Agent-based Construction (a-b-c) Interviews: A Generative Case Study

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Abstract

We propose agent-based construction (a-b-c) interviews as a new research methodology specifically designed to expose patterns of reasoning about emergent phenomena and complex systems. In an a-b-c interview, the researcher acts as an active mediator between the participant and an agent-based modeling environment. As the participant describes the model, the researcher tries to write the corresponding code and probes the participant about his or her reasoning. In this paper, we present a generative case study in which an adult participant constructs a NetLogo model of aging with the help of a researcher. We conduct a preliminary grounded analysis of this case study and trace the evolution of the participant's model throughout the hour-long interview. Our findings show that the act of mediation between the participant and the agent-based modeling environment can potentially afford, at times even obligate, the researcher to continuously make on-the-fly hypotheses about the participant's thinking, present these hypotheses through writing the model's code, and get immediate feedback from the participant. Our findings also show that a-b-c interviews can potentially expose more fine-grained, spontaneous, and connected reasoning processes that cannot easily be studied through traditional task-based or verbal clinical interviews.

Keywords

agent-based modelling; complex systems; emergence; knowledge; reasoning; research methodologies; clinical interviews

Introduction

Many of the world's pressing issues can be conceptualized as *emergent phenomena*. That is, they are macro level observable patterns emerging from micro level interactions between numerous individual entities (Johnson, 2006; Mitchell, 2009; Wilensky, 2001). Some examples are climate change, migration, and epidemics (United Nations, 2016). Research suggests that learning about complex systems and developing relevant reasoning skills would greatly benefit those who engage with the world's pressing issues in any formal or informal manner such as democratic participation, personal choices, or policy making (e.g., NRC, 2012; Sterman, 1994). However, studies have shown that it is difficult for most people to make sense of emergent phenomena, and the complex systems such phenomena arise from, because they are non-linear, non-deterministic, decentralized, and multi-leveled (e.g., Chi, 2005; Wilensky and Resnick, 1999). More importantly, even though lots of research has been done, there is controversy about the nature of reasoning processes that cause such difficulties (e.g., Chi and Roscoe, 2002; Jacobson, 2001; Hmelo-silver, Marathe and Liu, 2007; Levy and Wilensky, 2008; Penner, 2000; Sengupta and Wilensky, 2011).

Almost all of the studies on reasoning about emergent phenomena and complex systems rely on clinical interviews focusing on relatively simple, well-understood emergent phenomena such as diffusion of liquids (Chi, 2005) or ants foraging for food (Jacobson, 2001). During a clinical interview, a participant is presented with tasks, cases, or verbal questions and is expected to produce verbal answers (Clement, 2000; Ginsburg, 1997). We argue that the expectation of verbal articulation might be a limiting factor when it comes to emergent phenomena because it may be too difficult to form coherent on-the-fly explanations about phenomena or systems that include many actors, interactions, levels, and stochasticity. It may be necessary to support participants with an infrastructure that helps offload some of the more difficult aspects such as randomness and hypothesis testing.

We propose a new research methodology that emerged from our previous research on learning and thinking about emergent phenomena through agent-based modeling (Aslan and Wilensky, 2016a; 2016b). We tentatively call this approach agent-based-construction (a-b-c) interviews. As the name suggests, a-b-c interviews ask for participants to construct an agent-based model of an emergent phenomenon. A-b-c interviews incorporate agent-based modeling because it has been shown to be a particularly powerful methodology in learning and reasoning about emergent phenomena (e.g., Klopfer, 2003; Wilensky, 2001; Wilensky and Reisman, 2006; Wilensky and Papert, 2010; Wilkerson-Jerde and Wilensky, 2015). We hypothesize that observing people's reasoning as they are trying to construct an emergent phenomenon through agent-based modeling can offer us insights that may otherwise not be possible through traditional clinical interviewing. We also hypothesize that a productive avenue would be for a researcher to act as an active mediator between the participant and the agent-based modeling environment. This way, it would be possible to work with participants who do not have any prior experience in computation or agent-based modeling. It would also enable the researcher to observe and model the participants' reasoning on a moment-by-moment basis (Sherin, Krakowski and and Lee, 2012).

