CROSSING THE INTERDISCIPLINARY DIVIDE: POLITICAL SCIENCE AND BIOLOGICAL SCIENCE

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Abstract

This article argues that interdisciplinary collaboration can offer significant intellectual gains to political science in terms of methodological insights, questioning received assumptions and providing new perspectives on subject fields. Collaboration with natural scientists has been less common than collaboration with social scientists, but can be intellectually more rewarding. Interdisciplinary work with biological scientists can be especially valuable given the history of links between the two subjects and the similarity of some of the methodological challenges faced. The authors have been involved in two projects with biological scientists and this has led them to critically explore issues relating to the philosophy of science, in particular the similarities and differences between social and natural science, focusing on three issues: the problem of agency, the experimental research design and the individualistic fallacy. It is argued that interdisciplinary research can be fostered through shared understandings of what constitutes 'justified beliefs'. Political science can help natural scientists to understand a more sophisticated understanding of the policy process. Such research brings a number of practical challenges and the authors explain how they have sought to overcome them.

Introduction

> We are not students of some subject matter, but students of problems. And problems may cut right across the borders of any subject matter or discipline (Popper, 1963). [i]

This quote by Karl Popper points to the potential of interdisciplinary research. It has become more fashionable, but what are its intellectual benefits for political scientists? As Warleigh-Lack and Cini put it (2009, p. 1), 'many pressures for a turn towards interdisciplinarity exist', including a search for new or more complete knowledge, responding to new issues that cross established disciplinary boundaries, and the drive towards 'user focus' by many research funders. The policy challenges faced in today's world often require political science to work effectively with other disciplines to undertake analysis and develop policy solutions (examples include climate change politics, GM technology and stem cell research). In particular, there is an imperative to collaborate not just with other social sciences but also with the natural sciences, a territory that is less well mapped and explored. This imperative is academically driven as well as policy related. There are thus now 'multiple pressures on the discipline [of politics] to engage in interdisciplinarity'. (Newell and Bull, 2009, p. 2).

This is not an entirely new phenomenon. The American political scientist Charles Merriam was a strong advocate of interdisciplinarity. Leonard White (1942, cited in Smith, 2007, p. 128), for example, noted his 'bold and persistent effort to marry political science with biology, anthropology, psychology, sociology, economics and medicine'. However, some argue that interdisciplinarity is an over-used buzz word which lacks real content other than as a means to obtain research funding. Or, at least, 'interdisciplinarity is beneficial, but it's not the only way to advance knowledge. Specialisation remains essential' (Segal, 2009). It is also not without its intellectual costs:

> [interdisciplinarity] can ... be a mechanism to exclude or restrict particular theories, approaches or research themes. Interdisciplinarity may provide new synergies and insights but at the price of replacing one orthodoxy with another. Accordingly, it is wise to acknowledge that there can be a dark side to interdisciplinarity (Kelly, 2009, 48).

This article explores these issues in relation to the lessons to be learned from interdisciplinary cooperation involving political scientists in the Rural Economy and Land Use Programme (RELU). The programme is 'the most comprehensive interdisciplinary research initiative ever conducted by the UK Research Councils' and it is 'committed to pursue interdisciplinary working across the social and natural sciences in every research project it funds' (Lowe and Phillipson, 2006, pp 165/6). The authors of this paper have been involved with two projects under the programme, the second author as a principal investigator and a deputy principal investigator. The first project researched the environmental and regulatory sustainability of biopesticides in collaboration with biologists, or more specifically plant scientists. [ii] This article also draws upon ongoing research on developing more effective systems of managing endemic diseases of cattle (the Governance of Livestock Disease - GoLD), in collaboration with biological scientists (including a veterinary epidemiologist, an infectious disease epidemiologist and an ecologist), two economists and an academic lawyer. [iii] The main focus of this article is collaboration between politics and biological science. For both historical and methodological reasons, this is perhaps the natural science that offers most for political scientists. A distinction is often made between so-called 'hard' sciences such as physics and chemistry and 'soft sciences' such as ecology, evolutionary biology, and even more so fields such as psychology, sociology and politics. Cohen and Medley (2005) make a similar point by referring to 'a hierarchy of science'. This distinction is one of the themes running throughout the article.

What is Interdisciplinarity?

Our starting point is to distinguish between multidisciplinarity and interdisciplinarity. The former refers to the 'parallel existence of discrete bodies of knowledge in proximity to one another' (Griffin, Medhurst and Green, 2006). It involves the joining together of two or more disciplines with little or no integration. Interdisciplinarity refers to the 'integration of discrete bodies of knowledge with each other to create new knowledge synthesis' (Griffin, Medhurst and Green, 2006, p. 11). Axelrod helpfully elaborates on this, writing that 'by interdisciplinary research I mean a mode of research...that integrates information...techniques, perspective, concepts and/or theory from two or more disciplines or bodies of organized or specialized knowledge' (Axelrod, 2008, p. 3).

In our projects we have strived towards this form of interdisciplinarity. There are, however, some even stronger formulations. McNeill (1999, cited in Harvey, 2006, p. 331) writes that it involves 'the formulation of a uniform, discipline like terminology or common methodology' as well as 'co-operation within a common framework shared by the disciplines involved'. In short, interdisciplinarity requires a common language (Harvey, 2006, p. 331). Warleigh-Lack and Cini distinguish between interdisciplinarity as involving 'a sustained process of dialogue' and 'joint problem solving and methodology'; and transdiciplinarity which adds 'a common theoretical perspective' (Warleigh-Lack and Cini, 2009, p. 6). Harvey (2006, p. 332) suggests that interdisciplinary methods may be capable of developing into a transdisciplinary state. As he puts it:

> Quarrels about the meaning, significance and importance of research findings are, fundamentally, quarrels about what can possibly be known, or what count as facts (ontology) and about how we will know when we know it, our means of discrimination between fact, fiction, faction and fantasy (epistemology). Unification

of disciplines at a philosophical level could produce a fertile new discipline (Harvey, 2006, p. 332).

