

Editorial

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Editorial: Social Identity Modelling

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Abstract: This is an editorial to the special section on “Social Identity Modelling”, published in Volume 26, Issues 2 and 3, 2023 of the *Journal of Artificial Societies and Social Simulation*. It provides information on how the Social Identity Approach (SIA) and the research using its theoretical framework explains collective behaviour, tailored specifically for modellers. The discussion centres around describing and reflecting on the state of the art in modelling SIA. The editorial ends with looking ahead towards formalising SIA as a means to enable more collective behavioural realism in agent-based social simulations.

Keywords: Agent-based modelling; Behavioural realism; Formalising; Self-categorization; Social identity; Social theory

This article is part of a special section on “Social Identity Modelling”, guest-editors: Nanda Wijermans, Geeske Scholz, Martin Neumann, Rocco Paolillo, and Anne Templeton

● Introduction

- 1.1** Behavioural realism for our models often originates from the social realities humans are in. Especially in the context of global challenges our world is facing (pandemics, war, climate change, growing inequalities, etc.), collective action and decision-making are at the heart of the solution (Barth et al. 2021). Agent-based social simulation has a role to play in the understanding of these complex phenomena as an approach able to represent dynamic, heterogeneous actions and situations that incorporate knowledge from social and behavioural sciences. Particularly, exploring the many possible (collective) behavioural patterns emerging from interactions - based on social and behavioural theory and empirics - among agents and between agents and the environment.
- 1.2** Many relevant theories and empirical findings exist that may help us advance behavioural realism in our models. In this special section, we focus on the formalisation of one particular family of theories: the Social Identity Approach (SIA) (Reicher et al. 2010). SIA provides explanations for in- and between-group processes from the cognitive level to the collective level and relates behaviour to specific socio-contextual situations. SIA's relational approach allows for the description of the individual to collective behaviour and provides mechanisms of how individuals act when recognising themselves and others as part of a social group, which can explain the emergence of social phenomena. Thereby, SIA provides an example of a theoretical concept for addressing the

micro-macro link in social theory as well as for understanding how the macro level influences the micro level of individual action and interaction.

- 1.3 Research that is based on SIA is incredibly widespread in social psychology. The principles within the approach have been applied to research on intra- and inter-group processes in areas such as collective action, nationhood, crowd safety, leadership, physical and mental health, group conflict, prejudice, and many more. This collective body of research offers significant theoretical and empirical insights to use in agent-based models of collective behaviour - helping to improve their realism.
- 1.4 With this special section, we set out to bring a range of different SIA ABMs together. This enables others to find existing models and identify concrete examples in different application domains, providing the possibility to connect and learn from others formalising SIA. In this editorial, we briefly outline why SIA is relevant for social simulation and highlight key concepts of SIA. We then go into the state of the art of SIA modelling by introducing and reflecting on the content of this special section, and close off with our outlook on SIA modelling and the future research we envision with SIA and social simulation.

● **Situating SIA: Relevance and Uptake**

- 2.1 SIA is made up of social identity theory (Tajfel & Turner 1979) and self-categorisation theory (Turner et al. 1987) and provides us with conceptual tools on which to base the models of collective behaviour. Research using SIA provides insights into how the social self interacts with the personal self and shows the cognitive, behavioural, and emotional effects of group membership, such as how groups may exhibit bias towards ingroup members, how behaviour in collective contexts is often bound within what is perceived as socially acceptable (social norms), and how basic movement behaviour is impacted by coordinating around ingroup members.
- 2.2 When writing this editorial, Tajfel & Turner's (1979) seminal text on social identity theory has been cited 32,564 times and Turner et al.'s (1987) book on self-categorisation theory 19,397 times. To get a feeling for these numbers, the top cited article in JASSS, the Hegselmann-Krause model (Hegselmann & Krause 2002) is cited 3,479 times and one of the most well-known models, the Schelling model (Schelling 1971), is cited 6,553.¹
- 2.3 To get a sense of how much SIA is used in the field of social simulation in comparison to other disciplines, we ran a search query in the reference database SCOPUS, using the keywords "social identity" or "self category* theory" in the manuscript and its references list. To show the trend over time, Figure 1 shows the cumulative frequency of documents mentioning SIA for different research areas through the years (1957-2022). One can see that SIA is increasingly being mentioned. While dominant in the social sciences and psychology, also other disciplines, such as economics and environmental science, show an increase in the number of publications since the 1990s.²
- 2.4 In Figure 2, we compare mentions of SIA in JASSS - as representative of the social simulation community - with other journals that have high citation scores or reputability in other fields (social sciences or interdisciplinary domains). The journal with the highest number of SIA publications is "Group Processes and Intergroup Relations" with 624 papers. "Personality and Social Psychology Review" (PSPR) shows already in 2000 the highest number of publications connected to SIA (8), with an increasing trend similar to "Group and Organization Management". Interestingly, JASSS had one paper mentioning SIA already in the year 2000 (see: Zeggelink et al. 2000), and it shows a slow increase over time, though showing low reference to SIA compared to other journals. Overall, our query shows that there has been a growing interest in SIA in the last two decades also from disciplines outside of psychology and from interdisciplinary or topic-specific journals. The mild uptake signal in JASSS points out how timely our special issue is to a) show the fertile ground to the social simulation community, and b) show those formalising SIA how to find and connect to other work in Social Identity in Agent-based Models (SIAM).

