Modeling the Movement of Beliefs: Understanding Epistemic Bubbles and Echo Chambers

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In our current society, the gathering of knowledge and information is a very social matter. We constantly rely on information that we get through other people, and others have to rely on us. This reliance on each other is very useful: I do not have to become a doctor myself to get the right treatment if I am ill, and I can get information about the state of the world from reading a newspaper, which I then discuss with my friends who do not read newspapers. Scientists can build on the findings of other scientists, and in turn share their own results that can again be used by others again. In this sense, we can think of our society as a network[1] of people and organizations in which beliefs and information are exchanged with the ones we interact with.

However, being part of such a network can also make us vulnerable. Maybe the newspaper I read is only highlighting a single side of the story, or is even providing me with fake information. The philosophical field of social epistemology analyzes how our reliance on others influences (or should influence) our knowledge gathering.[2] This field has traditionally focused on single person-to-person testimonies, but there is increasing interest in how network-wide properties and constructs influence our knowledge gathering process.[3] In other words, there is an increasing interest in how beliefs move through networks of people.

Two social epistemological constructs that have seen a sharp rise in academic interest in the past decade, especially since Brexit and the electoral victory of Donald Trump in 2016, are the concepts

[1] Or a set of networks.
[2] O'Connor, Goldberg, and Goldman, "Social Epistemology."
[3] Sullivan et al. "Vulnerability," 732.

of 'epistemic bubbles'[4] and 'echo chambers' (hereafter also named 'bubbles' and 'chambers,' respectively).[5] This interest has transcended the field of social epistemology, and can also be found in other scientific domains like sociology and communication sciences.[6] There have been multiple papers mentioning one of these concepts in relation to polarization,[7] fake news and misinformation,[8] or the so called 'post-truth' era.[9]

While the interest in bubbles and chambers has peaked in recent years, consensus on what these concepts actually mean is missing. Systematic reviews show that bubbles and chambers have been defined and researched in many different ways (sometimes even without clearly specifying the concept),[10] leading to inconsistent and sometimes incomparable findings.[11] This inconsistency is also present in literature analyzing the effect of digitalization on bubbles and chambers.[12] One author has even called bubbles and chambers "the dumbest metaphor on the internet," while also pointing to the lack of a clear definition of these terms.[13]

Responding to this lack of consistency, philosopher C. Thi Nguyen has given a very influential clarification of both bubbles and chambers in which he advocates for a clear distinction between the terms. In short, Nguyen argues that epistemic bubbles are based on exposure to relevant sources, while echo chambers are based on trust.[14] He argues that people sometimes even end up in echo chambers through no fault of their own, but rather due to the network they are part of and their place in it.[15] Epistemic bubbles

[4] Including the related term 'filter bubbles.'
[5] Mahmoudi, Jemielniak, and Ciechanowski, "Online Social Networks," 9597.
[6] Arguedas et al., "Literature Review"; Mønsted and Lehmann, "Vaccine Discourse."
[7] Munroe, "Echo Chambers, Polarization, and 'Post-Truth'"; Arguedas et al., "Literature Review," 13.
[8] Mønsted and Lehmann, "Vaccine Discourse," 8–9.
[9] Lewandowsky, Ecker, and Cook, "Beyond Misinformation," 359.
[10] Mahmoudi, Jemielniak, and Ciechanowski, "Online Social Networks," 9600.
[11] Mahmoudi, Jemielniak, and Ciechanowski, "Online Social Networks"; Hartmann et al., "Systematic Review," 35.
[12] Mahmoudi, Jemielniak, and Ciechanowski, "Online Social Networks," 9595.
[13] Bruns, "Technology, Stupid," 8.
[14] Nguyen, "Echo Chambers," 146.
[15] *Id.*, 154.

and echo chambers are thus phenomena that are inherently social and network-related. However, while Nguyen does argue that we should look at these constructs as network problems,[16] his example-based approach impedes a more generalizable understanding of these terms and how these might be analyzed in a more systematic and network-based manner.