Building on this we can visualise the unification of disciplines at up to five levels (see Keating, 2009, p. 300). Firstly, ontology, or what we know. Secondly, epistemology, or how we know it. Thirdly, methodology, or how we approach the study of it. Fourthly, methods, or ways of gathering data. Fifthly, theory, or our working assumptions and frames of analysis.

Politics as an Interdisciplinary Discipline

Politics can be seen as the junction subject of the social sciences, born out of history and philosophy, but also drawing on the insights of economics and sociology and, to some extent, the study of law, psychology and geography (Burnham et al, 2008, p. 9). It is widely viewed as 'more eclectic than most disciplines in borrowing the approaches of others' (Peters, 1999, p. 20). However, this leads it open to the charge that it lacks a distinctive theoretical and methodological core, with some arguing that politics is a field of enquiry, rather than a distinctive discipline (Burnham et al, 2008, p. 10). Bracken and Oughton (2006, p. 372) consider a discipline to be 'a branch of learning or scholarly instruction which is defined by institutional boundaries constructed by the needs of teaching, funding, administration and professional development'. The study of politics would appear to fit such a definition. It has a distinctive subject matter in its focus on the distribution and exercise of power (Burnham et al, 2008, p. 1) and this allows political scientists to engage in interdisciplinarity as defined by Griffin, Medhurst and Green, and Axelrod.

This openness to other disciplines can be seen as a strength, potentially fostering interdisciplinary work. However, we have encountered the view that political scientists 'are a rather insular lot' who do not mix readily with cognate disciplines (Andrew Jordan, private communication, 10/11th January 2008). A recent Economic and Social Research Council

(ESRC) benchmarking review of political science notes that 'interdisciplinary networks' are patchy. 'In the UK, Politics and IS has traditionally strong roots in other disciplines from which it sprang – particularly History, Philosophy and Law ..... the above links, and ones with Sociology, remain strong. But links with the more formal branches of economics have not been built to the extent that they have in some countries' (ESRC, 2007, p. 24). The benchmarking review does not refer to interdisciplinary work with natural scientists, no doubt reflecting that very little has occurred. However, the ESRC is keen to promote such collaboration. As its *Strategic Plan 2009-14* puts it:

> Although much effort must be made to sustain the health of individual disciplines, the social scientist's value is increasingly realised in interdisciplinary work. The natural and physical sciences are extending the boundaries of technical possibility ... alongside this we need to understand the social and economic implications of such advances. This too is science (ESRC 2009, p. 1).

Interestingly, given one of the themes of this article, the document adds that 'Elucidating behaviour – economic, political, social, cultural is not "soft"; this research is now distinctly rugged' (ESRC, 2009, p. 1). Economics has, to date, led the social sciences in research collaboration with the natural sciences. The discipline has a long established tradition of joint working across faculties. 'The quantitative inclinations of economics and its commitment (at least in its neo-classical form) to positive (as opposed to normative) knowledge and explanations equip it well for technical collaboration with natural scientists' (Phillipson and Lowe, 2006, p. 163).

The term 'interdisciplinarity' is not always specifically referred to: see, for example, Keating's (2009) article on political scientists taking neighbouring disciplines more seriously and working across disciplinary boundaries. Moran (2006, pp 73-83) attempts to account for

the paradox as to why 'interdisciplinarity is simultaneously hugely popular but unable to make serious headway'. He points to the signs of growth of hierarchy, specialisation and control in the discipline since its eclectic beginnings, and suggests that interdisciplinarity arises as a challenge to these hierarchies. McKenzie (2007, pp. 119-122) argues that internal forces are underemphasised by Moran and outlines three main factors which 'inhibit genuine interdisciplinarity': training, career advancement and the self-regulation of the profession. Writers such as Moran and McKenzie can be criticised for an implicit assumption that interdisciplinarity involves collaboration *within* the social sciences. Warleigh-Lack and Cini (2009, pp. 1-12) touch on the potential for collaboration *between* the natural and social sciences. As 'natural science' moves away from the most hardened forms of positivism, and as the human and social sciences begin to appreciate this shift, the scope for collaboration 'across the biggest discipline barrier of all' – between the 'hard' and 'soft' sciences – may be increasing (Warleigh-Lack and Cini, 2009, p. 9). However, they fail to develop this potential further, something we hope to do in this article.

Links between Political Science and Biological Science

In a keynote address to the American Political Science Association (APSA) Axelrod argued that political science had benefited from imports from many fields, but that it also had much to offer in terms of exports to others (see Axelrod, 2008). He suggests ways in which political scientists could contribute to matters of public health and makes reference to biology, recalling how Darwin incorporated ideas from Malthus, who was a political economist, and how Marx imported Darwin's conception of struggle back into political economy. As Marx put it, 'Darwin's book is very important and serves me as the basis in natural sciences for the class struggle in history' (cited in Axelrod, 2008, p. 4).

Biological scientists have been a direct source of theoretical and conceptual inspiration to political science. The link between politics and biology is reflected in such terms as 'biopolitics' or 'political biology'. The first substantive chapter of W J M Mackenzie's survey of political science is 'The Biological Context' (Mackenzie, 1967, pp. 23-30). Mackenzie focuses particularly on social biology, encompassing not only humans and other primates but other animal groups such as social insects. Punctuated equilibrium models have their origins in evolutionary biology (Baumgartner and Jones, 1993). The interaction between entity and setting is one that is amenable to political scientists (at least to those from a new institutionalist or rational choice institutionalist perspective) who are interested in how institutions shape the conduct of political actors. In so far as biology is concerned with adaptation to environment, there is a broad sense in which that is also true of politics, for example regional forms of governance as a response to a more interdependent world. That being said, for biological scientists 'adaptation' has a more precise, technical definition, referring to an alteration or adjustment in structure and habit, often hereditary, by which a species or individual improves its condition in relation to its environment.

