European Journal of Operational Research 223 (2012) 392–406

Contents lists available at SciVerse ScienceDirect

European Journal of Operational Research

journal homepage: www.elsevier.com/locate/ejor

Decision Support

Messing about in transformations: Structured systemic planning for systemic solutions to systemic problems

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ARTICLE INFO

Article history:
Received 7 February 2011
Accepted 5 June 2012
Available online 13 June 2012

Keywords:
Cognitive mapping
Strategic Options Development and Analysis (SODA)
Soft Systems Methodology (SSM)
Planning
Multimethodology
Problem structuring

ABSTRACT

The literature on multimethodology indicates that cognitive mapping is relevant to enriching the preliminary, information-gathering phase of Soft Systems Methodology (SSM), and especially the rich picture. By noting the structural complementarity evidenced between SSM's transformations and the bipolar constructs used in the cognitive mapping methodology known as Strategic Options Development and Analysis (SODA), this paper shows how SODA can be applied beyond SSM's initial stage, and much more analytically within the heart of SSM, to guide the manner in which a systemic resolution to a problematic situation may be approached. It is proposed, and illustrated through examples, that a SODA map of large numbers of transformations, resulting from an exercise in SSM, offers a methodological means for structuring what might otherwise be perceived as a mess. The paper discusses how in such cases 'strategic options development and analysis' of transformations, or SODA-T maps, serve, among other things, to identify relations between transformations, their hierarchies and priorities, problem epicenters and starting points for intervention. In addition, the arsenal of graph theory can be used to cut through what would otherwise appear as interlinked chaos requiring structured operationalization. In this respect, the SODA-T map offers a high-level connective orientation which can guide the interconnections between the respective human activity systems of the transformations, resulting in the final systemic plan. Ultimately, SODA-T mapping is shown to facilitate a structured approach toward systemic planning.

1. Introduction

This paper will demonstrate how Soft Systems Methodology (SSM) may be enriched through the incorporation of Strategic Options Development and Analysis (SODA). Contrary to the extant literature on the SODA-SSM combination, it will be argued that SODA can be applied beyond SSM's initial stage, and much more analytically within the heart of SSM, to complement the manner in which a systemic plan for resolving a problematic situation may be developed. The focus within SSM will be on this methodology's development of transformations. The concern will be with how large numbers of such transformations may be managed so that their sheer quantity need not be an obstacle to effective planning for their resolution. This challenge will be addressed, both theoretically and through examples, through 'strategic options development and analysis' *of transformations*.

The paper aims to contribute to multimethodological research as well as to research concerned with problem structuring methods (PSMs). SSM and SODA appear as the most advanced PSMs in terms of, both, methodological development and application (Mingers and Rosenhead, 2004). The multimethodology literature, moreover, indicates that their combination is logical and theoretically sound (Mingers, 1997a; Mingers and Brocklesby, 1997).

The discussion will begin with a brief overview of multimethodology, followed by a critical description of SSM. The configuration of SSM that is offered will be appreciated as novel. This configuration will be justified as that which is required for the ensuing discussion, and its faithfulness to the methodology will be measured favorably against criteria stipulated in the SSM literature. A presentation of SODA will follow, emphasizing strict adherence to its unique incorporation of bipolar constructs. The current literature on the SODA-SSM combination will then be critically reviewed. This will lead to the proposition that, contrary to the literature, SODA can be applied much more analytically within SSM in guiding the manner in which a systemic resolution to a problematic situation is approached. The proposition will be explored by first examining the idea of transformation in SSM. This examination will lead to an observation concerning the manner in which the essential structure of SSM transformations mirrors that of SODA's bipolar constructs. The question will thus arise of whether such structural complementarity may serve an enriching multimethodological purpose. The question will be treated, theoretically and through examples, in the two final sections of the paper. The overall conclusion will be that SODA can be applied in an

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http://dx.doi.org/10.1016/j.ejor.2012.06.010

analytical manner within SSM, resulting in an enhanced methodological combination which can facilitate the systemic planning of resolutions of problematic situations.

2. Multimethodology

In the main, there are three general areas of methodological development with which operational research (OR) is concerned. The first, and the one for which OR is popularly known, has to do with the development of mathematical models that reflect the essential logic of diverse, but well-structured, recurring situations (Gass and Assad, 2005; Winston, 2004). The second, influenced by Rittel and Webber's (1973) call for a 'second generation' decision making paradigm, as well as Ackoff (1979) concerns for what he saw as OR's inability to tackle 'messes', has to do with the development of problem structuring methods (PSMs) (Rosenhead, 1989; Rosenhead and Mingers, 2001; Mingers and Rosenhead, 2004). Respective paradigms have been offered regarding these two developments, with the first being termed the 'traditional' paradigm, and the second being termed the 'alternative' paradigm (Rosenhead, 1989). The third, area of methodological development has been about the combination of methodologies to assist decision making, that is, the theory and practice of multimethodology (Mingers and Gill, 1997; Mingers, 2006, pp. 197–255). Such combinations may occur within or between the two paradigms (Mingers and Brocklesby, 1997; Kotiadis and Mingers, 2006). Of course, there are other, equally relevant branches of OR, like the systems movement (Jackson, 2003) and, in particular, system dynamics which, as Forrester (1961) argues, is very much a part of OR. In this paper, the focus will be on multimethodology, and on one particular combination within the 'alternative' paradigm, specifically a combination between two PSMs, SODA and SSM.

A developed theory of multimethodology, along with some illustrative reports of practice, was first presented in book form in the late 1990s (Mingers and Gill, 1997). It followed a notable account of multimethodological practice by Ormerod (1995, 1996a), who went on to report on five more cases of such practice (Ormerod, 1996b, 1998, 1999, 2005; Pauley and Ormerod, 1998). The first sustained argument for multimethodology, however, dates back to the mid-1980s, when Bennett (1985) discussed the issues and prospects for combining a number of PSMs, offering the first theoretical arguments for multimethodology, coupled with some practical considerations. Bennett's paper is especially notable for the three forms of linkage he identified as possible routes into multimethodology. The first type of linkage he termed 'comparison', and defined it as one which looks at how approaches might be theoretically or practically similar, incompatible or complementary – without necessarily altering any of them; it is a type of linkage which offers some clarification on the applicability of various combinations in any one particular situation. Another type of linkage he termed 'integration'. This type brings together elements of existing approaches, which union also offers something new, perhaps as an emerged overarching formal framework that can also derive special cases or offer explanatory value for practice. Finally, Bennett suggested a type of linkage which he termed 'enrichment'. Enrichment refers to the possibility that one might improve one approach by taking on board some elements, theoretical or practical, of another. Enrichment does not produce any new overall content. Instead, enhanced understanding of the existing content derived from one approach emerges by manipulating this content through the use of those elements introduced by the other approach. It is this type of linkage between SODA and SSM that will be discussed in this paper.

Specific aspects of the SODA-SSM multimethodological combination will be discussed following a critical description of both approaches.

3. Soft Systems Methodology (SSM)

SSM emerged through an intricate historical and philosophical background, although one that weaved theoretical developments with perceived practical necessities (Checkland, 1981; Mingers, 2000a). Ever since its initial development in the early 1970s, four main configurations of SSM have evolved, each being a reflection from lessons learnt through its application (Checkland, 2000). The best-known of these – the so-called 'seven-stage' configuration – is offered in two versions, one said to be more relevant to institutional contexts whilst the other is said to be more relevant to 'supra-institutional' contexts (Checkland, 1981, pp. 163, 212). Furthermore, this seven-stage configuration has evolved into one constituted by a 'logic-driven stream' and a 'cultural stream', whereby the impact of history on the problematic situation is brought to the fore (Checkland and Scholes, 1990, pp. 27–53). In addition, SSM has been postulated as usable in two 'modes', namely, Mode 1 and Mode 2 (Checkland and Scholes, 1990, pp. 280–290). In the main, each mode more or less concentrates on different aspects of the lessons learnt from the methodology's applications, with the former being associated with interventions into problematic situations, whilst the latter is associated with interactions between those involved in such situations. Mode 2 has also been postulated as 'a meta-level use of SSM' (Checkland and Scholes, 1990, p. 283), although the same could be said of what has been alternately termed the 'basic shape of SSM' (Checkland and Scholes, 1990, p. 7) or the 'inquiring/learning cycle of SSM' (Checkland, 2000).

The evolution of SSM into multiple configurations, modes, shapes, cycles and rich methodological novelties (Bergvall-Kareborn, 2002; Bergvall-Kareborn et al., 2004; Basden and Wood-Harper, 2006) reveals a methodology that is not prone to standardization, offers no set definitional convergence, and remains open to innovative research. Checkland (1981, pp. 245–285, 2000) reiterates this in discussing at length how SSM draws from interpretive social science, and notes the precedents for such interpretivist leanings in the decision-making literature as witnessed in the writings of Churchman (1968a,b, 1971), and Vickers (1965, 1968, 1973). To these, Checkland adds further theoretical underpinnings to SSM, such as hermeneutics, phenomenology, and even Habermas' (1970a,b) theory of communicative competence.