Analyzing the movement of beliefs on a system-based level is the domain of 'network epistemology'. Researchers in this field use models to simulate the movement of beliefs and knowledge through a network,[17] analyzing how certain factors or behaviors can influence such groups of people at large. I argue that the field of network epistemology can function as a bridge between social empirical research and 'armchair philosophy' in bettering our understanding of concepts like epistemic bubbles and echo chambers. In this article, I will therefore use insights from the field of network epistemology to expand on Nguyen's argument that people do not have to be irrational to end up in echo chambers, and to show how digitalization could possibly impact the prevalence of echo chambers separately from the prevalence of epistemic bubbles.

Bubbles vs. Chambers

According to Nguyen's influential characterization, an 'epistemic bubble' (or a 'filter bubble' if we are referring to the digital version) is "a social epistemic structure in which other relevant voices have been left out, perhaps accidentally."[18] These structures are ubiquitous and can form through the normal processes of finding friends and community. According to Nguyen, people often interact with others that are similar to them, for example in ideology. This can lead to a biased or incomplete set of information that gets shared within this network of similar-minded people.[19] The author argues that there is a lack of 'coverage reliability' in epistemic bubbles, which is "the completeness of relevant testimony from across one's whole epistemic community."[20] This lack of coverage reliability does

[16] *Id.*, 143.
[17] Weisberg, "Formal Epistemology."
[18] Nguyen, "Echo Chambers," 141.
[19] *Id.*, 143–44.
[20] *Id.*, 143.

not necessarily have anything to do with any of the single individuals in it: instead, Nguyen argues, coverage reliability should be seen as a network problem, which arises because of poor connectivity to other relevant sources. In these bubbles, therefore, relevant voices are thus "excluded by omission."[21]

At first glance, 'echo chambers' might seem similar to epistemic bubbles. Just like epistemic bubbles, echo chambers are (problematic) social epistemic structures in which certain voices and knowledge are excluded. But while this happens in a bubble through (unintentional) exclusion by omission, in an echo chamber this exclusion happens through the active discrediting and undermining of other voices and sources.[22] According to Nguyen, echo chambers lead their members to actively distrust all sources outside of their specific epistemic community, making them exclude information that is not in line with the beliefs in the echo chamber.[23] Echo chamber members are thus not necessarily isolated from other information flows, like in epistemic bubbles: rather, they are isolated "credentially," in that they only *trust* and take up information that fits their beliefs.[24] In this conceptualization, echo chambers and epistemic bubbles can thus theoretically exist completely separate from each other, even though they might often overlap in practice.[25]

Of course, it is not always bad to distrust or exclude certain sources. Sometimes, this is even necessary in contemporary society since, as Nguyen puts it, "the world is overstuffed with supposed sources of information, many of them terrible."[26] Moreover, we live in a hyper-specialized world, in which it is impossible to be an expert on more than a fraction of all the knowledge out there.[27] Nguyen argues that both the mechanisms of bubbles and chambers in this sense "function parasitically" on what are in moderation healthy epistemic practices of knowledge selection.[28]

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[21] *Ibid.*
[22] *Id.*, 146.
[23] *Ibid.*
[24] *Id.*, 147.
[25] *Id.*, 142.
[26] *Id.*, 143.
[27] *Id.*, 148.
[28] *Id.*, 149.

Nguyen points out that this perversion of healthy epistemic practices can, in the case of an echo chamber, even result in a situation in which a person gets trapped in an echo chamber.[29] This means that such a person could act 'epistemically virtuous' (meaning that they for example actively try to acquire new information and then critically assess this information against earlier acquired knowledge), but still reach the conclusion that all the information from outside sources is false.[30] This is because the discrediting mechanisms of echo chambers led them to have beliefs that include the (false) idea that all outsiders try to mislead them and are untrustworthy. In this sense, echo chambers "convert individually epistemically virtuous activity into collective epistemic vice."[31] This mechanism is not present in the same way in epistemic bubbles, because bubbles are only based on exposure mechanisms, not on mechanisms related to trust.