Boari (2005) reflects on how the issue of self-preservation (the fundamental right, liberty and duty of individuals to preserve their life) is foundational for both political science and economics, whilst a foundational concept in biological theory is that of 'fitness' (the number of offspring or reproductive success). He reflects on the relationship between these two concepts and, thereby, gives more solidity to the foundation of political theory and political economy by anchoring them in biology. This opens the path towards a unification between the two social sciences and their immediate juxtaposed science, biology. Oren (2006), meanwhile, brings up some links between biology, epidemiology and politics and international relations. As he puts it, 'The commitment of contemporary political science to the unity of science doctrine is evident in explicit analogies that prominent scholars draw

between natural scientists and their own research' (p. 76). [iv] Fowler and Schreiber (2008, pp 912-914), meanwhile, write that in the past 50 years biologists have learned a great deal about human brain function and its genetic basis. At the same time, political scientists have studied the effects of the social and institutional environment on mass political attitudes and behaviours. However, they argue that these separate fields of enquiry are subject to inherent limitations that may only be resolved by collaboration across disciplines. They describe recent advances, writing that biologists and political scientists must work together to advance a new science of human nature. They cite Aristotle, often credited as the first political scientist. He is also known for first asserting the biological uniqueness of human political behaviour with his famous observation: "Man is, by nature, a political animal"' (Fowler and Schreiber, 2008, p. 912). The new science of human nature demands recognition that genes are the institutions of the human body in that they regulate the neurological processes that drive social and political behaviour. We cannot, they argue, fully appreciate their function in humans without understanding their role in very complex social and political interactions that characterise our species.

Methodological and Philosophical Reflections

Working with natural scientists has encouraged us to think again about some of the methodological challenges we face in political science. It has also allowed us to focus critically on issues relating to the *philosophy of social science*, in particular the differences and similarities between social and natural science. Although there is already a large literature on this topic, working alongside natural scientists has allowed us to think in a novel way about many of the issues. We advocate a move away from the traditional 'ontology, epistemology, methodology' framework towards a more philosophical notion of 'justified belief'. A shared understanding of what this entails across the disciplines could be the ultimate goal in allowing truly interdisciplinary research to succeed. In this section we reflect

on three main areas: structure and agency, the rise of the experimental research design in political science, and the so-called 'individualistic fallacy'.

The problem of agency

A key qualitative difference between the social and physical sciences is that the former deals with conscious and reflective subjects, capable of acting differently under the same stimuli, whilst the units compromising the latter can be assumed inanimate, unreflexive and predictable in response to external stimuli (Hay, 2002). Agency injects indeterminacy and contingency into human affairs and there is no analogy for this in the physical sciences (Hay, 2002). This raises a problem for a predictive science of the political based on the natural sciences. Perhaps, as Hayward puts it, 'political scientists have the capacity to offer some hindsight, a little insight and almost no foresight' (Hayward, 1999, p. 34). Behaviouralists deal with the problem of agency in the same way as animal biology (which also studies animate and arguably reflexive subjects): in other words, by (statistical) *aggregation* (Hay, 2002). The logic here is that whilst the behaviour of any single individual (fruit fly, gazelle or human) is likely to prove unpredictable in response to a common stimulus, analysis of a *population* of individuals will throw up patterns of behaviour which can be described and analysed (Hay, 2002). In a sense there is no recognition of the role of agents apart from as carriers of behaviour which aggregate to form a particular pattern. This discussion begins to bring out some of the similarities between political science and biological science which may make collaborations easier than with 'harder sciences' such as physics or chemistry.

One related issue is that of the 'Oedipus effect', a phrase coined by Karl Popper. As Popper puts it:

> One of the ideas I had discussed in The Poverty of Historicism [1957] was the influence of a prediction upon the event predicted. I had called this the 'Oedipus

> effect' because the oracle played a most important role in the sequence of events which led to the fulfilment of its prophecy...For a time I thought that the existence of the Oedipus effect distinguished social from the natural sciences. But in biology too – even in molecular biology – expectations often play a role in bringing about what has been expected (Popper, 2002, p.139).

In social science a prediction may affect or even change the outcome. For example, supposing a credible source predicts that Party A is going to win a substantial majority over Party B in an election and that the gap cannot be closed. Supporters of Party B could be discouraged from voting because they think there is little point or supporters of Party A could decide that the election is already won and they do not need to vote. In either case (or a combination of both of them) the outcome is affected, albeit in somewhat complex or unpredictable ways. Popper concentrates on such 'self-fulfilling prophecies' but 'self negating predictions' are perhaps more frequent or significant (otherwise called, 'the paradox of prediction'). People confronted with a problem that will cause them misfortune (or they do not wish to occur) may take action to ensure the prediction will not come true. For example, on public health interventions, if a potential danger is predicted (eg: the variant Creutzfedt-Jakob Disease [CJD] epidemic) and serious, expensive steps are taken to halt it and it does not happen, it is common to accuse the intervention as not being a good use of resources. [v]