In this paper, we attempt to formulate a working definition of a-b-c interviews through presenting a *generative case study* with an adult participant who constructed a model of aging with the help of a researcher over the course of an hour. We analyze the interaction between the participant, the researcher, and the agent-based modeling environment and reconstruct a timeline of the evolution of the participant's model. We discuss the results of our analysis and determine main features, as well as major challenges, of a-b-c interviews.

Theoretical underpinnings

Our proposal of a-b-c interviews as a research methodology is founded on two paradigm shifts in the way we study knowledge and reasoning, and two paradigm shifts in the way we make sense of the world around us: (1) the theory of constructivism, (2) the methodology of clinical interviewing, (3) the field of complex systems, and (4) the practice of agent-based modeling. We hypothesize that a fruitful way to study people's ways of reasoning about the world could be through studying their reasoning about emergent phenomena and complex systems, so we propose a new research methodology specifically designed for the intersection of these four paradigm shifts. In this section, we review each of these topics briefly and explain our reasoning on why they are important for our proposal.

We begin with the emergence of the theory of constructivism, which fundamentally changed our understanding of the nature of human knowledge and reasoning. Piaget (1972) and his colleagues successfully demonstrated that knowledge is not readily acquired from an outside source but is actively constructed by the learner. Underpinning our proposal are two specific theories that extend Piaget's theory of constructivism: (1) constructionism and (2) knowledge-in-pieces. Constructionism is a theory of learning that takes constructivism's connotations of "*learning as building knowledge structures*" and "*to know an object is to act on it*" (Piaget, 1972, p.20), and adds the idea that this "*happens especially felicitously in a context where the learner is consciously engaged in constructing a public entity*" (Papert, 1980; Papert and Harel, 1991). Knowledge-in-pieces (KiP), on the other hand, is a constructivist theory that builds on artificial intelligence researchers' attempts to model knowledge and learning (e.g., Anderson, 1983; Minsky, 1986; Newell and Simon, 1972). KiP challenges conventional notions of knowledge as monolithic self-contained structures and conceptualizes it as a loosely organized network of primitive elements that are activated spontaneously and continuously reconfigured as the reasoning process is happening (diSessa, 1993).

The second paradigm shift is the methodology of clinical interviewing, which was invented by Piaget in the process of developing his theory of constructivism (Ginsburg, 1997). In contrast to standardized tests, which cannot go beyond behavioral manifestations of knowledge in pre-determined boundaries, clinical interviews give researchers the freedom to design object manipulation tasks, ask clarification questions, make on-the-spot hypotheses about subjects' reasoning, and test these hypotheses with follow-up questions. Thanks to these strengths, clinical interviews provide opportunities to study more naturalistic forms of reasoning and to uncover hidden structures and processes (Clement, 2000; Ginsburg, 1997). Even though the original clinical interviews conducted by Piaget and his colleagues were mostly based on simple tasks for children, the methodology has evolved considerably over the years and became more reliant on verbal question-answer sequences. In addition, researchers have shown that participants' reasoning about a subject may evolve and even develop further during the course of a clinical interview (Sherin, Krakowski and Lee, 2012).

The third paradigm shift that we incorporate in our proposal is the emergence of the field of complex systems due to the way it dramatically changed our understanding of the world around us (Bar-Yam, 2004; Mitchell, 2009; Waldrop, 1993; Wilensky, 2001). A complex system is defined as "a group or organization which is made up of many interacting parts" (Mitchell and Newman, 2001, p. 1). Our lives are embedded in many complex systems such as the internet, economies, the brain, ecosystems, the weather and the immune system. Within these systems, many simple entities — often called components or agents — organize themselves without any central controller and the interactions between them result in a "collective whole that creates patterns, uses information, and, in some cases, evolves and learns" (Mitchell, 2009, p.4). The macro-level patterns which arise out of micro-level interactions between the parts of complex systems are called *emergent phenomena* (Wilensky, 2001). As a result, many real-world phenomena are non-linear, non-deterministic, stochastic and multi-leveled (Mitchell, 2009; Wilensky, 2001; 2003).