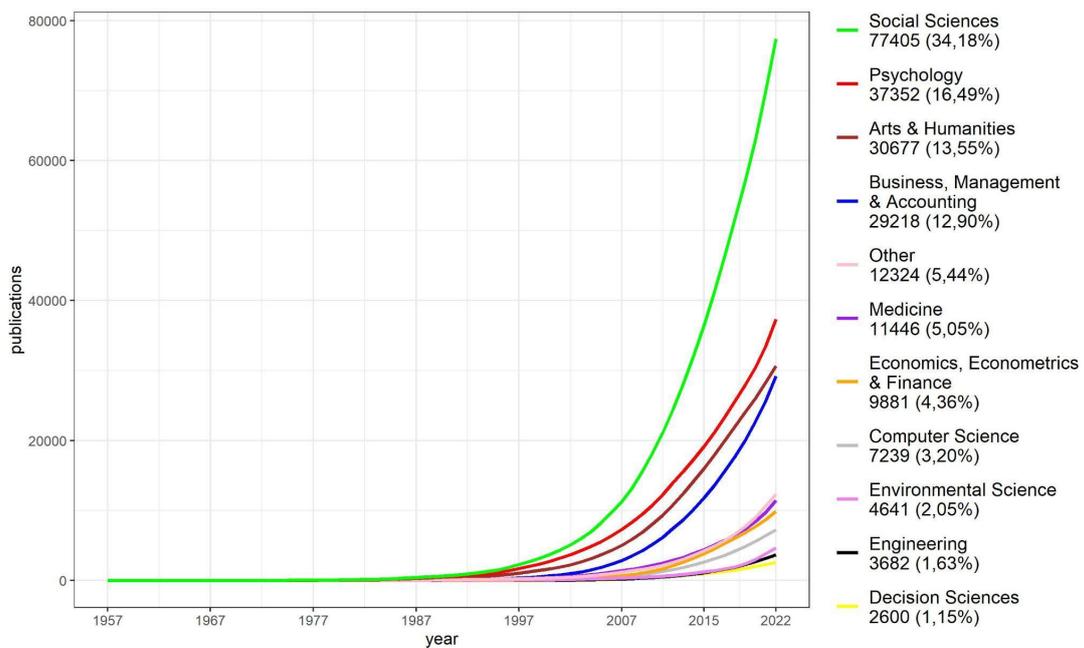


Figure 1: Cumulative frequency of SIA mentions in Scopus research areas. Numbers in the legend report the total publications cumulated and share percentages in 2022.

