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Boundary games: How teams of OR practitioners explore the boundaries of intervention

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ABSTRACT

An operational research (OR) practitioner designing an intervention needs to engage in a practical process for choosing methods and implementing them. When a *team* of OR practitioners does this, and/or clients and stakeholders are involved, the social dynamics of designing the approach can be complex. So far, hardly any theory has been provided to support our understanding of these social dynamics. To this end, our paper offers a theory of 'boundary games'. It is proposed that decision making on the configuration of the OR approach is shaped by communications concerning boundary judgements. These communications involve the OR practitioners in the team (and other participants, when relevant) 'setting', 'following', 'enhancing', 'wandering outside', 'challenging' and 'probing' boundaries concerning the nature of the context and the methods to be used. Empirical vignettes are provided of a project where three OR practitioners with different forms of methodological expertise collaborated on an intervention to support a Regional Council in New Zealand. In deciding how to approach a problem structuring workshop where the Regional Council employees would be participants, the OR team had to negotiate their methodological boundaries in some detail. The paper demonstrates that the theory of boundary games helps to analyse and describe the shifts in thinking that take place in this kind of team decision making. A number of implications for OR practitioners are discussed, including how this theory can contribute to reflective practice and improve awareness of what is happening during communications with OR colleagues, clients and participants.

1. Introduction

Operational research (OR) practitioners designing interventions need to engage in practical processes for choosing methods and implementing them. In the case of mixed methods interventions (often called 'methodological pluralism' or 'multimethodology'), a great deal of attention has been paid to how the design process should be conceptualised. For some early, seminal contributions, see Jackson, (1987a, b, 2000); Jackson and Keys (1984); Flood and Jackson, (1991a, b); Flood and Romm (1996); Midgley, (1992a, 2000); Mingers and Brocklesby (1997) and Mingers and Gill (1997). While there are disagreements between authors on some of the theory underpinning methodological pluralism (Midgley, 1996; Mingers & Brocklesby, 1997; Zhu, 2011), there is nevertheless a consensus amongst many OR practitioners that the practice of mixing methods, techniques and tools from a range of sources enhances the flexibility and responsiveness of OR interventions. Indeed, even OR practitioners who have not engaged in the debates on methodological pluralism, but pride themselves on taking an 'emergent' approach (i.e., they design interventions pragmatically in response to evolving analyses of problem contexts, and do not try to fit the problem context to a pre-existing methodology), recognise the value of mixing methods (e.g., Hutchinson, 1996; Ormerod, 1996; Zhu, 2011).

The process of negotiating and constructing a mixed methods intervention does not depend on OR practitioners using any prescribed meta-methodology, framework or indeed any other formalised 'way of doing things' (e.g., as outlined by Flood, 1995; Flood & Jackson, 1991a; Jackson, 1991; Jackson & Keys, 1984; Mingers & Gill, 1997) that

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could govern the choice of OR methods. As Keys (1997) points out, a myriad of different explanations are possible of how interventions come to be configured. Whether or not a formal approach is used, teams will still need to deal with the context and decide what kind of intervention is appropriate. Indeed, even if the team of OR practitioners prefers to use a single, favoured method (or set of methods) in every intervention, the context will still need to be negotiated and a practical process for implementing the favoured method agreed.

Some may regard this as a simple fact about OR practice that should just be taken for granted. However, when teams of OR practitioners come from different traditions, or even from different disciplines prior to their involvement in OR, the social dynamics of their methodological decision making can be quite complex. Indeed, the complexity can be even greater if clients and/or stakeholders participate in the decision making on what methods to use, as their knowledge of OR methods cannot be taken for granted (Ritchie, 2004).

We will argue below that there is a dearth of theory to help us understand the social dynamics of methodological decision making, and this is a critical area of research to which Behavioural OR (BOR) can contribute. We will advance a new theory of 'boundary games'; the proposition being that, to a greater or lesser extent, every communicative interaction can be taken to be a move in a dynamic game that shapes the boundary defining whatever the OR team considers important and/or relevant to the situation under investigation.

In what follows, we begin by examining some of the key questions raised in the literature about the process of OR interventions. Next, we propose our theory of 'boundary games', which can be used to support the analysis of the communications of OR practitioners and other stakeholders when they are discussing their boundary judgements concerning the design of an intervention. Our theory of boundary games draws on ideas from three sources: Wittgenstein's (1958) philosophy of language games; the theory of boundary critique from systems/OR (e.g., Midgley, 2000; Midgley & Pinzón, 2011, 2013; Midgley, Munlo, & Brown, 1998; Ulrich, 1994); and relevance theory from the discipline of linguistics (Sperber & Wilson, 1995; Wilson & Sperber, 2002a, b). The paper then presents some empirical vignettes to illustrate our theory, focusing on how 3 OR practitioners with different forms of methodological expertise collaborated on the design of a problem structuring workshop. It will be demonstrated that the theory of boundary games can make a useful contribution to understanding the shifts in thinking and communication that take place in complex OR team decision making. We will then discuss some implications of our research for practice, before finally concluding with some reflections on OR in general and BOR in particular.

2. The 'black box' in operational research

Descriptions of the OR process (e.g. Keys, 1997, 2000) and accounts of particular interventions generally follow a similar line. As Franco & Rouwette put it,

> "Typically, these studies offer thick descriptions of the context of the intervention, the rationale for the intervention design, the chronology of the intervention, and rich, in-depth reflections about the intervention effects from the perspective of the 'intervener', the 'intervened', or both" (Franco & Rouwette, 2011: 164).

While such an approach is informative, it will often leave readers wondering about the inevitable unreported 'goings on' behind the scenes. Experienced practitioners will know that, although what happens in the behavioural and social space of interventions is not always easily grasped (let alone easily described), these dynamics can nonetheless be pivotal in determining outcomes.

In situations where this aspect of interventions is acknowledged, authors typically rely on figures of speech to convey the nature of the problem. For example, speaking of Soft Systems Methodology (SSM), Checkland (interviewed by Stowell) states that:

> "What is left as obscured *are the mysterious things that happen* when you structure a debate about change looking for the accommodation between different worldviews that will enable action to be taken. I have held back from even *trying to be descriptive* never mind prescriptive about what happens *in that mysterious process* in which you shift peoples' thinking" (Checkland & Stowell, 2012, emphases added).

Similar concerns have been echoed by Keys (2000:311), who points out that "analysis fails to address questions concerning the development of process both by individuals and analysts as a group" (p.311). Likewise, Franco (2013) is interested in what happens inside what he refers to as the "black box" of interventions.

The notion that there are undescribed, possibly unrecognised and (at this point in time) relatively unexplored 'somethings' happening during intervention, is consistent with BOR's proposition that

> "Behavioural issues are always present when supporting human problem solving by modelling. Behavioural effects can relate to the group interaction and communication when facilitating with OR models as well as to the possibility of procedural mistakes and cognitive biases" (Hämäläinen, Luoma, & Saarinen, 2013:623).

Against this background, it seems clear that shedding more light on how decision making and actions in an OR intervention are shaped by practitioners' and stakeholders' communications is an important part of the BOR agenda. In the field of systems thinking, researchers have pursued a similar agenda, but without reference to the theories used here (e.g. Córdoba-Pachón, 2010; Winograd & Flores, 1986). To date, only a small number of OR authors have sought to address and tackle these kinds of issues (e.g., Franco & Rouwette, 2011; Hämäläinen et al., 2013; Tavella & Franco, 2014), and their contributions have built on each other as follows:

Early authors (e.g., Keys, 2000; Stansfield, 1981) simply point to the fact that there is a gap in our knowledge. Stansfield (1981) declares that the issue is too difficult to handle. He bemoans the fact that papers reporting OR projects tend to discuss methods rather than the 'messier' human issues involved in their design and application. This, he says, distorts both public and academic understandings of what OR is all about. However, he concludes that these messy human issues are impossible to write up because of their complexity and the fact that each local intervention is unique.

Keys and Midgley (2002) agree with Stansfield's (1981) diagnosis of the problem, but say we should not give up. They point to two strategies for providing theoretical explanations of the messy human issues involved in OR:

> "The first is to propose a theory or methodological insight of value in understanding a process issue, and then draw upon examples from practice … to support the arguments being constructed … [or] to make the primary focus a rich, detailed narrative about an application of OR, and then write about theory within this" (Keys & Midgley, 2002:123).

Preferring the first of the above strategies, White (2009) and Franco and Rouwette (2011) explore a range of approaches and possibilities for micro-analyses of OR sessions. In other words, they go further than Keys & Midgley, and delve into the kinds of theories that might be useful. White (2009) proposes a combination of actor-network theory and narrative analysis. Narrative analysis involves the coding of dialogue, and Franco and Rouwette (2011) examine several existing coding schemes in the group communication literature with a view to assessing their applicability for use in tracking various kinds of verbal and non-verbal behaviour in OR interventions.

Some of the most recent contributions have been focused on understanding the roles of models in interventions, drawing on theories from the social psychology literature and coded data from recordings

of OR workshops. For instance, Rouwette, Korzilius, Vennix, and Jacobs (2011) show how model building can change attitudes, subjective norms and the intentions of participants. In other words, they demonstrate that collective model building changes participants' individual mental models.

