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### Paradigmatic approaches to studying environment and human health: (Forgotten) implications for interdisciplinary research

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### Abstract

Interdisciplinary research is increasingly promoted in a wide range of fields, especially so in the study of relationships between the environment and human health. However, many projects and research teams struggle to address exactly how researchers from a multitude of disciplinary and methodological backgrounds can best work together to maximize the value of this approach to research. In this paper, we briefly review the role of interdisciplinary research, and emphasise that it is not only our discipline and methods, but our research paradigms, that shape the way that we work. We summarise three key research paradigms – positivism, postpositivism and interpretivism – with an example of how each might approach a given environment-health research issue. In turn, we argue that understanding the paradigm from which each researcher operates is fundamental to enabling and optimizing the integration of research disciplines, now argued by many to be necessary for our understanding of the complexities of the interconnections between human health and our environment as well as their impacts in the policy arena. We recognise that a comprehensive interrogation of research approaches and philosophies would require far greater length than is available in a journal paper. However, our intention is to instigate debate, recognition, and appreciation of the different worlds inhabited by the multitude of researchers involved in this rapidly expanding field.

**Keywords:** Interdisciplinary, Methodology, Philosophy of science, Epistemology, Ontology, Positivism, Postpositivism, Interpretivism, Generalizability.

### Introduction

Over the last two decades, interdisciplinary research has been highlighted as being the mantra of science policy (Metzger and Zare, 1999), a highly touted activity (Robertson et al., 2003), and an approach that “must increasingly become the standard rather than the exception” (Aboelela et al., 2007: 343). Such research must bring together scholars with “very different mental models, conceptual frameworks and methods with the goal of creating new ways of doing science” (Romero-Lankao et al., 2012: 3) (refer also to Table 1 for definitions).

An inclusive, interdisciplinary approach is highly valuable for the study of environment and human health relationships which often involve complex interactions between physical, social, biological, and ecological domains (Gohlke and Portier, 2007; Schwartz, 2005). This approach can lead to a complex evidence base that can prove difficult to incorporate into policy (Huby and Adams, 2009), but nevertheless can be an extremely effective mode of enquiry. When successful, the value of interdisciplinary research for addressing complex, policy-relevant problems regarding environment and human health linkages is apparent. As but one example, a program of research investigating the health impacts of Florida Red Tide (*Karenia brevis*, an algae that produces a harmful toxin) has brought together disciplines including biochemistry, oceanography, and epidemiology; and has highlighted the potential for aerosolised toxin to exacerbate respiratory conditions (Fleming et al., 2005, 2011). In turn, the Florida State Department of Health developed an Aquatic Toxins Disease Prevention Program ([www.doh.state.fl.us/environment/medicine/aquatic/](http://www.doh.state.fl.us/environment/medicine/aquatic/)), including guidance and action relating to the respiratory health impacts of toxins produced by *K. brevis*. Given the advances that can be made at the science–policy interface when this type of research is performed well, it is perhaps unsurprising to see an interdisciplinary approach being strongly advocated for environmental health research and policy on issues ranging from housing (Lawrence, 2004) and the built environment (Kent and Thompson, 2012) to air pollution (Nadadur et al., 2007) and climate change (Hrynkow, 2008).

That noted, many obstacles can prevent high quality, truly integrated (as opposed to complimentary/parallel) interdisciplinary work being accomplished. Shortcomings can include: researchers being chosen to fill a “nominal slot” rather than address a specific role (Rhoten, 2004) – or what Reich and Reich (2006: 57) term “tokenism”; additional demands on time (Kessel et al., 2009); the limited communication of interdisciplinary research resulting from inappropriate reviewers; and the perceived inferiority of interdisciplinary journals (Campbell, 2005). Underpinning many of these shortcomings is a lack of shared vocabularies, attitudes, use of tools, and understandings between the different disciplines and subsequent methods (Bracken and Oughton, 2006). For Jacobs and Frickel (2009), these “[E]pistemic barriers involve incompatible styles of thought, research traditions, techniques, and language that are difficult to translate across disciplinary domains” (p. 47). As one example, Kessel et al. (2009) highlight the consequences of epistemic barriers when discussing their interdisciplinary research on greenspace access. These authors note the research group’s inability to adopt an interdisciplinary framework, noting how the divergence of academic expertise within the group meant “discussions invariably returned to different ways of seeing the world” (p. 37).