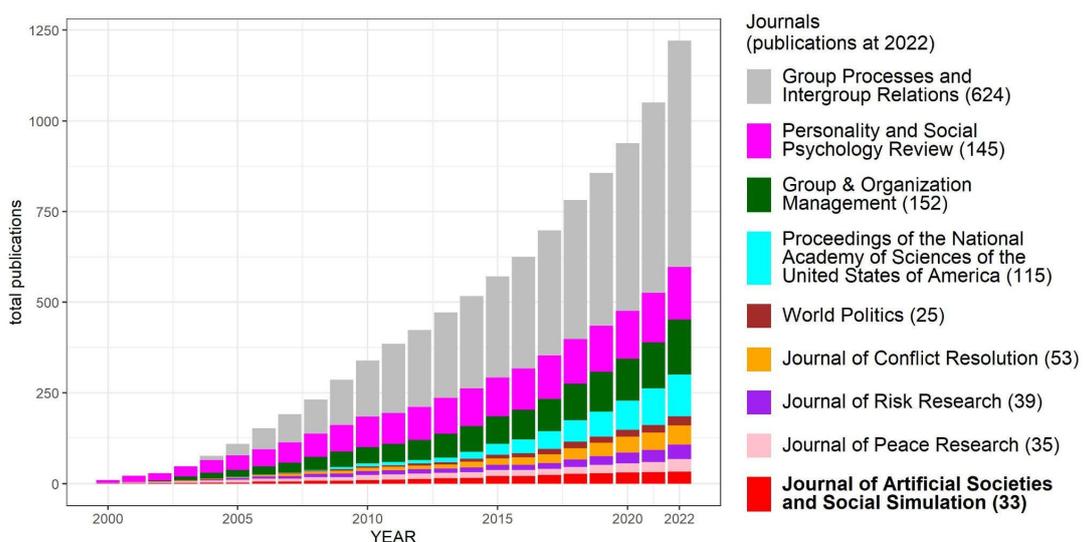


Figure 2: Journals mentioning SIA over time, with total amounts in brackets. Note that the range is restricted to 2000-2022 since JASSS is available in SCOPUS only from 2000.

● What You Need to Know About SIA

- 3.1 SIA addresses how groups inform people about their place and power in the social world, how to behave in different social contexts, and how groups impact emotions and well-being. As mentioned in Section 2, the approach consists of two core theories with over 40 years of research into group processes: social identity theory (Tajfel & Turner 1979) and self-categorisation theory (Turner et al. 1987).
- 3.2 **Social identity theory** describes that people have personal and social identities which exist on a continuum from our idiosyncratic differences (personal identities) to our group memberships (social identities). Social identities are cognitively, behaviourally, and emotionally important for how we navigate our social world. Groups have specific social norms, i.e., shared rules about what it means to be a member of that group in terms of values, beliefs and behaviours (Masson et al. 2016; Masson & Fritsche 2014). Being part of a group can be an intense

emotional experience, such as being empowered during collective action (Drury & Reicher 2005), feeling validation when being recognised by ingroup members (Hopkins et al. 2019), experiencing higher positive emotions in more central, denser areas of crowds (Novelli et al. 2013), and experiencing stronger negative emotions when being reminded of the group's (past) misconduct (Masson & Barth 2019, 2020). When a social identity becomes salient (cognitively 'active'), it can be associated with increased expectations of help from others in the group (Drury et al. 2019), provision of help to others in the group (Alnabulsi et al. 2018), and increased physical proximity among ingroup members (Novelli et al. 2010; Templeton et al. 2018, 2020).

3.3 Self-categorisation theory addresses the process of how people identify as a member of a group and begin to embody this group membership. A shift from the personal to social identity occurs through depersonalisation, and then self-stereotyping takes place where individuals define themselves in terms of their social identity and act according to the social norms of the group. Self-categorisation theory also details how the group membership of others is evaluated through concepts such as normative fit and comparative fit. Normative fit refers to the extent to which individuals act within a group's social norms. Comparative fit (based on the meta-contrast principle) refers to the comparative similarity or dissimilarity that the self and others have to group members, i.e., the perceived differences between members of the ingroup are smaller than the perceived differences between the ingroup and the outgroup.

3.4 To enable modelling in Table 1, we provide an overview of the core elements and processes of SIA with some examples and suggestions for modellers on what to consider when formalising this aspect of SIA, and collective phenomena that may be of interest.

Table 1: Main SIA elements for the modelling community (adapted from Templeton & Neville 2020; Scholz et al. 2023).