The objects of natural science rarely react to attempts to observe them while the objects of social science invariably do [various exceptions may be grouped together under the heading of 'the uncertainty principle']. (Stableford, 2006). There are many 'research effects' in the social sciences. For example, the *Hawthorne effect* whereby subjects are the focus of researchers attention and therefore may improve their performance. Or, the *Pygmalion effect*, a self-fulfilling prophecy most often cited in education where teachers expressed expectations

of pupils can greatly affect their performance. Differences between natural and social science may not be as great as assumed. In medical science there is the *Placebo effect* whereby inert medical remedies may meet the psychological needs of patients. Moreover, researchers in all disciplines are unlikely to begin with an open mind. Choices of research topic, question and starting hypothesis may reflect deep-seated values and prejudices (Pierce, 2008). There is a danger in seeing what you want to see and inferring conclusions. The best advice to follow is that of Beatrice Webb; namely '[the researcher] must realise that he is biased, and somehow or other he must manage to discover this bias' (Webb and Webb, 1975, cited in Pierce, 2008, p. 18). Discussions within our project team reveal that social and natural science do not differ in this respect. Pragmatically, experiments are often designed to give an answer that the investigator wants rather than strictly to falsify a hypothesis, even if this does not necessarily coincide with Ian Stewart's description of science as our 'best defence against believing what we want to' (cited in Cohen and Medley, 2005, p. 18). There is a fundamental paradox in all research – investigators usually have a mental note of what they want to show, and then set about trying to demonstrate it. As Cohen and Medley put it (2005, p. 25); 'They [scientists] like an experiment whose result is entirely comfortable, confirming their prejudices and satisfying the promises they made in the grant application which is funding the work'.

The experimentation design

An important difference between biological science and political science would appear to be the ease with which controlled experiments can be undertaken in biology. The experimental research design has not been commonly used in political science. As a former president of the APSA declared in 1909 (Lowell, 1910, p. 7); 'we are limited by the impossibility of experiment. Politics is an observational, not an experimental science'. Sixty years later Lijphart (1971) wrote a seminal article in which he commented: 'The experimental method is the most nearly ideal method for scientific explanation, but unfortunately it can only rarely be

used in political science because of practical and ethical impediments' (Lijphart, 1971, p. 684-5). As Druckman et al put it (2006, p. 627), 'The increased use of experiments in recent years...has been dramatic'. The move towards experiments is particularly apparent in the United States, with top UK journals such as *Political Studies* still carrying few experimental articles: one exception being Gerry Stoker, a UK political scientist, who has argued for the more widespread adoption of such methods in political science (see, for example, his article in this special issue).

Our work with natural scientists has provided an invaluable insight into experimental design. Firstly, in terms of what is meant by 'an experiment'. There are two main features of the classical experimental design: control and random assignment. *Control* relates to the analyst operationalizing both independent and dependent variables, in order to measure the impact of a given treatment or stimulus. *Random assignment* relates to being able to control all extraneous factors that may be linked to the phenomenon we are researching. Many writers have drawn attention to the notion of *quasi experiments* and a large number of different types of such experiments have been identified (Cook and Campbell, 1979). There is also a distinction between a laboratory experiment and a field experiment. The former takes place in a laboratory or a contrived setting, whilst the latter occurs in real-life settings. Morton and Williams (2008) argue that 'playing god' is the defining characteristic of experimental research. Intervention by the researcher in order to generate data is the basis of the experimental design. They believe that political scientists should abandon the idea that all experiments need follow an ideal pattern of manipulating a variable by way of intervention, creating a treatment and control group and randomly assigning subjects to the treatment. Our work with natural scientists shows that experiments are even more varied than social scientists suppose. Experimental design is a huge topic, especially in statistics where analytical methods are being developed to design complex experiments. Cohen and Medley

(2005) distinguish between defect experiments, latin squares (based on the idea of Analysis of Variance, ANOVA), result-reversal experiments, demi-reversal experiments and competition experiments. Defect experiments are essentially the form social scientists often refer to, but Cohen and Medley argue that scientists should 'have more weapons available than this rather blunt instrument' (p. 92).

Secondly, one should not push the notion that natural science is dominated by (manipulative) experiments too far: the gap with the social sciences may not be as great as assumed. In ecology and epidemiology much work is based on the statistical analysis of observational data. Whilst a manipulative experiment may be the ideal, the practical difficulties mean that they are often impossible, or restricted to small samples sizes or unrealistic simplified circumstances. Plentiful observational data gathered in natural circumstances 'in the field' is often preferable. Thirdly, one reason for political scientists adopting the experimental design is that it delivers unrivalled claims for the making of causal inferences. Our natural sciences colleagues have helped us see just how complex the idea of 'causation' is in practice, something not always explored adequately by political scientists advocating the use of experiments. There is much confusion about the term. As Cohen and Medley put it:

> It is ... unwise....to assume that events have but one cause: they are the result of things (everything?) that went before, and/or result from the coming together of several disparate, perhaps contingent events. This is reflected in the scientific world by analysis of variance kinds of questions which we might call 'multiple observation' – or undesigned – experiments: what factors, and how much of each, contribute to this result (Cohen and Medley, 2005, p. 125)

Therefore, more complex experiments may be needed than assumed in the political science literature (not least when you add in the difficulties of 'agency' in the social and political world). The word cause is used in many different ways. When we say smoking *causes* lung cancer we mean it increases the risk. We would still see lung cancer even if nobody smoked as there are other causes. This links to the debate in the social sciences as to whether causation should be seen as probabilistic or deterministic (see Burnham et al, 2008, p. 174). The 'fundamental' problem of inference making (see King, Keohane and Verba, 1994, pp. 79, 82), moreover, arises out of the fact it is usually impossible to observe the difference a cause makes. We cannot roll back time and re-run reality without the cause to see what happens. This can be termed the *time machine problem.* The next best thing is to run experiments on two [or more] different units that are 'homogenous'. Arguably, such unit homogeneity is easier to achieve in the natural than the social sciences (it would be difficult, for example, to find two voting districts which were perfectly homogenous).

