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Political complexity and the pervading role of ideology in policy-making

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Policy-makers use different decision-making strategies and base their decisions – more or less explicitly – on both expert knowledge and opinions in order to cope with the sheer complexity of societal challenges and the political environment. Most politicians rely to some extent on personal ideology in the implementation of public policies. Potential decision biases such as 'repair service behaviors' – the human tendency to fix immediate problems rather than employ long-term strategies – also influence decision-making. While ideology plays a prominent role in politics, we know too little about its effect on political decision-making. Some researchers would argue that the use of ideology and repair service behavior facilitate the decision process, while others suggest that it adversely affects the ability to make logical decisions. Using a political microworld simulation that reproduces complex real-world problems, we investigate the effects of repair service behavior and personal ideology on performance in a dynamic decision-making task. Although repair service behavior was not associated with performance, the results suggest that personal ideology significantly impaired goal attainment. Despite clear instructions to be as objective as possible and think critically in completing the task, ideology was powerful enough to disrupt logical policy-making, as indicated by the deviation from optimal scores and the overall microworld task goal, i.e., to win votes and be re-elected by the end of the game.

Keywords: dynamic decision-making, policy-making, political ideology, repair service behavior, microworlds

The limitations of human cognition in performing dynamic decision-making (DDM) and solving complex problems are well documented (e.g., Fischer, Greiff, & Funke, 2012; Funke, Fischer, & Holt, 2018; Jaradat, 2015). DDM requires decision-makers to perform cognitively demanding activities, such as understanding nonlinearity (e.g., Paich & Sterman, 1993), assessing side effects (e.g., Sterman, 2006), understanding accumulation and depletion in stock-and-flow problems (e.g., Cronin, Gonzalez, & Sterman, 2009; Ozgun & Barlas, 2015), and anticipating feedback and delays (e.g., Moxnes, 2000; Yasarcan, 2011). The political environment is one replete with complexity whereby politicians must make decisions to benefit a varied electorate, aiming to achieve a satisfactory balance on multiple interacting policies such as the economy, military defence, civilian safety, social policies, and the environment, many of which require longer-term strategies. DDM is a similar concept to those used in other domains such as education (complex problem solving; Funke, Fischer, & Holt, 2018), or cognitive psychology/human factors (dynamic cognition; Hodgetts et al., 2023), that seek to understand human limitations in dealing with complexity by taking a holistic view of cognition.

In politics, ideology serves as an intrinsic and essential guide for decision-making by aiding in the prioritization of issues and the resolution of conflicting goals (Feldman, 2013). However, in the current paper we ask whether ideology may in fact be *too* powerful with a potential influence beyond volition. Reducing the elaborate political environment to the more simplified pursuit of ideological goals could be considered short-sighted and potentially detrimental to the overall complex problem-solving aim of maximizing long-term benefits to most, if not all, people (Tetlock, 2017). Heuristics are often used fairly successful as a way to manage complex problems, bypassing much of the intricacies of the problem environment to arrive at an adequate solution (Gigerenzer & Selten, 2002); nevertheless, cognitive shortcuts can sometimes lead to outcomes that are too narrowly-focused, failing to take into account multiple interacting goals, secondary effects, and longer-term impacts (Gilovich et al., 2002). Some authors have notably discussed a tendency to adopt a reactive approach that favors short-term investment of resources to specifically attempt to solve problems that arise unexpectedly (see Senge, 2006; Sterman, 2001). Such behavior in the face of complexity has been previously documented and characterized as inappropriate and problematic (Dörner, 1981; Repenning, Gonçalves, & Black, 2001). In this context, our focus centers on political ideology and repair service behavior (the tendency to try to fix first whatever presents as an immediate problem; see, e.g., Deming, 2018; Dörner, 1981, 1997) from a cognitive perspective; both are examined as cognitive strategies for managing complexity in the execution of a dynamic decision-making task. While repair service behavior can be categorized as a heuristic, ideology,