Delving more deeply into how model building has an effect, Ackermann and Eden (2011) describe a case study of collaborative causal modelling assisted by computer software. Statements made by participants were mapped onto changes in the model as it developed, and the authors claim that this demonstrated cognitive changes in individuals, as their contributions to the collective discussion appeared to be altered as the model itself developed. Franco (2013) then builds some further theory around this work, introducing the idea of 'boundary objects'. He conceptualizes models as objects: artifacts that serve as interfaces for the collaboration of participants, helping them to negotiate shared languages, meanings and interests.

The final two contributions leading up to our own represent two very different approaches, but they also have shared characteristics: they expand their analysis beyond the model and include detailed accounts of the OR process. First, we have Ormerod's concern with technical accounts that leave aside "the human, contingent and contextual aspects" (Ormerod, 2014: p. 1245). He proposes to integrate discussions of material, human and cultural factors into narratives of OR interventions (similar to the second strategy of Keys & Midgley, 2002, mentioned earlier), and he offers what he describes as an "interesting story" of a real world project.

In contrast, Tavella and Franco (2014) use a list of communicative behaviours (inviting, proposing, affirming, clarifying, building, dismissing, deploying authority, reifying, challenging and reiterating) to conduct a micro level analysis of sections of dialogue from an OR workshop. Then they look for patterns of knowledge construction. Of all those discussed above, this is arguably the closest to our own approach.

Below we discuss the theory of boundary games, first introduced by Velez-Castiblanco (2006, 2011, 2012). This draws from three bodies of literature: philosophy, systems thinking and linguistics. The theory of boundary games offers a new way to understand the communicative dynamics of OR processes. In the empirical vignettes discussed later (Section 5), we analyse how an OR team collaborated to produce an intervention design, but the theory also has the potential (in future research) to be used to better understand the communications involved in actually applying OR methods.

3. A new theoretical approach to understanding interventions

The theory of boundary games has three pillars: Wittgenstein's (1958) concept of language games; the notion of 'boundary' in the work of Midgley (2000) and others; and Sperber and Wilson's (1995) relevance theory. These are introduced below.

Wittgenstein (1958) views language as a phenomenon that developed in the early history of humankind in contexts of action, and it is still primarily used in such contexts (also see Maturana & Varela, 1992). What is more, the meaning of words is not intrinsic to them: meaning arises when language is used in interaction with others. While private self-reflection and subjective meanings are possible up to a point, these meanings are still dependent on language that has already been learned interactively, and personal meanings can only be transformed into shared meanings through communication in the context of actual and/or potential actions. This is highly relevant for OR because our discipline is specifically concerned with *intervention*, and interventions by definition involve actions. It could be argued that all OR activities can be understood as language games.

The notion of boundary, as outlined by Churchman (1970), Midgley (2000), Midgley et al. (1998) and Ulrich (1994), resonates with this. Boundaries are viewed by these authors as conceptual markers of who and what is likely to be pertinent to an OR intervention. Because OR projects are often complex, and not all relevant information is apparent from the start, the explicit exploration of different possible boundary judgements (about who might be involved and affected, as well as the issues that concern them) can inform the design of an intervention process (Foote et al., 2007).

Obviously the extent to which boundary judgements are open to different interpretations will depend upon the circumstances; in the regularly recurring problem situations dealt with by much traditional OR, boundaries may be less open to dispute than in the less well defined situations typically addressed by problem structuring methods. However, even regularly recurring problem situations almost always contain some degree of novelty, and it can be as much the unique complexity and 'content details' of a situation that makes it problematic as it can be the form that makes it general (Checkland, 2000; Pidd, 2010). On this account, the question of boundaries is a generic one in OR and is not limited to particular regions of the discipline.

Setting boundaries determines how the context of the OR project is to be viewed, and therefore this is critically important for deciding on appropriate methods for intervention (Midgley, 2000). Indeed, we can go a little further, utilizing the insights of Wittgenstein (1958), and say that exploring different boundary judgements on the context of an intervention and the possible methods that may prove useful could actually facilitate the emergence of different meanings and uses for existing OR methods than those that might have been intended by their originators (also see Flood & Romm, 1995; Midgley, 1997). The theory of boundary games has been given this name because the term combines Midgley's understanding of boundaries with Wittgenstein's understanding of language games.

While these ideas about language and boundaries are relatively straightforward, identifying a mechanism that makes the dynamics of interaction in real OR projects more amenable to analysis is much more challenging. Relevance theory (Sperber & Wilson, 1995; Wilson & Sperber, 2002a) provides some clues as to how this might be accomplished.

Relevance theory is based on the idea that "an essential feature of most human communication, both verbal and non-verbal, is the expression and recognition of intentions" (Wilson & Sperber, 2002a:249). In other words, communication is about the hearer making an informed inference about the intention of the speaker, and he or she builds on that inference to judge what they are trying to say. Relevance theory proposes explanations of two things: how communicative intentions are recognized by the hearer, and how the speaker takes advantage of the recognition process to convey ideas.

The inferences and judgements produced by individuals are based on their 'cognitive environments'. This term refers to background knowledge that encompasses all the assumptions that individuals use to make inferences about communicative stimuli, and these assumptions are dynamic. A new stimulus can weaken or strengthen old assumptions according to whether it contradicts or reinforces them, as long as the new stimulus is accepted as relevant in the first place. In the communication process, we "alter the cognitive environment of your [our] addressees" and, as a consequence, the "actual thought processes" are also affected (Sperber & Wilson, 1995:46).

Notice that, in this theory, the meaning of a communication derives from the inferences that the receiver can make with reference to his or her cognitive environment. In traditional approaches to communication, the central concern is for the sender to communicate a good message, and shared meaning is taken for granted. This is the key innovation introduced by Sperber and Wilson (1995): problematizing the concept of shared meaning and introducing the idea that we continually refer to cognitive environments. Shared meaning is only possible in cases where enough of the cognitive environment is also shared.

Once communications are received, the receiver (largely unconsciously) compares different sets of assumptions and chooses the particular one that maximizes the relevance of the communication and

allows an inference of the sender's intention. 'Relevance' is understood in terms of two conditions:

> "a. Other things being equal, the greater the positive cognitive effects achieved by processing an input, the greater the relevance of the input to the individual at that time. b. Other things being equal, the greater the processing effort expended, the lower the relevance of the input to the individual at that time" (Wilson & Sperber, 2002a: 252).

Basically, a communicative stimulus is relevant to somebody if it is possible to obtain many inferences from it, and if it is not difficult to make such inferences. As speakers, when we try to communicate, we show others that they can connect our messages with their cognitive environments, and we aim to make sure that they do not have to do too much work in order to achieve this. Relevance "is a function of effort and effect" (Wilson & Sperber, 2002a:253); it involves a cost-benefit ratio. Even if a communication increases the effort needed for understanding, if the benefits outweigh this additional cost, it will still be perceived as relevant.

The proposal here (linking the theory of boundaries and relevance theory) is that *cognitive environments are bounded*. It is therefore possible to identify some generic models of 'boundary games' that represent how people communicate to affect the boundary of what is seen as relevant in the discussions of an OR team (Velez-Castiblanco, 2012).

Before proceeding to outline the different boundary games that participants in meetings and workshops can play, we need to make explicit what we mean when we call this a *theory* of boundary games. In traditional science, theories are propositions about biophysical, psychological or social phenomena (directly or indirectly observed) that are supported by empirical evidence, and these theories enhance our understanding of the phenomena (Popper, 1959). Here, however, we are making some propositions about boundaries, and boundaries are *conceptual* in nature: while we can point to some biophysical boundaries (such as the skin of the human body), in the systems/OR literature we more often use the term 'boundary' in the sense of a conceptual marker of what is included, excluded or marginalized (Midgley, 2000; Ulrich, 1994). 'Boundary' is therefore a useful metaphor, abstracted from the context of biophysical systems in which it was originally deployed (Rosenblatt, 1994). We argue that theories can be propositions about material *and/or conceptual* phenomena, as long as there is empirical evidence to support their explanatory value (without evidence, they are just hypotheses). The evidence for our theory of boundary games can be found in Velez-Castiblanco (2012), and vignettes from this are reproduced later in the paper.

3.1. The boundary games

Three principles have guided the formulation of our generic models of boundary games. First, it has been important to devise a parsimonious form of representation that is neither overly-complicated (thus causing OR practitioners to have to do too much work to incorporate it into their cognitive environments) nor overly-simplistic (thereby making it of little practical use for understanding interactions in OR teams). Second, we have identified types of communication about boundaries that make a difference in the design of OR interventions (as opposed to other contexts, where different boundary games may conceivably be relevant). Third, our generic models of boundary games had to be specifically relevant to how OR practitioners "modify and extend the mutual cognitive environment [that practitioners and their stakeholders] share with one another" (Sperber & Wilson, 1995:64).