It should be noted, however, that SSM did not develop out of a purely theoretical consideration for operationalizing some interpretive stance toward problem resolution. On the contrary, it developed from practical considerations in attempts to resolve very real problems, some of which are described by Checkland (1981), whilst others are described by Checkland and Scholes (1990). Philosophical/sociological underpinnings were thought through in conjunction with the practical attempts and as the methodology itself evolved through its multiple configurations.

Still, one consequence of SSM's interpretivist foundations has been the emergence of numerous third-party interpretations in the literature. Holwell (2000) and Checkland and Poulter (2006, pp. 147–155) have critiqued some of these as misinterpretations. This literature, however, repeatedly demonstrates the flexibility of the methodology, in particular its ability to be innovatively configured for particular contexts. For example, SSM has been demonstrated as a decision support vehicle (Winter, 2006), an exploratory approach (Checkland and Winter, 2006), an evaluation process (Rose and Haynes, 1999), a social science research tool (Rose, 1997), and a formal decision making method which offers systemic planning for systemic solutions to systemic problems (Georgiou, 2006, 2008). It has also been described as a learning system, as a process of inquiry, and as an action research cycle (Checkland, 2000). Furthermore, it may be used in part, in whole, iteratively or not, and even in conjunction with other methods (Ormerod, 1995; Mingers and Gill, 1997; Sosu et al., 2008). Given practically relevant innovative developments such as these, accusations of misinterpretation can appear as somewhat tangental. This is especially the case when one takes into account Checkland and Scholes' (1990, p. 287) more constructive advice; namely that, given SSM's continuing evolution, and the variety of perspectives that have been brought to bear upon it, any reported application or theoretical discussion of SSM should, at the very least, first delineate which understanding of the methodology is being discussed:

> Since SSM can be used in many different ways in different situations, and will in any case be interpreted somewhat differently by each user, any potential use of it ought to be characterized by conscious thought about how to adapt it to a particular situation.

This is a particularly important exigency that requires the user of SSM to stipulate, both, the situation in which SSM is being used and the manner in which the methodology has been adapted for use in that situation. Taking each requirement in turn, first, Checkland (1981, pp. 193–194) has highlighted five different types of common situations in which SSM is used. The one relevant to this paper concerns the use of SSM to explore an ill-structured situation deemed problematic, identify its problems, and plan resolutions against the background of multiple agents' perceptions and values – what is usually understood as an action research approach that leads to an intervention to improve the situation. Second, the manner in which the methodology has been adapted for the present purposes is somewhat different to that usually found in the literature. A novel configuration will be presented which delimits the methodology's internal functionality. This is because the ensuing discussion, focused as it is on enriching a somewhat technical, functional aspect of the methodology, demands a basic understanding only of the interrelationships of the methodology's tools. Undoubtedly, such a focus renders a functional interpretation of the methodology itself. Given the interpretive foundations of the methodology, however, this focus offers itself for consideration as equally valid as any one of the aforementioned application strategies. Indeed, the focus in no way minimizes nor discards the relevance of any of those strategies, for it does not seek to substitute them but merely to offer additional analytical assistance which any of them could incorporate.

Checkland and Scholes add that, given the inherent flexibility of the approach, a claim for being 'SSM-based' is probably the closest one can come to saying that one is 'doing' SSM. In this respect, they provide five 'Constitutive Rules', along with what they tabulate as an 'epistemology', in order to 'define SSM sufficiently for its use to be discussed coherently' (Checkland and Scholes, 1990, pp. 284–290). This provision of seemingly clear criteria, against which debates could be compared for interpretative accuracy, has been ignored by the literature. By contrast, the presentation of SSM that follows will be justified in accordance with Checkland and Scholes' guidelines in order to posit it as being SSM-based. The configuration upon which the ensuing discussion will be based is presented in Fig. 1.

Notwithstanding the malleability of SSM, Fig. 1 indicates that, if one were to focus purely on the internal mechanics of the methodology, there is an inherent logic in the interrelationships between its tools. In what is labeled in the figure as Phase 1, the rich picture offers a diagrammatic description of the problematic situation under consideration, which description also conveys information required of the three Analyses, as well as assisting in the identification of the transformations deemed necessary for improving the situation. As will be discussed in greater detail later, the transformations themselves, in Phase 2 of the figure, are stipulated in the format that follows the four transformation rules of the methodology and, as a set, offer, in quite exact terms, a definition of the problem (the stipulated inputs) as well as pointers toward its solution (the stipulated outputs). In Phase 3, each transformation is contextualized within a CATWOE, and the CATWOE is then expressed as a formal statement of intent in the form of a root definition. Based on the CATWOE and its root definition, a human activity system (HAS) is designed which serves to guide the realization of the output stipulated in the transformation. Once respective HASs have been designed for all the transformations, they are interlinked to form the overall systemic plan of action for improving the situation as a whole. This is a point which is not stressed by the SSM literature: a truly systemic plan emerges only once respective HASs have been linked in some way. Any planning of individual transformations, or some sub-group thereof, might indeed yield valuable results, but systemic planning *per se* can only be said to occur when relations between all respective HASs have either been at least considered or, better, incorporated into the plan. In the ensuing discussion, mention of particular 'Phases' in SSM will refer to those three indicated in Fig. 1.

Undoubtedly, SSM is not an approach that invites singularly functional reproduction, and the understanding above has left aside any discussion of the iterative nature of the methodology, of the inherent flexibility in the usage of its tools, of the value it places on comparing models with the real world situation, of its ability to structure (and, indeed, encourage) debate about change, and of its focus upon the cultural feasibility of its results as opposed to their purely systemic desirability. The understanding has also left aside any considerations of the multiple *Weltanschauungen* in use in SSM (Checkland, 1981, pp. 215–221; Checkland and Davies, 1986), and of subtleties such as issue-based and primary-task root definitions (Checkland, 1981, pp. 221–223). If such issues have been left aside, however, it is because of the technical focus presently imposed upon the methodology for the purposes of the discussion that is to follow. Their absence in no way discards their relevance – indeed, such relevance is assumed throughout, as would be the case with any application strategies.

More pertinently, the understanding of SSM offered through Fig. 1 abides by Checkland and Scholes' (1990, pp. 284–290) constitutional guidelines, in that the configuration:

- offers a structured way of thinking about problematic situations requiring some improvement whose design is initially indiscernible;
- is expressible in terms of the language of the epistemology proposed by Checkland and Scholes (1990, pp. 288–289);
- follows the constitutive guidelines in that,
  - it holds no presumptions regarding any systemicity that might be inherent in the problem context;
  - it allows the user to switch between involvement in the real world and reflecting systemically about that world (through an interplay between Phases 1 and 2 on the one hand, and Phase 3 on the other);
  - it leads the user toward the construction of human activity systems with particular properties; and,
  - it allows for such human activity systems to structure debate about change as well as to plan for improvements; and, finally,
- contributes a novel structure to the methodology based upon published research (Georgiou, 2006, 2008), with the aim of assisting one's understanding of the basic functionality of the approach.

Given the above, and in the words of Checkland and Scholes (1990, p. 286), the configuration of SSM thus laid out in Fig. 1 'lays