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although not inherently a heuristic, is studied in a similar manner due to its potential as an information processing strategy in navigating political complexity (see Feldman, 2013; Hinich & Munger, 2010). The game *Democracy 3* – used here as a research microworld – captures the underlying complexity of the political landscape, for which to be successful in the game – i.e., to win the largest number of votes and ultimately be re-elected – participants must maximise quality of life for the broadest number of people on a wide range of issues. We suggest that while such heuristics can be beneficial to guide decision-making, they may fall short of 'logical' decisions, i.e., decisions that entail a deliberate and thoughtful process involving analytical thinking, and conscious effort to reach well-reasoned conclusions (Kahneman, 2011).

Policy-making as dynamic decision-making

Policy-making is a DDM task which takes place in a complex and uncertain environment. Establishing a new policy is complex in that it involves consideration of: (1) a large number of variables (complexity); (2) potentially conflicting goals (*polytely*); (3) the unpredictable evolution of the environment over time and space (dynamism); (4) the mutual dependence between variables (connectivity); and (5) the partial (or complete) opacity of those dependencies and relationships (see Funke & Frensch, 2017). If we consider for example decisions faced by politicians regarding the degree and duration of lockdown policies to be implemented during the COVID-19 pandemic, there were a large number of variables at play (e.g., burden on health services, economy, social factors, education, etc.); goals were often conflicting (e.g., risk to life vs. harm to the economy); the evolution of the pandemic was unknown and data regarding spread/time course/fatality rates were incomplete and speculative; many factors were interdependent with opaque relations and undetermined secondary effects (e.g., lockdown preventing the spread of disease, but decreasing mental health, which in turn could impact physical health due to coping mechanisms, e.g., increased alcohol consumption). There was no simple 'correct answer' to the covid lockdown problem; indeed, politicians in different countries took different stances regarding when, how much, and how long lockdown policies should be enforced, none entirely sure how their actions would play out, but each acting on incomplete information and inferences from different sources to inform their decisions. The aim of all politicians was to manage the situation with minimal negative effects, but the complexity imposed by the global pandemic was such that approaches and opinions as to how best to achieve that goal would vary.

Individuals who assume a policy-making position (e.g., elected officials, political staff) use different decision-making strategies and heuristics to cope with the sheer complexity imposed by the political environment (see Vis, 2019). Such strategies play an important role in DDM, by reducing the need for complete information (Tversky & Kahneman, 1974; Walgrave & Dejaeghere, 2017): *"Faced with the overwhelming complexity of the real world, time pressure, and limited cognitive capabilities, we* [humans] *are forced to fall back on rote procedures, habit, rules of thumb, and simple mental models"* (Sterman, 2006, p. 510). Research in economics, and political science has improved our understanding of the role of cognitive strategies in political decision-making. Poliheuristic theory (e.g., Mintz, 2004; Mintz & Adamsky, 2019) seeks to explain the strategies used in decision-making during critical political junctures, or in situations characterized by temporal constraints and heightened stress. Apart from the poliheuristic approach, other studies (e.g., Miler, 2009) have shown that political decision-makers (in this particular case, legislative staff members) tend to rely on heuristics when making judgments about issues and concerns of the general population. However, they should also be aware of the potential limitations associated with cognitive heuristics, and strive to complement decision-making with more analytical techniques (see also Hafner-Burton, Hughes, & Victor, 2013; Hoppe, 2018; Kropp, 2010; Mousavi, 2018).