Some talk in terms of *necessary* or *sufficient* causes or conditions. A more sophisticated analysis is offered by Mackie (1974), as outlined by Shadish, Cook and Campbell (2002, pp. 4-5), in terms of an INUS condition, 'an i*nsufficient* but *nonredundant* part of an *unnecessary* but *sufficient* condition'. A lighted match, for example, is insufficient because a match cannot start a fire without other conditions. It is nonredundant only if it adds something fire-promoting that is uniquely different from what the other factors in the constellation contribute to starting a fire. It is part of a sufficient condition to start a fire in combination with the full constellation factors. But that condition is not necessarily because there are other sets of conditions that can also start fires. Arguably, most causes are best described as INUS conditions (Shadish, Cook and Campbell, 2002, p. 5), suggesting that causation across both the social and natural sciences may best be described as probabilistic

(contrary to the view that natural science is necessarily more deterministic). As Shadish, Cook and Campbell put it:

> It .. explains why a given causal relationship will occur under some conditions but not universally across time, space, human populations, or other kinds of treatments and outcomes that are more or less related to those studied. To different degrees, all causal relationships are context dependent, so the generalization of experimental effects is always at issue (Shadish, Cook and Campbell, 2002, p. 5):

The individualistic fallacy

Both biological science and political science face the risk of committing the ecological fallacy and the individualistic fallacy. The ecological fallacy entails 'inferring without investigation that relationships among collectivities are the same as those for individuals. Only under very specific circumstances … are such inferences from ecological data valid; otherwise, the observer has committed the *ecological fallacy.*' (Alker, 1965, p. 102). In other words, the ecological fallacy involves the identification of statistical relationships at the aggregate level that do not accurately reflect the corresponding relationship at the individual data level. 'Anyone who *draws a conclusion about individuals based about evidence about groups* commits what is called the "ecological fallacy"'. (McIntyre, 2005, p. 42). 'It is likewise a logical error to draw conclusions about groups based on data gathered with the individual as the unit of analysis.' (McIntyre, 2005, p. 43). This is known as the individualistic fallacy or sometimes as the reductionist fallacy. 'The individualistic fallacy is just the opposite of the ecological fallacy … social scientists are … likely to try to generalize from individual behaviour to aggregative relationships.' (Alker, 1965, p. 103). In biology, an individualistic fallacy can be committed in two ways: (a) by making inference about a group

from data collected on an individual of the same species; (b) making inference about one species from data collected on another species.

How is it possible for bio scientists to generalise on the basis of observations on an individual organism or species without committing an individualistic fallacy? One approach that is used is the use of model systems/organisms. These are chosen as they are easy to work with, but they still have relevance to less tractable world systems. Examples of model organisms include the lab rat, fruit fly and a model plant, a widely used example being *Arabidopis thalania,* a non-commercial member of the mustard family. Instead of studying many different plants one can study this particular plant that has a number of helpful characteristics for research purposes. Use of the model plant is possible because all flowering plants are closely related. Complete sequencing of the genes of a single, representative plant will yield knowledge about all higher plants. Biological material that is genetically identical can be generated through carefully designed crossing and backcrossing programmes that produce isogenic lines. This material is then used to study causal relationships. As only one organism/system is studied by many people, resources are pooled and knowledge is acquired rapidly. The degree to which a scientific observation made on the model organism applies to a different species (i.e. the probability of committing an individualistic fallacy) depends on the relationship between the two species and the scientific hypothesis that is being tested. One of the attractive properties of model organisms/systems is that they provide a baseline or anchor point. You can test a hypothesis in the tractable, well-studied model organism, and then see if it applies to other organisms.

Human behaviour is much more diverse. We cannot identify a 'model citizen' from whom we generalise. Political scientists are often prone to 'the individualistic fallacy', not least when they attempt to generalise from case studies. Arguably, so are the biological sciences. For example, the scaling up problem in biological science is a real one. Can an

experiment done on an individual level in pot plants be scaled up to a field level, to farm level and then on a broader scale? There is a propensity to overlook the broader consequences of solutions that work well at a micro level. The strategy of model organisms is made possible by the common descent of all living organisms, and the conservation of metabolic and development pathways and genetic material over the course of evolution. Studying model organisms can be informative, but care must be taken when generalising from one organism to another.

This discussion can be usefully broadened out to include the problem of 'hasty generalisation'. This is a logical fallacy of faulty generalisation by reaching an inductive generalisation based on insufficient evidence. It commonly involves basing a broad conclusion upon the statistics (or data) of a survey of a small group that fails to sufficiently represent the whole population. Natural scientists may hold the view that (qualitative) social science is not sufficiently rigorous (see Marzano, Carss and Bell, 2006, p. 188). Lack of respect between physical and social scientists is mentioned in published articles (see Bracken and Oughton, 2006, p. 375). Interdisciplinary research may be undermined if natural scientists do not have confidence in the research and findings of social scientists. In practice this has not been a problem in our projects but occasionally the biologists have commented on the 'anecdotal' findings of political science. In other words, the discipline has been seen to engage in 'hasty generalisation'. As we have seen, this can be as much a problem in natural science. One of Popper's great insights was that however many times we get our predictions right the explanation is not confirmed - the famous problem of induction.

The positivist/interpretivist debate is also relevant. Positivism is based upon a foundationalist ontology, so the world exists independently of our knowledge of it. To the positivist natural science and social science are broadly analogous. Social scientists from a more positivist perspective may find it easier to work with natural scientists (and vice versa).

Researchers from the interpretivist tradition reject the view that the world exists independently of our knowledge of it. Rather the world is socially or discursively constructed and in ontological terms they are anti-foundationalist. It may be more challenging for social scientists from this perspective to cross the interdisciplinary divide. 'Scientific realism' may offer a reconciliation of these perspectives. (Moses and Knutsen, 2007, pp. 12-15). This accepts that there exists a real world independent of our experience but that access to such a world is complicated and our understanding of it influenced by the webs of meaning that we construct. Scientific realism offers a new approach that can straddle the natural and social sciences. Indeed, 'a synthesis of this kind is particularly compatible with the interdisciplinary "turn" that is opening up collaboration between natural and social scientists' (Burnham et a, 2008, p. 29). Discussions with our GoLD team suggest that scientists often fall within this paradigm, reflecting Lane's view that 'it has now become possible to qualify as a scientist without being a positivist' (cited in Moses and Knutsen, 2007, p. 15).