Element/Process	Brief explanation
Personal & Social Identities	<p><i>Definition:</i> We have a personal identity (referring to our idiosyncratic self) and social identities (our membership of social groups) and operate on a continuum between these. People can be members of multiple social groups and each group has social norms, values, and beliefs that guide our meaning-making and behaviour. People within our group are referred to as ingroup members. Outgroup members are people who are not part of the group (those actively competing or in different groups).</p> <p><i>Example personal identities</i>³ : Having faced traumatic experiences in the past (e.g., a severe car accident), having a particular personality trait (e.g., openness)</p> <p><i>Example social identity:</i> Member of a social movement (e.g., Fridays for future), member of a sports team (e.g., volleyball).</p> <p><i>Modellers consider:</i> What does the context of your decision require? Do you need to include a personal identity, or one or multiple social identities? Can new social identities arise? Do these identities remain static or are they changeable? How are they signalled, i.e., are they visible/recognisable by other agents?</p>
Prototypical characteristics associated with social identity	<p><i>Definition:</i> Characteristics that are prototypical for this group. For example, this could be behaviour, attitudes or appearances considered appropriate and normative⁴.</p> <p><i>Example:</i> Climate activists (the social identity) demonstrating and drawing attention to the climate crises by striking from school, or other civil disobedience. Football fans wear certain clothing (e.g., team scarf) when going to a match, chanting and singing together.</p>

	<p><i>Modellers consider:</i> Prototypical elements can be very abstract and simple such as an opinion, or sophisticated like a behaviour. More complex prototypical elements could be modelled as their own entities. They could evolve (e.g., through ingroup observation) during the simulation or be static throughout a simulation run.</p>
Saliency	<p><i>Definition:</i> Reflects the extent to which a social identity is cognitively present at a particular time. A social identity can become salient depending on the social context. One factor is ‘perceptual readiness’ which refers to how accessible particular identities are to an individual, and the social context can influence whether these potential identities become salient.</p> <p><i>Example:</i> Changing social and/or physical space can be a trigger for social identities to become more or less active. A person may have potential social identities as a scientist, a parent, and a football fan. In their work environment, the scientist’s identity may be made salient by their environment, but a call from their child may make their parent identity salient. On the train home from work, they might encounter other fans of the football team they support and have their football fan identity become salient.</p> <p><i>Modellers consider:</i> What contextual elements/triggers are relevant that make social identities salient (e.g., making a specific football team fan identity salient)? How to operationalise and frame this for a model depends strongly on the contextual features included (e.g., sound, environment, and others present). Questions: Does saliency work like a switch (i.e., on/off) or is there a gradual change until the identity becomes salient? How do changes in physical and social space affect your agents?</p>
Social identification	<p><i>Definition:</i> Social identification reflects how important a particular social group is to a person’s self-concept, as well as the process by which one identifies more/less as a member of a particular social group (i.e., it gets more/less important). Shared social identification is the extent to which people believe that they and others feel part of the same social group.</p> <p><i>Example:</i> A person is a football fan, particularly for the world cup. It has always been very important to this person, to the extent that they would always go to the world cup with their football friends (high social identification with football friend group). However, something changed last year while learning about the practices in Qatar, which made going to Qatar for the world cup a personal no-go, and resulted in lower engagement with the World Cup games (lowering social identification with their football friend group).</p> <p><i>Modellers consider:</i> A core question is whether the importance of a social identity is a static or dynamic aspect of your model? When static, one can focus on how a social identity may affect behaviour given different degrees of social identification (importance). When dynamic, consider mechanisms that make a particular social identity less/more important (e.g., presence of an outgroup).</p>