The terms used to acknowledge these different ways of seeing the world have become common currency: quantitative versus qualitative, hard science versus soft science, natural science versus social science, and so on. Regardless of which labels are selected, there is a silence within environment and human health research regarding what these differences

might actually involve. At this crucial “time for teamwork” within the field (Hrynkow, 2008: 470), clarity on this issue is both timely and important. It can promote understanding between different disciplines, and move the researchers towards supporting familiar (if not shared) vocabularies. Combined, these developments might go some way to equipping researchers to respond to the commonly experienced shortcomings of interdisciplinary research that are highlighted above.

Against this backdrop, our paper develops the environmental science, human health, and policy literatures which, to date, have stated that philosophical obstacles are inherent to inter- and even transdisciplinary work, but rarely presented in detail what they are, what they mean, and what they might look like within a collaborative, policy-relevant research setting. Accordingly, drawing from the philosophy of science, in what follows we critically discuss different ways of seeing the world within the context of environment and human health research. To do this, we focus on three established research paradigms that commonly shape and guide work in this field: positivism, postpositivism, and interpretivism (see Table 2 for a summary of their basic beliefs). We provide a brief overview of these paradigms, and situate each within the context of environmental sciences and its link with human health by using the example research topic of “How weather impacts upon health via physical activity.”

Our personal motivations for this paper stem from experiences as researchers spanning a range of ‘home’ disciplines (e.g. environmental sciences, critical psychology/ sociology, epidemiology, graphic design, geography, and chemistry) and now members of a new research centre, which aspires to foster interdisciplinary work that contributes to research, policy, and commercial communities. Our intention is not to settle philosophical debates that have existed for thousands of years. Nor is it to assign labels to our colleagues, which may not be in keeping with how they view the world. We acknowledge that boundaries are blurred, and that paradigmatic debates are alive and indeed lively. Instead, the purpose of this paper is to advance knowledge and awareness within interdisciplinary teams, as a way to move beyond debates around ‘right’ and ‘wrong’ ways of approaching research (while being mindful that good and bad science does exist!), and move towards a cohesive, complementary, and respectful way of working. We believe this somewhat overdue paper represents a first – albeit “backward” – step, which is essential if we are to work in a truly interdisciplinary way: with rather than against our different ways of seeing the world.

### **Paradigms revisited**

The act of conducting research does not take place in a vacuum, but in the social context of “invisible colleges”; that is, a community of scholars who share similar conceptions of what constitutes appropriate questions, methods, techniques, and forms of interpretation and explanation. The beliefs and methodologies that these research communities share are referred to as “paradigms” (Kuhn, 1962). A paradigm may be viewed as a “set of basic beliefs (or metaphysics). . . a worldview that defines, for its holder, the nature of the ‘world’, the individual’s place in it, and the range of possible relationships to that world and its parts” (Guba and Lincoln, 2005: 107). Researchers learn the basic beliefs and assumptions of a paradigm via the process of socialization into their chosen discipline or institution, which informs them of what is important, legitimate, and reasonable to study (Broto et al., 2009). Central to this socialization process is the taking on of certain philosophical assumptions concerning questions of ontology (what is the nature of reality?) and epistemology (what is the relationship between the researcher and the researched?) (see Fig. 1).

We believe that understanding the basic premises of different research paradigms is essential for interdisciplinary research. This is because the paradigm that different researchers situate themselves within has great bearing on what they consider to be achievable through their research and the approach that should be taken (often signaled by the term ‘methodology’). It also has implications for research questions and/or hypotheses, methods of data collection, analysis and forms of presenting research findings, along with broader issues such as causality and generalizability. In turn, these have consequences for how and what kind of knowledge is formulated into policy. To that end, it is curious that within an interdisciplinary field such as environment and human health, the notion of research paradigms has been largely overlooked.