Lastly, agent-based modeling (Epstein, 2006; Wilensky & Rand, 2014) is a practice that emerged from the field of complex systems that "makes use of simple computational rules as the fundamental modeling elements" (Wilensky and Papert, 2010, p. 7) Hence, it is a paradigm shift from traditional aggregate-level models that are built using methods such as linear algebra or differential equations. The main reason that makes agent-based modeling compelling for our proposal is the fact that it offers a better epistemological match to our intuitive notions of *parts* that make up complex systems as distinct individuals or entities instead of aggregate populations (Wilensky and Papert, 2010). Thus, it is possible to teach the basics of agent-based modeling to a research participant and have them describe a real-world phenomenon through characteristics of entities such as people, organizations, or objects. In our initial formulation of the `a-b-c interviews`, we use the NetLogo agent-based modeling environment (Wilensky, 1999) as the construction tool because is the most widely used agent-based modeling environment and it has its roots in both the field of complex systems and the field of learning sciences (Wilensky, 1999; 2001). It is a direct descendant of the Logo programming language (Papert, 1980) and it is designed to be a "low threshold, high ceiling" programming environment. Research has shown that students as young as in upper elementary school level can learn to develop models (e.g., Wilensky, 2003), but it is also used by professional scientists in cutting edge research (e.g., Maroulis et al., 2010; Pumain and Reuillon, 2017).

We argue that, much like the wood blocks used in Piagetian interviews on conservation of volume (Piaget, Inhelder and Szeminska, 1960), agent-based modeling offers material affordances that match well with real world phenomena. Actively constructing an agent-based model would require a participant to explicitly think about the constituents of an emergent phenomenon, making it possible to observe the participants' reasoning processes at more fine-grained levels as they unfold over the course of an interview. Being an active mediator between the participant and the agent-based modeling environment enables researchers to work with non-programmer participants on complex phenomena through an active dialogue that involves making and testing on-the fly hypotheses about the participant's reasoning.

A generative case study

In this section, we present a preliminary form of an a-b-c `interview as` a *generative case study* (Clement, 2000). The data presented here is taken from a previous study that was designed as an intervention to introduce the basics of agent-based modeling to adults with no prior experience in computational practices, and then help them develop a NetLogo model with the specific goal of exploring the effects of such an experience on their reasoning about stochastic phenomena. The intervention consisted of three one-on-one meetings with each participant. In the first meeting, the participant was shown the basics of the NetLogo agent-based modeling environment. In the second and third meetings, a researcher helped each participant develop a model of a real-world issue of their choice. The participant described the model he or she wanted to develop and the researcher wrote the corresponding NetLogo code.

As we were analyzing the video data from this study, we came to notice the rich interaction between the researcher and the participants during the model construction process and decided to recalibrate our focus on the ideas presented in this paper. The case study shared in this section is one such interview conducted with **Karina** (pseudonym), who works as a special education paraprofessional in a public school in a large city in the U.S. We chose this case because it captures a single-meeting that starts with Karina expressing her idea and ending with her being satisfied with the model she developed with the help of the researcher.

Methodology

The interview with Karina lasted 50 minutes and 7 seconds and it is recorded in video. We analyzed the video by watching it through a qualitative video analysis software and marking instances in the video during which the participant was actively talking. We discarded in-between instances during which the researcher either just worked on writing the NetLogo code or explained how the code works to the participant. After this initial round of data reduction, we ended up with 22 short episodes. Out of these 22, we determined 9 of them as *main episodes* for the purposes of this paper. Then, we transcribed and analyzed each episode in detail by marking the parts of transcripts that highlighted Karina's reasoning. Finally, we built textual and visual representations of Karina's model for each episode (i.e., Sherin, Krakowski and Lee, 2012). We are going to present transcripts from these 9 episodes with visual snapshots of the NetLogo model, as well as our visual reconstruction of her model.