Ideology in policy-making

Ideology is perhaps one of the most studied concepts in all fields of social sciences. Ideology has been initially described as a sophisticated architecture used as a super-system of reasoning for political decision-making (Converse, 1964). Today, research on political attitudes provides a more refined understanding of ideology. The concept is depicted as a multifaceted phenotype that involves not only the psychological aspects but also the interaction between individuals and their environment. Notably, some researchers have delved into the realm of biological factors in understanding the origins of beliefs, pushing the boundaries of research to explore the connection between the complexities of the real world and an individual's intrinsic political beliefs (Smith & Warren, 2020). The study of political ideology involves multiple levels of analysis, making its definition and operationalization particularly challenging due to the numerous and sometimes conflicting conceptualizations proposed in social science research (see Feldman, 2013; Gerring, 1997). For instance, ideology may exist to outline formal systems of political beliefs (e.g., liberalism, conservatism), to describe how voters behave, or simply to organize political debate around a specific party system (Feldman, 2013). Although there is no single definition of the construct, political ideology may be considered as a structure of political beliefs that facilitates the understanding of complex problems through limited information that can be easily processed for decision-making (see Feldman, 2013; Inglehart & Klingemann, 1976; Popkin, 1991).

Although it may not always be the case, extensive research on *confirmation bias* in cognitive science (e.g., Mercier, 2017; Nickerson, 1998), as well as the existing literature in social psychology and political science

on 'motivated reasoning' (e.g., Druckman & McGrath, 2019; Kunda, 1990), suggests that beliefs formed on limited information can influence decision-making by simplifying the processing of complex inferential tasks (MacCoun, 1998). Pertaining to ideology, when individuals hold beliefs formed with limited information, this has the potential to result in unconscious resistance to evidence that contradicts their prevailing political beliefs (see Mercier, 2017). Instances of this resistance in decision-making can be observed in topics concerning important sociopolitical issues, such as the perceived deterrent effect of the death penalty (Lord, Ross, & Lepper, 1979), or the impact of gun control on crime rates (Taber & Lodge, 2006). Policy resistance is a macro phenomenon that occurs when policy decisions of this nature encounter obstacles as a result of the system's inherent response (Sterman, 2001, 2006).

Thus, policy-making can be guided by ideology, as voters elect policy-makers driven by a particular ideology, who are then expected to implement policies in accordance with that ideology. It is common practice for policy-makers to consider personally held ideology in implementing policies (e.g., former US President Donald J. Trump's *Tax Cuts and Jobs Act*, or Massachusetts senator Elizabeth Warren's *Ultra-Millionaire Tax Act*). Much empirical testing has been conducted on the structure, contents, and functions of ideological belief systems in voters (Jost, Federico, & Napier, 2009; see also Weber, 2019). However, there seems to be less research on the role of ideological preferences in policy-making, and the implications of these for making decisions that result in the overall best outcomes for the country. Studies addressing the relationship between political ideology and policy-making are limited (e.g., Baekgaard, Moynihan, & Thomsen, 2021; Baumann, Debus, & Müller, 2015; Rocca & Sanchez, 2008), due in part to the difficulty of replicating the context in which policy-making occurs. While policy-makers generally benefit from a wide range of resources to support decision-making (e.g., advisors, research departments, dedicated public funding), they are typically faced with a number of challenges including the complexity of information, the need to multitask and handle regular interruptions, as well as dealing with a dynamic context where policy-making is *ad hoc* at best (Brest, 2013). Ideology can help navigate the complexity of the political environment, meaning that a decision can be reached with less information, thus simplifying the difficult decisions of how to allocate funds, enforce rules, and prioritize goals. When simple assumptions can be made about cause and effect, this strategy can serve well; however, in many cases with multiple goals, side effects, and delayed feedback, there is the potential that being guided by ideology can be detrimental to decision-making by preventing a systematic and holistic approach.

Cognitive strategies and heuristics to cope with complexity

Heuristics (i.e., cognitive shortcuts used to make a decision without referring to all relevant information) play a dominant role in DDM to help simplify decisions, by reducing the need for complete information (Hjeij & Vilks, 2023; Walgrave & Dejaeghere, 2017). Every heuristic can be used as a deliberate strategy involving conscious effort, but may also unfold unconsciously (Gigerenzer & Gaissmaier, 2011); that is, they operate outside conscious awareness, are difficult to identify as well as to control, yet have a direct influence on decision-making. Thus, heuristics can be a useful strategy to save cognitive effort in complex problem-solving, but can also be problematic if decision-makers eschew relevant information to the detriment of task goals, and especially if this process occurs without conscious awareness.

