

Walking the Path to a Happy Medium:

Understanding the Problem of Polarization in the Media and Society

By Joshua Broomberg, Long Le, Marlette Sandoval, Adrian Stein

Introduction

This paper attempts to address the issue of increasing polarization in Western Society. Firstly, by proposing an explanation for the phenomenon and, secondly, by establishing the ethics and causal mechanics of an intervention. Rather than presenting a formalized intervention, we use a computerized model and a social experiment to test potential intervention strategies at social and individual levels.

Research

Context

The United States and other Western societies have become increasingly polarized. The percentage of consistently liberal or conservative-voting individuals in the US has doubled in the past two decades. More voters show antipathy towards ‘the other side’, with a tendency to view them as a ‘threat to the nation’ (Pew Research Center, 2014) and many choose to live in ideologically-homogeneous communities (Barber & McCarty, 2013) with geographical separation. Evidence of these social changes can be seen in increasingly extreme political activity from highly vocal citizens and organisations, as well as increasing extremity and polarisation of views amongst media organizations and politicians.

These trends have dangerous consequences. In the political realm, they hamper legislative productivity because parties catering to polarized support bases find it significantly harder to compromise on crucial issues. This creates deadlock and “public policy which does not adjust to changing economic and demographic circumstances” (Pierson & Skocpol, 2007). Weakened legislatures also threaten the separation of powers as the executive and judiciary try to make up for legislative failures and accumulate power (Barber & McCarty, 2013). On the social level, discourse deteriorates, and is frequently replaced by more violent interactions. In 2016, the Huffington Post reported on “Americans’ discomfort with condemning people who hold bigoted views” (Edwards-Levy, 2016). Building on this, (Sands, 2016) finds the acceptance of a polarization “along political, racial and religious lines” is associated with an increase in hate crimes. These trends create the real threat of good governance and social peace slipping away.

At the same time, society’s interactions have also fundamentally changed in another way. In 2014, 55% of Americans interacted using social media on a daily basis, with 20% using it extensively (Newport, 2014). As of 2016, 38% of Americans use social media as their primary source of news (Pew Research Center, 2016).¹

¹ Polarization is widely discussed but the discussions often lack empirical grounding. In the paragraphs above, we provide a #context for the problem, revealing the subtle changes in individual and media behavior that form the larger trend. We provide extensive #support to ensure the context is grounded in reality, bringing empirical rigor to the discussion.

This paper shows that changes in society's interactions, brought about by new communication media, and changes in society's perceptions of truth, brought about by a shift in social psychology, interact to form a vicious cycle which leads to the escalating polarization described above.^{2 3}

Formal Definition: What Does Polarization Mean?

Polarization can be understood as an increase in the degree to which opinions on an issue are divided (Calais Guerra et al, 2013). However, this does not adequately describe the manifestations of polarization on a social level. For this, we have to look at network theory as a tool to understand how polarization develops from modularity.

Modularity occurs when nodes, which can be both individuals or media outlets, cluster into distinct groups with homogeneous views. Modularity is a necessary but not sufficient cause for polarization, because groups can be modular but can still be fairly interconnected, preventing significant ideological divergence (Figure 1). Polarization only occurs when group members are more likely to interact within that group than with a node in another group. This leads to groups 'pulling apart', both ideologically and topologically. When this happens, popular, centrist nodes, which served to unite people with different views, lose connectivity and nodes in both groups become more densely connected to newly popular nodes on the extremes (Calais Guerra et al, 2013), driving ideological divergence.⁴

A 2011 study demonstrates how this mechanism of polarization plays out in group-level interactions on Twitter (Conover et. al.). Retweets - broadcasting a message from another user - show high levels of polarization because users largely reproduce messages from extreme popular nodes. Meanwhile, user-to-user-mentions - tagging another user in one's own message - show significant cross-group interactions, which are, however, mostly antagonistic disputes rather than attempted resolutions of arguments. Why are we seeing this phenomenon, on Twitter and in society at-large?

² This is a succinct guiding sentence which provides a high level schema of the analysis which will follow. It serves as the bridge between the contextual introduction and the analysis. It is an intentional iteration on the #thesis in our proposal.

³ We paid careful attention to #audience when constructing and formatting this paper. We wanted to create academically rigorous content that would be accessible to a non-academic reader. To achieve this, we have broken the paper into clear sections which are titled formally and with clear, rhetorical questions which explain their purpose in the larger analysis - applying #organization to promote understanding.

⁴ This formal definition shows the power of #network analysis in understanding complex social trends. It is hard to analyze/understand polarization without a formal definition/criteria.

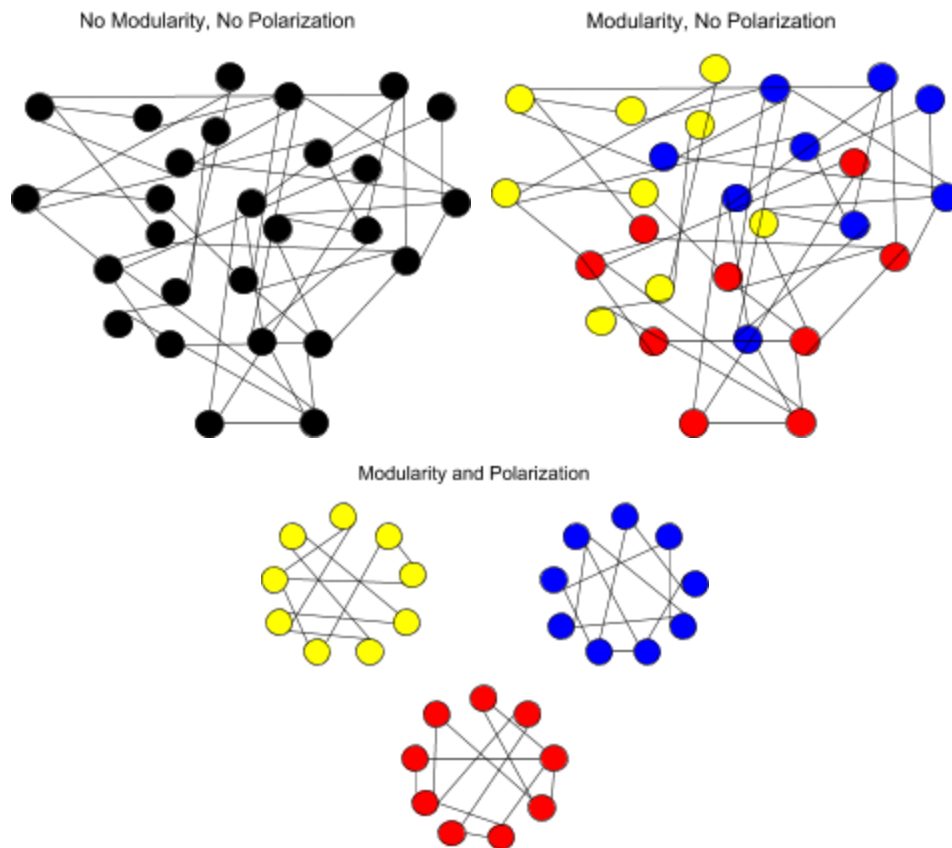


Figure 1. Shows stages of a network moving towards polarization through increased modularity.

Causal Analysis: Why is Polarization Occurring?