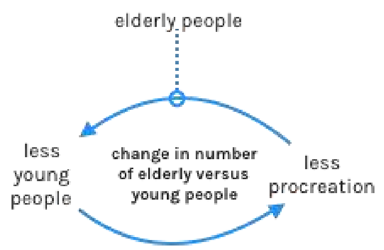
The topic of the interview: population decline

The emergent phenomenon presented in this section is chosen by the participant herself. Before the interview, she mentioned to the researcher that she read some news about declining populations in Japanese villages and she wanted to build a model of this issue. Population decline, or ageing, is listed as one of 18 global issues that "*transcend national boundaries and cannot be resolved by any one country acting alone*" by the United Nations (2016). It exhibits itself in many levels of the society and it is a constant headline in news, especially in developed countries, due to its implications for global economy in terms of workforce and health care systems (e.g., Anderson and Hussey, 2000; Rowe et al., 2016). It is a very suitable topic for the purposes of this paper because it is an emergent phenomenon embedded in greater complex systems in various levels such as local populations, global economies and healthcare systems.

Karina's model of population decline

The interview starts with Karina telling the researcher that she wants to work on a completely new idea that she came up with after coming across a story about the issue of ageing in Japanese villages in the news. The researcher welcomes her decision and asks her to articulate her idea on the record (see Table 1). She briefly talks about her idea and stops. The NetLogo model shown in Table 1 only contains two conventional buttons, *setup* and *go*, but no code.

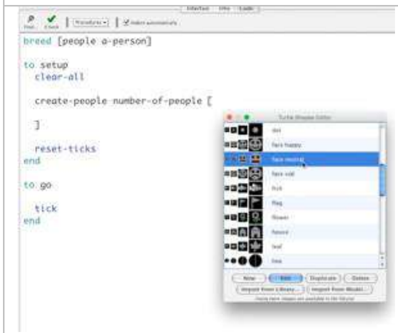
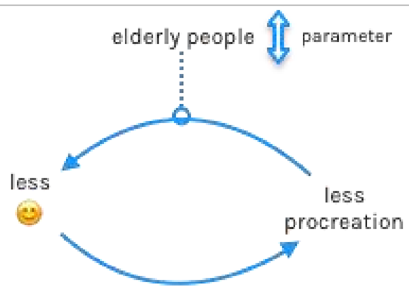
Table 1. Karina's description of her original idea

Screenshot	Transcript	Diagram model
	(K)arina: So, the idea is based on a fact, which is, in Japan 40% of the population is over 60 years old if I'm not mistaken. So, they are coming across, umm, they are experiencing, what, what's my word? what did I say? I don't, I can't remember …	

	(R)esearcher: Deaths and child birth and aging … K: Well, that the population is, no-one there *will be*, the percentage of young people is less, *therefore* there is a lot less people procreating. So, in *some instances* villages are dying out because of the, umm, big number of elderly versus young people and so for example, umm, a village of 300 is now down to 30 *because of* such a high population of old people.	

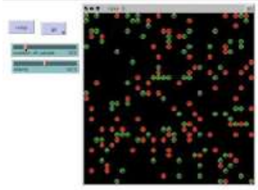
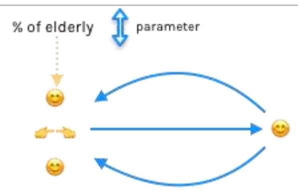
After Karina's initial explanation, the researcher proceeds to create a simple model in which there are old people and young people. He stops before creating any people in the model and asks Karina about how to visualize people in her model. As seen in Table 2, this question prompts Karina on not only deciding how the people in the model should look like but also talk about actual agent behavior. She also briefly mentions how she wants to be able to manipulate this model. We update our visual and textual representation of her model accordingly.

Table 2. Karina's first description of the agents

Screenshot	Transcript	Diagram model
	R: So, the turtle shapes, which one do you prefer for people? K: The people, oh, the old people *should be* unhappy. R: Old people should be unhappy? OK. K: Yeah, **just because they can't, yeah, sad face.** Just for the fun of it (laughs). R: Let's start with the natural face, …,no no no, but they will get older maybe. Or are we gonna just put older people initially and leave it like that? Or do you wanna create people like young ages, get them older, make them reproduce? Stuff like that? K: My idea was, **increase and decrease the number of old people and how that *affects* the population.** R: Oh, I see. So, then people will be old and young, right? K: Yes. Well, old people will be considered people that can't have kids, obviously. Or they are not reproducing.	