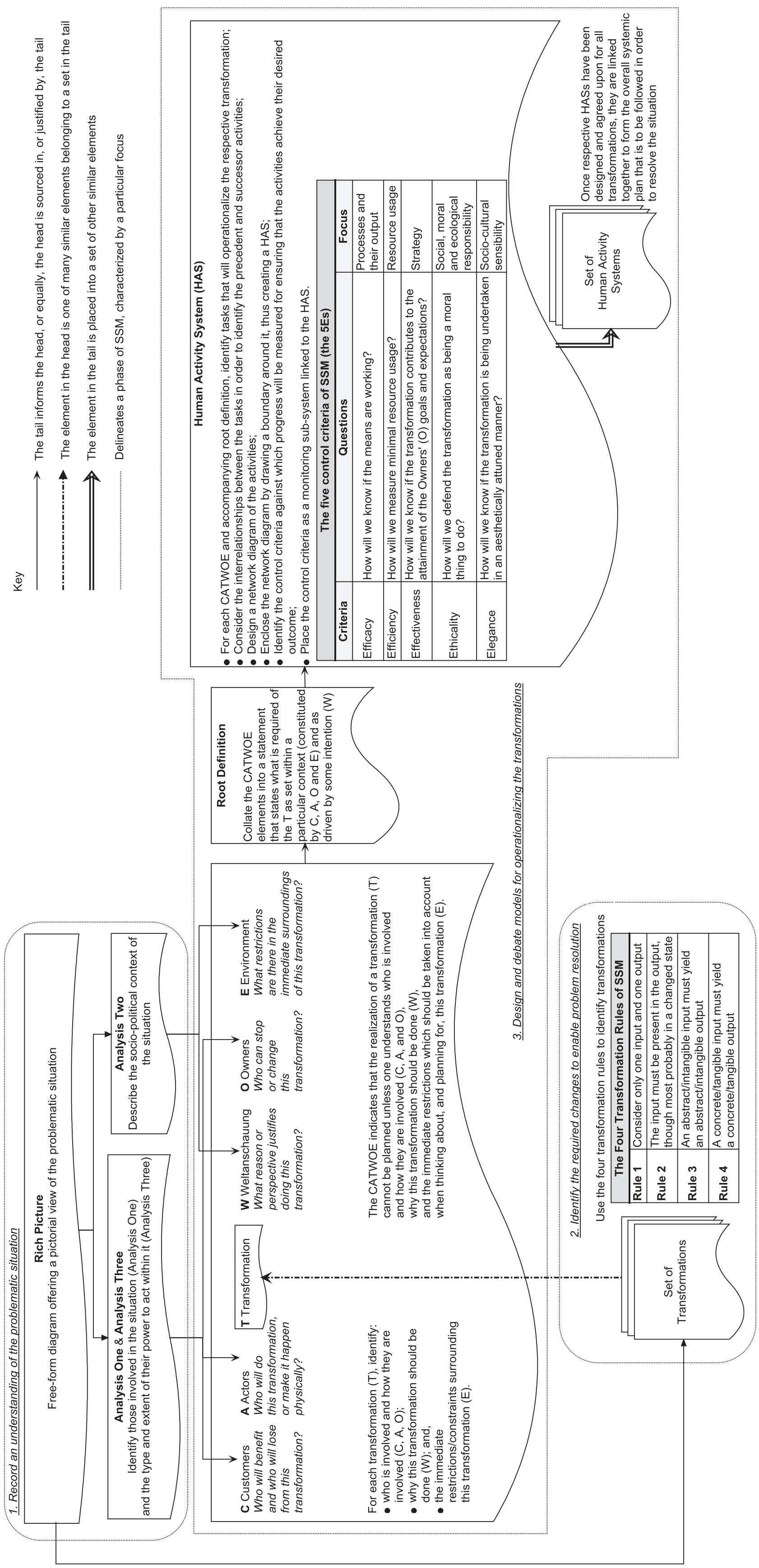


Fig. 1. The internal mechanics of SSM.

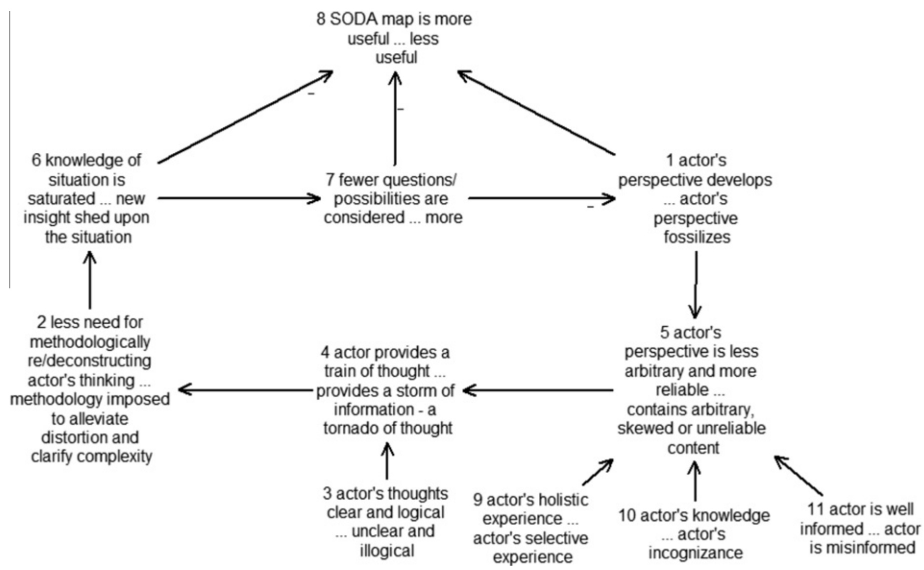


Fig. 2. Understanding SODA through a SODA map.

claim to being SSM-based.' It offers what is required in order to do basic SSM, and simultaneously offers expositors a framework for introducing SSM.

4. Strategic Options Development and Analysis (SODA)

The usefulness of cognitive mapping has gained currency since the mid-1980s because it offers users a transparent interface through which they can explore, learn about, and consequently take more confident decisions to improve, or otherwise change, a problematic situation (Bryant, 1984; Langfield-Smith, 1992; Fiol, 1992; Kitchin, 1994; Nicolini, 1999; Daniels and Johnson, 2002; Tegarden and Sheetz, 2003; Kane and Trochim, 2007; Okada et al., 2008). SODA offers a particular version of cognitive mapping as the main interface for group decision-making in situations characterized by non-trivial uncertainty and complexity unamenable to formal algorithmic modeling (Eden, 1988, 2004; Eden and Sims, 1981; Eden and Huxham, 1988).

Relevant to the ensuing multimethodological discussion is that SODA's cognitive mapping approach is different from all others due to its basis in George Kelly's (1955/1991, 1963, 1970) psychological theory of personal constructs. As the title of his theory indicates, Kelly's central theme is the manner in which human beings understand the world through mental *constructs*. Unlike a concept, a construct is dichotomously comprised of two poles, the relationship between them being one of contrast or alternativeness. Variations in the field of semiotics that include multiple poles also exist (Lévi-Strauss, 1958; Greimas, 1984; Danessi, 2007), but Kelly's adherence to bipolar constructs continues to attract attention, not least due to its perceived philosophical richness (Warren, 1998) and psychotherapeutical relevance (Fransella and Dalton, 2000).

In Kelly's theory, the alternative pole of a construct serves to contextualize, refine, and clarify the understanding of the primary pole (Jankowicz, 2004, p. 11). Say, for example, that a person is described as *pleasant*. In itself, this description is vague, not only because the term *pleasant* has numerous synonyms that open up a field of subtle variations in understanding, but because no alternatives have been put forth against which the meaning of *pleasant* can be deduced. To offer a strictly negative alternative, moreover, such as 'not pleasant', is rather useless in trying to understand what is being meant. Is the person pleasant in the sense that they are polite, or charming, or alluring, or perhaps gentle? Or is the person pleasant as opposed to being rude or perhaps exciting? A more precise alternative is required in order to obtain at least the flavor of what is meant. For instance, to say that the person is pleasant as opposed to alluring, or pleasant as opposed to rude, already offers more precise meanings in each case. SODA would write such constructs as follows, where the three dots serve to distinguish the two poles of a construct:

person is pleasant . . . person is alluring

person is pleasant . . . person is rude

SODA embraces Kelly's psychological insight and elicits bipolar constructs from the views and descriptions of those involved in a problematic situation. In accordance with the descriptive logic of such agents, it then interrelates these bipolar constructs into visual maps. When complete, such maps can be read independently of their sources and explored qualitatively for their written content. They can also be analyzed quantitatively, for their essential structure is that of a graph (nodes and links) or, more exactly, a directed graph (also known as a digraph) (Harary et al., 1965; Bang-Jensen and Gutin, 2002). As such, SODA maps are amenable to the powerful analytical tools of digraph theory (Eden et al., 1992; Langfield-Smith and Wirth, 1992; Wang, 1996; Montibeller and Belton, 2006; Montibeller et al., 2008; Georgiou, 2009a), as well as givens-means-ends analysis (Tegarden and Sheetz, 2003). SODA maps have also served as a basis for the design of system dynamics models (Eden, 1994; Bennett et al., 1997; Eden et al., 2000; Howick and Eden, 2001; Howick, 2003; Williams et al., 2003).

In brief, then, a SODA map methodologically manipulates an actor's thinking by imposing (what cartographers would call) a projection that minimizes distortion and clarifies complexity. SODA mapping does this by adhering to bipolar construct design, making for a *construct* mapping methodology, as opposed to one that involves concept mapping. This understanding is illustrated in Fig. 2 which, being a SODA map about SODA maps, enables an appreciation of both, the nature of SODA maps, as well as how to read them.

To begin with, in Fig. 2 note the following:

- The numbering of constructs is purely random and serves only to reference them (they will be referenced in italics throughout this paper).
- The arrows, or links, come with a negative sign, or are otherwise unsigned.
  - An unsigned link between two constructs indicates that their respective primary or secondary poles are to be read in order, from the arrow's tail to the arrow's head.
  - An arrow signed with a negative symbol ('–') indicates that, at that point, one must switch poles when following the argument along the link.

As an illustration, begin with the second pole of construct *3* and follow the links through constructs *4*, *2*, *6*, ending at construct *8*. An actor attempts to explain a problematic situation, but the description offered is not easy to follow (*3*). The complexity and uncertainty of the situation inhibit the actor from articulating a logical train of thought, resulting in a storm of information, a tornado of thought so to speak (*4*). There is a need to impose some sort of methodological structure on the information offered by the actor, calling for a methodologically-guided manipulation of the actor's description (*2*) – in this case, the use of SODA mapping. Through such methodological manipulation, knowledge of the situation is seen in a new light (*6*).