<p>Self and Other Categorisation</p>	<p><i>Definition:</i> Describes the process(es) in which people cognitively categorise themselves and others into social groups. The categorisation can be iterative, and context-dependent, and can involve processes of self-stereotyping, depersonalisation, comparative fit, and normative fit.</p> <p>The meta-contrast principle refers to the tendency to exaggerate our differences with outgroup members and emphasise the similarities with ingroup members. Based on the meta-contrast principle, the comparative fit describes the level of context-specific (dis)similarity perceived between an individual (including the self) and others. Thus, a group of people can be categorised as being in the same group if the differences perceived between themselves are less than the differences between them and another group. The normative fit is the extent to which stimuli align with the perceived norms of the group. Here, if someone acts in line with a group's social norms then they are more likely to be categorised as a member of that group.</p> <p><i>Example self-categorisation via comparative fit:</i> In an organisation, there are two working units: a technical blue-collar unit and an administrative white-collar unit. The technical blue-collar workers perceive that they have more in common with one another than they do with the white-collar workers. The likelihood of the blue-collar workers seeing each other as a distinct social group becomes higher the more similar the blue-collar workers are seen to be, and the more dissimilar the white-collar workers are seen to be from them.</p> <p><i>Example self-categorisation via normative fit:</i> A person is attending a football match and goes through a process of depersonalisation so that their social identity as a fan of football team A is salient. Fan team A sees someone else at the match and classifies them as being a fan of the opposing football team B because they are wearing clothes in support of the opposite team (normative fit). In another context, however, these fans of opposing football teams can be part of the same group. For example, they may see each other at the football world cup, notice they are both wearing the same t-shirts to support their national team and therefore categorise one another as ingroup members within this new context.</p> <p><i>Modellers consider:</i> Models often include preset social identities that remain stable over the simulation run. It may, however, be interesting to observe how agents categorise themselves and others to new or different social identities, or by having new social identities emerge. When formalising the comparative fit, consider which attributes are being compared in terms of similarity. Is this a dynamic process, subjective/different for agents (e.g., based on similar opinions) or static (e.g., blue versus white markers as a tag)? When formalising the normative fit: What is the consequence of (perceived) similarity, is that predefined or emergent? What is prototypical behaviour of a group and how can it be observed and quantified? How (much) of this behaviour/appearance, etc. is needed?</p>
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● Present Work on Social Identity Modelling

- 4.1** Recently, SIA is also being picked in social simulation, potentially following the trend of its use in the social sciences and other application domains (section 2, Figure 2). While momentum builds, initiatives are scattered, making this a good time to gauge the state of the art and connect via concepts, theoretical grounding, and awareness of each other. This special section (spread over the current and the previous issue of JASSS) aims to play a role at this critical time. It comprises a systematic review of the modelling literature using SIA and showcases five agent-based models that formalise aspects of SIA in different application domains. We will reflect briefly on the contribution towards SIA formalisation of each paper and take stock of where we are in formalising SIA.
- 4.2** **The systematic review (Scholz et al. 2023)** is a prime starting point to get an impression of the state of the art in SIA modelling. In the most fundamental form, the review makes related work visible, by providing access to work that is scattered over many different domains and enabling cumulative research. It provides an overview of which aspects of SIA have been included in the models reviewed for future SIA modellers to build upon. By taking a step back, the review also reveals some 'uncomfortable' realisations about the state of SIA formalisation. Most of the increased uptake of SIA is mainly anecdotal, i.e., the link with SIA is at most at the conceptual level of the model but does not materialise in the code. The models that do formalise (parts of) SIA mostly refrained from clearly using SIA terminology and no convergent SIA formalisation could be identified nor a unified practice of building on each other's work. The high expectations of the author team, as well as the challenges encountered in the review, shaped the review profoundly in fulfilling another important contribution by providing an overview of key SIA aspects and processes, complementary to, but more elaborated from 'what you need to know about SIA' in this editorial. The descriptions of these concepts reflect the common understanding and engagement with SIA literature of the interdisciplinary author team of social simulation modellers and SIA social psychologists. In short, the review provides a representative impression of the present work done in modelling SIA, where it puts its finger where it hurts in terms of what is needed from the modellers and from the theories while keeping an eye on the strong potential of modelling SIA.
- 4.3** **Wall (2023)** uses SIA to study the effect of social identity on managerial decision-making in the domain of management research. Based on the NK fitness landscapes framework, this model embodies the integration of theories from various disciplines, such as the theory of satisficing or organisational control, a rare cross-fertilisation. SIA in this model involves the representation of *social identity* as a mechanism for decentralised control and coordination. The strength of *social identification* is conceptualised as the extent to which an individual decision-maker (manager) pursues the overall objective of the group (being the overall organisation) or rather its own goals and self-interest. This is captured as an endogenously evolving variable. There are different activation mechanisms - social identity *saliency* - through a) perceived external threat to the group derived from changes in the organisation performance, b) individual self-esteem, and c) differentiation from perceived "underperformers" connecting to different social identity motives. Lastly, the managers' behaviours associated with a social identity change itself as a function of salient identities and the degree of identification affects preferences that inform their decision-making. The model's formalisation might be particularly appropriate to capture situations where the "group" has a clear objective. However, the proposed formalisation may also be suitable for modelling the identification with group norms in more general. In short, this model used SIA to allow for the role of considering oneself a member of an organisation in managerial decision-making and is an excellent resource due to the provided detail on the model and transparency on its application while being firmly anchored in the SIA literature.
- 4.4** **Dinkelberg et al. (2023)** extend Axelrod's model (Axelrod 1997) with an SIA-based version and test how well it competes with the standard Axelrod (baseline) and another extension (agreement-threshold model) in predicting longitudinal empirical dataset. It reflects a theoretical modelling exercise that includes careful triangulation of data and method, where they conclude that the standard Axelrod model performs best. SIA appears in this contribution by a) identifying SIA aspects in the Axelrod model (baseline and agreement-threshold extension) and b) the inclusion of SIA assumptions in SIA extension of the Axelrod model. The standard Axelrod model explicitly incorporates that people are motivated to maintain, and intensify, connections to people with whom they identify - links to the *self and other categorisation*. Whereas the agreement threshold model (extension of the Axelrod model by Maher et al. 2020) also operationalises the *social identification* of the SIA by this motivation to maintain connections to people with whom they identify, while not explicitly representing groups, the SIA extension involves an explicit ingroup preference. In the extension, an ingroup bias fosters a positive ingroup relation and group-dependent perception, with members from outgroups perceived as relatively homogeneous, while ingroup members are perceived as more heterogeneous, which are both assumptions that depart from *self- and other categorisation*. In short, the authors demonstrate that it is possible to depart from