As an example of such a situation where a person might act epistemically virtuous but still remains trapped in an echo chamber, Nguyen discusses the case of someone being born and raised in one.[32] The author makes the assumption that it is epistemically reasonable for a child to trust their parents, and I agree with him. In this case, the earliest epistemic contacts of such a child are members of an echo chamber, who teach the child that the only sources of information that can be trusted are the other people within this specific chamber and that 'outside' sources with a different opinion are only trying to mislead them. Even if this child would later, as a teenager or grownup, act in the epistemically virtuous ways stated earlier, they could still remain trapped in the echo chamber due to its discrediting mechanisms.[33]

Nguyen argues that there are "many cases" like these in which a person might be epistemically blameless for ending up in an echo chamber.[34] However, the only case he discusses is this example. The problem is that the example of an 'echo chamber child' is highly

[29] *Id.*, 143.
[30] *Id.*, 155.
[31] *Ibid.*
[32] *Id.*, 154–55.
[33] *Ibid.*
[34] *Id.*, 154.

specific, and due to its dependence on highly specific circumstances it does not provide an explanation for people ending up in echo chambers later in life, even though this group could be expected to be a much bigger part of the echo chamber population. In some other instances, Nguyen even mentions irrational behavior and epistemic vices like conformity as reasons for a person to end up in such a chamber,[35] while resorting to vices and irrationality is exactly the kind of individual-oriented explanation the author is trying to move away from.

Gaps like the one discussed above show that Nguyen's conceptualization is in need of some more generally applicable explanations of how we can understand bubbles and chambers as network-based problems. The question that remains is thus: Can we identify more generally applicable factors that explain how people can end up in echo chambers, without resorting to individual irrational behavior? Answering this question is exactly what the field of network epistemology can help us with. To be able to do so, I will first briefly explain the workings of epistemic network models in the next section.

Network Epistemology

Network epistemologists use models to simulate the movement of beliefs and knowledge through a network. It is a formal approach used in social epistemology, in which (mathematical) models are created that represent 'agents' (e.g. persons, companies, or an organization) and their relationships to each other.[36] The goal of network epistemologists is to explore how certain factors of interest could potentially impact the spread of information on a system-based level.[37] With the use of epistemic network modeling, two things can be analyzed: one, how the *structure of a network* influences belief spreading and two, how certain *behaviors and/or rules* influence belief spreading.

[35] *Ibid.*
[36] Weisberg, "Formal Epistemology."
[37] O'Connor, Goldberg, and Goldman, "Social Epistemology."

Figure 1 is a (simplified) example of an epistemological network. The nodes represent the agents in the network and the lines represent the connections between the agents. An agent can have multiple 'neighbors,' which are the other agents they are directly linked to. By communicating to their neighbors, beliefs are spread across the network.

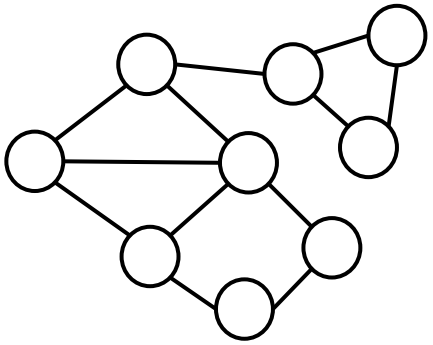

Figure 1: A simple random network model. The circles represent agents, the lines represent connections between agents.

Epistemic network models are often run as computer simulations.[38] In most models, agents are attributed a certain degree of belief (credence) about a proposition *p,* for example whether the agents believe that eating apples is good for your health. This credence can range between 0 (absolutely certain that not-*p*) and 1 (absolutely certain that *p*). A *run* of a model consists of a certain number of timesteps in which the model's dynamic is executed in each step.[39] In these steps, the agents communicate and exchange evidence, arguments or beliefs according to the setup of the model. After communicating with their neighbors, agents then update their credence about *p.* This communication and belief updating is repeated a certain number of times. A model is often run thousands of times with slightly different starting conditions, after which the results of these runs are statistically analyzed.[40]

Depending on the research, certain rules are added to the model, such as rules regarding how information is shared with

[38] Weisberg, "Formal Epistemology."
[39] Singer et al., "Epistemic Networks," 137.
[40] *Ibid.*

neighbors in the model. Sometimes, agents are built to simulate 'doing research' themselves, meaning that they acquire certain information about the true state of p in the model.[41] If we use our apple-example, agents might be thought of to have asked ten people to eat an apple each morning and count the number of people who feel fitter. Such results are then shared with their neighbors in the network (see fig. 2 for an example).[42] Another important example for this current article of a possible extra rule is the addition of a factor representing how much an agent trusts other agents.[43]