Note that this reading began by considering the second pole of construct *3* and continued by referring to the second poles of all subsequent constructs, the reason being that the arrows in this sequence are unsigned. Next, and due to the negative arrow between constructs *6* and *8*, there is a switch from the second pole of construct *6* to the first pole of construct *8*: as long as knowledge of the situation is seen in a new light (*6*), the SODA map is more useful (*8*). If, on the other hand, there is less new insight emerging (first pole of construct *6*), the SODA map's usefulness decreases proportionally (second pole of construct *8*), or equally, the SODA map has served its purpose.

Apart from making explicit the logical dependencies between constructs, a SODA map also renders explicit the structural significance of constructs. Constructs may be structurally categorized according to certain basic types, five of which are relevant for the ensuing discussion. A brief word on each is offered below (for a more advanced presentation in this vein, see Georgiou (2009b, 2011)).

4.1. Tails

Tails have no constructs leading into them. In the language of graph theory, they are *transmitters* whereby their indegree is zero and their outdegree is positive (Harary et al., 1965, p. 17). In SODA, they are otherwise known as prime causes. In Fig. 2, constructs *3*, *9*, *10*, and *11* are tails. They indicate that SODA mapping is primarily (but not exclusively) useful when actors' find difficulty in articulating their thoughts in a clear or logical manner (*3*), when they have a selective, as opposed to a holistic, appreciation of the situation (*9*), when their level of knowledge is relatively low (*10*), and when they have been victims of misinformation (*11*).

4.2. Heads

Heads have no constructs leading out of them. In the language of graph theory, they are *receivers* whereby their outdegree is zero and their indegree is positive (Harary et al., 1965, p. 17). They reflect objectives, outcomes, results, or consequences stemming from the dependency paths of arrows that lead into them. When first looking at a SODA map, the heads will usually offer a good idea of what it is about. Fig. 2 has only one head, construct *8*, from which the user quickly infers that the map is about the usefulness of SODA maps. Large maps of complex situations usually have numerous heads, indicating the requirement to address multiple, equally necessary, and at times conflicting, objectives or consequences usually measurable on different dimensions that preclude trade-offs between them.

4.3. Implosions

Implosions are constructs with a relatively high number of constructs directly leading into them. In the language of graph theory, they have a relatively high indegree or *inbundle* (Harary et al., 1965, p. 17). An implosion indicates a major effect. It is a construct affected by multiple other constructs and, by extension, multiple areas of the map. It is where a number of issues culminate or converge. In Fig. 2, construct *5* has an indegree of four, whilst the only other construct that comes close is the head (*8*) with indegree of three. The implosion of construct *5* serves to highlight the factors that lead to an actor's arbitrary, skewed or unreliable understanding of a situation: the actor's limited experience (*9*), incognizance (*10*), and misinformation (*11*), as well as a set, and perhaps inflexible, perspective (*1*).

4.4. Explosions

Explosions are constructs with a relatively high number of constructs directly leading out of them. In the language of graph theory, they have a relatively high outdegree or *outbundle* (Harary et al., 1965, p. 17). An explosion indicates a major cause. It is a construct that affects multiple other constructs and, by extension, multiple areas of the map. It is from where a number of multiple issues stem or diverge. In Fig. 2, constructs 6, 7, and 1 all share the same, relatively higher outdegree. To take one example, construct *7* indicates that, with the consideration of more questions and possibilities about the problematic situation, the usefulness of SODA maps is increased (*8*), and an actor will be open to new perspectives (*1*).

4.5. Dominants

Dominants are constructs with a relatively high total number of constructs leading into them and leading out of them. In the language of graph theory, they have a relatively high degree (sum of indegree and outdegree) (Harary et al., 1965, p. 17). A construct with a relatively high degree indicates cognitive centrality of an issue in an actor's perceptions, and/or central relevance of an issue to the situation in question. Depending on the balance between indegree and outdegree, a dominant will affect, and be affected by, multiple constructs and, by extension, multiple areas of the map. Whereas heads offer a good initial idea of what a map is about, dominants offer a good indication of the major issues that must be tackled in order to reach the heads. In Fig. 2, construct *5* has the highest degree of the map. It indicates that a major issue in judging the usefulness of SODA maps is their ability to render actors' perspectives less arbitrary and more reliable.

4.6. Critical appreciation

In summary, SODA offers a qualitative, bipolar, cartographic approach to complex situations that is amenable to quantitative analysis. The structural analyses outlined above are but an indication of the analytical potential offered by SODA. Computer software, called Decision Explorer®, has been designed to facilitate construction and analysis of SODA maps (see www.banxia.com). This is especially useful for the case of large maps that contain hundreds of constructs. Still, it is worth noting three research opportunities that may further develop the analytical potential of SODA: research related to graph theory, diagrammatic representation, and the use of constructs.

As mentioned earlier, recent years have seen some developments in methods for analyzing SODA maps, especially from a graph theoretical point of view. In comparison, however, to other approaches that utilize graph theory – such as, for example, social network analysis (Wasserman and Faust, 1994) – the SODA literature indicates relatively little use of this branch of mathematics. It can be shown that SODA maps share the four primitives and four axioms of digraphs (Harary et al., 1965, p. 9). This being the case, research is required into the numerous graph theoretic analyses that are available in order to uncover which ones are of especial relevance to SODA analyses. More research is also required on how matrices, graph mining (Cook and Holder, 2007), and blockmodeling (Doreian et al., 2005) can inform SODA map analyses.

The diagramming process itself has also been left largely unaddressed by SODA. Graph drawing (di Battista et al., 1999) is a novel area within graph theory and an interdisciplinary excursion here will undoubtedly benefit the representational design of SODA maps. The broader field of information visualization (Kosslyn, 1994, 2006; Glascow et al., 1995; Bertin, 2010; Tufte, 2001) also offers a wealth of research, which might not only be relevant to SODA map representations in general, but also useful to the further development of the Decision Explorer® software.

A scan of the literature shows that the use of bipolar constructs in SODA mapping appears less frequently than the use of single-issue concepts. This is surprising for an approach that explicitly draws from Kelly's theory. It also does not serve to differentiate SODA very effectively from other cognitive mapping approaches. One attempt at differentiation was made in the late 1990s whereby SODA was rechristened as 'Journey making' and aligned closely with strategic management (Eden and Ackermann, 1998). In the span of 500 pages, however, the idea of a construct got short shrift and only four diagrams contained any constructs at all (see pp. 96, 287, 291, 295). Since SODA is explicitly concerned with perceptions and meanings, rather than seemingly relegating the idea of construct to the background, research would arguably be better served by exploring it to its limits, perhaps alongside the contributions of semiotics and even linguistics. For the purposes of the present discussion, the cognitive mapping technique of SODA will be taken as one strictly involving bipolar constructs.

5. The literature on the SODA-SSM combination

SSM is concerned with an explicit exploration of a problematic situation, using conceptual tools that gradually elicit more and more accurate descriptions and help lead toward the design of HASs for its resolution. SODA is a methodology that also focuses on problem exploration: SODA maps offer a systemic view of a situation, with interconnections between ideas and/or actions that can be debated and researched and thus lead to better understanding of the problem in question. Mingers (1997a,b) and Mingers and Brocklesby (1997) have placed the common exploratory nature of the two methodologies into a wider multimethodological framework which they offer as a guide for multimethodological research. The framework draws from Habermas (1984, pp. 75–101; 1987) and posits three issues relevant to tackling problematic situations: the personal understanding of such situations by those involved in them; the material constraints or effects of such situations; and, the social dynamics or impacts of such situations. Mingers and Brocklesby propose that each of these three issues requires activities in appreciation, analysis, assessment, and action toward implementing a resolution. SODA and SSM are posited as relevant to the first of the stipulated issues, namely, as an aid to further personal understanding of the problem situation by those involved in it. The authors propose that SSM is strong for analyzing different perceptions and assessing alternative conceptualizations, and fair for appreciating individual beliefs and generating consensus for action (they also add that SSM offers some means for appreciating social dynamics and material/physical circumstances). The authors view cognitive mapping as strong for analyzing different perceptions, fair for generating consensus for action, and add that it offers some means for appreciating individual beliefs and assessing alternative conceptualizations. According to this framework, therefore, SODA and SSM complement each other in that, with respectively varying degrees of effectiveness, they both analyze different perceptions, assess alternative conceptualizations, render appreciations of individual beliefs, and generate consensus for action. A joint SODA-SSM combination, therefore, promises an enhanced approach to the personal understanding of problematic situations.

Surprisingly, the literature offers few studies in the particular SODA-SSM combination. What literature there is, however, does indicate the exploratory value perceived in the combination, and especially reinforces the relevance of this value to the personal dimension of Mingers and Brocklesby's framework. What is more significant, for the present purposes, is that this limited literature is vague in its understanding of SODA as a cognitive mapping approach whose uniqueness lies in its use of bipolar constructs. This, as will be shown later, neglects a potential use of SODA mapping within SSM beyond that described by the literature to date, and beyond that envisaged in Mingers and Brocklesby's framework. The literature is reviewed below.