an existing model, even when the original was not recognised as having SIA mechanisms, one can extend an existing model and build forth on existing empirically grounded work.

- 4.5 Lobo et al. (2023)** detail the formalisation and theoretical foundation of their model: The Dynamic Identity Model for Agents (DIMA). They focus on describing the formalisation of context-dependent behaviours, especially to enable others to integrate and improve behavioural believability in models of identity-related behaviour in their DIMA model. **SIA** is at the heart of DIMA, thereby formalising notions of *personal and social identity, salience*, and how an identity becomes *salient* depending on the context, what they call the *identity saliency mechanism*. For the authors, this formalisation of SIA is a way to reflect when identity becomes salient and affects behaviour and thus allows for (social group) context-sensitive behaviour. The detail provided on this identity saliency mechanism enables others to use this particular mechanism for their respective purposes. It involves both detail on the formalisation as well as the grounding in the literature to embed their choices in. For example, a personal identity does not appear nor change when a social identity is salient, it merely is a change in identity, i.e., depersonalisation. In short, this model used SIA to develop believable human behaviour in models and is an excellent demonstration of how its design is anchored in the SIA literature.
- 4.6 Carpentras et al. (2023)** use SIA as a social influence in an agent-based model of political polarisation. This model is a classic opinion dynamic model with SIA-type social influences used to connect to opinion dynamics research debate. More specifically, the debate is pushed by showing how opinion polarisation can emerge without the presence of repulsive forces, challenging insights from mainstream opinion dynamics literature. The model is the result of using behavioural experiments to design agent rules (internal validation) and to calibrate the model. Simulations calibrated with results from behavioural experiments are compared, setting 4 experimental simulation scenarios: influenced by in- or out-groups, both for arbitrary minimal groups and political groups. **SIA** in this model is formalised as a preset *social identity* - a tag (group A and group B). The group membership influences the initial opinion distribution of agents, which shifts opinions with calibrated weights, higher for ingroups than outgroups. The model also includes a tuneable variable affecting the probability to engage with ingroup members, which can be seen as an approximation of *social identification* formalisation. Each agent can thus recognise others and identify them as being in- or out-group, which approximates SIAs categorising of self and others. In short, the model provides an example of SIA theory in combination with empirics enabling the design of a testable explanation.
- 4.7 Sotnik et al. (2023)** use SIA to introduce some real-world complexity to a baseline theoretical model of common pool resource behaviour. This model is used to explore the emergence of prosociality. The core behavioural choice the agents make is to contribute or not to the common pool, that while randomly moving through space and thereby being part of a group or not depending on whether they have neighbours. The **SIA** aspects in the model reflect having new *social identities* whenever one is part of a group (the random movement leads to having neighbours) and depending on a situation that compares the energy level of one-self with that of one's group, as well as the energy level of one's group versus other groups, may lead to an experience of feeling threatened, which make it less likely that the agent will contribute, which can be regarded as a form of *social identification*. The model rules are broad abstractions that are not explicitly justified by reference to psychological domain theory. In a similar style as the Schelling model, conditions are explored under which sustainable common pool behaviour is shown, and the patterns the model generates are compared to global patterns seen in the world. In short, the model demonstrated the use of SIA here as part of a form of computational philosophy.
- 4.8** Each contribution in the special section has its own unique SIA angle to the research conducted. The obvious reflection concerns which aspects of SIA receive attention in the models, and more importantly, which aspects do not. For this purpose, we compare SIA focus in the models in the literature sampled in the review (Figure 3a) to the SIA focus in the model papers in this special issue (Figure 3b). What can be seen is that SIA aspects that were generally part of an attention gap in the review (grey lines in Figure 3a) have received attention from one/some of the contributions of this special section (Figure 3b - black lines and bold font). This hint of broadened attention gives a sign that formalising SIA is a dynamic space.