## **Paradigmatic approaches: guiding principles and theory in action**

### *The positivist paradigm*

The positivist paradigm emerged during the period of the Enlightenment, and underpinned the major principles of the natural sciences. This approach is based on non-contextual, formal, and standardised research that seeks analytically to separate distinct variables. Rationalism and empirical knowledge are valued over other ways of knowing reality. A unity of methods, which are able to establish relationships of cause and effect and the generation of laws about the natural world, are sought (Green and Thorogood, 2009). That which cannot be observed or measured, is positioned as having less value than that which can. Positivism adopts a dualist and objectivist position, whereby the researcher and researched “object” are viewed as independent entities. Data are not valued if considered the result of “judgment, interpretation or other subjective mental operation” (Hughes, 1990: 36). As such, positivist researchers distance themselves from the particular phenomenon under investigation, seeking a reality which is measurable and “objective”. For this reason, within the positivist paradigm, quantitative methods are commonly favoured over qualitative.

**Example 1.** Theory in action – a positivist approach to investigating impacts of weather on health via physical activity. [textbox]

*The research would assume a deductive quantitative design. It would begin by determining which components would act as variables, and which components can/will be controlled. For example, weather may be reduced to temperature variation, with all other weather factors (such as light and humidity) being controlled. Physical activity may be defined as a specified exercise performed at a specific intensity (e.g. % heart rate max) for a specific period of time. The impact of the specified exercise on health could be measured by using an appropriate physiologic measurable proxy, such as the quantity of endorphins produced. Based upon these definitions/boundaries, a hypothesis would be developed such as: “Running (under defined parameters) at higher temperatures (within predetermined range) gives rise to higher endorphin production (in comparison with control data).” Raw data would be collected using objective measures. Consideration would not be given to human perception, as this knowledge is subjective – i.e. unquantifiable, unreliable and unable to be reproduced; such knowledge does not contribute to the unity of methods or the generation of laws. The data would be collected in controlled laboratory conditions. Individual participants (selected according to pre-defined parameters e.g. age, sex, etc.) would exercise at different temperatures. For comparative purposes control data*

*(e.g. rest at different temperatures) would be collected and replicate experiments conducted for the purposes of test–retest reliability and reproducibility.*

*Data would be subjected to statistical analyses. Should the results of these analyses indicate that the data did not fall within accepted margins of error, the entire data set and methodological approach would be rejected, deemed poorly designed or executed inaccurately. Of course, in certain instances, such a finding might also be considered as an unexplained phenomenon worthy of further research. The findings would be reported in the form of a scientific report in which the author/researchers voice would remain absent or impersonal. In line with the principle of Occam's razor, the simplest explanation has greater value over more convoluted multifactorial hypotheses (until shown to be incorrect). The study would conclude with the data either supporting or being unsupportive of the hypothesis with minimal speculation.*

Scientific knowledge produced using the positivist paradigm links to policy development through, for example, notions of causality and statistical generalizability. Knowledge produced within this paradigm can be an appealing resource for those faced with the task of using research evidence to produce policy recommendations. This is because positivism fosters a deterministic understanding of causality, whereby explanations of whether “x causes y” are presented as predictable and generalizable “cause and effect” scenarios based upon scientific laws (Schwandt, 1997). Moreover, the importance of statistical generalizability is embedded within positivist research design. This enables the research findings to be used to apply ideas/observations universally within a chosen population for which the research study was representative. Policy makers can feel great confidence in the process, results, and applicability of the findings in terms of assuming that they can be applied on a large scale.

That noted, classic formulations of positivism have received much critique (e.g. Keat, 1981). These critiques have often challenged its reductionist approach whereby complex entities are understood by reducing them to the interactions of their parts. This can result in insights into and follow up of unexpected findings being blocked (Mol, 2006). Moreover, though derived from research designs lending themselves to statistically generalizable findings, positivist research pays little credence to – nor has any use for – the subjective/“unreliable” nature of research participant’s thoughts, feelings and/or interpretations. Thus, policies informed exclusively by positivist thought could run the risk of failing to “speak to” the very people they claim to serve. Finally, positivists have also been critiqued for failing to acknowledge the possible (subjective) influence of the researcher, in terms of the research design, analysis, results and/or interpretation.