We observe what we define as three key trends and we then show how these trends combine to cause the polarization defined above. We argue that all three of these trends are driven by a combination of natural proclivities and the rise of the internet as a means of communication. The first trend is the increasing extremity of news sources; the second is the personalization of Truth, and the third concerns the way in which internet based interactions appear to amplify natural, negative human biases and tendencies.

The Increasing Extremity of News Sources

Increased access to a wide range of information has been facilitated by the advent of the Internet and search engines (Lelkes, Sood & Iyengar, 2015). 62% of Americans now have access to news on social media (Pew Internet and American Life, 2017). This increased access and consumption has led to a diversification of media outlets by removing barriers to entry, and giving exposure to new, non-traditional sources of news. These new sources do not have the same editorial veracity which has, historically, defined more traditional news outlets, such as newspapers and mainstream national television networks (Baum & Groeling, 2008). These new non-traditional news sources tend to cater to a wide variety of audiences, with many of these falling on the extreme ends of the socio-political spectrum (Figure 2).

At the same time, the online consumption of media has changed the incentive structures for publishers. Pay-per-click advertising models strongly encourage sensationalist content, because more controversy means more attention, more clicks and, therefore, more income (Baum & Groeling, 2008). These developments have, in turn, increased the pressure on traditional media to produce more extreme content in order to compete with newly minted online sources.⁵ As a result, all popular media nodes in the system - both new and old - produce more politically/socially extreme content.

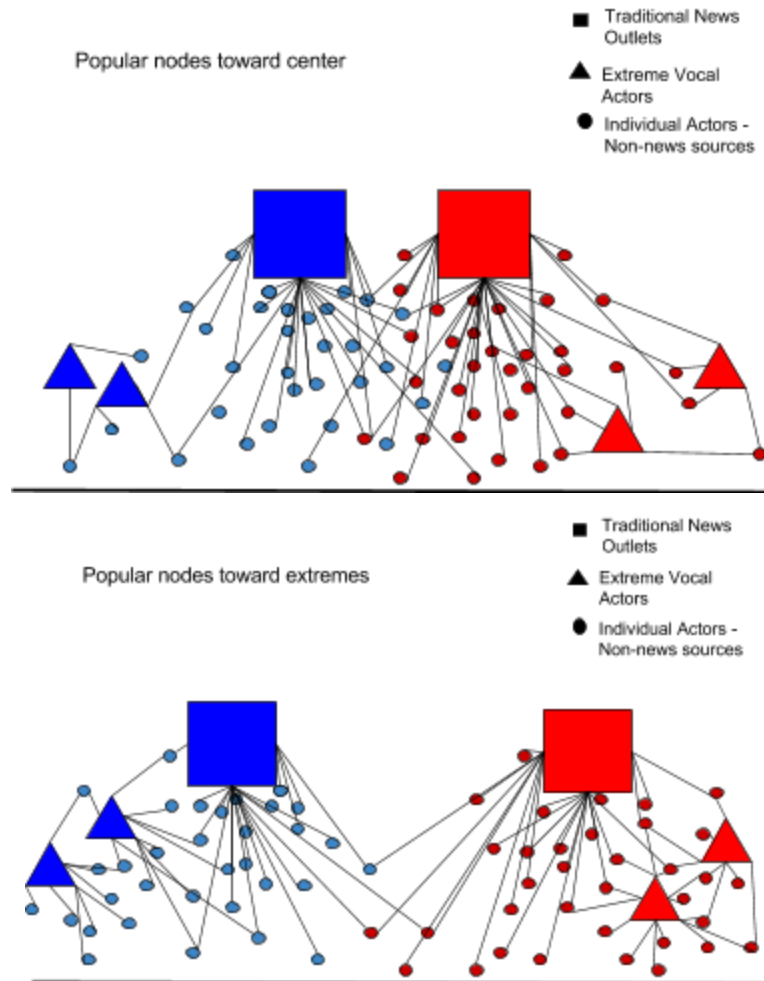


Figure 2. Demonstrates how as popular nodes move to the extremes, individual agents are exposed to and connect with more extreme, smaller nodes.

⁵ This media analysis blends #motivation and #carrotandstick. The media ostensibly operates to inform the public with fact/opinion. However, they also have a strong profit motive, and must make money to survive. They publish content which balances these explicit/hidden motives (#motivation). There is also an aspect of less 'intentional' adaptive learning. Publishers with clickbait-based business models were heavily rewarded by online revenue models. The behavior was reinforced, repeatedly and with high magnitude. If sensationalist/extreme content is rewarded with clicks, more similar content will be published.

The Personalization of Truth

Historically, notwithstanding many economic and social divisions, societies have possessed a belief in the existence of a single truth, vigorously debating what religion, behavior or principle should be deemed the *correct* underpinning of that single truth. “The Modern Era” built on this notion with the Enlightenment and then the Scientific Revolution, both elevating rationality as the supreme tool with which universal values could be found. But this modernist consensus has been undergoing increasingly rapid change, due in part to the influence of the postmodernist movement.

Postmodernism emerged in France in the 1970s. It “rejects the concept of a unified and coherent reality”, replacing rationality and ethics with subjective interpretation and belief. Importantly, “[it] attacks science and its goal of attaining objective knowledge about a reality which exists independently of human perceptions”. Ultimately, postmodernism lauds “epistemic relativism” - all knowledge becomes relative (Pluckrose, 2017).

The ideology was first adopted by the Left, “during the period of anti-colonialism and the fight for women’s suffrage” but now the “far-right is using [very similar] identity politics and epistemic relativism”. The arguments of Postmodernism have become the bedrock of a “post-truth” world which breeds a multiplicity of truths and views, and hence encourages social and political polarization. ‘Truth’ is now “local to experiences and beliefs”. There is no need to debate because the other side is simply wrong - they are “angry liberals who read fake news” or “ignorant conservatives who know nothing about the world”. Unifying facts have been replaced with inherently divisional identity politics (Malik, 2017). This is also why leaders like Donald Trump are free to assert “alternative facts” and to lie openly about everything from terror attacks in Sweden to the size of his inauguration crowd (Topping, 2017; Hirschfeld Davis & Rosenberg, 2017). Without a belief in truth, the sparse interactions between modular groups become, at best, worthless and, at worst, even more polarizing.⁶

“Politics rests also upon a willingness to have a public dialogue and debate, a readiness both to listen to others and to scrutinise our own beliefs, an openness to accommodate others and to change ourselves. It is the erosion of such willingness and readiness and openness that now gives us a sense of living in a ‘post-truth’ age” (Pluckrose, 2017).

Today, social-media algorithms supercharge this effect, by mirroring and amplifying postmodern, subjective realism into protected bubbles of interaction with different, contradictory perspectives on the world.

By pushing material into feeds based on ‘liked’ content and promoting material published by ‘friends’, social networks ensure that individuals are increasingly exposed only to their own version of the truth. These trends lead inevitably to the formation of distinct, ideologically and politically divergent groups, with little, and diminishing, common ground between them. (Gruzd & Roy, 2014).

⁶ #perspective taking is crucial for the progression of discussion. Here, we apply this HC at a meta level, observing that postmodern thinking creates irreconcilable divergence in the way people see the world and makes them feel their perspective is *correct*. This means neither side can sufficiently engage with, or persuade, the other.