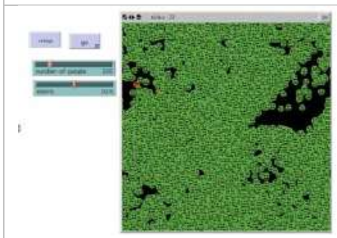
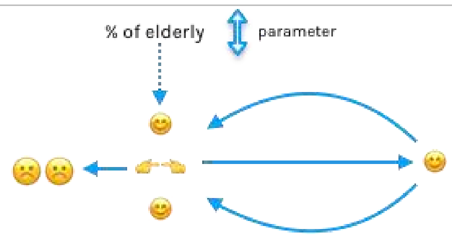
Once again, the researcher proceeds to write the code that, he thinks, will produce the model that reflects *the model in Karina's mind*. He adds a `number-of-people` slider to the interface that determines the size of the population's village and an `elderly` slider that determines what percentage of this village is elderly people. When the `setup` button is clicked, the people of the model are created. Each person is designated as either young or old and then they are placed on random locations in the model's twodimensional world. Once he finishes writing this code, the researcher clicks the `setup` button and asks Karina what she wants to do next. Table 3 shows Karina's response to this question.

Table 3. Karina's first description of agent behaviour

Screenshot	Transcript	Diagram model
	R: OK. So, I have these people, they are in random places. They are the residents of this village. Umm, what's next? What are these people gonna do? K: Well, I'm assuming, umm, that's what I'm trying to wrap my head around. Umm. I guess **if two people meet, they are gonna reproduce one person.** And then, then now I'm thinking, yeah, we'll start there.	

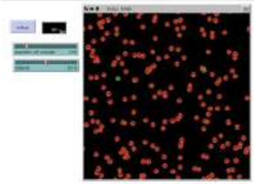
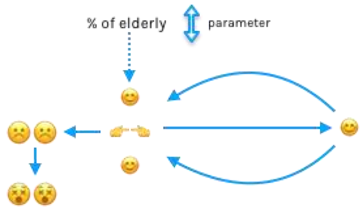
After hearing Karina's idea, the researcher starts writing the code so that each person continuously moves around randomly. When two young people touch each other, they produce a new young person. Once he writes this code and shows it to Karina, they run the model and notice that the number of young people grows exponentially in a very short time. In Table 4, Karina reacts to this outcome and notices that the model is not complete. She adds that she wants the parents to become immediately old when they make a baby.

Table 4. Karina's update of agent behavior

Screenshot	Transcript	Diagram model
	R: Let's see if this works, … oh yeah … K: Wait, **what about my old people?** R: They are, they are in there but we are making so many babies randomly … K: (laughs) … R: Maybe we should like decrease the … K: So, my thing is now, **now the green people, the parents should be old now!** R: They should be gr, oh, wha? … K: When they make one baby, yeah, let's just, yeah.	

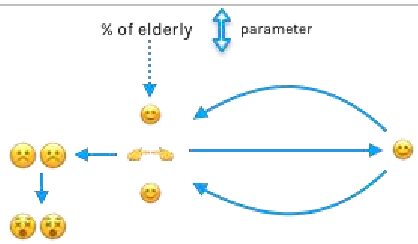
Once the researcher modifies the code accordingly, they run the model and they see that the number of young people decrease very quickly but the number of elderly people keeps increasing. Here, Karina thinks the outcome is interesting but her reaction indicates that she is not content with her model yet. The researcher senses her hesitation and asks her to elaborate. She hesitantly deliberates on whether the old people in the model should eventually die and what would be the implications of such an addition on the size of the village

Table 5. Karina's further updates of agent behavior

Screenshot	Transcript	Diagram model
	K: I think it is interesting still, to see … R: Yeah, almost everybody is old red, yeah … K: **But** … R: No, say it. K: I was just gonna say, **not that it would affect our findings**, but **the old people have to [expletive] die** … R: Wanna do that? K: But that doesn't really matter, you know what I'm saying? R: Yeah! They just turn red and they cannot reproduce again. K: Right, exactly. **But what does it tell about the size of the village?** Do you know what I'm saying? R: Yeah! Do you wanna do that? K: (Nods approvingly).	

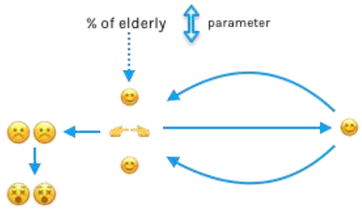
After this change, the researcher runs the model and Karina expresses excitement with the model because everyone dies. This point is marked as the completion of her initial model.