Such criticisms gave rise to the development of postpositivism (discussed in the following section). Modern positivists generally acknowledge in far greater detail observer bias and structural limitations, though maintain a belief that the scientific process is disassociated from the observer’s personality and/or social positioning (Gartell and Gartell, 1996). It is accepted that the inquirer can effect experimental outcome, though this effect is due to methods, and possibly less on data interpretation. Importance is attached to methodological debates regarding reliability, validity, and how accurately work can be replicated rather than theoretical concerns. This differs from the assumptions underpinning the interpretive paradigm as outlined later in the paper.

## *The postpositivist paradigm*

Postpositivism emerged from the rejection of many central tenets informing the positivist paradigm. That noted, these two paradigms do share some common ground. For example, ontologically, they both emphasise reality as being external. Epistemologically, knowledge is understood as being “objective.” These paradigms differ in how issues of ontology and epistemology are negotiated. Specifically, postpositivism developed from the perception that when it came to researching human experience, a phenomenon characterised by multiplicity and complexity, dualistic thinking is often inadequate. Thus, postpositivism assumes that all observations and measurements have a degree of error, and that researchers cannot operate outside of their biases. This implicit bias of the researcher means that no single method or perspective can provide the answer, nor capture an external reality in its totality. Like positivism, postpositivism also places great emphasis on empirical evidence to support a hypothesis. What differs between these two paradigms is how postpositivism deals with objectivity as something to be approached or sought (rather than assumed) through engaging with multiple methods and perspectives.

A “mixed method design” is characteristic of postpositivist research. Researchers within this paradigm point out several shortcomings of using quantitative research techniques in isolation when seeking to understand complex social issues. Accordingly, qualitative measures are incorporated to address these. Mixing methods can, therefore, be viewed as a pragmatic style to conducting research (Creswell and Plano Clark, 2011), and has risen in popularity over the last 20 years (Johnson et al., 2007). In this context, gathering data using both quantitative and qualitative methods produces a range of results, which are subsequently triangulated to provide an overarching finding. The metaphor of a triangle signals the use of multiple reference points to locate a singular position (Denzin, 1978). Crucially, it is this act of seeking an objective, singular truth through the processes of triangulation, which differentiates the postpositivist from the interpretive paradigm (described below).

**Example 2.** Theory in action – a postpositivist approach to investigating impacts of weather on health via physical activity. [Textbox]

*Similar to research influenced by positivism, research situated within a postpositivist paradigm would also focus on the measurable relationship between weather and physical activity. However, recognising the degrees of error likely to be incurred from each method, a complete picture may be sought through a mixed method study.*

*A hypothesis would be developed regarding the immediate and long-term effects of monthly/daily/hourly temperature, precipitation and sunshine on physical activity patterns. For example: “Short-term participation in outdoor physical activity is influenced by daily rainfall, temperature and sunshine hours.” A random, representative sample would be drawn from the population of interest. Objective measurements would be collected (e.g. heart rate variation using heart rate monitors) and used to assess individuals’ activity patterns. These measurements would be complemented with standardised, validated questionnaires to assess other individual characteristics (e.g. age, sex, socioeconomic status).*

*These quantitative measures might be supplemented with qualitative data (e.g. participant-led activity diaries). This element of the study would enable the researcher to establish*

*interpretations and perceptions of how activity patterns are affected by the weather, while acknowledging the strengths and weaknesses of each source and type of data. By triangulating the findings from the heart rate monitors, standardised questionnaires, and activity diaries, the observed quantitative (and by necessity, summarised/averaged) activity–weather relationships could be contextualised. Combined, these findings would result in a more accurate understanding of the relationship.*

*The physical activity measures could then be related to weather data from local climate data. The relationships would be measured, adjusting for individual and area characteristics to provide more accurate knowledge of the relationship between the two variables (physical activity and weather). This permits quantitative assessment of how the sample's – and by statistical inference the population's – physical activity behaviour varies with weather at a variety of timescales.*