Internet Interactions Amplify Human Biases

Firstly, the internet, combined with confirmation bias, leads people to consume more confirmatory material which strengthens, rather than challenges, their existing views. Confirmation bias refers to individuals' search for, and preferential integration of, information which agrees with existing beliefs (Kahneman, 2011). The increased access to media on the internet creates an information overflow, which requires individuals to choose their personal sources of news. Their confirmation bias makes them choose online sources which confirm their world views. Even when people doubt something, they search for, and can almost always find, information that confirms their existing beliefs (PBS Newshour, 2015). Thus, confirmation bias in the internet-age creates the tendency for people to consume and to search for content that reinforces their existing beliefs.⁷

Secondly, the anonymity of many online posts creates a lack of public self-awareness and social control. Users' actions on internet opinion forums are not directly tied to their public presence, reducing or eliminating the social consequences of their remarks and online actions, and thus freeing them from their responsibilities towards their own public image (Lee, 2007). They can freely exhibit stronger emotions, including hate, knowing that they can walk away without serious consequences, for example by simply exiting the discussion forum. Even worse, 'attention-seeking outrage mongering' (Pew Internet and American Life, 2017) gets rewarded by likes, attention and advertising clicks.⁸ Together with the polarization of media sources, interactions and content thus become increasingly polarized.

Thirdly, individuals have become increasingly vulnerable to manipulation as many of the issues discussed in these new media forums- such as globalization, automation and macroeconomic trends in a rapidly changing world - appear increasingly complex (McGrath, 2011). People do not "'lift [them]selves out' of this complexity, in order to see [their] lives and the world in broader perspective" (Life Squared, 2010) and therefore lack explanations for any negative personal consequences of these complex, system-level issues. Based on the Appraisal-Tendency Framework (Lerner et al, 2015), this uncertainty creates fear. In these conditions, people turn to their group, over outside sources, for factual information - happily aligning with people who display confidence (Barber & McCarty, 2013).⁹ This is also a form of informational conformity, when individuals are uncertain, they turn to those who appear to know more (Sands, 2016).¹⁰ Combined, these effects mean extreme nodes, who exude confidence, can easily manipulate people despite their opinions

⁷ This analysis combines an understanding of the internet and the psychology of #confirmationbias. It shows that when these concepts are combined, the result is 'confirmatory behavior'. People consistently strengthen existing beliefs through active search and passive information exposure. This shows how biases can create behavior and become self-enforcing.

⁸ Anonymity reduces social awareness, and thus creates an environment in which people are freed from social pressure. Normally, social shaming prevents aggressive/damaging behaviour - people #conform such that the group experiences less negative behaviour. On the internet, shame is hard to create and, at best, fleeting leading to a trend of extreme, damaging content or 'trolling' where the perpetrators can enjoy shame-free real-world relationships and simply switch online accounts if they choose. The world is a scary place without social #conformity.

⁹ Individuals inundated with information on complex issues are understandably uncertain. The Appraisal-Tendency Framework shows uncertainty leads to feelings of discomfort and fear, on an emotional level, which individuals seek to mitigate. This creates an #emotionalbias - people willingly accepting information from those who appear strong/confident in order to mitigate their discomfort.

¹⁰ This is informational #conformity. People accept answers from those who appear to know more. This makes evolutionary sense because the person *should* know more than you to be confident. But, in the age of the internet, where many espouse invalid opinions with great confidence, it causes problems.

having poor factual backing (Timothy, 2017; Liu et al, 2014). People accept confident answers on issues about which they are uncertain. Lastly, individuals fail to critically analyze extreme arguments because of an illusion of explanatory depth (Galef, 2016). This means that they attach validity to strength of opinion and their familiarity with the concept, not evidence-based logic. Identification with ideologically-homogeneous groups also positively correlates with the perceived quality of this group's arguments - due to continuous reinforcement - exacerbating the illusion (Lee, 2007).¹¹ So, increasing issue complexity, paired with emotional bias and conformity, means people accept opinions from confident sources, often found online, regardless of validity. Additionally, they fail to identify that the opinions received are not valid or well supported.

Bringing it All Together

Society's current polarization results from a complex, interlinked pattern of increasingly polarized interactions. Media organizations produce more extreme content, and individuals consume more of it as online algorithms based on their historical preferences control the material they are exposed to, thus feeding and amplifying their existing biases. This pattern of interactions finds fertile ground in a world where the underlying rise of postmodernism has weakened the basis for seeking a common truth. In this world, cross-group interactions become increasingly antagonistic as neither side has a strong incentive to compromise with the other. The ensuing polarization of society then further incentivizes media to produce extreme content that appeals to increasingly extreme views. So, individuals, groups and the media reinforce each other's moves towards extremist views on various social and political issues, and the boundary region becomes filled with fierce battles. This vicious cycle continues as long as nobody attempts to pursue an objective truth in their argument.¹²

¹¹ This last point applies #metaknowledge. People tend to assume familiar or confidently-made arguments are logically valid/sound even if they are not. People do not check that they actually know the reasons something is true/correct. This is termed the illusion of explanatory depth. Here, we extend this illusion by showing that it is worsened when opinions are common to a group. Dangerous consequences emerge when #metaknowledge is lacking.

¹² This section (the entire causal analysis) first applies #multipleagents, identifying two agent types, individuals and the media, showing how each behaves in certain, 'rule-based' ways to output and internalize information. Behaviors are premised on long-standing properties (biases, profit motives etc) which manifest differently because of the rise of the internet and shifts in social psychology (#multiplecauses - standing and triggering causes).

Agents are heavily interconnected, so their interactions can best be understood through #network analysis. Agent properties and algorithms determine the formation of new edges and information/influence propagates along these edges, changing ideology. Again, the internet acts as a trigger, leading to edge formation strategies which prime the network for polarization. For example, people search for, and find, agreeable information and are suggested friends they are likely to agree with.

In this paradigm, polarization emerges at a system-level. Interactions between individuals and the media create a vicious cycle in which both become more extreme. Ideologically-distinct groups form and become self-sustaining. Polarization is, thus, an #emergentproperty which results from a feedback loop (#multiplecauses) that occurs at the social level, a level above individual interactions described above (#levelsofanalysis).

Ethical Framing: Are Polarized Opinions Invalid?

The ethics behind polarization are complex. At an individual level, is it illegitimate for people in society to hold the deeply contradictory beliefs described above? When is it acceptable to try to change someone else's beliefs? When should they be allowed to exist? This sections aims to create an evaluative framework for individual beliefs, providing an entry point for possible interventions.

We need to establish a better understanding of the 'subjective beliefs' which underlie social division. This means examining the principles of objectivism and subjectivism and how they interact in the creation of beliefs.

There are many issues which cannot be resolved without factoring in some subjective thought (Shea, 2009). These issues demand subjectivity because they are not based in fact alone. A spectrum exists within this category. On one extreme is religion, which is an entirely personal choice with very little factual backing for any particular belief. On the other extreme are issues like abortion, where the biological facts are clear but different ethical framings and prioritizations result in very different moral judgements. A utilitarian may arrive at the conclusion that allowing abortion does more good than harm based on utility for the mother and society, while a Kantian would argue that this utility cannot be realized by ending a (potential) human life. In either case, the moral conclusion reached is necessarily premised on subjective criteria.