Each of the 6 boundary games identified below is intended by the speaker to change the boundary of the shared cognitive environments of the people involved. They are expressed as actions on the boundary: *Setting*, *Following*, *Enhancing*, *Wandering outside*, *Challenging* and *Probing*. Defining this set involved an iterative process of proposing possible actions on the boundary, applying them to interpret the recorded and transcribed interactions of OR practitioners, and adjusting them until all the communications of the practitioners in our data set could be explained in a reasonable manner. Our data set came from a single research study undertaken over 10 months with an OR team in a New Zealand government research institute (Velez-Castiblanco, 2012), and the empirical vignettes used to illustrate the theory (Section 5) came from this same data set.

In addition to *Setting*, *Following*, *Enhancing*, *Wandering outside*, *Challenging* and *Probing*, it is possible that other boundary games could be defined. We are open to further research on this, but we have found these 6 to be adequate for the purposes of analysing our research study data. The 6 boundary games are explained below:

3.1.1. Setting

If the intention in an interaction is to develop a shared cognitive environment, then the first boundary action is to try to set one. As the words 'setting a boundary' suggest, the idea is to establish some relatively firm rules for dialogue or define some conceptual space that will either contain any further boundary games or at least provide a reference point for them.

However, the person trying to set a boundary does not do this in a vacuum. When defining a new boundary, he or she may consider two things: the set of boundaries that might possibly have relevance (from his or her own, and the various participants', points of view); plus expectations of how others in the discussion will receive the proposals he or she might make. In other words, the person playing the *Setting* game has to anticipate the types of possible relevant boundaries that others see and how strongly they might be committed to them.

The result of a proposal to set a boundary could be full agreement to use it (involving at least an initial presumption that the group has found a shared cognitive environment); the stimulation of counter-proposals (with each individual maintaining their own differentiated cognitive environments); agreement amongst a sub-group with other individuals dissenting (resulting in some people sharing a cognitive environment and others not); or disagreement between groups (two or more groups with competing cognitive environments might emerge).

If repeated efforts to set a single boundary prove fruitless, then one possibility available to the group is to explore different options. In such a case, the *Setting* of a boundary is acknowledged as merely provisional, and only for the purposes of applying other boundary games to test it.

3.1.2. Following

Following presupposes that a boundary has already been set, at least provisionally. Participants in the discussion conform to the boundary, acknowledging and/or accepting the assumptions and value judgements that come with it. *Following* does not have the aim of producing big cognitive effects (the first condition for the relevance of a communication). There is no new information that enables this, although understandings of existing information may be reinforced. However, "the more a representation is processed, the more accessible it becomes. Hence, the greater the amount of processing involved in the formation of an assumption, and the more often it is accessed thereafter, the greater its accessibility" (Sperber & Wilson, 1995:77).

Generally speaking, the more we rehearse the use of a boundary without encountering opposition, the more confident we become that there is mutual understanding of it, and therefore it becomes easier to allow the boundary to become implicit. Thus, over time, *Following* helps reduce the cognitive effort applied (the second condition for the relevance of a communication). With less effort, there is an increase in relevance. More relevance results in a clearer, stronger

boundary that may even become unquestioned. For the people involved, this makes it easier to play the game.

3.1.3. Enhancing

In principle, the intention behind *Enhancing* is very similar to *Following*. Both games are consistent with the established boundary. However, in contrast with *Following*, *Enhancing* is about introducing new information. This new information allows people to infer new things, but without challenging the existing implications of the boundary that have been accepted through previous games. This might be thought of as 'expanding' a boundary, except that, in many previous writings on boundaries, the word 'expanding' has been used to refer to situations where pushing out the boundary leads to radically new implications being seen that undermine the previously discussed boundary (Churchman, 1970; Midgley, 2000; Ulrich, 1994). In our terminology, this form of expansion is described as *Challenging* (see Section 3.1.5). The difference between *Following* and *Enhancing* is also explicable in terms of relevance theory. While in *Following* the idea is to ease the effort required, here it is more about producing greater positive cognitive effects. The expanded boundary covers more ground and, because there are more cognitive effects, it is more relevant and hence stronger. This is to say that the old communications and the new communications reinforce each other, thereby increasing the trust that the participants have in the boundary.

A caveat is that *Enhancing* involves new information, and this often increases the processing effort involved. However, the aim of an *Enhancing* is for the cognitive effects (benefits of including the new information) to outweigh the increased cost. This implies a possible scenario where an attempted *Enhancing* increases the cost to the point where intelligibility is compromised (Churchman, 1970; Ulrich, 1994) and the cost of including the new information begins to outweigh its benefits. In such a scenario, the communication will not be perceived as an *Enhancing* by others, and may be refused. Regardless of the speaker's intention, a communication can only be counted as *Enhancing* if it is accepted by these others, as the point is to change their *shared* cognitive environment.

3.1.4. Wandering outside

Like *Enhancing*, *Wandering outside* is also related to *Following*, but in a different way. Again the idea is to act in agreement with the established boundary and introduce new information. However, whereas *Enhancing* involves new information becoming part of what is seen as pertinent in the analysis, with *Wandering*, the new information remains outside the boundary.

Despite this, as with *Following*, the boundary becomes clearer. This is because *Wandering* is making people aware that what is said is in direct contrast with the boundary that has already been set. It therefore has an indirect role in emphasising what is pertinent and it reinforces the boundary. An example is when an OR practitioner says "We're thinking of doing this workshop with employees, but another practitioner might involve wider stakeholders. The trouble is, if we were to do this, the organisation wouldn't agree". While this communication contains the *potential* to challenge a boundary, the conclusion of the *Wandering* is that the boundary that has already been set is correct.

3.1.5. Challenging

Up to this point, the role of the different boundary games has been to reinforce the boundary in different ways. The role of *Challenging* is in contrast to this. *Challenging* is to say that what it is inside the boundary is not pertinent, or is problematic in some way.

In order to mount a challenge, both information within and outside of the boundary can be used. The speaker who uses information from within the boundary points to contradictions between elements of that information. The use of outside information looks to show that, from a different perspective than the one employed so far, the selected boundary is problematic. Consequently, if the challenge utilises outside information, a second external boundary is implied (Midgley, 1992b, 2000). If the challenge is from the inside only, then no other boundary is implied.

From the point of view of relevance theory, *Challenging* reduces the positive cognitive implications and/or increases the processing effort required to operate inside the boundary. It shows that some previously accepted implications lack grounding, or new information shows that is not so easy to obtain inferences with the existing boundary. It would appear that *Challenging* is a destructive boundary game, but this is not necessarily the case: often a *Challenge* is necessary to stimulate the *Setting* of a new boundary (see Section 6.3 for a discussion of how all the boundary games can be played in a constructive or destructive manner).

3.1.6. Probing

Probing differs from all of the above. With the others, it is clear whether the information comes from inside or outside of the boundary, and we can deduce whether the boundary has been weakened or strengthened. Since *Probing* involves exploration, this is much less clear.

Probing happens when the boundary is not as clear as it needs to be to give confidence that a mutually shared cognitive environment exists. If the boundary is fuzzy, it is normal that someone will call attention to this in order to provide or ask for clarity. Clarification may give the participants greater confidence in the boundary, but in principle it is always possible that people will become aware of new (previously inaccessible) assumptions at some point, requiring a return to *Probing* – or indeed it may trigger some other boundary game, such as *Challenging* or *Wandering*.

Because of the fuzziness of the situation, it is difficult to clearly see if the area probed is inside or outside of the boundary. It is also difficult to understand the effects on the boundary because the way the situation is probed can produce effects that mimic the effects of the other games. However, unlike the other games, the distinguishing feature of *Probing* is that it involves a speaker calling attention to a fuzzy or problematic understanding with a view to triggering a clarifying response.

3.2. Visualising boundary games

Fig. 1 shows a visual representation of the aforementioned boundary games. In each case three stages are shown: the initial state, the move (or operation) and its outcome.

With the exception of *Setting*, the initial state is the same for all. In *Setting*, people are attempting to find a boundary that they can all accept, at least provisionally, in place of the various different boundaries that individuals started with. All the other moves are performed on an already established boundary.

In the second stage (the column headed "move" in Fig. 1), the operation focuses in some cases on where the movement lies: inside (*Following*), outside (*Wandering*) or on the boundary (*Probing*). In the other cases, it shows a kind of action on the boundary: enclosing (*Setting*), breaking (*Challenging*) and expanding (*Enhancing*).

The third stage, the outcome, shows the effect of the operation on the boundary. *Setting* shows that a boundary was constituted. *Following*, *Enhancing* and *Wandering* have a bold boundary as an outcome, meaning that it was strengthened. The increased size of the circle in *Enhancing* shows that the boundary has been expanded, but without a challenge to the original elements within it. The dotted line in *Challenging* represents a weakening of the boundary. Finally, *Probing* creates a kind of 'sub boundary' to be clarified on a segment of the boundary.