The reasons why decision-makers faced with complexity may engage in problematic strategies and shortcuts fall into two schools of thought (for a comprehensive discussion, see Kelman, 2011). Some argue that under evolutionary pressures, human cognitive functions have evolved to process environmental cues in a *satisfactory* manner in response to the constraints imposed by complex uncertain environments – i.e., the 'fast and frugal' approach, whereby humans are only motivated to be 'good enough'; Luan, Reb, & Gigerenzer, 2019; Simon, 1955). On the other hand, other researchers (e.g., Kahneman & Tversky, 2013) rather assume that people do seek to make logical decisions, but that it often fails because of cognitive limitations (see Kahneman, 2011), for example, responding poorly to delayed feedback, making decisions according to context-specific features only, thinking in simple causal chains, assuming that each effect has a single cause, collecting only confirmatory information while refusing to acknowledge contradictory information (see Dörner, 1997). Regardless of whether the aim is for satisficing or optimizing, it is clear that in the face of complexity and uncertainty, human problem-solvers may fall short. Nevertheless, problem-solving is still required in such complex environments and heuristics can be a useful strategy to avoid falling into non-decision and naturalistic fallacies (i.e., the assumption that a native or natural state – without human action – is necessarily good).

Repair service behavior is one example of a mental shortcut that has already been observed anecdotally in complex and uncertain environments (Dörner, 1981, 1997). Also known as 'fire-fighting', repair service occurs when decisions are made considering one goal only, irrespective of the interrelationships between the many factors that mould the environment: Decision-makers *"go out in search of things that are malfunctioning, and once they find them, their immediate goal becomes fixing whatever is broken"* (Dörner, 1997, p. 59). Repair service behavior is about knowing what is urgent, not what is important. In addition to the sense of urgency stemming from time pressure, the inherent

reactive nature of repair service may occasionally be ill-suited to problem-solving, posing a significant challenge to managing complex systems and making dynamic decisions in the real world (Deming, 2018). For instance, when addressing traffic congestion, decision-makers could choose to implement isolated policies instead of tackling the root causes of the issue. This urgency-driven approach could lead to a fixation on expanding road capacity over considering public transport holistically, while a more comprehensive strategy would involve investing in public transportation infrastructure, promoting telecommuting or flexible working hours to reduce rush hour traffic, encouraging carpooling, and implementing urban planning measures that reduce reliance on cars. While a short-term solution may temporarily ease traffic congestion, it could also lead to increased car usage, encouraging more people to drive and ultimately exacerbating congestion in the long run.

In the political realm, repair service appears particularly relevant as it occurs in uncertain, dynamic, and complex decision-making environments with high time pressure (see Dörner & Güss, 2022), and is predominantly observed in large organizations – such as governments – where decision-makers possess the requisite authority to act on behalf of a collective (see Repenning, Gonçalves, & Black, 2001; Senge, 2006). Faced with political complexity (i.e., the properties of complexity applied to the political environment), policy-makers may try to solve potentially less significant yet salient problems, or simply address issues that fit their area of expertise (or personal interests), thus downplaying the importance of other factors, and overlooking more fundamental issues. This may particularly be the case when policy-makers are confronted with a critical issue that they have not previously encountered in performing their public duties (e.g., the COVID-19 pandemic). This type of strategy is – as per Kahneman's (2001) definition – not logical for complex problems because it displays a narrow approach that fails to take into account broader and longer-term cause-and-effect relationships within the system. Inefficient problem-solving is concerned with treating symptoms and immediate problems; efficient problem-solving improves longer-term processes and resolves underlying causes (Deming, 2018; Sterman, 2001). When policy-makers exhibit "emergency reactions" (Dörner, 1981), one could argue that they find themselves subjected to repair service behavior.