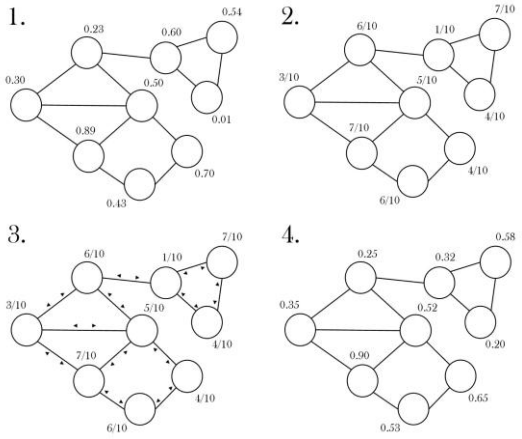

Figure 2: Example of a model run with 'testing', where agents test how many out of ten times a hypothesis yields a positive result (2). These results are shared by the agents with their neighbors (3) and used for belief updating (4)

A big focus in the field of network epistemology lies in analyzing factors leading to polarization.[44] This research is often not explicitly linked to the concepts of bubbles and chambers,[45] but their

[41] O'Connor and Weatherall, "Scientific Polarization."
[42] Variations of this mechanism have been used or discussed by e.g. O'Connor and Weatherall, "Scientific Polarization," 862; O'Connor and Weatherall, *The Misinformation Age,* 62; Hahn, Merdes, and Von Sydow, "Social Networks," 4.
[43] O'Connor and Weatherall, "Scientific Polarization," 857; Hahn, Merdes, and Von Sydow, "Social Networks," 4; Olsson, "A Bayesian Simulation Model," 118.
[44] O'Connor and Weatherall, "Scientific Polarization"; Olsson, "A Bayesian Simulation Model."
[45] Two notable exceptions are Madsen, Bailey, and Pilditch, "Large Networks"; Hahn, Merdes, and Von Sydow, "Social Networks."

findings can still be very useful for our discussion because the mechanisms underlying this polarization can sometimes be linked to one of the mechanisms underlying bubbles and chambers. Recall that the main mechanism behind epistemic bubbles is a lack of exposure to relevant sources.[46] In network epistemology, exposure to sources is represented by the connections an agent has. If an agent is only linked to a few neighbors that have highly similar views while there are also other agents in the network that have different views, then the agent can be said to sit in an epistemic bubble. Echo chambers can be studied in network epistemology by focusing on *trust* between agents in a network, since chambers are based on a difference in trust between one's in-group and others. Research on polarization where trust-factors are added to the model can thus help us better understand echo chambers.[47]

The influence of trust

Let us now return to the question that has remained after Nguyen's contribution: Can we identify generally applicable factors that explain how people can end up in echo chambers, without resorting to individual irrational behavior? When looking at the literature in network epistemology, the answer to this question is overwhelmingly: yes. Multiple studies using rational agents found that their agents could end up in what are, arguably, echo chambers. Take the work on polarization by O'Connor and Weatherall, for example.[48] These researchers created a model that runs in a way that is similar to the one explained in the previous section, including agents that 'do research' themselves: the agents start of with an initial credence about *p* (or not-*p*),[49] test their own hypothesis about *p*, communicate their findings with their neighbors and then update their credence about *p* based on their own research and the findings they get from neighbors. All agents in the model are connected to all other agents, meaning that they are all exposed to all the available

[46] Nguyen, "Echo Chambers," 143.
[47] Perfors and Navarro, "Role of Trust."
[48] O'Connor and Weatherall, "Scientific Polarization."
[49] In their research, p or not-p was replaced with a preference for action A or B, but the mechanism remains the same.

information and none of them can accidentally get trapped in an epistemic bubble.

The researchers made one important change to this standard picture: they added a rule that simulates a heuristic of trust. In their model, the evidence an agent gets from others is treated as uncertain. How uncertain this evidence is considered is based on how distant the belief in *p* of this other agent is from their own belief. In other words, the more their neighbor's belief is different from their own, the more that evidence is distrusted and vice versa.