A Different Kind of Philosophy?

As mentioned at the outset, a distinction is often made between 'hard' and 'soft' science. One perceived difference supporting the distinction is the degree to which conclusions in different fields are controversial within those fields (whether this stands up to scrutiny is another matter). Or, that the harder sciences find it easier to make clear and rapid progress, whilst the others go round in circles (Platt, 1964, cited in Pigliucci, 2009). Perhaps the key distinction is that of 'complexity'. Particle physics deals with the simplest objects in the universe: atoms and their constituents. Biology, however, deals with far more complex matter: organisms made of billions of cells, and ecosystems whose properties are affected by tens of thousands of variables. As Cohen and Medley put it (2005, pp. 32/33), 'the chemists and physicists can get away with 'isolating' their experiments. It is far more difficult for biologists'. The social and political world would appear even more complex, perhaps undermining the potential for

experiments before we have even started. One way of distinguishing between hard and soft science is in terms of 'strong inference' (Platt, 1964, cited in Pigliucci, 2009). Inference is a general term for whenever we arrive at a (tentative) conclusion based on the available evidence. An inference can be weaker or stronger depending on how much evidence points to a particular conclusion (if there is insufficient evidence we end up committing one of the fallacies outlined above). Platt (1964, cited in Pigliucci, 2009) believed that hard science works because its practitioners are versed in strong inference. Pigliucci (2009), however, writes that strong inference only works well with a certain kind of scientific question. The so-called soft sciences are concerned with complex issues requiring more sophisticated but less clear cut approaches; as opposed to 'strong inference' they yield only probabilistic answers. Therefore, soft science is soft because of the nature of the object of study, not the intellectual inferiority of its practitioners.

This does link to a related point where political and social scientists do need to be more realistic and honest. As Blyth writes: 'one can posit ontologies all day long without either reward or contradiction ... ontology – as an *a priori* theory of what the world is made up of – is necessarily irrefutable in its own terms' (Blyth, 2002, p. 294). Blyth suggests that we 'don't worry about the philosophy' (Blyth, 2002, p 294). However, our view is we need a *different* kind of philosophy or to reflect on the issues *more* philosophically (and to question our underlying assumptions). We should supplement our 'ontology, epistemology and methodology' frameworks and assessments of social science research in terms of reliability and validity. Philosophers often ask 'what is knowledge' and one answer is 'justified true belief'. In a sense this is the wrong question. Philosophers have asked 'Do I (or we) *know* anything, when really they have sought the justification for our *beliefs* (Scruton, 2004). It is arguably possible for a belief to be justified in the light of existing evidence, even if it is found to be false in the light of later evidence. In other words, there is a difference between a

justified (or rationally held) belief and knowledge. As academics and researchers what is important is not the pursuit of knowledge per se, but whether our conclusions are justified given the evidence (or arguments) we produce to support them. Or, rather, that they are backed up by sufficient evidence to justify the confidence to which they are asserted. For example, if we claim our conclusions are *likely* rather than certain or definitive, our arguments should be required to support the claim that they are probable. This relates back to the above point; it is often inevitable that the conclusions of social scientists cannot be definitive. Nevertheless, we should be careful not to offer conclusions with a level of confidence not justified by the evidence. This, however, will not be easy. We are taught to believe that it is often not what we say but the confidence with which we say it. Such attitudes may not, however, be conducive to the best research or our credibility with natural scientists.

This brings us to 'probability', a complex and disputed area, and perhaps the most important question in the philosophy of science today. Probability is often seen statistically, for example in terms of *a priori* calculus of chance or 'long term frequency' samples. Another variant, however, concerns the *weight of evidence* for a particular hypothesis, for example, the probability that the Big Bang theory of the universe is true. Some argue that such probability judgments are merely 'subjective' but others, such as John Maynard Keynes, suggest that they are 'degrees of rational belief' (see Kneale, 1949). There are other issues to consider. If our conclusion is likely or probable given the information we have collected should we have collected more evidence, therefore is our conclusion actually justified? Lucus (1970) advocates an absolute conception of probability, whereby the true probability of a proposition is the target we approach as we call in the evidence. Lewis (1983), meanwhile, distinguishes between epistemic probability (what is probable relative to our existing body of evidence) and objective probability (which bases the concept more in

objective fact). Our view is we need to move beyond ontology and epistemology and 'simplistic' concerns with knowledge and truth. Though a shared understanding of what constitutes 'justified beliefs' successful interdisciplinary research can be fostered.

The Practice of Interdisciplinary Research

The analysis now turns to consider the practicalities of interdisciplinary cooperation. What are the practical benefits of such co-operation with natural scientists and to whom to do they accrue? What kind of difficulties may be encountered and how can they be resolved?

What do political scientists bring to interdisciplinary work?

RELU's commitment to interdisciplinarity aims to avoid the trap of approaching problems from either a purely technical or sociological perspective (see Lowe, 2008). The thinking behind this is that when social and natural sciences work separately they can fail to appreciate the value of each other's contribution. The involvement of social scientists may too often be incorporated at the end of a project in 'end of pipe' mode, in order to smooth out social constraints standing in the way of technical advances or to address unintended impacts. 'A simplistic sociology or economics often pervades scientists' conceptions of society' (Lowe and Phillipson, 2006, p. 167). 'Equally, social scientists may incorporate naive models of environmental or technical possibilities into their analyses and projections of social and economic change' (Lowe, 2008, p. 9).