Use of a microworld as a simulation of policy-making

Computer interactive simulations, microworlds and games (albeit serious or not) are often mentioned interchangeably, and distinctions between them are not always clear-cut (see Rieber, 1996). Microworlds could be described as interactive computer simulations that have some game-like characteristics and require participants (or trainees) to make series of decisions. Microworlds have proven to be effective in capturing the fundamental properties of real-world dynamic systems, replicating the key attributes that characterize uncertain and complex environments (see Dörner & Funke, 2017), and simulating goal-oriented DDM tasks (see, e.g., Gonzalez, Vanyukov, & Martin, 2005). In a series of classic experiments, Dietrich Dörner and colleagues showed a fairly high level of incompetence in participants who had to manage a complex sociopolitical system by promoting the well-being of the inhabitants of a fictitious community (see the *TANALAND* experiment by Dörner & Reither, 1978, *LOHHAUSEN* by Dörner et al., 1983, and the *MORO* scenario by Putz-Osterloh, 1985; Strohschneider & Güss, 1999). In particular, participants found it difficult to manage their time well, to evaluate the exponential development of processes, and to take into account side effects and long-term repercussions of their actions (Dörner, 1997). In fact, whereas they initially had a positive impact on the system with short-term gains, participants failed to stabilize the system and produced disastrous effects overall. Microworlds are therefore able to compress the key features of everyday complex problems into a simulation that imposes a comparable level of demand as that required in solving real-world problems.

In this paper, we examine the relationship between goal attainment on a political DDM task with both repair service behavior, and personally held ideology. Specifically, we investigated whether the extent to which individuals implement policies based on repair service, or compliance with their personal ideology are effective at managing political complexity. We hypothesized that the inclination to adhere to personal ideology or adopt a reactive repair service approach to problem-solving may potentially hinder goal attainment in performing the DDM task. This hypothesis was tested in a laboratory experiment using a political microworld.

Methods

We used the *Democracy 3* (D3) game (Positech Games, 2013) as a research microworld to simulate political complexity (see Figure 1). Some games – as is the case with D3 in the present study – that were initially and primarily developed for pure entertainment value, have been exploited for research purposes because their "microworld" (storyline, scenarios, and system dynamics) capture the properties of complexity imposed by real-life complex problems, and require series of dynamic decisions from players (e.g., City Skyline, see Bartholdy & Kipman, 2019). D3 simulates real-world features that provide a compelling and ecologically valid virtual depiction of politics; it is a non-linear turn-based political simulation that reproduces the major systems thinking challenges in various areas of social life, namely welfare, economy, taxes, public services, law and order, foreign affairs and transportation. Players assume the position of president (or prime minister) of a real-world country for a fixed term