Table 6. Karina's reaction to the first completed version

Screenshot	Transcript	Diagram model
	R: Let's see … So? K: [expletive]! Everyone's [expletive] oh damn! Look at that!	

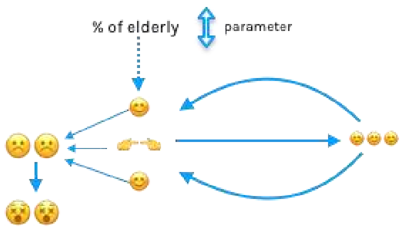
After the addition of the mechanism of death, they run the model again and Karina now displays excitement about her model. The researcher probes her about the model's outcomes. He also intervenes with his own ideas. He first suggests adding a plot that shows the number of all the people in the village and also the number of elderly over time. When they add this plot and run the model, they see that the percentage stays relatively stable even though the village continuously declines and eventually dies. The researcher probes her about this outcome. She asks to change the model in a way that young people may get old even if they never made babies. The researcher intervenes and suggests adding the possibility of making more than one baby, too. When the researcher asks this question, Karina decides that she wants each family to have between 1 to 3 kids.

Table 7. Researcher's intervention with his ideas

Screenshot	Transcript	Diagram model
	K: I think it is interesting still, to see … R: I don't know what to make of this because the difference between the elderly and, didn't change much. K: Yeah. R: There was always similar proportion of elderly and young people. K: Hmm, but then the young people don't stay, they can't go on forever until they make a partner, until they meet a partner, right? **Young people also die!** R: Yeah. Young people, if they make just one baby they die out. K: Right. That's the only reason why they die. They don't die because of natural causes. R: (Nods) They turn to old and they die. I think we should also add the more than one baby thing here … K: Yeah, yeah, yeah. R: Because it's like, **of course this is gonna die because they don't make more than one baby**, so like they keep decreasing. K: Yeah, yeah, yeah. OK!	

The idea of having multiple babies in `Episode 7` causes confusion between the researcher and Karina, probably due to the fact that the researcher introduced the idea himself. `Episode 8` starts when the researcher implements a mechanism for multiple babies. Karina pushes back because she wants to know how this model works. Once the researcher explains how the current version of the model works, she realizes that the model does not do what was on her mind and explains exactly how she wants the model to work. Even more, she explains why she wants the model to work that way.

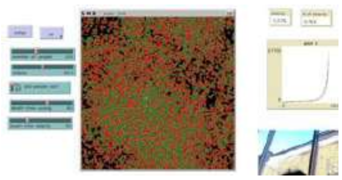
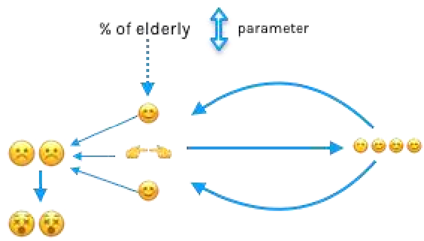
Table 8. Karina's first implementation of the idea of fertility rate

Screenshot	Transcript	Diagram model
	R: So, we, we give them some initial fertility. You know what that means? K: OK. But, but, how many babies can be made after the initial interaction? Is there a range or are they all automatic? OK there is a … R: Yeah. Right now, every single time I create a person, I give them a baby count. So, I have 3, you have 2, and after making 2 babies you turn old, after making 3 babies I turn old. K: Oh! I see. R: Minimum is 1, maximum is 3 and it's random. K: OK. I see. But I guess, I guess what I'm saying is, from you with, you and I	

	reproduce, how many babies are we gonna have? R: Just one. Every single time … K: Oh! See, that's where, that's where I wasn't wrapping my head. **I wanted it to be where they can either make 1 baby to 3 baby, the family size.** R: Ah! That's so much better!!! K: Yeah. Because I'm thinking 3, because 3 is like the average in US.	