However, subjectivism, is not always valid or acceptable. There are many issues, such as the existence of global warming, or the health value of vaccines, which are proven beyond *reasonable doubt* by large bodies of factual evidence. In cases like these, it is irrational and damaging to deny the claim based on a subjective "belief" that it is untrue.¹³ This, however, occurs often in today's world (Shreck & Vedlitz, 2014). Secondly, even on issues for which validly involves subjectivity, not all beliefs are equally valid. Subjective beliefs about the world must still be based on facts which are known and must be built using valid logic. The fact that some issues involve subjectivity does not justify literally any subjective belief, even though this appears to have become a common, but damaging, fallacy in modern thought. This principle can be developed through the example of gay marriage:

¹³This is a simplification. Science is not hard fact - theories are almost always incomplete explanations of natural phenomena and can change as new evidence is uncovered. However, this doesn't make denying them logical or acceptable. There is an important difference between healthy doubt and complete denial of theories which have been validated by a multitude of independent experiments. This applies #epistemology to real-world knowledge.

Factually speaking, sexual orientation is not a choice. This means that laws which protect against discrimination based on inherent characteristics must extend to providing protection against homophobic discrimination. It is illegitimate to choose to believe that homosexuality is a choice and to discriminate against people based on this belief. However, if you are a priest whose religion forbids gay marriage, you may choose not to marry same-sex couples, exercising a personal, subjective belief in the principles of your religion. This seems perfectly legitimate. But it would also be legitimate to argue that you do not have the right to deny members of your church, who believe in your god, the right to marry. Their subjective beliefs lead them to believe they can be both religious and married to a partner of the same sex. Here, no one is right and everyone is. The decisions cannot be divorced from personal truth and judgement. The best that can be done is to carefully examine each moral conclusion on its merits, compare them on different metrics, and make decisions - moving closer to some truly correct ideal. This is the role entrusted to judges in modern legal systems, examining fact and testimony to interpret laws and make decisions which in turn modify the law.

All of the above can be combined into a principled view which we call The Pursuit of Truth. Where an objective truth exists, commitment to this principle means accepting that truth. Where no objective truth exists, the commitment means building beliefs based on factual premises and valid argument - belief cannot deny fact. Finally, where judgements must be based on ethics, the assumption should be that everyone is both right, from a subjective perspective, and wrong from an objective one (because no subjective principles are universally accepted). Steps should be taken to carefully validate beliefs through self-reflection and meaningful engagement with other viewpoints. This is what it means to pursue the truth.^{14 15 16}

¹⁴ In this section, we blended #ethicalframing and #ethicalconflicts to develop a normative framework for opinions. We create objectivist and subjectivist frameworks for opinion judgement. Subjectivism is based on Kantian philosophy while Objectivism is premised on fact, integrated with utilitarianism. We show that these frameworks necessarily conflict and are, alone, insufficient. Rather than just describing this #ethicalconflict, we draw out a unified principle - blending objectivism and subjectivism. Co-incidentally, the principle we draw quite neatly justifies Mills' ideals from *On liberty*. We save this discussion for a different essay.

¹⁵ NON-HC footnote: It is interesting to consider when we have "enough" knowledge on uncertain topics. Confidence in knowledge is the precursor to action. If people always doubt their opinions and question if they are operating based on "the truth", it would be hard to ever act. While understanding how much knowledge is "enough" is a fascinating epistemic question, we believe that society is currently far too confident and that a movement closer to doubt would still allow for enough confidence to avoid decision paralysis. Additionally, if two polarised sides on any one issue are very confident, we end up with deadlock in the political system as described in context section at the start of the paper. This creates no value.

¹⁶ NON-HC footnote: When issues involve unresolvable subjective differences, the only way to proceed is to choose personal ethical principles and evaluate choices based on them. But it is crucial to realize that your principles are your own and may differ from others. Engagement with others is an opportunity to refine either your principles or the way your principles translate to beliefs or perhaps both of these. To do either, you must know what your principles are and realize that they are not universally accepted.

Practical Impact: How Would an Intervention Affect Society?

This section first outlines a simplified, theoretical causal model for polarization based on the analysis above. We then use this framework to create an agent-based model (ABM) of society and to design a social experiment. These tools allow us to confirm whether the causal factors defined below do indeed give rise to the phenomena we observe in society. The ABM allows us to observe social level phenomena while the social experiment observes individual level phenomena. Both tools could be used to test possible interventions for efficacy in reversing polarization.

Theoretical Model

The causal model is build on four interacting variables¹⁷:

1. *Ideological Diversity of Belief* at a social level.
2. *Quality of Belief* amongst individuals, where high quality means fact-based, logically-valid and recognizing of inherent subjectivity. (Defined in detail in the ethics section).
3. *Willingness to Change Beliefs* amongst individuals. Where high willingness means an individual embraces the notion that objective truth exists and is willing to update their beliefs if they are shown to be invalid.
4. *Effectiveness of Debate* between individuals. Where effective debate means debate which weeds out weaker opinions. This can occur when weaker beliefs are held by participants who lose and update their beliefs. Or, when those viewing a high quality debate, based on nuanced subjective difference, update their beliefs based on the arguments presented.

Causal relationships:

- *Diversity and Quality of Belief* are related. Low quality of belief allows for the existence of many, notionally ‘untrue’, beliefs which would not exist otherwise. A society may be diverse with high quality.
- *Quality* and *Willingness to Change* belief are directly related. High quality beliefs are built on fact and logic. If these change, or are proven wrong, the belief should change. Low quality beliefs rely on subjectivism to assert false truths about the world. These beliefs may not change when contradictory facts are encountered.
- *Effectiveness of Debate* is directly related *Quality* and *Willingness to Change* belief:
 - Debate requires shared premises and the comparison of logic to advance towards a conclusion. High *quality* beliefs have these components.
 - Participants and observers must be *willing* to update their views based on the content/result.
- Effectiveness of *Debate* is inversely related to *Diversity of Belief* in a society with varied *Quality of Opinion*. Effective debate weeds out low quality beliefs, reducing diversity created by these beliefs. This can create a virtuous cycle. Debate improves average quality of belief, which improves debate, which improves quality of belief. This can occur until beliefs are high enough quality that they can no longer be updated.

¹⁷ Here, we analyzed all of the research above and abstracted social and individual properties into 4 ‘quantifiable’ #variables. Creating these variables allows us to establish formal, testable causal relationships. Used in the experiment and ABM below.

Society currently has extreme *Diversity in Belief*. This is because many individuals have very low *Quality of Belief* and low *Willingness to Change*. These views remain static because effective debate cannot occur where *Quality* and *Willingness to Change* are low. As a result, society is stuck - effective debate cannot occur, which means that quality of beliefs is not improving. On the contrary, emotional, low quality debates are further reducing the quality of beliefs, making people more extreme and unwilling to change their views.

Agent-Based Model

We created an agent-based model (ABM) to study the causal framework outlined above. We model individuals (called Citizens) and influencers (called Media). The code for the model is [here](#).