In studying actor interactions, the symbols in the middle column of Fig. 1 can be annotated next to transcribed statements to identify

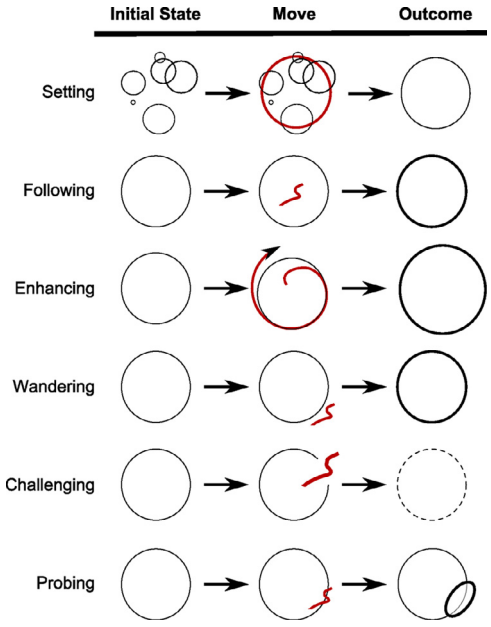

Fig. 1. Boundary games.

and link the kinds of operation performed by successive interactions (see the segments of interaction in Section 5).

Table 1 summarises and compares the different boundary games in relation to the conditions for relevance (cognitive effects that represent a good return for the cognitive effort); the origin of the information used to make the move (inside or outside of the current boundary); the overall effect on relevance; and the overall effect on the boundary.

4. The empirical study: analytic methods and data collection

4.1. The coding process

Fig. 2 presents a flowchart with decision criteria to help in the identification and coding of the different games.

Below, we give some hypothetical examples of communications in an OR workshop to show how the decision criteria in Fig. 2 can be employed to code them. Imagine an OR practitioner working with employees in her organization. She starts a discussion of a problematic situation by saying "let's use Methodology X to build a model". This is a proposal of an initial boundary defining the appropriate methodological language to use, so it should be coded as a *Setting*. The participants begin to discuss what should be in the model, which *Sets* a further boundary, at least provisionally. After a while, a participant suddenly declares that something significant has been left out of the model, and this completely changes what should be the focus of the modelling. This person is pointing to a lack of coherence between the boundary being used for model building and important information from outside the boundary, so it weakens the boundary. This is a signal that it should be coded as a *Challenging*. As the group re-focuses their modelling, one of the participants begins to look perplexed and points to an aspect of the problematic situation being modelled and asks "what does that mean?" This does not strengthen or weaken the boundary being used, but elicits a clarifying response from the person who had introduced the aspect being discussed. This is therefore an example of a *Probe*. As people begin to gain greater understanding, they start to enrich the information in the model. One participant says that there are several important new aspects that should be included because they interact with what is already there. As this expands the boundary, and strengthens it at the same time (it adds to, rather than detracts from, what was already there), it is an *Enhancing*. Getting to grips with this new information, another participant repeats back some of what has been said about the new aspects and how they interact with the previous ones that were already in the model. Because this is just a repetition (there is no enriching of information, and the focus is wholly within the boundary, strengthening it through rehearsal), it should be coded as a *Following*. Finally, reflecting on the whole exercise, one of the participants observes "if our customers had been here, they might have wanted a whole different issue to be the focus – but our boss doesn't want us to air our dirty

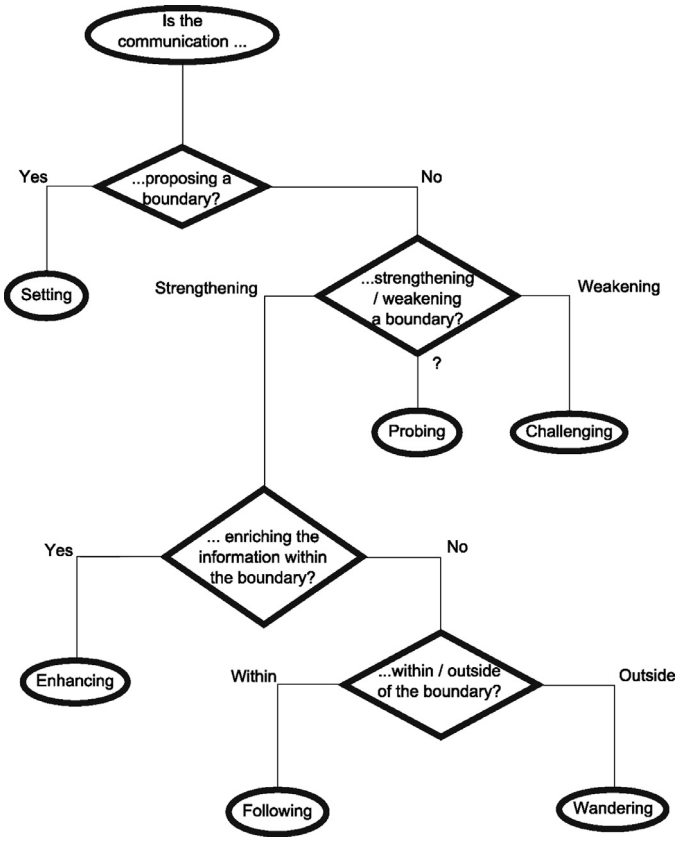

Fig. 2. Criteria for deciding on which boundary games are being played.

Table 1
Games overview.

Move:	Setting	Following	Enhancing	Wandering	Challenging	Probing
Cognitive effects:	Ideally >	=	>	=	<	?
Cognitive effort:	Ideally <	<	>	<	>	?
Information from inside/outside?	Outside & inside	Inside	Outside	Outside	Inside/outside	?
Relevance:	To be evaluated	>	>	>	<	?
Effect on the Boundary:	Comprises elements from other boundaries	Strengthened	Strengthened	Strengthened	Weakened	Focus on a small part of the boundary

laundry in public, so it's probably a good thing that we're doing it the way we are". This draws on information from outside the boundary (a customer focus and their boss's attitude), but the communication ends up strengthening the original boundary through the reference to airing dirty laundry, so it is a *Wandering*.

4.2. Methodological issues associated with coding

Sometimes it is the propositional content of a communication that gives the information that the researcher needs in order to decide which boundary game is being played. However, sometimes it is the reaction of other people that is more telling. Ideally, both should be referred to, and the interactions between participants need to be seen in relation to the wider dialogical context. Fig. 2 might erroneously give the impression that judging which boundary game is in operation at a particular moment in time is a reductionist process (i.e., separating each communication from its context), but this can never be the case: the person coding boundary games needs to have some knowledge of the OR process and the wider context in which it is unfolding. In short, accurate coding requires a sufficiently shared cognitive environment with the participants, so the wider context from their point of view is reasonably clear. This requires the researcher to be immersed in the context to an extent, rather than coming into it cold and assuming that the meanings of communications will be apparent.

Linked with this is the issue of 'representational validity': i.e., is the coding able to accurately represent the meanings being expressed? "Evidence for representational validity would demonstrate that the particular constructs or functions identified by the coding system are part of the … meanings ascribed to the interaction by participants" (Poole & Folger, 1981: 27). This requires that the meanings ascribed to participants' communications are explicitly cross-checked with those participants.

4.3. Some caveats

Before we move on to an example of an application of this way of thinking about boundary games, it is necessary to note some caveats. First, it is significant to observe that changes in cognitive environments can occur at both the personal and collective levels.

Second, the stimuli that bring about these changes do not just include verbal communications made up of words and phrases; they can also include body language and tone of voice.

Third, an important note here is that any single communication may have just one or multiple effects (Leech, 1983) in terms of the boundary games being played. Later, in our empirical vignettes (Section 5), we will give a number of examples of how very simple utterances can contribute to quite complex and multi-layered boundary games.

Finally, because we are making the assumption in analysing our empirical work that many of the intentions underlying boundary games are unconscious or preconscious, we inevitably have to acknowledge that our own interpretations of the data are pivotal in the retrospective construction of meaning, although we thoroughly checked these in interviews and feedback sessions with the team members. We have striven to evidence our interpretations in what follows.

4.4. Data collection methods

The data used in this paper for illustrative purposes comes from following the work of an OR team in a New Zealand government research institute for 10 months while they engaged in an intervention with a Regional Council. For this whole period, the 1st author shared office space with the OR team, as he was based there on his PhD fieldwork (Velez-Castiblanco, 2012). This closeness to the team allowed for sufficient immersion in the context to enable meaningful interpretations of what was happening. The data were gathered through observations, voice recordings and note-taking on practitioner interactions in 44 meetings. We also undertook 9 follow-up interviews with the members of the team and held 3 feedback sessions where the findings were presented and cross-checked with the participants. These interviews and feedback sessions were critical for ensuring representational validity, as discussed earlier. The coding of boundary games was initially undertaken by the 1st author, and then checked by the 2nd author, with both agreeing on interpretations with reference to the interview data.

5. An analysis of interactions using the theory of boundary games

5.1. The OR intervention being studied

The intervention being undertaken by the OR team came about because of a request from a Regional Council for support in developing self-evaluation methods. Regional Councils in New Zealand have responsibility for environmental management and the sustainability of local resources, such as rivers. Within Regional Councils are Resource Care Sections (RCSs), which work with grass-roots community groups to support their sustainability initiatives. It was the RCS that wanted to engage in self-evaluation to inform the on-going improvement of its activities.