Turning the focus more specifically to political science, their knowledge and understanding of the policy process may be of particular relevance. Some natural scientists have tended to adopt a '"deficit model" of turning science into policy, the view that if only politicians are told what the science reveals, "correct" policies will automatically follow.' (Lawton, 2007, p. 465). For natural scientists, 'it is all too easy to fall into the trap of

believing that if only we could get the message across everything will be just fine.' (Lawton, 2007, p. 468). The authors found this misperception when interacting with scientists in an EU policy action concerning the regulation of biological control agents for crop protection. Scientists may assume that they are the experts and 'they should simply give what they regard as the best advice that their expertise recommends, regardless of any political implications. If the politicians fail to listen to this advice, they are simply perverse' (Burnham et al, 2008, p. 311). This is where a political science input can be helpful, and 'fortunately, many natural scientists are becoming increasingly receptive to the need for political scientists to provide a systematic understanding of the political dimension by working with them in an interdisciplinary framework on policy related projects' (Burnham et al, 2008, p. 311).

We can also point to the invaluable knowledge exchanges that took place between members of our research teams. For example, in both projects the political scientists relied on the technical knowledge of the natural scientists to understand the precise nature of the policy challenges and the options open to the regulatory system to respond to them (see Greaves, 2009, Greaves and Grant, 2010). In the biopesticides project, the political scientists found that the scientists possessed considerable knowledge and understanding of the composition and operation of the relevant policy networks, but had lacked the tools to place that knowledge in a more systematic framework. From their perspective, the biologists considered that the political scientists helped them to be deductive and theoretically guided in their approach. (Chandler and Grant, 2007). This might seem to be counter intuitive, given the widespread use of inductive approaches in political science. [vi] However, the biologists had worked in what was formerly a government research station in which there had been a considerable emphasis on the application of research findings to the challenges encountered by growers. Therefore, they were more accustomed to identifying problems and then using their expertise to identify a solution through purely empirical means.

The issue of research framing is important. 'Social constructivist' approaches to the study of politics have emphasised the importance of the ways in which issues are framed and the discourses that are used in their presentation. As Lowe, Phillipson and Lee note:

> The potential solution sought to any problem depends crucially on how it is characterised ... problems may be open to radically different framings ... Collaboration with the social sciences can bring different perspectives and methodologies to help reframe problems, or indeed reveal multiple or disputed understandings and thus expose diverse possibilities and ambivalent tendencies (Lowe, Phillipson and Lee, 2008, p. 231).

This is an area in which political scientists may be able to offer insights that have not occurred to natural scientists or even other social scientists. For example, in the GoLD project using archival evidence Grant was able to show how a construction of the 'rogue badger' had become prominent in policy discourse about bovine tuberculosis, even though there was no 'scientific' evidence to substantiate the existence of such a badger (Grant, 2010).

Practical challenges

The RELU projects involved started with little knowledge of each other's disciplines. This was the first time the political scientists had encountered biology since GCSE or O level and it was a steep learning curve to familiarise ourselves with another discipline and involved reading undergraduate textbooks. Our scientific colleagues thought that political scientists might be identified with a particular political position, or at least be researching the legitimacy of different political positions. However, they came to appreciate that they were policy analysts who used theories and categorisations to derive and test hypothesis in a similar way to biology. In part, an understanding of the differences between the disciplines has been developed by a guided reading of each other's literature. In both of our projects a

procedure has been followed of each discipline reading literature selected from the other disciplines and presenting their understanding of the article to research meetings. This allowed misunderstandings to be resolved and helped create an appreciation of how the other disciplines worked in terms of assumptions, methodology and vocabulary.

Some argue for a 'common language' in interdisciplinary research. The phrase 'trading zone' is often used to denote an interdisciplinary partnership in which two or more perspectives are combined and a new, shared language develops (Collins, Evans and Gorman, 2007). Bracken and Oughton (2006) identify dialects, metaphor and articulation as three overlapping aspects of language which play an important role in developing understandings between different disciplines. Words in everyday use by non experts may be those that cause the most difficulty for the unwary practitioner. As Bracken and Oughton (2006) put it, a common language would result in the dumbing down of disciplinary knowledge and expertise. It is necessary, however, that experts from different disciplines develop a common understanding and interdisciplinary projects allocate time and effort to achieve this.

It has been a particular challenge to write together for joint publications. Biological scientists are used to tersely argued research papers that present key findings in a few printed pages, perhaps as few as one, whilst political scientists are more discursive. It can be challenge to carve out a coherent and readable paper. Differences in writing style may mean the paper or article becomes disjointed or does not read as well it could. There is also the issue of standardising the jargon of different disciplines without losing the thread of the content. The GoLD project involves a large and diverse mix of disciplines. It is more challenging than a simple collaboration between political science and specialists in the interaction of plants and insects. Veterinary medicine and epidemiology has proved more difficult for the political scientists to grasp than plant biology. Perhaps systems biology in which mathematics and computing are used to understand highly complex biological systems

would prove beyond political scientists, not least to those used to working with qualitative data. Collaborating with physicists or chemists could be even more challenging. The abstruse models of physicists may be particularly difficult for social scientists to grasp. For example, string theory is a developing branch of theoretical physics which combines quantum mechanics and general relativity into a quantum theory of gravity. Many detractors criticise string theory because it has not yet provided quantitative experimental predictions (see Smolin 2006). Like any other quantum theory of gravity, it is widely believed that testing the theory directly by experiment would require prohibitively expensive feats of engineering. Given it is not verifiable or falsifiable it can be seen as 'unscientific'. In that sense it shares characteristics with some of the more abstract 'grand theories' in social science (see Merton, 1967).