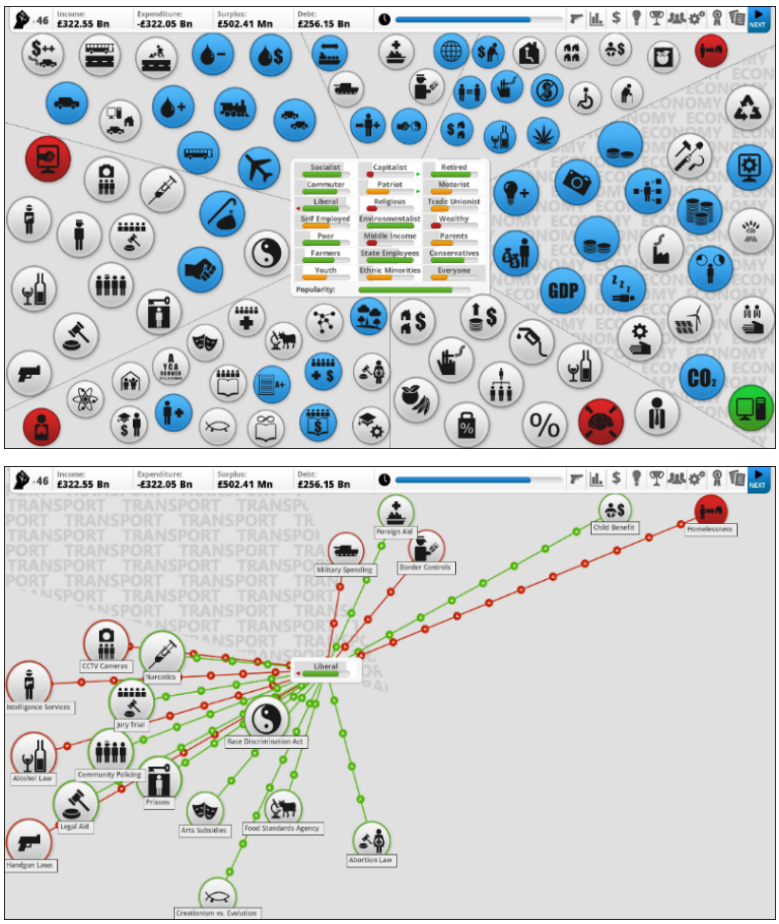

Figure 1. D3 main interface (top): progress bars represent projected popularity for subgroups of the electorate; blue icons are statistics, white icons are active policies, while red and green icons are situations (problems) and technological advantage respectively. D3 model of dynamism (bottom): green and red lines are dynamic and indicate that the impact is to increase (or decrease) the value of the target variable.

of four years (16 rounds of play) with the objective of increasing public support and keeping the electorate sufficiently satisfied to be re-elected by the end of the game (Harris, 2013). Players may influence the environment through introducing new policies (and modifying or cancelling existing ones), dealing with any social dilemmas as they arise, and managing the government cabinet (i.e., reshuffles and dismissals).

Each decision in the game is influenced by a point allocation system that constrains the player's choices based on the available political capital in each turn. Political capital is generated by a 7-member cabinet, each member representing one of the aforementioned areas of social life. Apart from generating political capital depending upon their loyalty to the player, the cabinet members embody the social and collaborative aspect of political decision-making, as their generated information influences policy effectiveness within their departments, provides electoral advantages to specific voter groups, and favors certain policies over others for implementation.

Policy-making is done on the basis of information that provides the player with a fragmentary understanding (partial opacity) of the potential impact the policy may have on the population and public finances (i.e., estimated popularity with different sectors of voters, potential cost, potential income). The player has access to a total of 83 policies to implement. When implementing policies, players must consider the specific affinities of each cabinet member (ministers) with the different subgroups of the population (e.g., liberals, conservatives, environmentalists, religious, poor, patriots, etc.). The effect of policies can range from a few to a substantial number of implications, some of which remain hidden (i.e., there are dormant situations that are influenced by the player's existing policies, even though the specific effects will only become apparent upon the activation of these situations). An example of a hidden situation could involve the buildup of public discontent among specific social groups or factions due to the player's policies or the neglect of certain issues. If not addressed, such discontent may eventually lead to visible protests, strikes, or even civil unrest.

The game automatically generates consequential side effects and draws on exploration, trial and error, and feedback loops to foster interactive learning, and simulate real-life politics, while retaining empirical control. Although D3 adequately captures the properties of complexity, it remains simple in its use; ground rules and user interface functionalities are straightfor-