Design

Individuals have an opinion extremity (ideological position), quality and confidence, all ranging [-10; 10]. These are initially set based on a normal distribution between a defined min and max. Individuals are also connected to a number of other nodes (their ‘group’), initially randomly assigned with connection strengths 1. Connected individuals which are within a 2 unit distance of an individual’s extremity are considered to be the “in-group” with all others in the “out-group”. At each step, Citizens update their opinion values based on interactions within their group of connections and update the connections themselves.

- Confidence is modified depending on the ratio of in-group to out-group individuals. More in-group increases higher confidence as per evidence above.
- Quality moves towards the group’s average, based on the analysis in the causal framework on how debates improve quality.
- Extremity or ideology is a function of confidence and quality. Low confidence people move toward the group average, with higher quality individuals moving more slowly (as they assess argument more carefully). High confidence individuals with low quality opinions move away from their out-group - representing low quality, polarising debates. High quality, high confidence individuals do not move.
- At each turn, an Individual adds a friend of a friend randomly. They also reduce their connection strength to other nodes based on the ideological gap, removing the connection if the strength falls to zero.

Media have a position (akin to extremity), set according to a normal or manually defined distribution. Their “subscribers” are individuals with extremities within 2 units of their positions. They exert some “influence” on nodes within 4 units of their position - moving these individuals slightly closer to their position (by one twentieth of the distance). Each turn, they will optimise their position by moving within a range of 6 units to maximise their subscriber count and minimize competition (caused by being close to other Media nodes’ positions).¹⁸

¹⁸ This model applies #algorithms and #simulation. Describing the behaviour and interaction of nodes involved creating a number of moderately complex #algorithms. These algorithms had to be designed to be both realistic, in terms of researched behavior, and had to be adjustable based on experimental and fixed parameters. This required careful design and clean code.

The ABM itself applies #simulation. While it had limitations, discussed below, we were pretty happy with the ability to simulate the expected system level effects by changing individual parameters. There is no way to experiment with variables like these at scale in the real world, making the ABMs a useful tool.

Validating the Model

First, we validated the model. Based on our causal framework and research, we would expect the following: If the three opinion variables are fairly neutral, society should display diversity with some modularity (opinion grouping) but no polarization (separation of the groups with little to no interaction). If quality decreases and confidence increases then we expect polarization to occur. We tested for this behaviour by performing two trials. First, Trial 1, Citizens ($n=200$) with extremity, quality and confidence set to normal $[-5;5]$ (Figure 3) and, Trial 2, with extremity normal $[-5, 5]$, quality normal $[-8, 2]$ and confidence normal $[-2, 8]$ (Figure 4). Both trials had media ($n=10$), positions normal $[-2, 2]$. All plots below are created using the Fruchterman-Reingold Force Algorithm which iteratively repels all nodes with force X and attracts them with a force based on the weight of the connection between them. It thus reveals community structures with heavy interlinkage. Media nodes are not highlighted in these plots.¹⁹

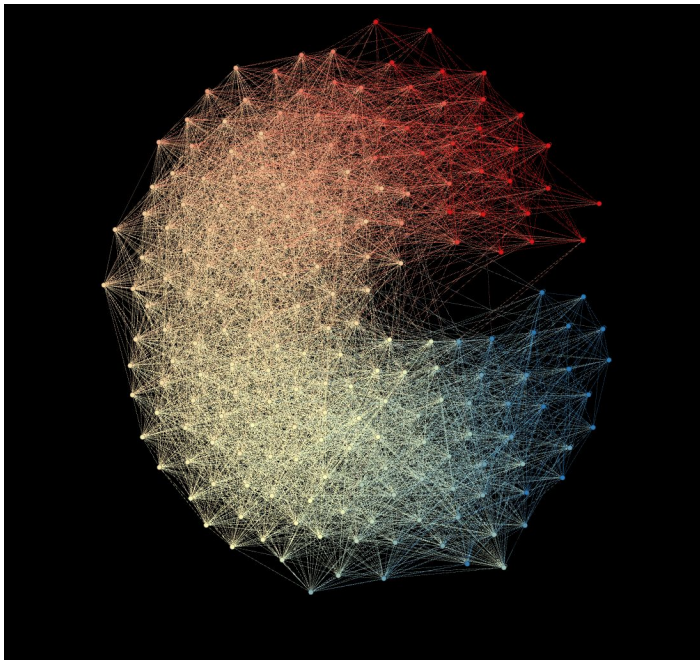


Figure 3.

Trial 1, neutral individual opinion values, neutral media results in modularity without polarization.

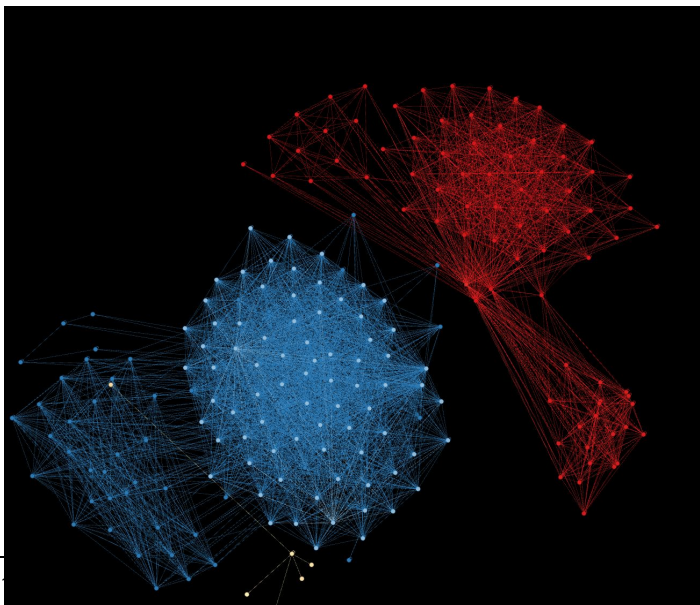


Figure 4.

Trial 2, high confidence and low quality (relative to Trial 1) results in near-complete polarization.

Based on visual analysis, the result is exactly as we would predict. Trial 1 shows interconnected, but modular groups with moderately strong opinions on the extremes. Trial 2 shows two distinct groups with more extreme ideology (darker shades than in Trial 1). One concern is that the effect seems too extreme to be realistic. This is likely because, in the real world, there are moderating factors not captured in the model. Nodes will maintain connections with some family/friends despite universal ideological divides and ideology may be multidimensional: individuals could maintain a connection based on one position and then discuss other positions on which they disagree strongly. However, the tests we wish to perform are based on the question “does polarization occur?”. Thus, the fact the model displayed stable, non-polarized results and then polarized meant we felt comfortable to proceed.

Experimental Analysis

After confirming the model, we performed two tests to determine how the media and individuals interact to create polarisation. We used less extreme individual conditions than above, shifting the quality and confidence ranges 2 instead of 3 units in their respective directions. Without extreme media, these values produced a modular but not polarised society. We then performed two trials with different position distribution of media nodes. Experiment 1, with uniformly extreme media (positions: -8, -8, -7, -6, -3, 3, 6, 7, 8, 8) and, Experiment 2, with a mix of neutral and extreme media (media positions: -8, -8, -7, 0, 0, 0, 1, 2, 8, 8). If polarization occurred in Experiment 1, it would show that media extremity, combined with changes in individuals, could cause polarization (Figure 5). If polarization occurred in Experiment 2, it would show that only some media nodes need to become extreme for polarization to occur (Figure 6). Polarization occurred in both trials, confirming these hypotheses. Below, we conduct more formal analysis on the societies that resulted. Values quoted are averaged across 10 runs of each model configuration.