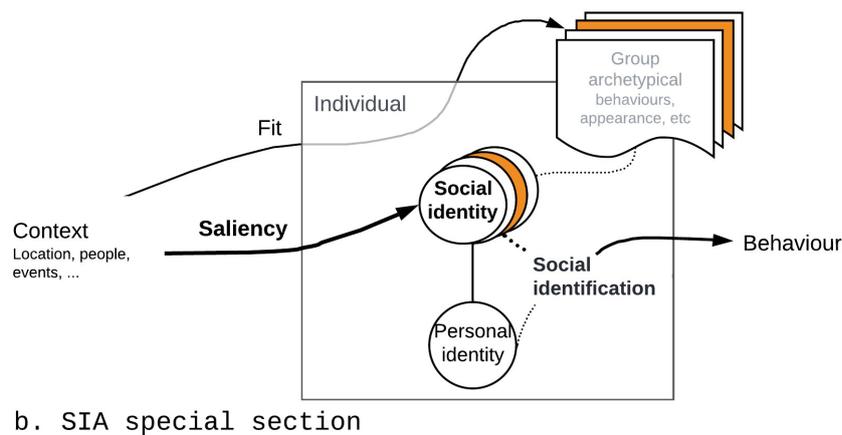
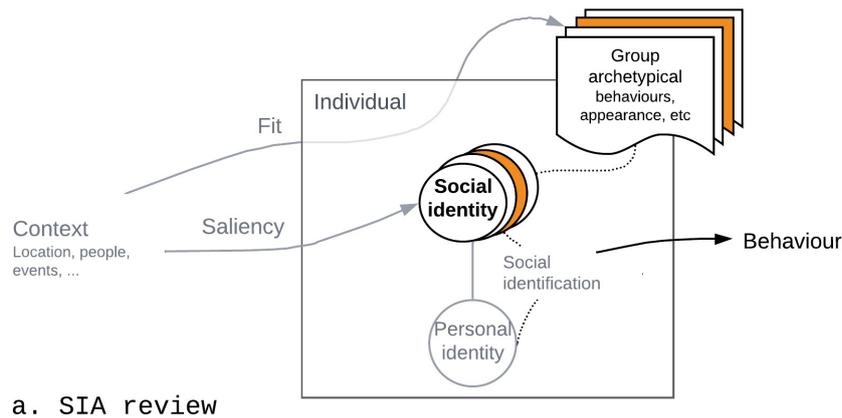


Figure 3: Comparing the focus on modelling aspects of SIA in the sample of papers analysed in the systematic review of SIA models (Scholz et al. 2023) versus the focus on SIA components in the model papers of the special issue.

● The Way Ahead

- 5.1** In this editorial of the special issue on social identity modelling, we aimed to make the JASSS readership acquainted with SIA and guide them on their way to find more to read, learn and consider in their own work. The special section entails a systematic review aiming to make those formalising SIA seen, despite being scattered over different domains (Scholz et al. 2023) as well as five model paper contributions that push the frontiers of current SIA formalisations and can inspire future SIA modellers. We now reflect on what is needed to proceed since formalising theory comes with its own challenges. We believe there is an abundance of potential, but also much fundamental formalisation work that needs to be done. We close this editorial with our reflections and invite anyone interested to join the ESSA special interest group SIAM-SIG (<https://www.siam-network.online/networks/siam-sig>) and join forces to formalise and shape the future developments of SIA modelling.
- 5.2** Below we list our two most prominent wishes for modelling SIA:
- 1. Adopting a practice of engaging with a SIA modelling community.**
- 5.3 Process|Formalising as a community.** Formalising SIA is challenging, interpreting the theory, applying it to a particular domain and specifying this all on a formal level on which the theory does not reside. Formalising SIA benefits from exchange, especially from an interdisciplinary exchange in how to proceed. Here, having a shared understanding and steady exchange between psychologists and modellers (Wijermans et al. 2022) is essential. This can concretely be operationalised by becoming part of and engaging in the existing ESSA special interest group to model SIA (SIAM-SIG).

