal, perceived, climate change experiences for many, and have certainly not achieved the credible and crucial transdisciplinary understanding that is needed (e.g., ^{8, 254, 258}).

The research landscape looking forward

It is arguably helpful and strategic to think through where further research on personal experience of climate change might head. The need for more longitudinal research which can capture individuals' changing encounters and experiences and a transforming natural environment and landscape is a very important component of psychosocial environmental impact assessment (PSIA) and monitoring over the crucial decades facing human communities and their governance. This requires some consensus, other discipline awareness, and where possible and useful, standardized procedures, methods, and measures both within and ideally across disciplines. Clearly, the current research landscape reflects many interdisciplinary and transdisciplinary research studies and reviews, and some heartening signs of ongoing, well-funded, programmatic research platforms and programs. There is of course considerable value in retaining and well-utilising the distinctive disciplinary lenses we bring to the study of the human dimensions of climate change, including the crucial cross-validation that such convergent research brings. But these social and behavioral science research approaches must also provide a much clearer and coherent research landscape and set of substantive findings to better inform the views of many natural/physical climate change science colleagues and organizations. This might insure a stronger representation of the social sciences and humanities in such bodies, and a fuller appreciation of the findings of the past four decades of research addressing the human dimensions of climate change.

In summary, we recommend the following in the context of further research in this area:

- that researchers who are addressing the nature and context, salience and significance, and issue engagement influence of perceived personal encounters with environmental changes, conditions, or events deemed to be likely manifestations of climate change, clearly state this, along with their specific research focus(i) and objective(s).
- that researchers *not directly asking* individual respondents whether they have personally encountered or experienced what they perceived to be probable environmental manifestations of climate change clearly state this, explaining why and how their research nonetheless addresses perceived personal experience of probable climate change manifestations.

- that researchers employing extreme weather events, conditions, or personal, household, or property impacts resulting from extreme weather events, as de facto operationalizations of, or indicators of, ‘personal’ experience of climate change’ clearly explain and support such use;
- that researchers clearly indicate their working specification/definition of climate change [i.e., Kyoto Protocol or IPCC or other definition/specification], and how this use and understanding might pertain to the wording of survey items, or interview questions concerning ‘climate change’.
- that researchers also clearly communicate and specify their understanding, definition, and use of ‘experience’ [or ‘personal’ or ‘direct’ experience] and how this experience has been operationalized and examined, clarifying level(s) of analysis;
- that researchers writing for and addressing multidisciplinary audiences state their disciplinary perspective(s) and attempt, where possible, to adopt more standardized language and terminology concerning construct and parameter specification, and operational procedures and measures, allowing for more meaningful comparisons across studies, and enhanced reader understanding and evaluation of stated findings;
- that researchers situate/locate their research with respect to other relevant research approaches and methodologies in this multidisciplinary ‘personal experience of climate change’ space;
- that researchers more clearly address and explain what can or cannot be concluded from their research findings given their approach, procedures, measures, and analyses, and the limitations thereof.

The current state and speed of already unfolding natural environment and ecosystem system impacts of climate change are such that *initial* perceived and impactful personal encounters with noteworthy environmental changes, conditions, and events attributed to climate change may be far less frequent and striking moving forward. It might also seem that the dividends of a closer and more informed focus on the nature and significance of individual level experiences of perceived climate change consequences in one’s known, familiar natural environment are very real and promising at present, but likely to fade as the world moves past this liminal period in which mitigation and adaptation measures might make a consequential difference to how severe and irreversible this climate change disequilibrium and disruption will be. However this makes it even more imperative that there exist a more informed transdisciplinary and transactional understanding and language for addressing, researching and better utilising ‘internal environment’ adaptation processes that

are and will continue to be mediating how individuals come to terms with the ongoing environmental stressor and psychological and societal impacts of global climate change. Such a focus will not displace the need for continued monitoring and risk and impact assessments relating to geographic proximity and exposure to high risk environments in this phase of the Anthropocene, but it will substantially assist in the design of risk communication, adaptation, and issue engagement strategies and policies for what is already shaping up to be the new and very stressful abnormal.

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