We analyzed the results using formal network analysis, build on Mastering Gephi Network Visualization (Cherven, 2015). The metric used:

- Average path length: Measure the network communication efficiency, by calculating the shortest path between all nodes in the network. Lower number means higher network efficiency. The smaller it is, the easier information could flow in the graph.
- Modularity: Measure the extent to which the network is separated into modules. Modularity ranges from 0 to 1, inclusively. Higher modularity indicates stronger interconnectedness among nodes *within* a group and sparser connection among nodes *between* groups.
- Number of Communities: Identify existing clusters within the network, which are defined as groups of interconnected triplets (or “triangles”), but with limited connections between one group and another.
- Clustering Coefficient: Measure the extent to which nodes in the network are connected, by taking the ratio between all the existing triangles and all the possible triangles in the network. Clustering Coefficient ranges from 0 to 1, inclusively. The higher the number of triangles in the network, the higher the clustering coefficient is.

Note: in the figures below, media nodes have been increased in size. The size has no connection to the connectivity of the media nodes. Media nodes in ideologically homogenous groups, which share the same opinion extremity/position as the group, have been colored green. The color does not represent their position. These changes help visualize the connective role of the media. Neutral media nodes is left with original coloring.

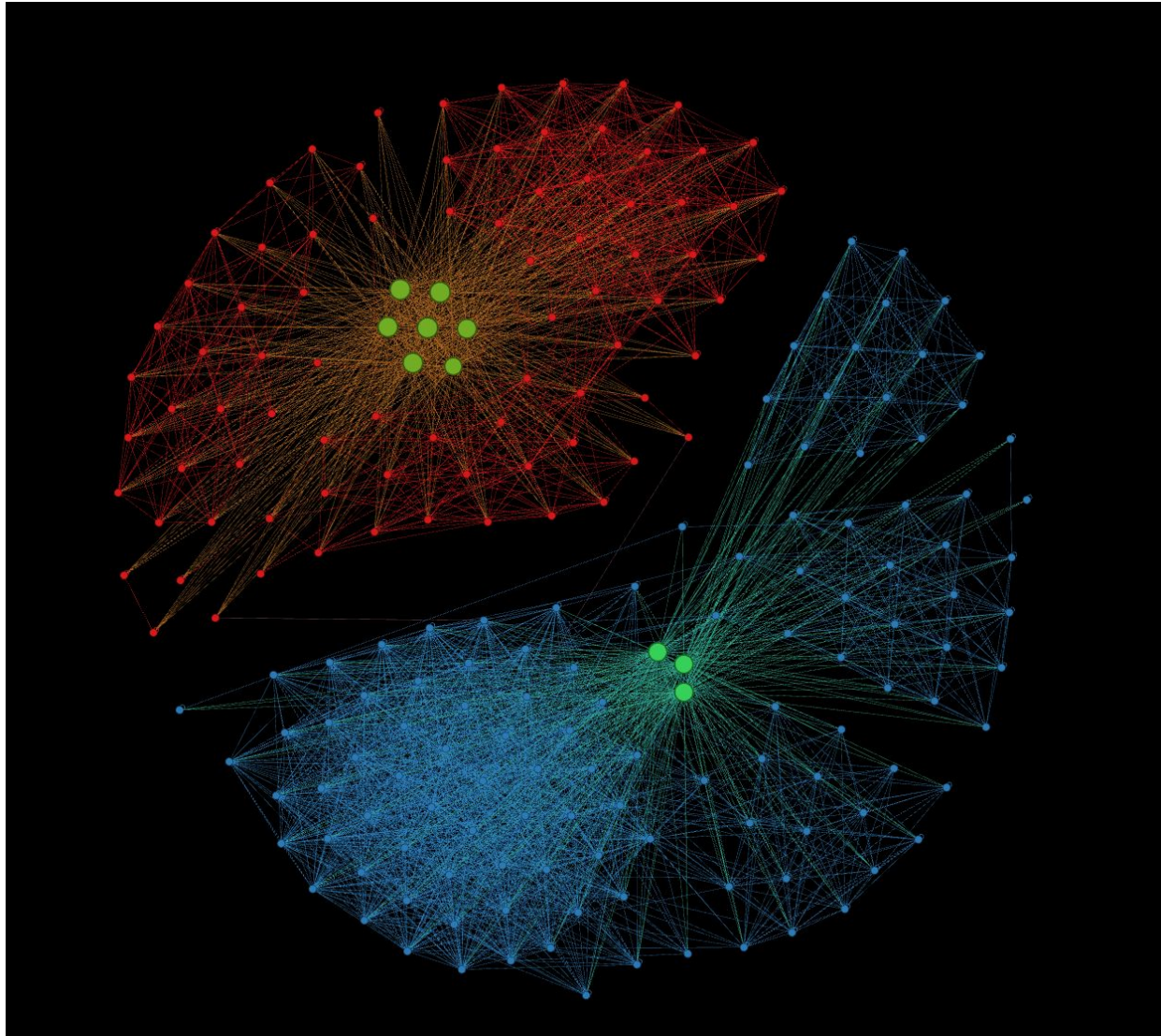


Figure 5. Experiment 1 - Polarized media: Modularity: 0.565; Average Path Length: 2.99; Number of Communities: 6; Average Clustering Coefficient: 0.74

This graph displays clear polarization. Each distinct group displays a homogenous, fairly extreme ideology (indicated by the matching, dark colors). Media nodes are central to each group, connecting to almost all individuals. Interestingly, the two nodes with relatively lower positive values (3, 6), became extremely negative over the run.