The OR intervention involved a series of workshops exploring the evaluation needs of the RCS and its clients (community groups) and wider stakeholders. In the background to these workshops, many meetings were held: some with just the OR practitioners to discuss the context and design the workshops; some with RCS representatives to share ideas and modify the workshop designs; some with the senior management of the Regional Council to discuss progress; and some with a governance group overseeing a range of OR interventions being undertaken by the team. This paper draws upon segments of the data collected from just one of these meetings, attended by the OR practitioners alone: Hannah (the project co-ordinator, who came into OR with a background in Māori Studies), Frederick (who had a background in quantitative OR, systems thinking and the use of problem structuring methods) and Dianne (who was a Psychologist by training, and was also employed as a Māori researcher). These different disciplinary backgrounds are relevant because, although the team was now working together on an OR project, they could not count on having an extensive, shared methodological language. Indeed, while Frederick had a background in OR, he could not unilaterally design the project; he had to be mindful of the disciplinary sensitivities of the other participants if they were to work together as a cohesive team. The 1st author of this paper was present in the meeting as an observer, and the names of the participants have been changed to preserve confidentiality.

5.2. Vignettes of interaction

Segments One and Two (below) were extracted from a single session in which the OR team was designing a workshop. This session was chosen because it was the most in-depth discussion of OR methodologies. In fact, Soft Systems Methodology (SSM) (Checkland, 1981; Checkland & Poulter, 2006; Checkland & Scholes, 1990) was a major focus, but the chosen segments, which involve almost all the boundary games, concentrate on interactions prior to the explicit discussion of SSM. In these segments only Hannah, Frederick, Dianne and Jorge (the first author of this paper) were present.

Segment One is from the initial moments of the session. Fig. 3, which annotates the OR team's dialogue using the boundary game diagrams (Fig. 1), basically shows 2 branches of discussion (the 2nd

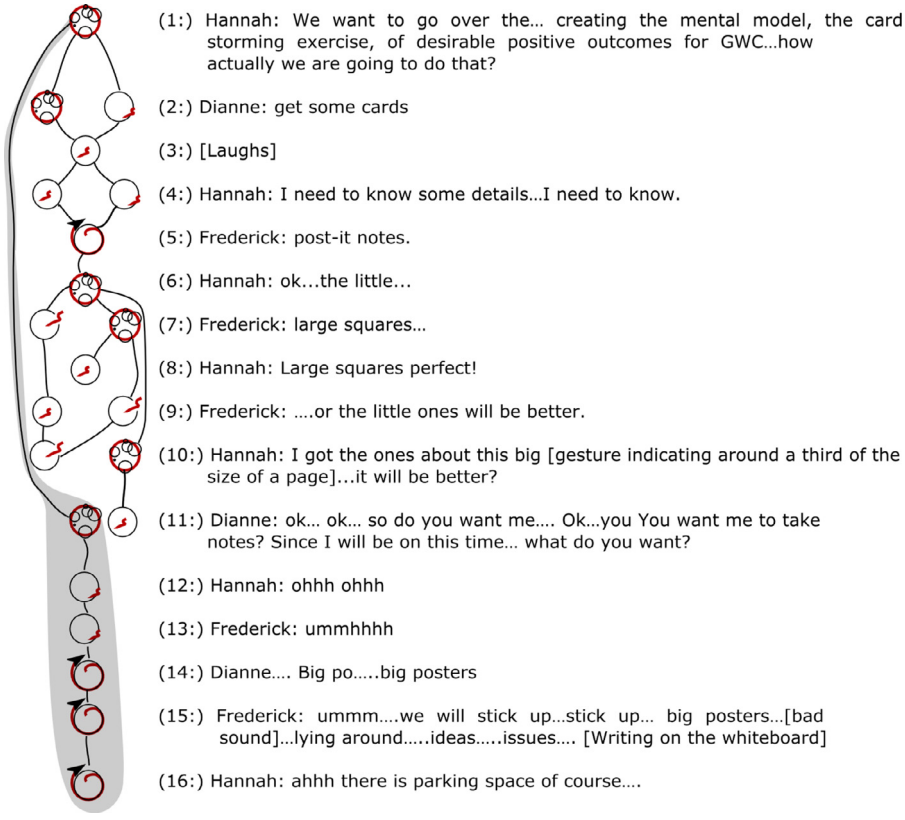

Fig. 3. Segment One (2nd branch is shadowed).

branch in Fig. 3 is shadowed). Each one contributes to how to design the workshop. The 1st branch is about the cards to be used in a brainstorming exercise. The 2nd branch is about taking notes on big posters around the room. The 1st branch is messier due to a discussion of the kinds of cards that should be used; they finally settle on the post-its that they already have in stock. The 2nd branch, about taking notes on posters, developed more straight forwardly. As mentioned earlier, we are not suggesting that the OR practitioners were conscious of all their boundary games: some of the group dynamics were very complex and the conversation moved much too quickly for extensive, conscious deliberation.

In (1), Hannah is *Setting* the context and purpose of the meeting. When she says "we want to go over the … creating a mental model", she is referring to a decision that had been made in a previous meeting to do 'mental modelling'. There is a reason for this terminology: Frederick had introduced the idea of *conceptual* modelling in a previous meeting (this is a technique, discussed by Checkland & Poulter, 2006, for developing a map of linked actions that would be needed to bring a proposed system transformation into being). However, Hannah had called it 'mental modelling' in the discussion by mistake. Frederick had not corrected her; instead, he adopted her language. In an interview with Frederick, we asked why. His answer was actually nothing to do with Hannah; it was to do with the fact that Dianne was a Psychologist by training, and on occasion expressed resistance to the use of some systems/OR methods. He thought that, by allowing conceptual modelling to be called mental modelling, the disciplinary gap might be bridged.

In (2), Dianne says "get some cards". In order to interpret this accurately, it is important to see the effects that the communication immediately produced. Dianne says the phrase half jokingly and then laughs in an engaging manner (3). This tells us that she is *Probing* to see if talking about cards might be appropriate (if her interjection had been sarcastic, rather than good humoured, it might have been interpreted as a *Challenge*). The others join in the laughter, thereby getting on side with Dianne, *Following* the initial boundary and confirming the validity of her *Probe*. If we look at what happens next, we see that the others respond to her communication and start to think about the cards. Consequently her phrase, "get some cards", contributes to further *Setting* the initial boundary and allowing others to start to elaborate on it.

In (4), Hannah's response ("I need to know some details") shows that she *Follows* the boundary *Set* by Dianne. It gives further strength to this boundary without adding anything new. Additionally, she is *Probing* for more ideas regarding the cards. In (5), Frederick answers Hannah by saying "post-it notes". This is in line with the discussion of cards, but provides more information, and is therefore *Enhancing* the boundary.

The next bit revolves around the size of the cards. In (6), we know that Hannah *Sets* a new boundary within the old one because she triggers this discussion of size by saying "OK … the little …". In (7), the first choice of size is *Challenged* by Frederick, making this option weaker. Also, he is *Setting* an additional possible boundary, or rule, for the size ("large squares"). In (8), Hannah *Follows* and agrees with Frederick about the size. Frederick has doubts, however, and in (9) *Challenges* his own initial idea. Hannah responds as well in (10), *Challenging* the whole idea of size, saying that she already has post-its that they can use. This simultaneously *Sets* a new boundary around their use.

The next part sees Dianne first *Following* the previous discussion and then introducing a new topic, *Setting* a boundary concerned with note taking (11). Hannah and Frederick's ohhs and umms in (12) and (13) are not creating anything new, and neither are they strengthening or weakening the boundary. They are *Probing*; declaring a lack of certainty to indicate that the idea needs to be tested. In the next three moves, the idea of using posters for note taking is fleshed out by successive *Enhancings* from Dianne, Frederick and Hannah: they

all strengthen the focus on posters and introduce new information to guide the activity of note taking.

Following Segment One there were 4 minutes of interaction, not represented diagrammatically. The OR team discussed how to integrate new people into the workshop who had not participated in previous events; there was a concern that they would affect the group dynamics. However, instead of dealing with this issue directly, the team started to talk about what possible future projects could be devised with these new people. This was a side-track with its own boundary. Hence, as we look at Segment Two (Fig. 4), we have represented this by starting the diagram with two *Settings*: one is the original topic of designing the workshop, and the other is the side-track of future possible projects.

Segment Two is basically about how to manage outcomes. There is a small detour when Frederick is not convinced about using post-its, but this is assertively contained by Hannah. The start of the detour is represented in Fig. 4 by an asterisk (∗) on the left of the boundary game icons, taking the discussion back to the dialogue about cards in Segment One. At the end of the segment there is another asterisk, this time noting a reference back to the idea of working on a 'mental model'. The detours are shadowed in Fig. 4.

In (1), Hannah makes a call to order and returns the meeting to its original topic. In the process she *Challenges* the boundary of the side-track ("OK anyway …"), but acknowledges "it's fun" (thereby avoiding rudeness), and *Follows* the boundary around the workshop design issue (it is a *Following* because she does not provide any new information). In response, Frederick suddenly proposes a new issue for discussion ("outcomes", and the importance of these to the client) (2), which *Sets* a new boundary within the wider workshop design boundary. The idea that outcomes are important is then the focus of the following moves. In (3), Hannah asks for clarification ("for the GWC?"), *Probing* Frederick's boundary. In (4), Frederick *Follows* and provides the clarification for Hannah with "yeah". Additionally, he *Enhances* the boundary by saying that the outcomes are actually *potential* outcomes; this is a small refinement of the original statement about outcomes (2), but a significant one in the context of an OR workshop design because the implication is that the team needs to focus on new kinds of outcome and not on outcomes that the organization is already achieving.

