# An Introduction to the Themed Section on "*Using agent-based simulation for integrating qualitative and quantitative evidence*"

Patrycja Antosz[a], Sukaina Bharwani[b], Melania Borit[c]*, and Bruce Edmonds[d]

[a] *Department of Health and Social Science, NORCE Norwegian Research Centre AS, Kristiansand, Norway;*

[b] *Stockholm Environment Institute, United Kingdom;*

[c] *Norwegian College of Fisheries Science, UiT The Arctic University of Norway, Norway:*

[d] *Centre for Policy Modelling, Manchester Metropolitan University, Manchester, United Kingdom*

* Corresponding author: Melania Borit, melania.borit@uit.no

Many approaches to understanding social phenomena use either only qualitative or only quantitative methods and have well-developed traditions concerning how to interpret their data or observations and formulate their conclusions. However, this is a luxury unavailable to researchers that are part of inter- or transdisciplinary projects addressing practical problems within a complex context – what Bammer (2013) calls 'applied integrative research'. This themed section is devoted to discussing topics relevant for researchers working in such projects, who have no other option but to consider both qualitative and quantitative evidence, unless they intend to deliberately ignore or exclude some information[1]. Using multiple methods in one study came a long way since Cambell and Fiske (1959) advocated implementing more than one method in validation to ensure rightfully ascribing variance to the investigated trait, rather than to the measurement instrument. However, integrating or even merely reconciling qualitative and quantitative evidence is still far from easy[2]. Depending on the level of information integration, multiple

[1] Which is surely not an option for anyone who considers themselves as doing science of any kind.

[2] Some authors have argued that this is highly problematic (e.g. Giddings 2006).

methods can be combined in a multi-method (methods are used independently, usually investigate different aspects of the phenomenon, and/or are of the same type (e.g. two qualitative techniques)) or mixed-method fashion (exhibiting greater integration on the levels of design, sampling, analysis (e.g. following a thread; Moran-Ellis et al 2006), and/or interpretation (e.g. triangulation of findings; Foster 1997); for an elaborated discussion on the topic of integration in mixed-methods see O'Cathain et al. 2007). There are now many varieties of these approaches[3].

In all of these approaches, usually, the integration or reconciliation is done *discursively* - that is, in the mind of someone or described in some natural language text. This discursive integration has significant benefits and draw-backs. On the plus side, integrating a variety of beliefs, evidence, arguments, feelings etc. is something all of us do all the time in our lives – we thus have experience in doing this and some natural expertise. When reading an account of such integration we can easily imagine how this might have been done. However, due to the imprecision, subtlety, and complexity of natural language (and thought) we can not be sure that we fully understand the process involved in that integration, and we should not assume reliability (it would be very surprising if our understanding was *exactly* the same, as that of another scholar). In other words, the integration process itself is not precisely specified, so it can be difficult to either completely replicate the original process or to be fully clear as to the assumptions that were involved. In many cases this imprecision is not critical and anyway amply compensated for by the semantic richness of natural language. In some cases it does matter. For example, when considering issues where social and ecological concerns need to be addressed together in order to inform policy decisions (as elaborated in (Elsawah et al 2020)). In such cases it not only matters *what* evidence is considered but *how* it is integrated with other evidence, since this can affect the conclusions of the

[3] See Creswell (2014) for an introduction to these.

exercise. Also, it is important that the basis of such conclusions are as open to critique as possible and this involves making the processes transparent.

In this themed section we discuss the use of a formal, but flexible approach that can be mapped to many kinds of evidence, called agent-based modelling (ABM)[4]. This approach can be used to make assumptions that are introduced into bridging processes explicit and hence more easily traced and critiqued. ABM is an approach to simulation where every relevant actor is separately represented by software entities called 'agents'. Each agent can have its own characteristics and behaviours, so heterogeneity is built into the technique. When the simulation is run, the agents interact with each other and their environment over time, producing a complex set of outcomes resulting from a dynamic, interwoven process. Whilst the 'story' of each agent is retained and can be traced within this, it can also be measured as a whole, giving rise to macro-level, quantitative measures and qualitative judgements on the outcomes. For example, it may be that the network of interactions or knowledge between agents evolves as a simulation progresses causing agents to behave differently, e.g. adapting and/or learning as their environment changes. Although ABM is a formal technique – in the sense that it is precisely specified and computationally executable – it is uniquely expressive as it allows for more of the 'social mess' that we observe to be included in the model representation of the target system. It is not bound to any particular theoretical basis, but can be programmed to be so if desired – thus, the processes and behaviour in the model can be tailored to fit individual accounts and opinions as to their nature.

This combination enables ABM to play a new role in integrating and relating very different kinds of evidence and types of knowledge, including: narrative accounts, observational data, stakeholder opinion,

[4] For a non-technical introduction to this see (Gilbert & Troitzsch 2005); for a more extensive account covering many different aspects see (Edmonds & Meyer 2017).

social network data, surveys, time-series, and other aggregate measures. For example, interviews with decision makers can be used to inform the range of strategies that are used to program the agents – when the simulation using these is run, statistics can be extracted that can be related to available macro level data (Moss & Edmonds 2005). This ability has resulted in ABM being increasingly used as an integrating method in inter- and transdisciplinary research projects. The four articles included in this themed section will help illustrate some of the potential, but also difficulties of this approach.