Mingers and Taylor (1992) offer the first hints of combined SODA-SSM applications based on a survey of SSM practice. 'Cognitive mapping' and 'personal constructs' are tabulated as having been used in conjunction with SSM's 'rich pictures/relevant systems'. In each case, they are respectively referenced to Eden et al.'s (1983) seminal text that gave rise to SODA, and to Kelly (1955/1991). Personal constructs are qualified as having been used as 'replacements' for the rich picture. Neither SODA nor bipolar construct mapping, however, are mentioned explicitly, and no qualification is offered as to the manner in which cognitive mapping was used.

In his first of a series that reported multimethodological applications, Ormerod (1995) refers to 'cognitive mapping' and references Eden et al. (1983), but does not refer to SODA explicitly and neither to bipolar constructs. Furthermore, in this case, cognitive mapping and SSM were kept 'theoretically separate, each being used in a different phase of the project.' Any practical linkages are described as 'results feeding through' from one approach to the other. Ormerod used other methods to 'enrich' (according to Bennett) cognitive mapping and SSM, but only a hint that cognitive mapping might enrich SSM, or vice versa, is given:

> The understanding gained from cognitive mapping was used to shape, inform and stimulate the SSM analysis. Subsequently the results of cognitive mapping were used in the design of the evaluation framework to prioritize the ideas generated by the SSM analysis.

It is worth noting that Ormerod writes '*the results*' of cognitive mapping were used in the evaluation framework to prioritize the ideas generated by the SSM analysis. In other words, it is not clear whether cognitive mapping *itself was used* to design the evaluation framework to prioritize the ideas generated by using SSM.

In a later account of the same work, Ormerod (1997) writes that 'the strategic choice method was used to structure the evaluation of the systems suggestions resulting from the SSM investigation.' Yet in another account of the same work, Ormerod (1996a) offers evidence that SODA mapping (that is, with bipolar constructs) was used. The map fed evaluation criteria directly into a tool of the Strategic Choice Approach of Friend and Hickling (2005).

Furthermore, the map explicitly identified different areas of the business which were subsequently investigated through the use of SSM. In this latter case, the SODA map seems to have assisted the identification of focal areas which were analyzed in more detail using other SSM tools.

In the year that saw multimethodology being given detailed consideration (Mingers and Gill, 1997), Mingers and Brocklesby (1997) offered a theoretical justification for using 'cognitive mapping' to supplement SSM's rich picture. Although they referenced Eden et al. (1983) and mentioned COPE (the SODA software available at the time), any discussion of cognitive mapping as an enrichment of SSM made no explicit mention of SODA or bipolar constructs (SODA was mentioned explicitly only in reference to its use with other approaches). Mingers (1997a) echoed this in the first book-length treatment of multimethodology, noting that 'cognitive mapping' can complement, or replace, rich pictures – where again, neither SODA nor bipolar constructs were mentioned explicitly in this context. A few years later, Mingers (2000b) noted that 'cognitive mapping… is often used in the early stages of SSM to enhance the appreciation of the problem situation.' Soon after, when he contributed the 13th chapter of *Rational Analysis for a Problematic World*, Mingers (2001) echoed his previous writings on the SODA-SSM combination.

Based on a survey of multimethodological practice among practitioners, Munro and Mingers (2002) found evidence of 'a variety of exploratory techniques [that] can be used to augment SSM, e.g. cognitive mapping, critical systems heuristics, statistical analysis and scenarios,' but they do not explicitly discuss the contribution of such techniques. When graphing and tabulating the reported usage and success of methods, they refer to 'Cognitive mapping/SODA' and 'Cognitive mapping (SODA)', respectively. When highlighting the reported combinations of methods, however, SSM is combined with 'cognitive mapping', with no mention of SODA. Furthermore, the authors' understanding of 'cognitive maps' is somewhat surprisingly reduced to 'a form of influence diagram', with no mention of bipolar construct mapping. Finally, instead of referencing any part of the mainstream literature on SODA, the authors simply choose to mention the 'people at Strathclyde University', from where much work on SODA has emerged.

Setting aside the nuances of whether 'cognitive mapping' is understood as the bipolar construct mapping approach for which SODA is unique among mapping methodologies, all references cited so far have indicated the value of 'cognitive mapping' as an enrichment of the preliminary stage of SSM, and especially as an enriching contribution to rich pictures. When a paper comes along, therefore, with the title 'Improving the Quality of Conceptual Modeling Using Cognitive Mapping Techniques', and which paper explicitly focuses on SSM, one can reasonably expect something new, namely: the usage of cognitive mapping in the design of HASs, which are also known as conceptual models, and which appear at the other end of the SSM spectrum of tools, as shown in Fig. 1. The authors, Siau and Tan (2005), indicate that 'the paper describes ways of incorporating cognitive mapping techniques to a popular systems development methodology – Soft Systems Methodology – to improve the quality of conceptual modeling', and aim to show 'how these cognitive mapping techniques can supplement a popular systems development methodology – Soft System Methodology – to improve quality in conceptual modeling.' Despite these promising indications, however, the paper is disappointing as Siau and Tan delimit their multimethodological thesis quite explicitly:

> [With SSM] cognitive mapping techniques can be used in two ways. The first is to use cognitive mapping as a communication tool when analysts conduct interviews with various stakeholders. The second way is to decompose a rich picture into cognitive maps of greater detail.

In other words, nothing new is on offer compared to the previous literature. Furthermore, although Siau and Tan discuss a number of mapping approaches, when discussing anything near SODA their understanding is confused. They write, for instance, that 'Avison and Fitzgerald (2003) introduced causal mapping as a technique used in Strategic Options Development and Analysis (SODA) (Ackermann and Eden, 2001).' This is really not the case at all. Eden (1988) was the first to explicitly introduce the term 'SODA', in a paper which drew from his earlier contributions to this approach. Curiously, Siau and Tan do cite this paper but fail to recognize their historical equivocation. In another paragraph, although Siau and Tan cite 'Kelly's personal construct theory', they add that 'constructs are expressed using a short single-polar phrase or contextually rich bi-polar phrases.' This distorts Kelly's theory since Kelly (1955/1991, vol. 1, p. 96) is quite explicit about his strict insistence on, and the value of, bipolar constructs. Ultimately, Siau and Tan quickly set the term 'SODA' aside and refer thereafter to 'causal mapping', even when discussing the mapping of constructs; indeed, in those of their maps indicated as containing constructs, none have any bipolar constructs. This may be due to the authors' seeming reliance on Eden and Ackermann's (1998) book on 'journey making', whose weakness with respect to SODA's uniqueness was mentioned earlier.

The above constitutes the limited literature to date that discusses, and/or attempts to demonstrate, the combined use of SODA and SSM. This literature indicates that SODA is relevant to enhancing the preliminary phase of SSM, helping users to understand the interaction between constituent issues of a problem situation, and revealing increasing richness and detail, as well as connections, that may complement results stemming from traditional SSM tools such as the rich picture and the three Analyses. As such, the literature reinforces the manner in which the SODA-SSM combination has been theorized by Mingers and Brocklesby. The ensuing discussion seeks to further advance the relevance of SODA within SSM. What is to be proposed is a particular use of SODA mapping within SSM in order to aid the transition from Phase 2 to Phase 3 or, in other words, the transition from having identified what might be problematic in a situation to planning for its systemic resolution.

Significant for the ensuing argument is the fact that the literature betrays a lack of rigor in its tendency to ignore SODA's uniqueness as a bipolar construct mapping approach. This is not a pedantic point. The seemingly preferred term 'cognitive map' has become so general that one is at pains to understand which of the many mapping approaches is being discussed, and whether that which is being referred to is actually being reported correctly or clearly. The concern of this paper is to show that SODA can *enrich* SSM beyond the rich picture – and this according to Bennett's definition, discussed earlier. This requires strict adherence to SODA as a bipolar construct mapping approach. It will be argued that, if such strict adherence is followed, SODA can be applied much more analytically within SSM in guiding the manner in which a systemic resolution to a problematic situation is approached. Indeed, whereas the literature to date has pointed to the use of SODA *with* SSM, the focus here will be on the use of SODA *in* SSM. In this respect, the discussion must first turn to an understanding of the idea of *transformation* in SSM.

6. The idea of *transformation* in SSM

The identification of what might be deemed problematic in a situation is facilitated throughout an SSM process. Since SSM encourages iterative, and not necessarily ordered, use of all its aspects and, furthermore, since information available from one part may be used in other parts, problems may become identifiable through consideration of any one part or combinations thereof.

Table 1
A set of transformations – adapted from a case study by Georgiou (2008).