In (5), Dianne *Follows* with "yeah". Additionally, she may also be *Probing* the boundary when she asks if the activity will be carried out at an individual level. However, it can be argued that this is actually an *Enhancing* because her suggestion of doing the activity at the individual level could not be inferred from the already established boundary. After a couple of intervening comments (6 and 7), the idea of developing an individual activity is *Followed* by Frederick (8).

In (6), Frederick interjects "just … just …". However, there is not enough information for the participants (or us) to identify anything meaningful, and no responses are offered. For this reason, the icon next to (6) is a question mark. Perhaps Frederick is just *Probing* himself about something not shared, or perhaps he was going to say something new but thought better of it. In any case, because nobody *Probed* his communication in return, we will never know.

In (7), Hannah *Probes* (4) by asking "they are like, 'improve environment?' ", and then she answers the question herself. This is also a *Following* because it reinforces the boundary concerning outcomes without adding new information (the outcome of 'improve environment' is not new information; the team were already very well aware that the primary function of the organization was to improve the environment).

In (9), Hannah affirms that the idea of individuals performing the activity is useful ("yeah"), which is another *Following*.

In (10), Frederick *Enhances* the idea of how to work with outcomes by discussing the fact that they can be grouped. The method to be used is beginning to emerge through this *Enhancing*. However, he then abruptly diverts to *Challenging* the notion of using post-its; this is a reference back to a boundary that was defined in Segment One (hence the ∗ in Fig. 4). He thinks post-its will be troublesome because they are sticky. Hannah then *Probes* if she hears right, and assertively *Challenges* Frederick's objection to post-its. This makes Frederick's boundary weaker, and he quickly gives in (12) and finds a reason why post-its might be useful after all, thus *Following* the established boundary once again whilst offering an *Enhancement*. From (12) through to (17), the dynamic is Frederick suggesting additional *Enhancements*, with Hannah and Dianne *Following*.

After Frederick has talked about summarizing each little pile of outcomes with a name (16), in (18) Hannah *Probes* if she understands well ("each little pile?"). Dianne confirms that she *Follows* (19), and her answer seems to reassure Hannah, as she terminates her *Probing* with another "yeah" (20). In (21), Frederick *Enhances* again and Dianne *Follows* (22).

Now, (23) is interesting. Hannah suggests that the process they had been talking about is the creation of a mental model. The way she poses this implies that she is connecting the current discussion of grouping potential outcomes back to the original purpose of the workshop, specified at the start of Segment One. She therefore thinks that she is *Following*. However Frederick's reaction in (24), an emphatic "no", shows that Hannah has inadvertently created a new boundary, with a notion of mental model that is different from his. When he says "no", he is *Challenging*. This response is *Probed* by Hannah in (25) and strongly *Challenged* once more by Frederick in (26) ("no no no").

For space reasons it is not possible to present the complete story after Segments One and Two. However, we will just point out that the interaction examined above, far from ending with a confrontation, actually established the conditions in which Frederick could successfully introduce the idea of using some methods from SSM (Checkland, 1981, 2000).

In light of this, it is important to summarize Frederick's strategy to influence the design of the workshop (discussed with him in a follow-up interview). In short, he tried to adapt all the concepts from SSM to the cognitive environments of the other participants in the OR team. The first evidence of this, although it is not part of the boundary games analysis presented here, is his acceptance of the term 'mental model' in a previous session as a way to resonate with Dianne's vocabulary from the discipline of Psychology. This pattern of adapting his own message is particularly strong when he takes the notion of 'outcomes' proposed by one of their clients as the basis for something that could be pursued in the workshop design. Notice that neither 'mental models' nor 'outcomes' are part of the SSM vocabulary, yet the whole OR team ended up describing their design as an SSM workshop once the details had been worked through. These adaptations of language make sense from the point of view of relevance theory (Sperber & Wilson, 1995; Wilson & Sperber, 2002a, b): had Frederick used a vocabulary different to that of his peers, he would have violated both conditions for relevance – first, by using unfamiliar jargon he would have increased the processing effort required to understand what he was saying; and second, assuming that his colleagues would not have made the effort, he would have failed to show them that they could get positive cognitive effects from his proposals.

Additionally, in these two segments, it is worth noting that Frederick only performs three *Challenges*, and two of them (15 and 32) are directed to his own proposals concerning post-its. The other one arises when Hannah reveals that she has a different understanding of a 'mental model' to his. The rest of the time, whenever Frederick listens to an idea introduced by someone else, he either *Follows* or *Enhances* it. His strategy therefore involved, not only adapting his methodological ideas to the cognitive environments of his colleagues, but also to be as supportive as possible of their own contributions (within limits, as he did not accept the term 'mental model' in the Segment Two dialogue). Both of these elements of his strategy combined to facilitate his influence, to the point where the

Fig. 4. Segment Two (detours are shadowed).

whole team eventually accepted the label of SSM for their workshop design.

6. Discussion

Our discussion is organised into five parts. We start by looking at the implications of this work for understanding the construction of OR interventions. Then we consider some normative implications for OR practitioners before focusing on how some of the questions already outlined in Section 2 on the 'black box' can be explored from the perspective of our theory of boundary games. Next, we reflect on the relevance of our work for the BOR agenda before concluding with some suggestions for further research.

6.1. Implications for understanding the construction of OR interventions

Boundaries are usually dynamic: with the exception of some entrenched processes of value conflict and marginalization, which are very difficult (but not impossible) to shift (Midgley, 1992b, 2000; Midgley & Pinzón, 2011, 2013), boundaries often unfold, mutate and evolve through interactions (Brocklesby, 2007; Checkland, 1981, 2000; Checkland & Sholes, 1990; Churchman, 1968, 1979; Maturana & Varela, 1992; Mingers, 2006; Vickers, 1983).

The empirical vignettes presented earlier indicate that the participants were initially unsure about boundaries and only became clearer through further interaction. Ordinarily some pre-existing biases and predispositions will be relatively immune to change, and others will alter as the relational circumstances of the intervention evolve (Brocklesby, 2009). In this case, Frederick, for example, who was the person with a more or less clear idea of the methodology and how it should be used, was constantly adapting his position in relation to what he both heard from others and anticipated hearing from them.

Our analysis also shows how different methods and techniques, such as conceptual modelling (or 'mental modelling' in this case), outcome identification, brainstorming and card grouping can be used as foci for deliberating on the boundaries of what is considered relevant in the situation. It is important to note that participants' everyday talk, behaviour and body language intermingles with the technical foci to create an understanding of the situation and a picture of the task at hand. As a consequence, these things all contribute to constructing a distinctive, bounded 'story' of how the intervention could or should proceed.

Another related point is that our data clearly demonstrates that there was no pre-chosen meta-theory or framework used by the OR team in their discussion of their workshop design; i.e., a framework guiding the diagnosis of context and choice of an 'appropriate' methodology, like the System of Systems Methodologies (Flood & Jackson, 1991a; Jackson, 1987a, 1991; Jackson & Keys, 1984). Neither was there a set of pre-existing methodological predispositions on the part of the OR practitioners that served to determine outcomes; the nearest to this was Frederick's introduction of some methods from SSM, but even these were reframed in the meeting and combined with other methods as a consequence of evolving boundaries.

Of course, an advocate of the System of Systems Methodologies (or any other framework to support methodology choice) could argue that the methodological design would have been much easier and the outcome would have been better if such a framework had been used. In reply to this, we point to the application of, and reflections on, the System of Systems Methodologies by Midgley (1990, 2000), and the cogent argument by Mingers (1992), which demonstrate that this framework is too simplistic to capture all the variables that need to be taken into account in designing highly complex, multi-method OR interventions. This is one reason why Midgley (2000) abandoned that framework and introduced his Systemic Intervention approach, which supports the creative mixing of methods in response to a multi-dimensional understanding of the situation – and 'the situation' includes, for example, the group dynamics in the OR team, as well as what clients and stakeholders might need. Indeed, far from weakening the methodological design, it could be argued that the evolving and overlapping nature of these boundary games builds some robustness into the outcome.

Such a view resonates with the proposal by Mauws and Phillips (1995:327) to approach managerial practice in terms of "collections of diverse language games" or "flexible networks of language games". It also provides some support to the assertion by Keys (2000:311) that it is important in an intervention to "maintain cohesion and stability" between roles, techniques (which may be altered from their original presentations in the literature), ways to apply the techniques, etc. This means that, even when an OR practitioner has a favourite methodology that he or she always tries to use, it may be an important *element* for understanding why and how to engage in a certain intervention process, but it cannot be applied in the absence of reference to many other factors – and when *teams* of practitioners with different methodological expertise come together, the situation is even more complex, as it is unlikely that any single methodological rationale will dominate.

A final consideration is that, since an OR intervention is a process and not a discrete event, the operational boundaries that apply are very much a combination of what has happened in previous interactions on the one hand, and on-going interactions on the other. The session examined in this illustrative case was setting the stage for future activity, but there were on-going interactions with multiple stakeholders throughout the project life-cycle, which continued to shape and reshape the intervention.