Knowledge produced from postpositivist research can contribute to policy development in similar ways to that aligned with positivism. Research situated within both of these paradigms is committed to ascertaining “the answer” through pursuit of a singular, external reality that can be found independent from the researchers. Yet because postpositivism is characterised by a recognition of the degrees of error implicit within different research techniques, claims concerning causality may be inferred through the layering of research findings from different methods of data collection (Calnan, 2007). This differs from the uni-dimensional deterministic notion of causality underpinning positivist thought. Like positivists, postpositivists seek statistical generalizability in order to apply ideas universally across identified populations. However, in this paradigm, generalizability is conveyed at both macro and micro levels. Statistically generalizable findings ascertained from large quantitative experiments/ trials are often combined with individual (qualitative) thoughts and opinions of its participants (qualitative research). This can be beneficial to policymakers who must face the task of translating broad “macro” scientific knowledge into policy recommendations, which might ultimately impact individuals and their environment at a micro level.

Critiques of postpositivism have generally emerged from those adopting a purist position to mixed method research, asserting that mixing methods is incommensurable at philosophical and theoretical levels (Guba and Lincoln, 2005). Purists problematize what is believed to be the use of qualitative methods by postpositivists to test positivist theories (Lather, 1992). In these scenarios, it is argued that the way in which qualitative methods are used (i.e. as a means of ascertaining an “objective” external reality) often conflicts with the very strength of qualitative methods (i.e. as tools to examine subjective realities). Moreover, while mixing methods within the postpositivist paradigm may be implied as representing “the best of both worlds,” Giddings (2006) argues that the normative descriptors of “qualitative” versus “quantitative” methods effectively marginalizes the methodological diversity within them. These limitations have led to further developments towards paradigmatic frameworks more specifically suited to qualitative work, such as the interpretive paradigm.

### *The interpretive paradigm*

The interpretive paradigm is framed by an internal ontology. From this perspective, it is understood that humans continually construct reality in fluid and multifaceted ways. Rather than adhering to a singular objective truth, interpretive researchers believe that realities are multiple, subjective, and exist dependent upon rather than independent of people's minds and

bodies (Smith, 1989). In terms of epistemological assumptions, interpretive researchers consider all knowledge as being fundamentally subjective, and therefore, the research process itself as being subjective and interactive: researchers – as people and professionals – are inseparable from what and who is studied. What comes to be understood as “knowledge” within the interpretive paradigm is inescapably framed by one’s gender, class, age, physical (dis)ability, and so forth. Moreover, research findings are understood to be the result of a process of interaction between the researcher and the researched and embedded within power relationships.

**Example 3.** Theory in action – an interpretive approach to investigating impacts of weather on health via physical activity. [Textbox]

*An interpretive approach to this topic would most likely involve a qualitative research design. It would aim to explore experiences of weather, physical activity, and health – and the potential interplay between these issues – from the perspective of those concerned. The meanings that participants attribute to these phenomena, rather than the measurement of them, would be the focus of interpretive inquiry. Rather than responding to a predetermined hypothesis, a set of research questions and sensitising concepts/theoretical frameworks would be used to frame the study. For example, research questions might include: “What is the role and meaning of weather in everyday life?” “How and why is weather believed to influence experiences of physical activity (if at all)?” “To what extent are individual experiences of weather and physical activity framed by broader social structures (e.g. institutions) and/or campaigns situated in historical time (e.g. ‘Let’s Move Outside’ (US Government); ‘SunSmart’ campaigns (UK, Australia), etc.)?”*

*An emergent and flexible research design would be employed to enable the researcher to respond to unanticipated factors that may arise throughout the research process relative to the original research question(s). Data would be collected using a range of qualitative methods. For example, life history interviews could be conducted to investigate how the interplay between weather, physical activity, and health has changed in participants’ lives over time; participant observation (as part of a wider ethnographic study) could be undertaken in selected institutions (e.g. schools) to understand how, when, and by whom weather-related decisions (“wet break/indoor play”; “games is cancelled”, etc.) are made, how they are responded to (e.g. gender differences), and the implications this has for opportunities for physical activity to occur. The emphasis throughout the research would be far more on process than product (Woods, 1999).*

*Using the interview transcripts and/or ethnographic field notes, an inductive approach to data analysis would generally be adopted. This involves researchers generating codes and themes from the data, rather than using a pre-existing theory to identify codes or themes that might be applied to the data. A common way of reporting qualitative research is in the form of a realist tale (Van Maanen, 1998). These are characterised by the use of extensive, closely edited quotations in order to convey the participant’s point of view throughout the text.*