In the final episode of the interview, the researcher and Karina run the version of the model where each pair of parents procreate either 1 or 2 or 3 young people randomly and then turn to old people, as well as some young people eventually becoming old even if they cannot find a partner to make babies. When they run this version of the model, they notice that the population grows exponentially. Once again, Karina probes the researcher about the way the model works. She asks whether a couple can have 0 babies. When she realizes that it is not the case, she tells the researcher that she actually wanted some couples to have 0 babies because there are "some sterile people". After this episode, Karina was satisfied with the model and the interview ended.

Table 9. Karina's reaction to the first completed version

Screenshot	Transcript	Diagram model
	Researcher: It goes crazy. Karina: And they can have 0 babies, right? Researcher: No! Karina: **Yeah, they can have 0 babies, too!** Researcher: Let's make it … Karina: I thought that's what we have said, Umit! [expletive]! …. Researcher: Let's do … Karina: Because I mean there is some people that are sterile. Researcher: Yeah. So, …, this time the population died out. Let's make it 200, maybe … Now it is like, interesting, … Karina: (yelling) I'm [expletive] smart!!! When am I gonna get accepted to U of C, (yelling) when? (laughs)	

Discussion

Although it was an early form of `a-b-c interviews`, this case study provides us valuable insights to hypothesize about the main features of `a-b-c interviews`, as well as the major challenges in conducting such interviews systematically. We summarize our preliminary findings in two arguments: (1) the interaction between Karina, the researcher and the model afforded us to observe patterns in Karina's reasoning about this emergent phenomenon that may not have been possible through asking only verbal questions, (2) the interview highlighted a reasoning process that resembles models or mini theories that Karina constructed on the fly and continuously reconfigured drawing on many smaller pieces of her knowledge from many different contexts and levels. We also discuss the researcher's moves as an interviewer in two arguments (1) the researcher's active participation ended up problematizing the validity of the findings but also provoked fruitful reasoning as seen in episodes 6 through 8, (2) the researcher failed in taking full advantage of Karina's model in probing her to elaborate her reasoning in greater detail.

Karina’s reasoning

Episode 1 starts with Karina explaining the phenomenon she chose to model: the decline of the population in Japanese villages. Within itself, this episode resembles a short verbal interview with her. She mentions a positive feedback loop mechanism when she says "*therefore there is a lot less people procreating*", brings up two variables when she utters "*the number of elderly versus young people*", and finally speculates on the cause of this emergent phenomenon with her utterance "*because of such a high population of old people*". As the interview proceeds, we observe Karina develop a more and more sophisticated model. She first adds a mechanism for procreation and then adds a mechanism for aging, both through definitions of how young people behave and how old people behave. She also describes how she envisions using the model by "*increasing and decreasing the number of old people and how that affects the population*". Her reasoning goes beyond a simple causal relationship between the percentage of elderly people and her final model incorporates the idea of *fertility rate* as the major factor, although rather accidentally and implicitly. We argue that without the construction element of the interview, we would not have been able to observe her reasoning about the individuals that make up this complex system and we could have even concluded that she holds misconceptions (or naive theories) about the phenomenon of population decline such as assuming deterministic mechanisms (Wilensky and Resnick, 1999).

Constructing an agent-based model with her enables exposition of her reasoning about an emergent phenomenon at a fine-grained level including some less salient ideas. For instance, we notice that she draws from a number of ideas from her personal knowledge about how people behave and how people procreate. Even though she is specifically thinking about the population of a Japanese village, she justifies her design decisions based on ideas from various resources in various levels such as making old people look like *sad faces* because "*they can't*" procreate, making families have up to 3 babies because "*it is the US average*", and making it possible for some families to have no babies because "*some people are sterile*". Taken together, these episodes show us that she is not just throwing random ideas at the model. Quite the contrary, she has a specific explanation for each of her modeling decisions.

Lastly, her modeling decisions expose a non-monolithic reasoning process about this emergent phenomenon. For example, she decides to make the model so that "*two people produce only one baby and immediately get old*" but with the caution that this is only where she wants to "*start from*". We see another such instance in Episode 4, when she hesitates whether the old people in the model should eventually die or not. In both cases, we see her bringing together many pieces of her knowledge about people, aging and procreation, but also having difficulty in figuring out how all these pieces fit together when it comes to population decline. This finding is consistent with diSessa’s (1993) knowledge-in-pieces theory, but we are cautious about such straightforward associations because we do not have any data that could highlight the exact nature of this process, and further research needs to be conducted.