5.4 Alignment & Transparency. To be able to connect and build forth on each other's work it is key to have a shared language and a common understanding of SIA. We would thus strongly encourage people to use the same type of language and concepts, e.g., as specified in the review of Scholz et al. (2023) and in Table 1 of this editorial, to enable communication and understanding of each other's use of SIA, as well as the ability to compare and build forth on existing models. We also encourage transparent communication regarding where one's SIA model is applicable and where it is not, as well as specifying which aspects of SIA aspects have been included in a model. This practice would enable reviews and frameworks to better accumulate the patterns of formalisation to learn from each other.

2. Focusing on the frontiers in social identity modelling.

- 5.5** The emergence of new social identities. We encourage the exploration of how people begin to identify as group members, especially when those people were not previously part of the group or were part of a different group. What process does that person go through to become a group member, and what processes or changes do the group as a whole go through? The ability to formalise these processes would e.g., allow the modelling of migration, spontaneous group formation (e.g., during disasters, in ethnic conflicts), collaboration in new teams/groups, and the development of group dynamics as new members enter.
- 5.6** Modelling social identity dynamics as events unfold. Exploring how social identities become salient, how quickly they switch back and forth and the consequences of that (Vestergren et al. 2018) would allow for dynamic, transformative simulations of collective behaviour, and to test whether these processes are the same across different contexts such as during protests or emergencies. With this objective, one could use models to test theories or combine them with other (empirical) methods to advance these fundamental questions of what part of the self affects a person at a given moment.
- 5.7** Formalising and specifying the different ways a salient social identity affects behaviour. SIA focuses on how our group memberships may affect our behaviour when salient. However, most people do not behave in the same way, even if they feel part of a group at that moment. How this may work is a core question in (modelling) SIA. This is something that can serve as a building block relevant for any SIA model, but also a key role that can be played in further developing SIA theory.
- 5.8** Applying SIA models to address big societal challenges. For example, more attention to application in sustainability science, how to transform behaviour to be pro-environmental, or more broadly, whether and how can one globally engage in collective action as stewards of this planet, i.e., the scalability of our capacity to feel part of a group. Another societal challenge resides in the complexity of having multiple (overlapping) social identities (Roccas & Brewer 2007) that in these modern times reflect the large diversity of our societies (Vertovec 2007) in the context of inequality and discrimination using an intersectional lens (e.g., across gender and ethnicity).
- 5.9** Focusing on formalising unexplored aspects of SIA. Both the review (Scholz et al. 2023) and Figure 3 in this editorial highlight some key SIA elements and processes that have not yet received sufficient attention. For example, even though some models included salience and fit, they were mostly absent in the review and their application is still thinly spread. Another area of focus is social identification and the importance of a group to an individual changes. This is a theoretical and empirically relevant question that can be supported by approaching this (in combination) with a model.
- 5.10** While the gaps, challenges and hurdles became obvious, so too did the great potential and promising attempts at formalising SIA. We see this as a first step towards a sound integration of promising social and behavioural science theories in our models and cannot wait to take the next steps together with the social simulation community.

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Notes

¹Citation counts are data from Google Scholar.

²Many interdisciplinary journals identify their research domains as "other" or "engineering".

³Note it can be tricky to specifically define personal identity, in Spears (2011) words: "For example, as the sociologist Simmel (1955) noted, the same attributes that can define a group identity when shared with others (e.g., the left-wing group, the students, or the extroverts) can define individual identity in an interpersonal comparative context (e.g., unlike my sister, I am left-wing, a student, and an introvert)"

⁴Shared rules regarding how to think, feel and act within a social group. These can be descriptive (what group members do) and injunctive (what group members ought to do).

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