Unlike the positivist and the postpositivist paradigms, interpretivism is characterised by subjective knowledge, and multiple truths and meanings. It is aligned with a plethora of



“interpretive” qualitative approaches including narrative (see Andrews et al., 2008), ethnography (see O’Reilly, 2012), and image-based research (see Phoenix and Smith, 2011), to name but a few. These approaches have much to offer the policy arena. They can provide rich detail into the nuanced influences of structural (“macro”) forces on cultural and individual experiences. They can also offer insight into contradictions and resistances experienced at individual levels in response to macro level forces and ideologies (Anderson and Scott, 2012).

There is a misconception that qualitative research findings – especially those informed by interpretivism – cannot shed light on issues of causality, nor produce generalizable research findings (e.g. see Lincoln and Guba, 1985). Interpretive research does not deal with notions of causality and generalizability as defined by positivist and postpositivist thought. Rather, it treats causality differently by adopting a process-orientated conception of causal explanation. This acknowledges the importance of context as integral to causal processes, and the role of meaning and interpretive understanding in causal explanation – all issues for which qualitative research offers particular strengths (Maxwell, 2004). In terms of generalizability, interpretive researchers do not seek statistical generalization. Instead, they might strive for naturalistic generalizability (as but one example) whereby personal experience is presented in a way that means readers are able to empathize with that experience (Stake and Trumbull, 1982). These differences are important because they can expand the repertoire of policy makers to use positivist, postpositivist and interpretivist research findings to initiate meaningful impact.

While knowledge generated within the interpretive paradigm makes no claim to represent “the” answer, it seeks instead to reveal the idiosyncrasies of people in their everyday lives. Its value lies in the insight it provides into the diversity of everyday “real life,” and its connection to cultural and structural forces. This knowledge (as distinct from policy evaluation) has much to offer our understanding of policy success and/or failure. It can inform policy development in such a way that avoids the pitfalls of “one size fits all” whole, communicating how recommendations might be played out in individual lives and relationships between people and their environment.

Interpretivism has been critiqued because it seemingly abandons “scientific procedures of verification,” such that any results yielded through this line of inquiry cannot, therefore, be generalized (in the positivist sense) to other situations (for a discussion on qualitative methods and generalizability see Chenail, 2010; Ruddin, 2006). Another criticism, broadened to qualitative research in general, is its lack of “testing” of theoretical frameworks. For example, Hagger and Chatzisarantis (2011) argue that qualitative research is sometimes perceived by the quantitative research community as not being driven by an explanatory system that allows one to pose hypotheses or research questions and match/‘test’ against observations to test their validity. Finally, research located within the interpretive paradigm has been noted for its neglect to acknowledge the political and ideological influences on knowledge and social reality (Keat and Urry, 2011). These are issues taken up by the critical paradigm (not discussed here).

## **Discussion**

This paper focuses on the philosophical assumptions underpinning three different paradigms in which researchers wishing to undertake interdisciplinary research in environment and human health might be situated. Before discussing the potential implications of this for the production of scientific evidence (and subsequent policy recommendations),

it is worth briefly acknowledging the role of data from different paradigms in policy development. These paradigms articulate a different concept of what counts as “evidence,” which may then be taken on board (or not) by the end user. A discussion of “what constitutes evidence – when, where and for whom?” is beyond the aspirations of this particular paper. That said, in discussing the science–policy interface and the manner in which knowledge produced from different paradigms contributes to it, two issues are worthy of highlighting.

First, policies are multiple and varied, influencing a broad spectrum of scientific and social life. For example, within the field of environment and human health, this can range from policies relating to water quality (e.g. European Commission, 2009) and those concerned with the use of greenspace and health (e.g. DEFRA, 2011; Department of Health, 2011). Research resulting from the different paradigmatic approaches, is likely to take on greater or lesser relevance depending upon the core purpose of the policy. For example, are recommendations calling for legislation based upon known health outcomes of water contamination? Or is the focus the need for a cultural shift in terms of how we come to value (and place a value upon) our greenspaces? The point here is that policies themselves, like research paradigms, might be conceptualized as existing along a continuum – and different times, for different people and purposes.