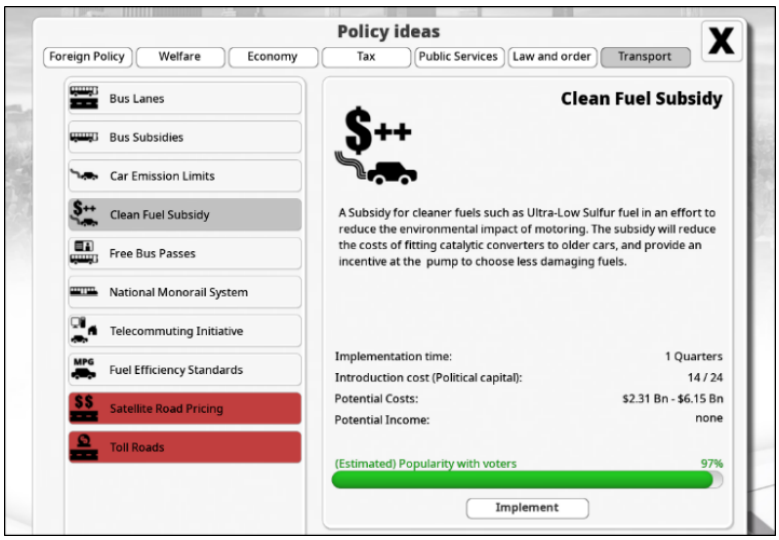

Figure 2. The 'Policy ideas' tab in D3.

ward, and the game's main features (e.g., policy implementation tab) are easily understood. The game is immersive and combines both the playful settings of a game and the learning experience associated with a simulation. D3 also introduces a scoring system based on a real-time composite index of projected popularity which provides the player with a prediction of the number of votes that could be received if the session were to end at any given time. Such a system elicits intrinsic motivation for task completion.

Participants

The sample consisted of 56 participants (34 men, 22 women) recruited through the psychology course and campus advertisements at Université Laval in Québec city (Canada) between January and October 2019. Participants were all students enrolled on either a full-time or part-time undergraduate or postgraduate degree course, some of whom were employed alongside their studies. All participants gave their informed consent after having received complete information about the nature of the experiment. For their participation, each participant was given a monetary compensation of $20 CAD, which was fixed and independent of their performance or level of success within the experimental task.

Procedure

The experimenter began by explaining the various objects displayed on the main user interface and their purpose (i.e., policies, statistics, problem situations, and technological advantage). Also provided was information about action tabs on the main screen, including the 'Policy ideas' interface (i.e., used for policy-making) (see Figure 2). Participants were then guided by a virtual avatar to complete a 30-minute tutorial of D3.

The aim of the tutorial was to provide an overview of the turn-based mechanics and resource allocation system in D3, while providing a detailed account of the way in which new policies are introduced into the game. The tutorial allowed participants to actively participate in a practice session during which they were introduced to and prompted to use the same game mechanics employed during the experimental session. It provides a comprehensive and user-friendly introduction which is ample for being able to play D3; the game itself is relatively simple to play, with its complexity deriving from the underlying structure. Participants next took part in a 16-round gaming session on D3 (typical of a 4-year term in office) during which experimental data were collected. All participants were exposed to the same open-ended policy-making scenario, which gave access to every available policy in D3. A short sociodemographic survey was integrated as part of the simulation. The point at which the sociodemographic survey was completed during the experiment was counterbalanced.

Participants were given clear instructions to try to make 'optimal' policy decisions to increase public support and be re-elected by the end of the game. It was presented as a challenge, and they were explicitly told by the experimenter to try to be as objective as possible in completing the task, by focusing on policies that would be beneficial to the greatest proportion of a diverse electorate. They were also instructed to try to think critically and holistically, and to focus on overall goal attainment rather than trying to micro-manage all policy objects displayed on the main interface. Game play depended on the participant and ranged from 26 min 49 s to 87 min 31 s (M = 56 min 29 s, SD = 16 min 14 s). The whole session usually lasted an hour and a half, comprising the 30-min tutorial, around an hour of game play, and additional time to complete the ideology questionnaire.

Table 1. Sociodemographic characteristics of participants and study variables (N = 56).