6.2. Normative Implications for Practitioners

Experienced practitioners understand that the design of interventions is not an exercise in purely rational analysis: diagnosing the context and using a pre-existing theoretical framework (like the System of Systems Methodologies) to determine the 'correct' methodological approach, as if methodologies can easily be aligned to categories of context in one-to-one relationships. To be fair to the creators of the System of Systems Methodologies, this is never how it was intended to be used: Jackson (1990) strongly criticises its treatment as a rule book, as all it can really do for the OR practitioner is highlight some of the key assumptions that are made by different methodologies (e.g., that there is agreement or disagreement on the goals of an intervention). This is different from saying that the dimensions of the framework are all that OR practitioners need to account for in deciding what the most useful methodology (or mix of methods) might be. Nevertheless, it is easy for an inexperienced practitioner, insecure about whether his or her tacit knowledge is sufficient to inform the OR design process, to reach out for a rule book. We believe that our research clearly demonstrates that a competent OR design process addresses much more than the diagnosis of context using standard variables: in particular, OR practitioners need to consider their relationships with others in their team, their clients, and indeed wider stakeholders. This is why Weil (1998) and Midgley (2000) describe the intervention design process as 'multi-layered'. Indeed, the boundary games involved in the negotiation of a design with shared meaning are highly complex and dynamic. The implication for inexperienced practitioners is therefore to heed the warning from Jackson (1990), and only use theoretical frameworks as one quite limited type of relevant information, and certainly not as rule books.

It is also important to note that boundary games are so fast moving that it is not reasonable to think that OR practitioners could be fully conscious of all the implications of their communications: there is a large amount of tacit knowledge involved, which can only be made visible retrospectively by the kind of analysis undertaken in this paper. While, in our experience, repeated immersions in OR projects bring greater mindfulness of the intricacies of social relationships (including emotional dynamics), reliance on tacit knowledge is necessary and normal. This is an important insight for practitioners who write up OR projects for journal publication, as there is an unfortunate tendency in the literature to 'sanitise' accounts of the OR process (Ormerod, 2014); even sometimes going so far as to present an emergent set of methods as flawlessly pre-planned (see Midgley, 2000, for a critique of this practice). If OR teams actually draw heavily on their tacit knowledge, then sanitisation is a serious mistake because it gives a false impression of OR as the simple application of already existing methods. If students in University only learn about sanitised accounts of OR practice, they will get a rude awakening when they undertake their first interventions and find that, not only

is there often a need for the creative design of new methods and the development of hybrid methods from parts of old ones (Midgley, 1990, 1997; Mingers & Gill, 1997), but even when an existing method can be applied, the process of negotiating the context and building relationships with clients and stakeholders is still highly complex.

It is also important for practitioners to understand the *relationship between* tacit and explicit knowledge: the former dominates much of the decision making in both OR design teams and in applications of their designs to interventions. However, retrospective analysis can generate explicit theory that, when internalised by the practitioner (usually through conscious experiment), can augment tacit knowledge (Midgley, 2000).

With regard to internalising theoretical knowledge, we suggest that the theory of boundary games can support greater mindfulness, both when OR teams are designing an intervention and when the intervention is being undertaken. By 'mindfulness', we mean conscious reflection in the context of the flow of dialogue and action, which can augment the tacit knowledge that is inevitably a major feature of OR processes. This kind of reflective practice has been understood for decades in family therapy, where a great deal of psychodynamic, systemic and linguistic theory is deployed (e.g., Selvini Palazzoli, Cirillo, Selvini, & Sorrentino, 1989), and it is clearly relevant to facilitation in OR (Bilson, 1997; Taket, 2002).

Our own theory of boundary games provides a language that can improve awareness of what is happening during communications with OR colleagues, clients and participants. For instance, knowing that *Setting* a boundary is necessary for meaningful communication, the practitioner can be on the lookout for when people are bringing different boundaries into play and talking past one another; then he or she can try to identify a new boundary that has the potential to embrace all the participants' concerns. Another example is when the practitioner sees that participants in an OR design process or a modelling exercise are repeatedly *Challenging* each other with "yes, but …" comments. If participants get into a pattern of saying "yes, but …" to every attempt to set a boundary, it can be disempowering and frustrate progress. In such a situation, a "paradoxical injunction" (Watzlawick, Helmick Beavin, & Jackson, 1967: 194) can be useful. This is when the practitioner takes advantage of the entrenched pattern of communication to say something that, if responded to with another "yes, but …", *must* result in a boundary being set. For instance, the practitioner might say "Well, it looks like this problem can't be solved". Propelled by the momentum of repeated *Challenges*, a participant is likely to say "*yes, but* a possible approach is …". The pattern of *Challenges* is then broken, and a new boundary is *Set*, at least provisionally. The 3rd author used a paradoxical injunction to good effect in an OR project (Gregory & Midgley, 2000) when the participants were resisting any attempts by their colleagues to define potential transformations of the problematic situation: his suggestion that "maybe there's nothing you can do after all" was responded to with a firm "yes, but …", and an idea for a transformation went up on the wall! The language of boundary games can sensitise OR practitioners to patterns of repeated *Challenges*, helping to inform their own communication strategy. Likewise, awareness of the other boundary games can help the practitioner with facilitation: supporting participants in *Probing*, *Enhancing* and *Challenging* when useful. Even understanding the role of *Wandering* is beneficial, as it can help the OR practitioner discriminate between productive (boundary strengthening) and distracting detours in dialogue.

A final implication of this work for practitioners *and* academics is that the adaptation of methodological language to fit the cognitive environments of people without prior knowledge of OR is essential. As Wilson and Sperber (2002a) make clear, if a great deal of effort is required to understand a communication, it is likely to be perceived as irrelevant unless the cognitive effects it could produce have a good chance of outweighing this effort. The problem for OR practitioners is that 'uninitiated' clients and stakeholders cannot evaluate the benefits of OR methodologies in OR terms, as they have not (yet) invested in learning those terms, so practitioners need to think carefully about what communications will be most meaningful to those clients and stakeholders, taking account of their cognitive environments. Frederick's communication strategy with his colleagues, discussed earlier, exemplifies this, as he knew they would not know enough about SSM to accept use of SSM methods unless he could find a way to frame his communications in a manner that made sense to them. For the most part, experienced practitioners readily appreciate this, as they may fail to secure projects if they appear to be talking in an 'obscure' language that others find difficult to understand (Zhu, 2002). However, this is equally relevant for academics, as they are more and more frequently asked to engage with people in other disciplines. While the pressures of collaborating in the context of the 2nd World War helped the multi-disciplinary founders of OR to forge a shared cognitive environment relatively quickly (Trefethen, 1954), this is more difficult in the present day when there are strong institutional pressures to maintain distinct disciplinary identities (Frodeman, Thompson Klein, & Mitcham, 2010). Now OR is often just one of many contributing disciplines, and a bespoke cognitive environment has to be forged for each team.

6.3. Delving more deeply into the black box

Including, but extending beyond, the specific question of a team of researchers making decisions about the configuration of an intervention, the following section considers how the theory of boundary games could be more widely applied to better understand some of the micro-dynamics of OR practice.

Let us start by recalling Checkland's reference to the "mysterious process" (Checkland & Stowell, 2012) that occurs when people shift their thinking. The theory of boundary games can help identify when these changes occur, who triggers them and what happens as a result. Boundary games can help to identity the assumptions behind these changes, and the function that these play in the evolving picture. On some occasions, boundary games are just introduced and interact with what is already in place; sometimes they gain or lose strength; and sometimes they are transformational.

As a limitation of existing accounts of interventions, Keys (2000) draws attention to the paucity of information about the actual behaviours of the actors involved. In response to this, the present approach makes it possible to identify, catalogue and analyse all actor boundary moves as well as how others react to them. Moreover, it is possible to begin to unravel how these complex interactions combine to realise (or not) a common set of boundaries. Such an approach further demystifies the social construction and process of interventions.

Franco (2013) and Franco and Rouwette (2011) care about models; how they enable or constrain interaction and help to create knowledge. From a boundary games perspective, new knowledge is the synergy of elements within a new boundary that were previously defined by older boundaries. If a model just helps people to work within an already established boundary (*Following*), or only *Enhances* a boundary without really transforming it, then there is no significant new knowledge. New knowledge comes when the act of model building involves the establishment of a new boundary with implications that are impossible to infer from any of the individual, contributing boundaries of previous knowledge.

Also, from a boundary games perspective, using a model is just another way of channelling communicative stimuli. Models embody data and relationships, but when they are used by an actor in a communication, they are merely another way to convey a message that, in interaction with others, can lead to the introduction of new boundaries, or strengthen or debilitate old ones. The theory of boundary

games can be used to trace whether a shared boundary has been constructed and, if so, how any model that is used fares when subjected to tests of relevance: producing positive cognitive effects with an acceptable level of processing effort. If the model is relevant, it will enable constructive interaction. If it is not relevant, it will hinder it.