Second, the policy arena is not static. Policies are not only conceived, they must also be implemented and enacted. The science–policy interface is, therefore, dynamic, and calls for complex ways of understanding complex issues (Sarewitz, 2004). Awareness and respect for different ways of seeing the world is a salient part of this process. Different paradigmatic approaches generate different types of knowledge, which in turn link with different aspects of the “policy journey.” Specifically, there will be times when research driven statements regarding deterministic, inferred, and/or process-orientated causality will have something to offer policy development. Similarly, there will be policy situations that can benefit from statistical and/or naturalistic generalizability. Each paradigm has value for knowledge creation and evidence-based policy development. As calls for interdisciplinary research increase, the challenge therefore, is not to uproot researchers from their paradigmatic frameworks. Rather, it is to promote understanding and respect for what these different ways of seeing the world can offer within and across both the research and policy communities.

Different paradigms and “ways of knowing” become increasingly important as we aspire to bridge the gaps between the natural and social sciences within environment and human health research, and where appropriate, apply our findings to policy. While interdisciplinary teams working from within the same paradigm might enjoy shared/very similar languages and practices (e.g. biologist, chemist, geologist, physiologist, etc.), bringing together those who span the paradigm continuum is likely to present greater challenges (as an example of such an interdisciplinary team, refer to Fig. 1). Revisiting the philosophical assumptions that underpin what we claim to know, and how we claim to know it is, we contend, an essential starting point for interdisciplinary work (that is currently lacking within environmental science and policy research).

Developing an understanding of, and tolerance towards, these different ways of knowing extends beyond the mindset of quantitative versus qualitative methods (see Westerman and Yanchar, 2011 for a discussion on this). It calls for an appreciation of the distinction between methodology and method; “methodology” referring to the principles and epistemology on which different approaches are based, and “method” referring to a set of procedures, strategies,

and techniques for the collection and analysis of data. Thus, the similarities and differences between positivist, postpositivist, and interpretivist paradigms lie not entirely in the methods to which they are commonly aligned with, but more importantly with the beliefs about what those methods can and will achieve relative to truth and knowledge (Spector-Mersel, 2010). In light of these different conceptions, how then, might interdisciplinary teams continue to move forward in a way where barriers to successful working relationships and outcomes are minimised?

One positive step would be to guard against inadvertently aligning interdisciplinary research with a singular paradigm. The prominence of mixed method designs within interdisciplinary work can all too easily result in the entire project being situated within postpositivism. While “meeting in the middle” may seem to glean the best of both worlds and provide a pragmatic approach to addressing complex research questions (inadvertently) pulling researchers from their paradigmatic ‘home’ would appear to underpin many of the challenges encountered by those pursuing interdisciplinary research. One size rarely fits all, and postpositivism is unlikely to sit anymore comfortably with, for example, the anthropologist than it does with the chemist. Our issue here is not with postpositivism per se (to which a number of the authors from this paper comfortably adhere), but the tendency to frame interdisciplinary research within a singular paradigm (usually postpositivism).

An alternative framework, which has the ability to accommodate multiple – rather than singular – ways of seeing the world could support not only interdisciplinary, but interparadigmatic research. In this regard, we would suggest learning from Ellingson’s (2009) notion of engaging in crystallization. The notion of crystallization is used to move beyond two dimensional and rigid forms of knowing that may be evoked through the mixed methods “triangle” metaphor. It involves bringing together not only different forms of data and analyses, but also different ways of knowing the world. As a framework for managing interdisciplinary research, it advocates re-imagining attempts to triangulate and validate multiple findings from different paradigm-spanning disciplines. Calling instead for a “paradigm-spanning approach to resisting the art/science dichotomy” (p. xii). Engaging in crystallization provides a legitimate and practical means to draw researchers together in a way where differences are celebrated rather than curtailed. Until this is achieved, our interdisciplinary research will seldom produce the truly integrated knowledge of the complexity and interconnections between the environment and human health that is sought. We hope that this paper acts as an informative and thought provoking resource for interdisciplinary teams as they continue in this (ad)venture.

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