	Input		Output
T_1	Unacceptable time lag in dealing with urgent demand	→	acceptable time lag in dealing with urgent demand
T_2	Uncoordinated approach to service provision	→	coordinated approach to service provision
T_3	Poor quality of service	→	quality level of service which does not detrimentally affect customers' businesses
T_4	Consequent detrimental effects to our customers' businesses	→	detrimental effects to our customers' businesses are minimized
T_5	Unclear expectations of our organization	→	organizational expectations clarified
T_6	Unclear expectations of our clients	→	client expectations clarified
T_7	Unaddressed issues about the roles of staff within the team	→	issues about the roles of staff within the team are addressed
T_8	Unaddressed issues about who we will provide a service for	→	issues about who we will provide a service for are addressed
T_9	Negotiation required with various external specialist organizations we work with	→	negotiation with external specialist organizations realized

Note: The numbering does not indicate priority, but merely facilitates quick referencing.

There is one aspect of SSM, however, which is quite directly and explicitly focused on problem identification. This is the idea of transformation.

SSM advises that one should not think in terms of *problem* since this concept does not get to the root of the matter of what is problematic in a situation, and the term itself can be quite ambiguous (Checkland, 1981, pp. 154–155; Landry, 1995). A problematic situation implies an undesirable state which needs to be *transformed* into a desirable state. SSM, therefore, advises that one should focus on the essential issue, in other words, the identification of the *transformations* evidently required in the problematic situation. In order to identify transformations, SSM stipulates four rules that must be followed to the letter. They are given in Fig. 1.

The reason why the four transformation rules should be followed is that they do result in something quite useful: a set of identified transformations simultaneously defines the problem, as well as the desirable state to be attained if the situation is to be relieved of its problematical aspects. This may be illustrated by the set of transformations in Table 1. If someone were to ask 'what is the problem to be solved?', the left-hand side (the inputs) provides the answer; for all of these things, together, constitute the problem at hand. If someone were then to ask 'what would be a solution to this problem?', the right-hand side (the outputs) provides the answer; because a complete solution will not have been attained until all of these outputs together are realized.

Following the four transformation rules, therefore, allows decision makers to obtain an overview of the particularly problematic aspects of a situation prior to attempting to resolve it. In essence, by the time Phases 1 and 2 have been completed, the decision makers have available to them (a) a diagrammatic schema of the situation (rich picture); (b) identities of those involved in the situation (Analysis One), the type and extent of their power (Analysis Three), and descriptions of their contextual immersion (Analysis Two); and, finally, (c) a detailed set of transformations that provides an initial overview of what is problematic in the situation. Of course, such outputs are but exercises in description. Effective description, however, is the necessary precursor to explanation and consequent resolution – a point not lost to the internal logic of SSM.

Examining a set of transformations, such as those in Table 1, leads one to recall bipolar constructs. To begin with, one sees the application of alternativeness in the structure of a transformation: a transformation offers one state, the input, and follows it with an alternative state, the output. Granted, the output might not necessarily serve a clarificatory function in relation to the input in the same manner that a second pole clarifies a primary pole in bipolar constructs. This clarificatory function, however, might well be present in a particular transformation. For example, a standard response to the input of T_3, in Table 1, might be to aim for top quality of service. In this particular case, however, attention to the context of the situation has yielded an output which stipulates a quality level that 'does not detrimentally affect customers' businesses'. In other words, there might not be any need to attain some top quality level, as long as the quality level that is attained does not yield the stipulated detrimental effects. Here, the transformation's stipulated output enables a better contextual understanding of the nature of this part (this input) of the problematic situation. A similar observation is evident in T_4 where 'detrimental effects' are not to be effaced but merely 'minimized.'

From these observations of alternativeness and a possible clarificatory function ascribed to the output, it is evident that the essential structure of a transformation mirrors that of a bipolar construct: in each respective case, there is an input or primary pole, followed by an output or secondary pole. Undoubtedly, transformations and bipolar constructs are, in themselves, completely different concepts. The first follow rules for the identification of concrete problems whose resolution requires the detailed planning approach shown in Phase 3. The second reflect much more fluid cognitions of relevant aspects of a situation, cognitions which are, furthermore, interconnected through a mapping interface. Notwithstanding these differences, however, transformations and bipolar constructs do share a common structure in the manner in which they are stipulated. As such they exhibit structural complementarity. The question arises as to whether such structural complementarity can serve an enriching multimethodological purpose.

7. Structured systemic planning using SODA-T maps

As shown in Fig. 1, each transformation must be contextualized in a CATWOE, phrased in a root definition, planned as an HAS and, ultimately, linked with other HASs in a systemic plan. If one is faced with a small set of transformations, such as those given in Table 1, planning for them all might be clear and easily manageable, and the design of a systemic plan might not appear a daunting task. In complex problems, however, it is not unusual to uncover many more transformations; tens, say, or hundreds. One can imagine that the 'messes' Ackoff was fond of discussing would yield such numbers. As Rittel and Webber (1973) noted, in such cases it 'become[s] less apparent where problem centers lie, and less apparent where and how we should intervene even if we do happen to know what aims we seek.' Here, then, those involved in the situation will be skeptical of the viability of tackling *all* transformations without some methodological guidance on how to choose between them. More pertinently, in large-scale, complex change-management projects that require a route-map involving hundreds of transformations, decision makers will need to make informed decisions as to which transformations are best handled first, and how such handling can lead to the consideration of further transformations. This is not merely an issue in delineating priorities, as the following questions reveal:

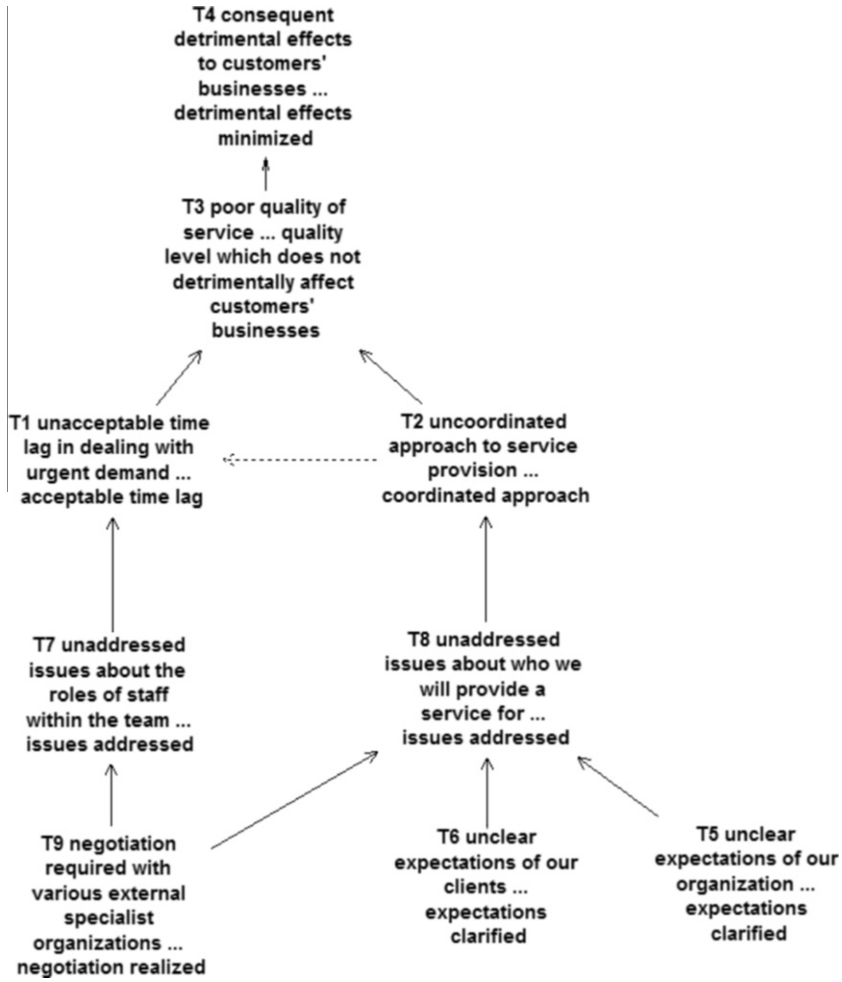


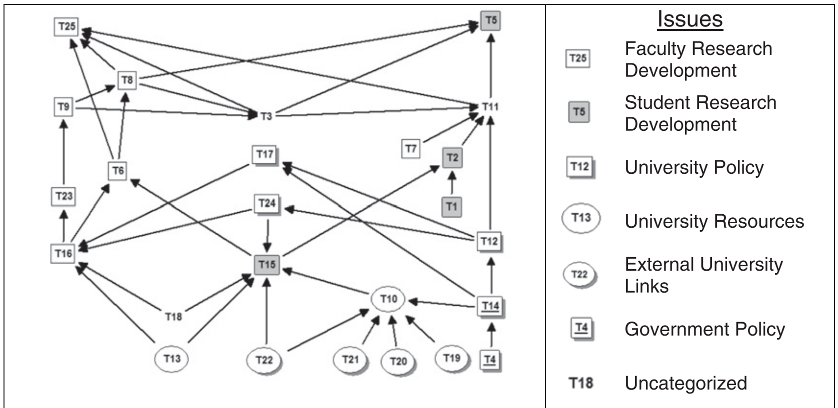
Fig. 3. A SODA-T map of those transformations listed in Table 1.