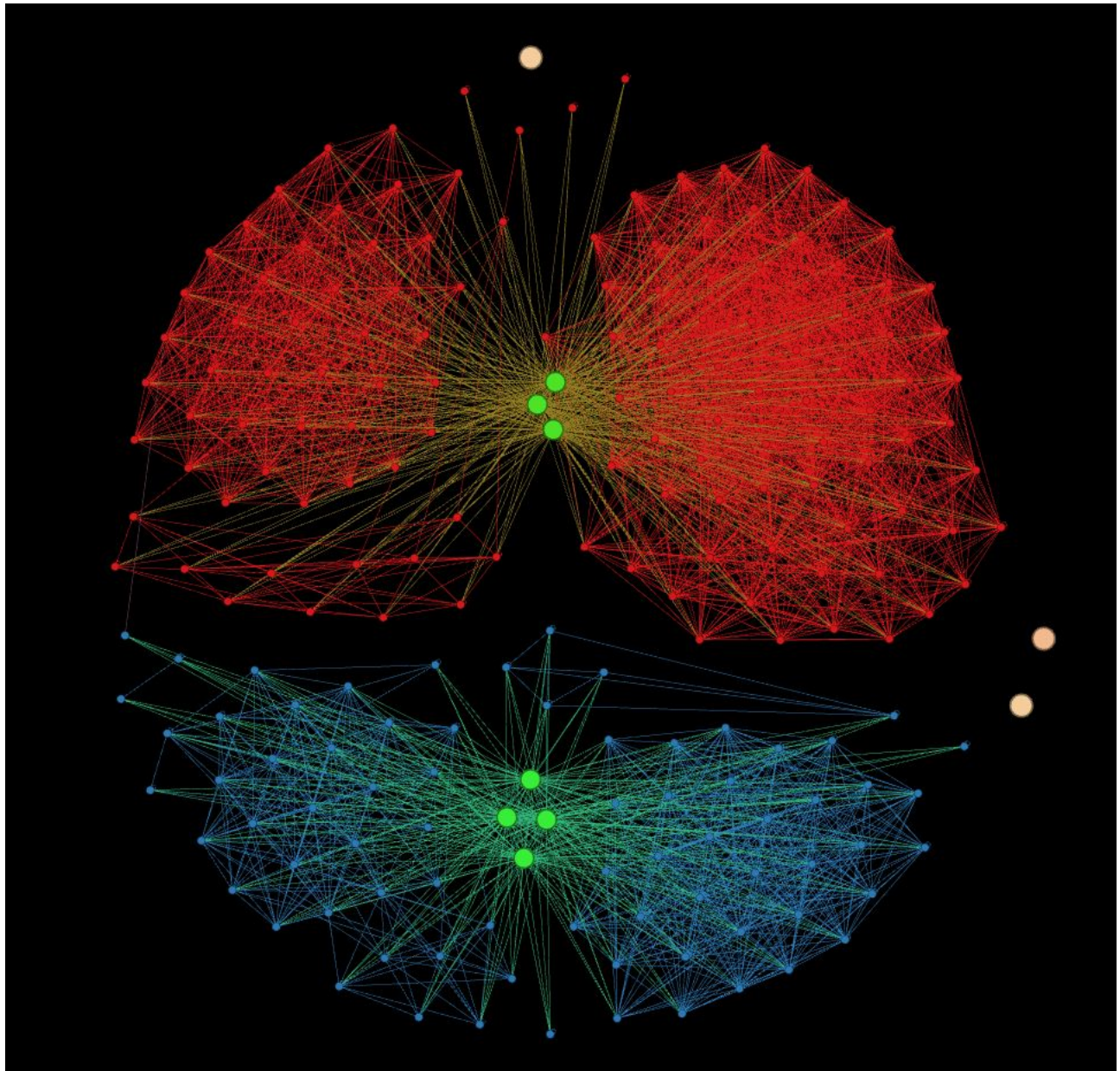


Figure 6. Experiment 2 - A mix of extreme and neutral Media: Modularity: 0.579; Average Path Length: 3.07; Number of Communities: 6; Average Clustering Coefficient: 0.76.

Here, we see very similar polarization as above. Indicating even a few extreme media nodes tip society into a vicious cycle. Interestingly, we see neutral media having been ejected from the network. Possibly indicating that media nodes must adapt their position sufficiently or risk losing all subscribers as society becomes increasingly polarized.

Social Experiment

Purpose

This experimental case study examines the influence of different articles on individuals' opinions about an issue.

Hypotheses

- (1) Factual information will improve quality of opinion.
- (2) Questioning a non-fact-based opinion will decrease extremity of opinion.
- (3) Questioning a non-fact-based opinion and then giving factual information will improve quality of opinion and decrease extremity of opinion.²⁰

Variables

Independent variables:

- Factual information
- Questioning

Dependent variables:

- Extremity of opinion, measured as the distance from neutral on a standard seven-point Likert scale (4 on the scale yields 0 - neutral, therefore positive - agreement, negative - disagreement).
- Quality of opinion, measured by the relative extremity of opinion between pretest and posttest in regard to the introduction of factual information.

Interventions:

- Phase 1: Biased articles
- Phase 2:
 - Factual articles
 - Questioning

Potential confounding variables

- Preconceptions about the issue
- Environmental influences on participants' opinions and emotional states
- Different interpretations of information and questions
- Level of scrutiny applied to information provided

²⁰ We created three hypotheses from the research we had conducted previously. These hypotheses not only reflect how we believe a social system to operate, but were created with interventions/solutions in mind. They dictated the interventions each of the testing groups received (#hypothesisdriven).

Narrative description

The 20 subjects were students from Minerva Schools at KGI. They were assigned randomly to five groups that each received different combinations of controls, priming, and interventions (Table 2). To mitigate any preconceptions or biases, we devised articles and questions about a fictional conflict scenario. All subjects were given the same persona to frame the experiment. All subjects individually interacted on a digital platform with a character we created. The experiment and all interventions were part of a fictional conversation with links to surveys and articles sent via chat.²¹

The process, questions and articles were pre-tested with five individuals, who provided feedback that we implemented by changing confusing names in the setup and screening subjects for biases identified in testing.

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Process:

Group	Intervention Phase 1			Intervention Phase 2			
	Neutral Summary	Priming with 3 Biased Articles	Pretest Survey (9 statements)	Tetris Game to pass time	Questioning Survey	3 Factual Articles (support 4, refute 5 statements)	Posttest Survey (9 statements)
Control	X		X	X			X
Primed with Biased Articles	X	X	X	X			X
Questions	X	X	X		X		X
Facts	X	X	X			X	X
Questions and Facts (QF)	X	X	X		X	X	X

Table 2. Organization of testing groups and the various types of information they received (X if group received information).

Results

²¹ #casestudy: We designed a scenario to test the effectiveness of possible interventions through media tools aimed at improving quality and decreasing extremity of opinions of a small group of students. We use this as a first step in devising and testing interventions to counter the polarization mechanisms we described above. A case study approach best allowed us to test interventions with the limited resources we had and serves as a starting point for further discussion and research on the topic.

²² We created a case study that used experimental methods to test our ideas. By randomly assigning groups, pre-testing the experiment and implementing resulting feedback, including control groups, manipulating each intervention independently, and mitigating variables where possible, we ensured rigor in our #experimental design.

1. Biased articles successfully primed.

Control Group Pretest Mean	-0.417
Primed Group Pretest Mean	0.528
Difference	0.945
Significance	$p = 0.042 < 0.05$ Statistically significant difference

Table 3. Comparison of control group and primed only group means in pretest survey. Primed subjects had more extreme positive opinions than the control group.

2. The control group displayed expected results - no priming.

	Control Group	Primed Group
Pretest Mean	-0.417	0.528
Posttest Mean	-0.306	0.472
Change	-0.111	-0.056
Significance and Effect Size	$p = 0.345 > 0.05$ Cohen's $d = 0.262$ No significant change	$p = 0.372 > 0.05$ Cohen's $d = 0.070$ No significant change

Table 4. Comparison of pretest and posttest means in the control group and primed groups. Both the control group and the primed group who did not see an intervention in phase 2 did not change their opinions significantly between pretest and posttest. From this we can infer that any results in the other groups were due to the interventions and natural variance.

3. Factual information did not significantly improve quality of opinion.

Expectation: When you get facts, you should be more confident in an opinion that was supported, and less confident in an opinion that was not supported. The data do not confirm this.

Pretest Mean	1.125
Posttest Mean	0.688
Change	-0.437
Significance	$p = 0.228 > 0.05$ No significant change

Table 5. Comparison of pretest and posttest means of opinions on statements supported by factual articles in the fact group. Agreement with fact-supported statements decreased in comparison to uninformed biased opinions about them after reading factual articles. This change could be due to chance.