In relation to this, the theory of boundary games can help us specify what a 'constructive interaction' might look like. Each of the games can be useful. Boundary *Settings* are required because they combine a group of individual concerns into a new focus that can be used as the basis for further collective exploration. *Enhancings* are individual contributions to this collective exploration that, when accepted by others, enrich the shared cognitive environment. *Probings* allow the participants to test whether a shared cognitive environment actually exists, and *Followings* help individuals familiarise themselves with the emergent meaning that is being created. *Wanderings* strengthen boundaries by ruling out possible alternative understandings. Finally, *Challenges* point to problems with existing boundaries, can lead to the *Setting* of new ones, and can undermine 'groupthink' (Janis, 1982) – collective collusion with overly-limiting boundaries in order to maintain group cohesion.

However, these are useful, but not sufficient, concepts for identifying constructive interactions. The earlier discussion of the disempowering effect that a pattern of repeated *Challenges* can have on group dynamics points to the reason why: *Challenges* may have constructive effects when they highlight new options for boundary setting and undermine limiting assumptions (Churchman, 1979; Mason & Mitroff, 1981; Ulrich, 1994), or they may have destructive effects when they frustrate the ability to make progress. Likewise, *Enhancings*, *Wanderings* and *Followings* may strengthen a useful boundary, but may also contribute to groupthink. Ultimately, whether these boundary games are contributing to a constructive or a destructive interaction is a matter of *judgement in context*. To make such a judgement, one can ask: have sufficient boundaries been explored to give confidence, not only that there is a shared cognitive environment, but also that nothing of major significance has been missed? To address this question we have to assume that comprehensive analysis is forever out of reach, but it is nevertheless still possible to *improve* understanding through boundary explorations (Midgley & Ochoa-Arias, 2004; Midgley et al., 1998; Ulrich, 1994). However, the answer may only become apparent some time later when actions are taken and outcomes are evaluated (Chess & Purcell, 1999; Midgley et al., 2013; Rowe & Frewer, 2004): if major, unforeseen issues emerge, retrospective analysis may suggest that more exploration could have been useful. Pragmatically, the best sign that sufficient boundary exploration has been undertaken prior to the emergence of outcomes is arguably when knowledgeable participants say that this is the case (Eden, 1995; Eden & Ackermann, 1996; Shaw, 2003) – and also, the viewpoints of experienced OR practitioners are useful, as they can judge the quality of the process that has been followed. These are the most usual foci of evaluations of OR interventions (Mingers & Rosenhead, 2004; White, 2006). So, we may treat boundary games as *indicators* of constructive interaction, but it is still important to use our tacit knowledge of group dynamics during engagements with participants (including colleagues, clients and other stakeholders) to judge whether they are *actually* constructive. It is also important to explicitly check our interpretations with participants (Midgley et al., 2013).

The final concern presented in Section 2, and previously discussed by Franco and Rouwette (2011), focuses on how workshop design affects group decision making. Here the approach is to consider the design as a set of boundaries defining how to operate in the workshop: the boundaries enable the use of some activities and constrain possibilities of others. Then, as in the case of models, it is possible to examine how these boundaries fare when exposed to the two conditions of relevance discussed earlier: the production of positive cognitive effects and the cognitive effort expended.

6.4. Reflections on the BOR agenda

Now returning to BOR, in Section 2 we presented one definition of it that identified as central issues the interaction and communication of actors, their procedural mistakes and their cognitive biases (Hämäläinen et al., 2013). It can be seen that the theory of boundary games is all about interaction and communication. Our paper does not deal with procedural mistakes, although it can be argued that the theory presented here could be used to explain issues around them.

This leaves a final topic: cognitive biases. The contribution of the theory of boundary games to understanding cognitive biases is distinctive. Hämäläinen et al. (2013) talk about biases as fixed, structural givens at the biological, psychological and social levels. In contrast, we argue that every time a boundary is affected by a game, this changes the strength of the associated assumptions, and hence it also changes how people process subsequent stimuli. Thus, biases can be subject to change.

> "As a discourse proceeds, the hearer retrieves or constructs and then processes a number of assumptions. These form a gradually changing background against which new information is processed. Interpreting an utterance involves more than merely identifying the assumption explicitly expressed: it crucially involves working out the consequences of adding this assumption to a set of assumptions that have themselves already been processed" (Sperber & Wilson, 1995, p.118).

We do not deny that there are biological, psychological and social biases that might be relatively fixed. However, there are far more ubiquitous biases, inherent in the very act of taking a perspective (also see Cabrera, Cabrera & Powers, 2015). In our view, to look solely at structural biases is a serious mistake.

6.5. Proposals for further research

Before concluding, we wish to highlight some possible next steps in research on the theory of boundary games. First, it will be useful to analyse diverse forms of OR intervention to see whether a move from a focus on OR team discussions to actual interventions necessitates the definition of new boundary games. Velez-Castiblanco (2012) analysed a substantial amount of data, so we think it is unlikely that major new games will be discovered, but refinements of the set of 6 may be necessary in light of analyses of interventions with clients and participants.

Second, it is worth evaluating whether the theory of boundary games really does usefully augment the tacit knowledge of practitioners. It would be possible to train practitioners to understand their interactions in terms of boundary games and then arrange to video-record their interventions. These recordings would be the basis for interviews with both the practitioners and participants. This way, examples of conscious uses of the theory of boundary games could be isolated, and the perceived effects from the points of view of both the practitioner and participants could be assessed.

Third, we need to ask about how the expressed purposes of OR methodologies, methods and tools connect with the boundary games that participants play. Is it possible to show that different methods facilitate different boundary games (or combinations of games), or is it the micro-interventions of OR practitioners in dialogue that matter more than the method? If the former is the case, then this could provide useful evidence for the efficacy of OR methods; but if it is actually the agency of the practitioner that matters most, then there might be a need for a shift away from a primary emphasis on methodology and methods towards a greater focus on communication and facilitation.

Finally, are there patterns of game playing that are generic for all 'successful' OR interventions (as perceived by the participants), regardless of methodology? And can indicators of failure be found at the micro-communication level when participants are unsatisfied

with an intervention? If the OR practitioner could identify a failure pattern during an intervention, he or she might be able to change direction and rescue the situation.

7. Conclusions

In this paper, we have presented a theory of boundary games for analysing interactions in OR interventions. It is proposed that actions on a boundary can take at least six possible forms: *Setting*, *Following*, *Wandering outside*, *Probing*, *Enhancing* and *Challenging*. Although the intentions of OR practitioners and other stakeholders in an intervention can be relatively fixed on occasion, most often they are fluid and open to change through the interactions in the setting.

Intentions are present in every communication, giving everyone who is free to communicate and able to do so effectively the opportunity to intervene in and change people's boundaries of understanding. It is possible to produce effects in interventions in many ways: using words, gestures, models, methods, methodologies, etc. All of these can both *enable* boundary games and can be reinterpreted *using* boundary games.

At the outset of this paper, we emphasised the utility of the theory of boundary games in understanding the dynamics in OR teams that embrace methodological pluralism and the practice of mixing methods. Certainly, when there are no pre-set methods, and the team has to design an intervention from scratch, the boundary games are very clear (as in the vignettes we presented). However, this theory is also relevant to sole practitioners who have a single, favourite methodology or set of methods. Because such a practitioner still has to communicate with clients and stakeholders, and the cognitive environments of these people are never 100 percent certain, the idea of a 'standard' presentation of a methodology, method or model is undermined: adaptation to fit with the cognitive environments of audiences is usually necessary if utility across contexts is to be attained.

Using the theory of boundary games, an intervention process can be expressed as a succession of actions on boundaries. It is possible to identify the actors carrying out the actions, and processes of generating, strengthening and weakening boundaries and their associated assumptions can be traced through analysis. This allows for an understanding of how individual actors affect the shared cognitive environment of a group (e.g., how an individual OR practitioner affects the thinking of his or her team), and it is also possible to trace how individual communications condition the possibilities for future actions through their effects on boundaries. It is argued that the theory can be used to study the 'black box' of the micro dynamics in OR interventions, and some suggestions about how to proceed from the boundary games perspective have been presented.

There are implications of this theory for OR practitioners. It suggests that overly simplistic 'rule books' for diagnosing the context and selecting the most appropriate methodology should be viewed with scepticism. Also, when writing up projects for publication, the temptation to 'sanitise' accounts of intervention and pretend that they are flawlessly pre-planned should be resisted. The theory may support conscious reflection during communications with colleagues, clients and participants, and this can augment the practitioner's tacit knowledge. Finally, the theory makes clear why adapting the methodological language of OR to reflect the languages of clients and stakeholders is so important.

The key aspect of the theory of boundary games that makes it relevant to BOR is that it offers a form of analysis which "focuses on the psychological and social interaction-related aspects of model use in problem solving" (Hämäläinen et al., 2013:624), including the proposition that boundary judgments circumscribing an OR intervention are the result of a rich mixture of communications exchanged over time, some of which relate to methodologies, methods and models, and some of which do not. Interventions are evolving processes, not discrete events.

The theory of boundary games is a young approach inside the nascent field of BOR. Further research is required to see if the envisioned promises for OR theory and practice can be delivered. Some avenues for possible further research have been explored. Arguably, the main contribution of this paper is not simply to demonstrate that designing an OR intervention is an incorrigibly human and social process, but crucially to indicate what this process involves and how it might be investigated.

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