1. Which transformations act as prime causes to the problematic situation?
2. Which transformations depend on others for their own ultimate resolution?
3. Which transformations are affected by relatively large numbers of other transformations?
4. Which transformations affect relatively large numbers of other transformations?
5. Which transformations are central to the problematic situation?
6. Which transformations might belong to subsets that may initially be tackled independently from other transformations?
7. Which transformations might belong to subsets that may initially be set aside whilst other transformations are being tackled?
8. Might there be evidence of partial effects, total effects, indetermination, indistinction, and potency in the relations between transformations?

Although by no means exhaustive, the list of eight questions indicates the range of issues surrounding the resolution of multiple transformations, and serves to warn that such resolution needs to be approached carefully and might therefore require methodological guidance. In essence, what is required is some idea of how the identified transformations are interrelated. Such an idea must be made explicit if adequate problem resolution is to occur. Questions 1–5 respectively reflect the identification of tails, heads, implosions, explosions, and dominants, as defined earlier when discussing SODA maps. Questions 6 and 7 refer to the possible clustering of transformations. Question 8 refers to advanced analyses as discussed by Montibeller and Belton (2006) in their review of evaluative techniques for tackling relational decision options.

Considering the structural complementarity evident between transformations and bipolar constructs, SODA mapping offers itself as the natural means for tackling the aforementioned questions that may arise when faced with multiple transformations. In accordance with Bennett's definition, SODA promises an enrichment of SSM by manipulating the existing transformations through mapping so that their relations may be explicitly taken into account. An enhanced understanding may be said to emerge from 'strategic options development and analysis' *of transformations*. As such, the acronym SODA-T lends itself to the discussion, serving to differentiate the content of the maps about to be presented from those of SODA proper. An example of a SODA-T map is given in Fig. 3. It concerns the interrelationships deemed to hold between those transformations identified in Table 1.

Beginning at the bottom of the SODA-T map, with T_9, T_6 and T_5, and in reading only the inputs (primary poles) as the eye travels upwards, one sees how they are perceived to cause each other. Similarly, in reading only the outputs (secondary poles), one sees how, in realizing them, the situation can be resolved to its ultimate objective of minimizing detrimental effects to customers' businesses in T_4. With T_4 emerging as an overall end for the resolution of the problematic situation, the SODA-T map serves to indicate that it would not be logically coherent to immediately tackle T_4, since it depends to a great extent on the resolutions of the prior



Basic Structural Information

Number of transformations:
25

Tails:
9 (*T1, T4, T7, T13, T18, T19, T20, T21, T22*)

Heads:
2 (*T25, T5*)

Implosions of note (listed by indegree):
- indegree of 5: *T10*
- indegree of 4: *T16, T25, T11, T15*

Explosions of note (listed by outdegree):
- outdegree of 3: *T3, T8, T12, T14*

Dominants of note (listed by degree):
- degree of 7: *T15*
- degree of 6: *T10, T11, T16*
- degree of 5: *T3, T8*

Fig. 4. Digraph of SODA-T map with legend of issues and basic structural information.

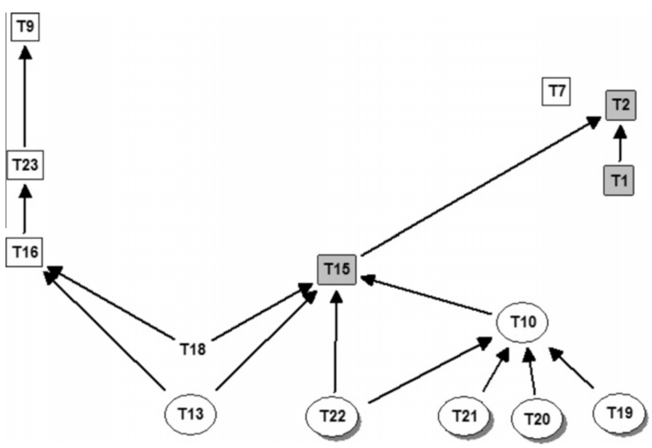


Fig. 5. Digraph of reduced SODA-T map, following deletions of heads, transformations directly linked to heads, and transformations concerning government and university policies.

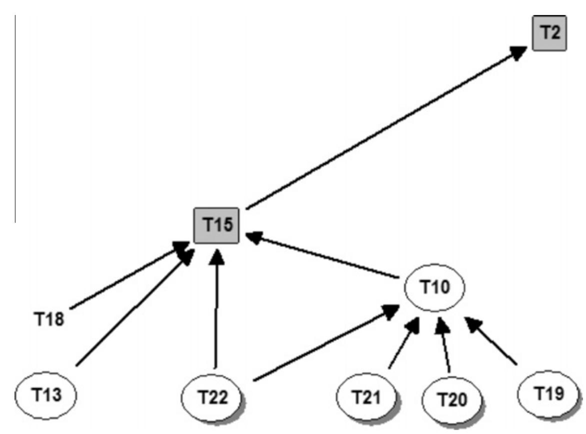


Fig. 6. Digraph of reduced SODA-T map centered on dominant transformation.

transformations in the chain of causation. Various levels of subsystem interdependencies also appear, with the first level (the tails) being constituted by T_9, T_6 and T_5, a second level constituted by T_7 and T_8, a third level by T_1 and T_2, and a penultimate level by T_3. Different formats of arrows may also be used, depending on how causation is understood in the situation in question. One example is evident between T_2 and T_1, perhaps because of some suspicion that the uncoordinated approach to service provision is directly contributing to the unacceptable time lag in dealing with urgent demand.

Given the SODA-T map, decision makers might decide that it is best to begin tackling those transformations at the bottom and work upwards toward T_4; or, perhaps, that it is best to tackle a dominant such as T_8 and its surrounding links. At the very least, the map allows the users to make an informed decision as to which transformations are best handled first, and how such handling can lead to the consideration, or even simultaneous resolution, of further transformations.

The relations exhibited on a SODA-T map can also guide the manner in which the transformations' respective HASs can be interlinked at the final stage of Phase 3 in SSM. Since their respective transformations refer to (are parts of) the same problematic

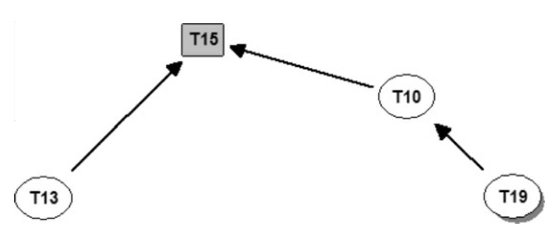


Fig. 7. Digraph of pilot SODA-T map.