In order for ABMto make a more general contribution to research methods as a better integration tool across disciplines, it is vital to be clear about how it uses qualitative and quantitative data. Although the benefits of a formal integration method stem from explicit representation, this is at risk of involving imprecisions and undisclosed decisions. The contribution by *Achter, Borit, Chattoe-Brown, and Siebers* to this themed section therefore focuses on justifying the need to create rigour and transparency in reporting how qualitative and quantitative evidence is transformed into the data that is used in developing an agent-based model. The article introduces the Rigour and Transparency (RAT) Reporting Standard, a structured approach for the documentation of data use. This standard provides template questions about data use for different approaches to ABM, helping to elicit rationales for decisions taken and create shared procedural knowledge about the research process. The standard is designed to be flexible, so it can be applied in the diverse domains that make up the ABM community, and has been progressively improved by user feedback. We hope that the article makes the value and use of the RAT-RS clear and thus motivates readers to apply it in their own research.

Combining **G**ames and **A**gent-based **M**odels (GAM) is a relatively new development that marked its first applications supporting the creation of more integrated natural resource management in the early 2000's. While GAM is relatively popular in research that engages stakeholders, it also shows potential for integrating qualitative and quantitative data. However, the GAM approaches have been developed in

disciplinary isolation, producing little methodological advice and overall standardization. *Szczepanska, Antosz, Berndt, Borit, Chattoe-Brown, Meyer, Mehryar, Onggo, and Verhagen* describe the status quo of the GAM field across disciplinary boundaries. Through a systematic literature review of previous research efforts, the authors characterize six archetypical research designs. The article is a first step towards consolidating the new research domain, and is particularly interesting to agent-based models developers and game designers alike. The authors invite academics and practitioners to join a methodological discussion that drives the field forward.

*Antosz, Szczepanska, Bouman, Polhill, and Jager* try to make sense of causality in agent-based models. The main assumption of the text is that an agent-based model is a computer representation of the target system with multiple causal assumptions about how that particular system works. As a methodology, ABM is famously capable of representing complex social systems and focuses on how macro-level outcomes emerge from micro-level interactions. Even though historically the identity of ABM was developed around this focus, the authors argue that ABM is not exclusively committed to a single account of causality i.e., to building mechanistic, generative explanations of emergent phenomena. They present previous arguments challenging the claim that highlighted downward causation (how macro-level features influence the micro) and bi-directional causality, and give further empirical examples of various within-level causal relationships integrated into a complex mechanism represented by an agent-based model. After all, implementing various types of causal relationships that complement the generative causation allows for building more complete causal explanations of complex social phenomena.

*Wijermans, Schill, Lindahl, and Schlüter* place the integration of evidence within the context of who, what, and how integration takes place by encouraging sharing experiences of combining approaches. They do so themselves by inviting the reader behind the scenes of their 10-year collaboration in which

they combine ABM and controlled behavioural experiments. They highlight that there are multiple ways of integrating with agent-based models, each serving their own purpose, stressing different stages of the scientific cycle – exploring and testing. The flexibility of agent-based models to integrate relevant understandings (regardless of its form qualitative and/or quantitative) is incredibly enabling for understanding complex (social) systems and thereby uncovering under-explored terrain. Sharing integration experiences, besides sharing project results, are a crucial process towards transparency and reproduction, and thus our collective ability to advance science. It forces a reflective language that can be used to describe and identify different combinations/integrations and thereby being more precise, but at the same time provide space for the diversity of combinations that exist.

The methodological advances reflected in these papers suggest that the approach of integrating qualitative and quantitative evidence using agent-based models is starting to mature. Such maturity would facilitate the development and enrichment of both social science and agent-based modelling. Though impossible to gauge the exact impact, we anticipate that this would include the following.

- It should encourage modellers to utilise the wealth of qualitative data that is available, since they will have more guidelines as to how to deal with it.
- It will influence agent-based modelling to include more of the messy and complexity of observed social life and hence help move modelling away from highly abstract ‘toy’ models.
- It may encourage more qualitative researchers to engage with agent-based modellers as they see that a non-reductive approach is used, more cautiously abstracting from what they observe.
- It will provide another piece of the knowledge-integration jigsaw, thus facilitating inter- and transdisciplinary projects with a huge variety of kinds of evidence, particularly those with participatory elements.
- It could allow for the cautious generalisations from the qualitative data to be better checked and understood by others.

- It might allow for the assumptions that underlie some qualitative methods (e.g. scenario development) to be better understood, which might suggest further empirical research to round out the understanding.

We feel this is an exciting journey that we and the authors in this special section are embarked upon. We encourage all those who are interested to join in.

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