In some ways, however, collaboration with the natural sciences may be easier than with the other social sciences. Perhaps the sheer distance between the two sets of disciplines will, in itself, create an initial atmosphere of mutual respect and willingness to learn from each other. There may be particular problems with some of the other social sciences where competing methodologies are brought to bear on the same research topic. For example, methodological individualism is seen as an essential part of modern neoclassical economics which usually analyzes collective action in terms of rational utility maximising individuals. Economics tends to treat some of the concerns of political science as second order questions. In other words, institutions are seen as a means to achieve policy goals, rather than entities that may shape human action. Some accounts are unclear whether methodological individualism means (a) explanations in terms of individuals *alone* or (b) explanations in terms of individuals *plus relations between individuals* (Hodgson, 2007). Nevertheless, there is still force in the argument advanced by Guy Peters that methodological individualism 'is the argument that the only actors in political settings are individuals, and therefore the only

appropriate foci for political inquiry are individuals and their behaviour' (Peters, 1999, p. 13). The point being made is that working with cognate disciplines in the social sciences may in some cases be more difficult than working with natural sciences, in part because there may be contested boundaries and fears about capture. The closer the disciplines, the greater this fear may be. For example, Ashworth argues (2009, p. 23) that 'It was IR's capture by political science in the 1950s that closed off this link to other disciplines and led to a thirty-year isolation'. Because the gap is wider than natural science, it may be more challenging to bridge, but there may be fewer fears about leaping the chasm and the rewards of doing so may be greater.

Conclusions

Much of the literature on interdisciplinarity and political science focuses on collaboration with other social sciences which is more common. This article has sought to argue that collaboration with natural scientists can often be more rewarding. Our interdisciplinary work has encouraged us to think afresh many of the methodological challenges in political science; indeed, our discussions with natural scientists have probably proved more fruitful in developing our thinking on *the philosophy of social science* than would have been the case with other social scientists. Natural scientists do not always reflect on such issues and we hope we have encouraged them to do so. There are very few books on method and methodology in the natural sciences (at least compared to the social sciences). Wellington and Szczerbinski (2007) suggest that scientists 'just get on with it' without questioning their methods of whether they are seeking 'the truth' or the best theory. Despite the large literature on the philosophy and sociology of science, scientists as a community do not spend much time reflecting on 'the scientific method'. The scientist Sir Peter Medawar described the scientific method as a 'mixture of guesswork and checkwork' (cited in Wellington and Szczerbinski, 2007, p. 14). That being said, in our discussions the natural scientists often

introduce the names of philosophers such as Aristotle and Popper and our principal investigator on GoLD is the co-author of a book that talks of '*more social science'* (Cohen and Medley, 2005, p. 142) and aims to put the *philosophy* back into PhD's. Perhaps natural scientists who decide to work on interdisciplinary projects with social scientists are more open minded and 'enlightened' when it comes to philosophical and methodological reflections. Of course, it should not be forgotten that natural philosophy was the precursor of natural science as understood today.

The article has also discussed the practical issues involved and how difficulties can be overcome. Working with biological scientists may be less challenging than with 'harder sciences', not least because of some of the methodological similarities between politics and biology. Engagement with some aspects of biological science may be easier than others; it is important not to treat bio-science as an undifferentiated whole and to acknowledge sub-disciplines (for example, engagement may be easier with ecologists or microbiologists compared to molecular biologists). Substantial obstacles have remained in the way of interdisciplinary collaboration in the UK, including how the structure of the Research Assessment Exercise (RAE) has been structured around disciplinary panels. 'By privileging subject research, the RAE [acted] as a driver that promot[ed] the formation of groups of researchers with closely aligned research interests' (Kelly, 2009, p. 50). This is also likely to be the case with its successor, the Research Excellence Framework (REF). It is proposed that REF will place a considerable emphasis on metric measurement, based notably on bibliometric indicators but supplemented by an element of 'light touch expert review' (see Richards, 2009, pp. 1-2). It is unclear how this will impact on interdisciplinarity, although Johnson (2009, p. 58) and Russell (2009, p. 65) point to some concerns. One of REF's assessment criteria will be impact on public policy; this could potentially benefit interdisciplinarity research, despite some of the concerns over quantitative indicators.

The view taken here of interdisciplinarity has been generally positive but one has to take account of Kelly's contention that there is a dark side which can be exclusionary. Our own projects and the RELU programme as a whole has sought to be inclusive in its approach. Perhaps the price of working together effectively is that one is too deferential to other disciplines and too reluctant to challenge them. Nevertheless, our experience leads to positive conclusions about the possibility for interdisciplinary work in political science. We are reminded of a quote by Schön:

> Shall the practitioner stay on the high, hard ground where he can practice rigorously...but where he is constrained to deal with problems of relatively little social importance. Or shall he descend into the swamp where he can engage in the most important and challenging problems if he is willing to forsake technical rigor (Schön, 1983). [vii]

We hope we have shown, however, that interdisciplinary research need not downplay rigour or disciplinary expertise. That being said, compromise, understanding and good relationships are required. We believe that political scientists can benefit from collaborating with natural scientists: practically, methodologically and philosophically. We hope this article may encourage some of the readers of this special issue to cross the interdisciplinary divide.

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NOTES

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[i] Cited at http://www.rcss.ed.ac.uk/isstiwiki/ISSTI_Interdisciplinary_Wiki [accessed 07/10/2008].

[ii] For more information on this project see: http://www2.warwick.ac.uk/fac/soc/pais/biopesticides

[iii] For more information see: http://www2.warwick.ac.uk/fac/cross_fac/gld

[iv] Oren is talking predominantly about American political science in this context.

[v] Swine flu, or Swine influenza virus (SIV), may prove to be another example.

[vi] Of course, whether political science is inductive or deductive is a large topic in itself (see, for example, Hay 2002).

[vii] Cited at http://www.rcss.ed.ac.uk/isstiwiki/ISSTI_Interdisciplinary_Wiki [accessed 07/10/2008]