The authors found that with the addition of this rule, polarization is very likely to occur, meaning that one subgroup of the agents in the model ends up strongly believing the true belief that *p,* while another subgroup of agents is strongly holding the false belief that not-*p*.[50] Moreover, these subgroups end up only trusting the agents that have the same belief as them, and end up strongly distrusting the agents with the other belief.[51] In these models, there would thus arise a subgroup of agents that keeps holding on to a false belief that goes against the empirical evidence, completely distrusting all agents that do not have the same belief as them. In other words, in these simulations there would arise an echo chamber. These results show that the simple heuristic of trusting a person more if their beliefs are closer to one's own beliefs is possibly enough to create echo chambers, even if the agents in the model are honest, rational, empirically test their theories against the real world, and all aim to discover the true best action.

Other authors with slight variations in their trust mechanism or network structure have found similar results,[52] making clear that O'Connor and Weatherall's findings are not just a product of their specific model settings. These researchers have, for example, used models in which agents were connected to only some of the others, not to all.[53] Another difference lies in the exact setup of the trust mechanism: for example, Perfors & Navarro created a model in

[50] O'Connor and Weatherall, "Scientific Polarization," 869.
[51] *Id.*, 869.
[52] E.g. Madsen, Bailey, and Pilditch, "Large Networks"; Perfors and Navarro, "Role of Trust"; Olsson, "Bayesian Simulation."
[53] Perfors and Navarro, "The Role of Trust"; Hahn, Merdes, and Von Sydow, "Social Networks."

which trust in another agent is not directly based on the current distance in belief, but is slightly adjusted after each interaction.[54] In the model created by Hahn et al., all agents start out believing that the chances of *p* or not-*p* are equally likely.[55] They found that even under these conditions agents could still end up in echo chambers, purely based on their coincidental position in the network, or, in the words of the authors themselves, "through sheer bad luck."[56]

One question that could arise based on the above findings is the following: is the used rule in these models a valid and rational heuristic of trust? While O'Connor and Weatherall themselves do not claim that the heuristic they introduced in their model is individually rational, they do think that it is justifiable and, in a sense, in practice even essential.[57] Moreover, Endre Begby provides good insight into why this behavior could even be considered rational. Scientists (and other people) need to make judgements about how reliable they think another person's evidence is. The author argues that it is quite common sense that one should not update their beliefs based on the beliefs of others if they have reason to think that the other person is misinformed or incompetent.[58] Most people will feel like they have a reason for their own belief in a certain fact. They do not have to be absolute experts in the respective topic for this: people might have done a little research and have drawn certain conclusions based on it that they find logical. I, for example, have learned at school that eating fruit is good for you and that they contain many essential vitamins. This has led me to believe that apples are good for you. If one has such a "reasonable starting confidence" in their own beliefs,[59] then it is only logical to be more inclined to define someone as a peer to yourself and trust their judgement more if they share your judgement, and vice versa. If I meet someone who tells me that apples are actually very poisonous and are only promoted because the government tries to make humans weaker, I have quite good a reason to trust this person's

[54] Perfors and Navarro, "Role of Trust," 2.
[55] Hahn, Merdes, and Von Sydow, "Social Networks," 4.
[56] *Id.*, 13.
[57] O'Connor and Weatherall, "Scientific Polarization," 857.
[58] Begby, "Belief Polarization," 527.
[59] *Ibid.*

judgement less. The fact that such a rational heuristic can still lead to echo chamber formation shows even more clearly how echo chambers are perversions of healthy epistemic practices, even more than Nguyen argued they are.[60]

To sum up, the literature in network epistemology points to the idea that even rational agents that are motivated to find the truth, are honest, and who are not initially put in echo chamber conditions can become trapped in an echo chamber. Factors that seem to influence these chances are reliance on what seem to be justifiable heuristics of trust, and unfortunately, also just a form of bad luck.

The role of digitalization

One aspect of bubbles and chambers that has been under dispute in scholarly debate is the possible role of digitalization in their formation and prevalence. Multiple scholars have argued that digitalization plays a significant role in a growing concern for increased polarization,[61] and/or an increase in the prevalence of both echo chambers and epistemic bubbles.[62] However, other scholars have criticized the above perspectives, arguing that new technology has not had this impact at all.[63] The questions that then arise are the following: Firstly, how can we understand where this dispute between scholars about the impact of digitalization comes from, and secondly, can network epistemology help us understand the possible impact of digitalization on epistemic bubbles and echo chambers better?