Pretest Mean	0.550
Posttest Mean	-0.650
Change	-1.200
Significance	$p = 0.228 > 0.05$ No significant change

Table 6. Comparison of pretest and posttest means of opinions on statements refuted by factual articles in the fact group. Factual articles made people switch from agreeing to disagreeing with statements that were refuted. This change could be due to chance.

4. Questioning did not significantly improve quality, in fact, it may have made it worse.

Expectation: Questioning should show people that they do not have evidence for their opinion, and therefore disprove their illusion of explanatory depth, which should make them move towards a more neutral opinion on all statements.

Pretest Mean	0.139
Posttest Mean	0.889
Change	+0.750
Significance	$p = 0.129 > 0.05$ No significant change

Table 7. Comparison of pretest and posttest means in the question intervention group. Questioning seems to strengthen one's illusion of explanatory depth and make one more confident in a biased, uninformed opinion. This change could be due to chance.

5. Questioning and factual information together sometimes create higher quality opinions and show no significant changes in extremity of opinions.

Expectation: The intervention is supposed to cancel out the bias through questioning and then convince one of the side that evidence in the factual articles directs one to (agreement if supported, disagreement if refuted).

They should create informed opinions that are in line with the evidence presented. With this evidence, subjects should show more confidence in the opinions than uninformed, unbiased stances in the control group. The data confirm this for factually-supported statements but do not show more confidence in disagreement with factually-refuted opinions.

Control Group Posttest Mean	0.000
QF Group Posttest Mean	1.000
Difference	1.000
Significance	$p = 0.038 < 0.05$ Statistically significant difference

Table 8. Difference of means between QF group answers and control group answers for supported statements. Opinions about supported statements are stronger than unbiased, uninformed opinions. The 95% confidence interval for supported questions after QF intervention of 0.018 to 1.982. This indicates a confident, qualified agreeing opinion.

Control Group Posttest Mean	-0.550
QF Group Posttest Mean	-0.650
Difference	0.100
Significance	$p = 0.371 > 0.05$ No significant difference

Table 9. Difference of means between QF group compared to control group for refuted statements. Opinions about refuted statements are not significantly different from unbiased, uninformed opinions. The 95% confidence interval for refuted questions after QF intervention is -1.907 to 1.607, which does not indicate a confident, qualified disagreeing opinion.

At the same time, the intervention should reduce the bias in the pretest to a more nuanced, less extreme stance on the opinion. The data show no significant changes in extremity.

Pretest Mean	0.750
Posttest Mean	1.000
Change	+0.250
Significance	$p = 0.307 > 0.05$ No significant change

Table 10. QF group results for supported statements. No significant changes in extremity.

Pretest Mean	-0.050
Posttest Mean	-0.650
Change	-0.600
Significance	$p = 0.287 > 0.05$ No significant change

Table 11. QF group results for refuted statements. No significant changes in extremity.

Discussion

We can prime individuals towards extreme opinions with biased articles. This bias will stay, if we do not intervene.

Factual articles, although supportive of a statement, do not move individuals more towards an extreme than bias would. Additionally, factual articles can sway people from a one-sided biased opinion to the other side, if the facts support the other side. Both of these findings could be due to chance. However, if true, discussion solely based on facts should make people revert to opinions that are based on facts and stay close to neutral positions.

Surprisingly, questioning biased opinions appeared to strengthen biased beliefs. Although this could have been down to chance, it could be one of many reasons for aggressive behavior of people in discussions between different, polarized groups.

When an individual is biased, they will strongly believe factual articles that support the biased opinion they held before, even after questioning the biased beliefs. However, if the factual articles refute the former biased opinion, the individual will not come around to hold a strong, qualified opinion that goes against the original bias, despite being questioned about this bias. Of the three interventions, this one proved most likely to be useful and should therefore be investigated further.²³

This experiment was limited due to sample size and the constraints of a fictional social issue. It would prove most useful if tested with a much larger group on a real issue facing society. We would hope to see stronger opinions initially, reflecting the extreme opinions existing in a polarized society, which would make any significant results of this intervention testing more applicable to an actionable solution.

Based on our study, we have formulated a measurement for quality of opinion that takes into account on the variables presented in our study and ties them the amount of bias present in and quality of an opinion.

$$\text{Amount of bias } B = \frac{\text{Extremity of opinion } E + \text{Questioning } Q}{\text{Factual information } F}$$

$$\text{Quality of opinion } O = \frac{1}{\text{Amount of bias } B}$$

Therefore:

$$\text{Quality of opinion } O = \frac{\text{Factual information } F}{\text{Extremity of opinion } E + \text{Questioning } Q}$$

Quality of opinion is the ratio of your extremity of opinion and the questioning that affects it to the factual information you have received. This measure of quality of opinion would be best applied to overarching opinions on issues, instead of details. Factual information can be assigned a value 0-1, based on the amount

²³ #significance: We calculated p values in significance tests for all changes observed in the experiment. We compared them to a standard 5% alpha significance level. We used these calculations to evaluate the impact of the interventions and draw conclusions as well as recommendations for further research from them.

of information the subject has been exposed to on the whole topic. Values can similarly be assigned to questioning. Extremity of opinion can be measured as it was in the experiment, where the mean opinion of society serves as the most neutral, and individual extremity is measured as the distance from that opinion. Values should be decided by the researcher prior to calculations. We propose this as a future measure of quality of opinion.

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²⁴ #sourcequality: To better understand and frame the topic, we worked with recent scholarly sources to draw on the best current understanding in the field and supplemented this with popular articles that discuss and demonstrate the consequences in society. We used this extensive research to build support for our causal explanations and then designed experiments to prove our combination of the knowledge as well as provide starting points to combine the knowledge and our experimental results for further research.

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Appendix A: Division of Labor

Proposed Division of Labor

	Research	Product Design	Product Creation	Product Testing	Editing/ Presentation	Blogging
Josh B.	25%	25%	50%	15%	10%	30%
Long L.	25%	25%	50%	15%	10%	10%
Marlette S.	25%	25%	0%	35%	40%	10%
Adrian S.	25%	25%	0%	35%	40%	50%
Total	100%	100%	100%	100%	100%	100%

Actual Division of Labor²⁵

	Research	ABM	Social Experiment	Editing/ Presentation	Blogging
Josh B.	25%	45%	5%	25%	5%
Long L.	25%	45%	5%	25%	5%
Marlette S.	25%	5%	45%	25%	5%
Adrian S.	25%	5%	45%	25%	85%
Total	100%	100%	100%	100%	100%

²⁵ A completely non-arbitrary table of numbers that totally represent reality. On a serious note, our team gelled very well. Everyone was consistently engaged, contributed meaningful value and ended on a high.

Appendix B: Social Experiment Documents

Content

- Conversation Modules
- Consent Form
- Biased Articles
 - Tensions Rising Between Dellmount and Waydale
 - Dellmount Considering Action Against Waydale
 - Intervention Against Waydale
- Factual Articles
 - Waydalic Economy Still Not Recovering Amidst Tensions
 - Mayor Warns of War with Waydale
 - Dellmount and Waydale Positioning at Border
- Questions about Dellmount and Waydale (Pre and Posttest Survey)
 - Survey Statements
 - Responses
- Further Questions on the Tensions Between Dellmount and Waydale (Questioning)
 - Survey Statements
 - Responses