Researcher moves

We notice a number of potentially problematic interventions from the researcher throughout the interview. This is mainly due to the fact that his goal was not to interview Karina but to help her create a NetLogo model. The first of these interventions come at the very beginning of the interview. When Karina asks the researcher to remind her of what she said about population decline, the researcher mentions "*deaths and child birth and aging*". We observe all these ideas in Karina's utterances in the following episodes. It seems like Karina does not immediately pick up these ideas and keeps talking about her original idea but it is still unclear whether the researcher's move implicitly impacted Karina's reasoning. Hence, a potential argument against the validity of our preliminary findings would be that such moves might have led her towards specific ideas. We acknowledge that this is a *major* challenge in conducting `a-b-c interviews`; much attention must be paid to prevent the interview from turning into a teaching intervention. On the other hand, we argue that it is important to position the researcher as an active mediator not only because the participant is assumed to be a novice in agent-based modeling, but also because the researcher attempts to model the participant's reasoning through writing the model's code and gets immediate feedback from the participant. This is a direct extension of a major strength of clinical interviews; the researcher is expected to formulate on-the-fly hypotheses based on the participants' responses and ask follow-up questions (Ginsburg, 1997).

In this specific case study, the researcher's interventions also end up triggering `fruitful episodes` that, we argue, may not have happened otherwise. Such an intervention happens in Episode 6, when Karina brings up the idea to make young people old after some time. The researcher suggests adding an initial mechanism of *"multiple babies"* and she agrees. However, instead of probing Karina on how to implement this idea in the model, the researcher proceeds to implement his own mechanism, which ends up being quite different from what was in Karina's mind. She eventually catches the researcher's intervention and forces the researcher to correct the model. This episode affords us to notice that Karina wants to configure procreation in her model as a process that only happens in monogamous families. This observation may or may not reflect her actual reasoning but `implies` that she assumes other possibilities as negligible. Unfortunately, the researcher does not ask follow-up questions about such important points. This brings us to our last point that the researcher's moves fail in asking Karina questions that probe her to elaborate her ideas in greater detail. We end up not being able to certainly assert whether she actually changed her focus from the percentage of elderly to fertility rate. We also cannot know whether she left out some factors, such as polygamy, nutrition and migrations, deliberately or she did not think of those.

Concluding Remarks

It has been shown that people, young and old, struggle greatly in making sense of emergent phenomena (Chi, 2005; Wilensky and Resnick, 1999) although our lives are embedded in such phenomena in many levels (Mitchell, 2009; Wilensky, 2001). Agent-based modeling has been shown to be effective at progressing learners in their understanding about emergent phenomena (Wilensky, 2003; Wilensky and Reisman, 2006). We proposed a new research methodology, tentatively named agent-based construction (a-b-c) interviews, specifically to study people's reasoning of emergent phenomena and complex systems. We situated our methodology at the intersection of four major paradigm shifts: (1) the theory of constructivism (Piaget, 1972), (2) the methodology of clinical interviews (Ginsburg, 1997), (3) the field of complex systems (Mitchell, 2009), and (4) the practice of agent-based modeling (Wilensky, 2001). We then presented a generative case study, which was originally designed as an intervention, but offered a first glimpse on potential affordances and challenges of a-b-c interviews. In the case study, an adult participant, Karina, described a model of aging in a Japanese village and the researcher wrote the code for her. We argued that the interaction between Karina and the researcher exposed complex, spontaneous patterns of reasoning, which could not have been observed through verbal questions or simple tasks such as drawings. We also argued that the main challenge of a-b-c interviews is also the main strength of them. The act of mediating is simply the act of hypothesizing about the participant's reasoning, much like traditional clinical interviews (Ginsburg, 1997), but testing these hypotheses through writing the code and getting feedback from the participant instead of only asking verbal questions. Yet, if not done carefully, this can easily evolve into intervening rather than mediating. We end this paper by offering a very first working definition: a-b-c interviews are a special class of clinical interviews that are conducted through an open-ended agent-based modeling task that is actively mediated by a researcher.

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