As has already been briefly stated in the introduction, the concepts of epistemic (or filter) bubbles and echo chambers have often been conflated with each other in current scholarly literature. Many scholars have defined echo chambers similarly to the way epistemic bubbles have been defined in this paper: based on exposure and communication rather than on trust discrepancies. An example of this is the article of Mønsted & Lehmann, who argue to have found evidence in support of echo chambers. They state that

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[60] Nguyen, "Echo Chambers," 148.
[61] Bennett and Iyengar, "Minimal Effects?," 720, 724.
[62] Bail et al., "Opposing Views," 9216; Sunstein, *#Republic*, 68.
[63] Bruns, "Technology, Stupid," 9; Masip, Suau, and Ruiz-Caballero, "Incidental Exposure," 59; Arguedas et al., "Literature Review," 17.

the vaccine discourse on Twitter is highly polarized, and that users on the extreme ends formed "relatively disjoint 'epistemic echo chambers' which imply that members of the two groups of users rarely interact, and in which users experience highly dissimilar 'information landscapes' depending on their stance."[64] Notice that their use of 'echo chamber' in this quote is used to refer to the low level of interaction and exposure to similar sources, which were actually identified by Nguyen as properties of *epistemic bubbles* instead of echo chambers.[65] This study about 'echo chambers' tells us nothing about how the exposed content is actually *received* and whether opposing content is actually taken into consideration or just gets distrusted and dismissed. This same mix up of the two concepts is also found in articles arguing that supposed 'echo chambers' actually make for a *bigger* diversity in exposure,[66] and in most scientific reviews about empirical evidence for echo chambers.[67]

So, it appears that most empirical literature that claims to be written about echo chambers, is not written about echo chambers at all. Instead, these papers describe mechanisms linked to *epistemic bubbles*. This is problematic, not only because these empirical articles are analyzing a different concept than they are claiming, but also because the models from network epistemology discussed in the previous section show that the incorporation of trust mechanisms in a network has a big impact on the level of polarization. Nguyen already foreshadowed this, arguing that echo chambers pose a much bigger threat to our current democratic processes than epistemic bubbles.[68]

While we might thus not be able to draw any conclusion about *chambers* based on the empirical research, this literature can tell us something about the effect of digitalization on *bubbles*. Even though the evidence is not overwhelmingly clear and there are some contradictory or mixed results,[69] there does seem to be some

[64] Mønsted and Lehmann, "Vaccine Discourse," 8.
[65] Nguyen, "Echo Chambers."
[66] Arguedas et al., "Literature Review," 17; Masip, Suau, and Ruiz-Caballero, "Incidental Exposure," 59.
[67] e.g. Arguedas et al., "Literature Review," 10; Terren and Borge, "Social Media," 100.
[68] Nguyen, "Echo Chambers," 153.
[69] Mønsted and Lehmann, "Vaccine Discourse."

evidence that the use of online environments actually leads to a *bigger* diversity in content-exposure than the use of only offline environments.[70] Let us, for the sake of the argument, follow these authors in the notion that digitalization has not led to more bubbles. The question that remains is the following: is it possible for digitalization to influence the prevalence of *echo chambers*, even if it does not affect (or even negatively affects) the prevalence of bubbles?

Since there is, to this author's knowledge, little related empirical data, we will again turn to the field of network epistemology to see if the analyses there could give us some theories about the prevalence of echo chambers in digital environments. To do that, we first need to identify ways in which digital environments differ from physical environments in their network properties. The internet has radically changed how we look for information and connect with others. First of all, it has made it possible to expand our network much more than before. In addition, agents are not only able to have a bigger network, but also to be much more targeted in their search for information.[71] To analyze the prevalence of chambers in digital environments compared to physical ones, we thus need to look at networks that, one, are bigger in size, and two, allow for some sense of 'searching' for information.