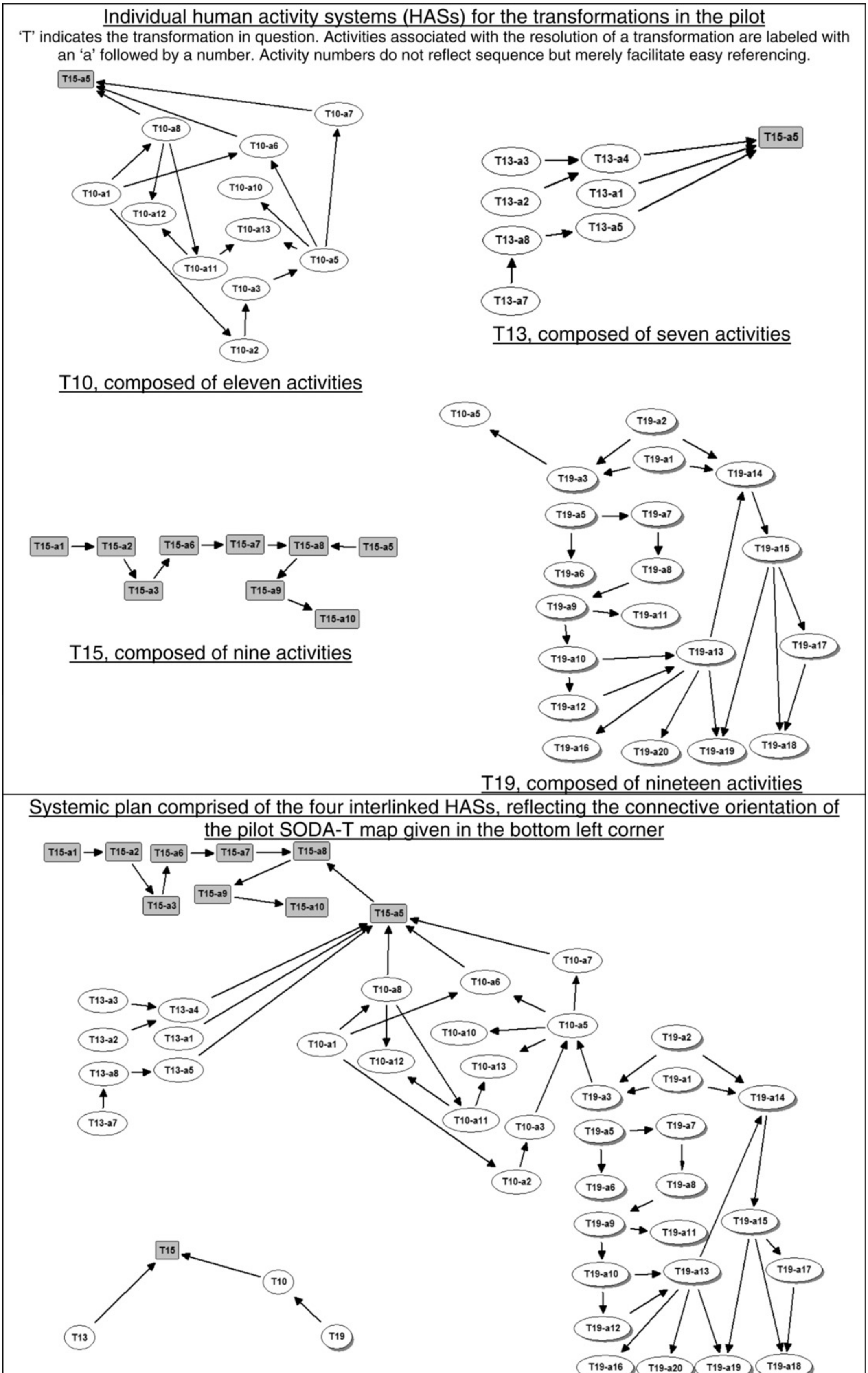


Fig. 8. Digraphs of four individual human activity systems and of the resulting systemic plan.

situation, HASs for the planned resolution of the situation are expected to show interconnections between them. It is as an aid to the discovery of such connections that a SODA-T map can be of use at this late stage. A further example will illustrate this point by showing how the SODA-T map, in addressing challenges listed earlier, can offer a high-level connective orientation for the eventual systemic plan.

8. A study of the application of SODA-T maps

The example is adapted from what appears to be the first real-world application of the multimethodological approach discussed here (Curo, 2011). Fig. 4 is a digraph of the SODA-T map constituted by interlinked transformations identified as requiring resolution in order to develop a research culture in a South American university. The transformations revealed, and were accordingly categorized (conceptually clustered) into, issues bearing upon the situation, such as government policy, university policy, faculty and student research development, as well as resource availability and links between the university and the outside world.

The decision makers required a pilot systemic plan of interlinked HASs for three reasons. First, the pilot plan was to be used as a starting point from which to plan the complete resolution involving all transformations. Second, the pilot plan was to be used as a negotiation device to convince other targeted parties of their systemic involvement in the situation as well as of the relevance to them of such planning. One such targeted party was the government whose policies could not be controlled by the university, but upon which the university depended to realize its objective of developing a research culture. Additionally, strategic university policy was beyond the control of the decision makers. In this respect, the development of a pilot was perceived as useful for structuring eventual debate between parties, and especially seen as one means through which to convince the university administration of the viability of designing policy that could meet research needs.

All three reasons pointed to the need for tackling a subset of transformations. Government and university policies, being beyond the control of the decision makers, would need to be excluded from the pilot. It remained to identify, from the remaining transformations, those which could logically constitute the pilot. In order to do this, the decision makers relied on analyses applicable to SODA-T maps which could result in a justifiable, defensible and workable pilot.

To begin with, the heads were discarded since they depended on the resolution of lower-level transformations. In addition, and for the same reason, those transformations immediately linked to heads were discarded. Accounting for the exclusions regarding government and university policies, the resulting options are shown in Fig. 5, comprised of eight of the nine tails, three of the five notable implosions, none of the notable explosions and three of the six notable dominants.

From this map, it was decided that the centrality of the primary dominant transformation, T_{15}, should not be ignored, and that any pilot should include it. Given the issue to which T_{15} was associated, it became obvious that the pilot would focus on students' development of research abilities – an issue perceived as within reach of the expertise of the decision makers. The map was accordingly reduced to those transformations directly linked to the dominant, including their inbundles (if any). The result is given in Fig. 6.

From Fig. 6, it was decided that, given the centrality of the dominant, T_{15}, and of the notable implosion, T_{10}, linking into it, a pilot would have to include these two transformations. In terms of overarching issues, therefore, the pilot would consider how aspects of university resources could be planned to facilitate student development in research.

At this stage, it remained to choose from the six remaining tails and the local head, T_2. T_{18}, being an uncategorized transformation, was set aside for future consideration. T_{13}, for being associated with the same issue as T_{10}, was deemed relevant for inclusion since the relationship of university resources to student research was emerging as the focus of the pilot. It now remained to choose between the local head, T_2, and the remaining tails, all of which concerned external university links. In having a pilot focused on student research development, and given that such development would necessarily require the involvement of external university links such as, for example, junior consulting projects and trainee opportunities, it was deemed more relevant to exclude the local head and choose from among the tails. In the event, T_{19} was judged to be the most significant transformation associated with external university links. The overall structure of the eventual pilot plan would, therefore, include T_{15} as the head HAS concerned with student research development, fed directly by university resources from T_{13} and T_{10}, and indirectly by external university links from T_{19}. This is shown in Fig. 7.

Through this methodological process of elimination, the decision makers could justify their choice of pilot and thus proceed with more confidence toward modeling a resolution, both for introductory modeling purposes as well as for negotiation purposes with third parties, such as the university administration and government representatives.

Four individual HASs were designed for the respective transformations. Digraph structures of the individual HASs as well as of the systemic plan are given in Fig. 8. The digraphs reflect the essential structure of the models and therefore omit the respective controlling subsystems as required by SSM. The omission enables a clearer illustration of the manner in which the systemic plan follows the connective orientation offered by the pilot SODA-T map.

Fig. 8 shows that, in the event, the linkage between HASs did follow the connective orientation of the SODA-T map. Whereas, however, the SODA-T map might suggest links between whole HASs, the HASs in this case were actually linked through respectively associated activities from within them. This resulted from what has been termed *analytical linking* in SSM (Georgiou, 2006, 2008): duplicates or synonymous activities observed across two or more HASs were merged into one activity, and associated links also merged. In this case, the resulting 'linking pins' were T_{15}-a5 and T_{10}-a5.

For the case in question a pilot plan was required. As such, the SODA-T map was useful in identifying, and subsequently connecting the HASs of, a subset of transformations. The example, however, serves to indicate what was discussed earlier, namely, that even when all transformations are to be considered, the SODA-T map can guide the order in which they may be tackled and the manner in which their respective HASs are to be connected into a systemic plan.

9. Conclusion

The literature on SODA mapping offers evidence that, when used singularly, it is a viable methodology for assisting in the identification of what may be problematic in a situation. It is always possible that singular use of SODA mapping can help identify issues requiring resolution beyond those identified through SSM, and especially beyond those identified through SSM's focus on transformations. The literature on the SODA-SSM combination, reviewed earlier, offers evidence that this is indeed the case.

Notwithstanding SODA's particular advantages, the present discussion has sought to highlight how SODA might also be used more analytically within SSM. From such considerations has emerged the idea of a SODA-T map. This is a map of transformations, as opposed to constructs, whose logical viability has been argued to stem from the structural complementarity evident between SSM's transformations and SODA's bipolar constructs. A SODA-T map enriches SSM by offering a methodological means for structuring large numbers of transformations. The map helps to identify relations between transformations, their hierarchies and priorities, problem epicenters and starting points for intervention – all of which serve to inform the manner in which such interventions may be undertaken. In addition, the arsenal of graph theory can be used to cut through what would otherwise appear as interlinked chaos. Furthermore, the SODA-T map, in offering a high-level connective orientation, can also serve as a reference for routing interconnections between the respective HASs of the transformations, resulting in a final systemic plan. The discussion has shown how SODA's analytical incorporation into SSM extends from choosing transformations for CATWOE and root definition contextualization based upon a mapped understanding of their priorities and dependencies, to guiding and justifying the interrelationships between different HASs in the systemic plan that constitutes the decision reached through an exercise in SSM. Briefly put, SODA-T maps allow for a structured approach toward systemic planning of transformations.

This analytical application of SODA mapping, at the heart of SSM, suggests that the multimethodological link between the two methodologies constitutes a greater methodological whole that should be considered whenever *one or the other* methodology is being used. For even where a problematic situation is approached initially through SODA, resultant interlinked constructs might require operationalization. In such a case, which would be the reverse of that presented in this paper and more aligned with Bennett's multimethodological 'integration', SSM's Phase 3 (see Fig. 1) can be called upon to translate the mapped constructs into HASs whose combination into a systemic plan would be guided by the original SODA map. With such evident mutual complementarity, it is hoped that greater confidence might ensue in systemic planning that involves the SODA-SSM combination.

Acknowledgement

This paper is based on research sponsored by the Escola de Administração de Empresas de São Paulo of the Fundação Getulio Vargas.

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