One article in which the impact of network size is discussed is that of Hahn et al.[72] The authors used a network structure in their model that they argue is similar to the structure of actual online networks on social media like Facebook. They found that the larger the network, the higher the percentage of agents that ended up polarized and believing a false belief.[73] Madsen et al. found similar results: these researchers studied relatively large networks of up to 1.000 agents, and also found that the formation of echo chambers in their model was more likely to occur with the increase of the number of agents in their model.[74]

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[70] Fletcher and Nielsen, "Comparative Analysis," 2462.
[71] Sunstein, *#Republic*, 60.
[72] Hahn, Merdes, and Von Sydow, "Social Networks."
[73] *Id.*, 16.
[74] Madsen, Bailey, and Pilditch, "Large Networks."

What makes the model of Madsen et al. even more interesting for our current endeavor is that they used a 'search parameter.'[75] In their model, an agent 'searches' across their network for people with similar beliefs, only listening to these other agents if their beliefs sufficiently align with their own. The authors ran their model using a range of different search parameters, representing how big the part of the network was the agents could search. The authors found that the formation of echo chambers in their model was not only more likely to occur with the increase of the number of agents in the model, but also with the increase of the search parameter. They argued that this is probably the case due to a higher chance for more close-minded agents with initial extreme beliefs to be able to find other agents with similarly extreme beliefs, since their pool was simply bigger. In smaller networks, they argued, these agents are more often "'starved' of sufficient numbers of like-minded agents, and therefore their belief confidence is somewhat stymied."[76] In other words, extreme agents that are able to search across a bigger number of sources are more likely to be able to find another like-minded extremists, leading to an (unjustly) higher confidence in their own beliefs.

What these results show is that what some initially believed to be the democratizing forces of the internet[77] have had different consequences than might have been expected. On a personal level, the possibility to have a bigger and further-reaching network mostly seems to mean that a person has access to much more information and can thus make more informed inferences about their belief. However, once a trust variable is added, this reasoning has been shown not to hold up on the system level; in fact, the opposite occurs and more people end up polarized and in echo chambers.

Conclusion

In this article, I have tried to show how network epistemology can help us to better understand the social epistemological concepts of epistemic bubbles and echo chambers. I started by addressing the conflation of these phenomena in the academic literature and by

[75] *Id.*, 2.
[76] *Ibid.*
[77] Waisbord, "What Happens to News," 1870.

explaining Nguyen's influential distinction between both concepts.[78] After explaining the functionality of network epistemology, I used insights from this field to address a gap left in Nguyen's argumentation, namely how we can explain that people end up in echo chambers other than pointing to their epistemic vices or to exceptional circumstances. The findings in network epistemology show that the addition of a simple and justifiable heuristic for trust is enough for rational agents to form echo chambers.

Lastly, I discussed the possible role of digitalization in the formation of epistemic bubbles and echo chambers. These findings seem to support Nguyen's statement that the biggest problem for online communication might not be epistemic bubbles, but echo chambers.[79] The network-epistemological models also clearly show what has been lacking from empirical research on these epistemic phenomena: the factor of trust. All empirical studies discussed in this paper have focused on the exposure to different content and different sources, not on how these different sources actually have been perceived and to what extent these sources are trusted differently. The models created in network epistemology show that this empirical measuring of trust could potentially lead to new and very interesting insights into why people are still polarizing. Therefore, a recommendation for future research is to find a way to incorporate a factor of trust and the perception of information in echo chamber research, so that these phenomena are really captured.

One limitation of the current article is that the models of network epistemology discussed here are only that: *models*. Models can only provide *how-possibly* explanations, meaning that they help explain how a phenomenon can *possibly* be explained. This is different from how the phenomenon can *actually* be explained.[80] Empirical evidence is necessary to link the working of a model to reality and to validate the actual explanatory power of a model.[81] While models like the network models explained in this chapter can certainly aid us in understanding the possible mechanisms behind

[78] Nguyen, "Echo Chambers."
[79] Id, 153.
[80] Sullivan, "Understanding," 112.
[81] *Ibid.*

epistemic bubbles and echo chambers, as well as give direction to empirical research, the actual empirical research is still an integral part in really understanding the real-world phenomenon in question. This limitation only strengthens the recommendation to conduct more empirical research in which factors of trust are incorporated.

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