			Deviation of Ideology	Repair Service Behavior	Goal Attainment
	n	%	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)
Sex					
Female	22	39.3	2.19 (1.66)	4.13 (2.64)	2.21 (1.28)
Male	34	60.7	2.07 (1.54)	4.60 (3.54)	2.59 (1.36)
Level of education (completed)					
Below college	17	30.4	2.50 (1.53)	5.54 (3.04)	2.82 (1.59)
Undergraduate	25	44.6	1.93 (1.56)	4.11 (2.92)	2.25 (1.13)
Graduate	14	25.0	2.10 (1.79)	3.19 (2.76)	1.98 (1.16)
Employment					
Employed/part-time working	31	55.4	1.82 (1.48)	3.87 (2.96)	2.44 (1.53)
Full-time student	25	44.6	2.54 (1.70)	4.87 (3.03)	2.25 (0.99)

Note. Participants were between 18 and 45 years of age ($M = 27.5$, $SD = 6.9$).

Measures

Goal attainment

Performance – i.e., how well decision-making has met the needs of the DDM task – was assessed by the 'goal attainment' metric. An exponential function of goal attainment was developed based on the percentage of votes received (whereby decisions made during the gaming session impacted a wide variety of political issues, the success of which influenced the number of votes received). This indicator was chosen above other performance indices under established theoretical bases in political science which support the idea that politicians (and their parties) act first and foremost as vote maximizers (e.g., Mueller, 2003; Riker & Ordeshook, 1968). Specifically, our choice of indicator was grounded in the theoretical framework of the median voter theory (see the seminal works by Black, 1948; Downs, 1957; see also Congleton, 2004), which suggests that policy-makers align their decisions with the majority of voters – particularly the preferences of the median voter – to secure re-election. Thus, the percentage of votes received from the electorate at the end of the game could be seen as an indicator of success in achieving the game's goal; that is, managing political complexity in order to increase public support and be re-elected. Although this was taken as a single measure, attaining this goal (maximizing votes) was a complex task involving multiple interacting factors. D3 provides a percentage of public support which allows the player to track their progress towards re-election and identify what still needs to be achieved. The function was specifically designed to capture the particularly difficult challenge of increasing (and maintaining) popularity when the player reaches higher levels of public support, as it is typically easier and quicker to gain the confidence of political supporters, harder to win over swing voters, harder still to convert a core voter of an opponent to your cause, and infinitely harder to achieve unanimity. The function served as a reliable tool to accurately model these intricate dynamics, which were not adequately represented by the mere raw percentage score of votes presented to the player at the end of the gaming session. Formally, let $X \in [0, 100]$ be the percentage of the total votes collected and let

$$\exp\left(\tan\left(\left(\frac{\pi}{2}\right) \times \left(\frac{X}{100}\right)\right)\right)$$

be an exponential function (composed with the tangent function so that the expected behavior is expressed over the desired interval, namely 0 to 100) which varies according to X. The function rewarded good performance (i.e., the higher the percentage of votes collected, the higher the coefficient) and allowed the linear ordering of data and the comparison of scores between participants (on the basis of a common coefficient). Furthermore, in accordance with the aforementioned principle that the more you improve, the harder it becomes to make further progress, the function exhibited a monotonically increasing derivative.

Repair Service Behavior

Dörner (1997) introduced the repair service principle as a post-hoc explanation to describe a type of problematic behavior that led decision-makers to devote all their attention to the problems of the present without considering the future. Here, we attempt to empirically test repair service behaviors by extracting data on the time spent by the participant seeking information about 'problem situations'. Problem situations are on-going problematic events that are triggered by some combination of policies and statistics during the game. Problem situations (e.g., traffic congestion) are shown on the main screen as red icons (see Figure 3). Using screen capture analysis software to extract times spent on problem situations, the metric for repair service was derived as a percentage ratio, obtained by dividing the time spent on information search for problem situations by the total game time and multiplying the result by 100. While high scores on this met-

Figure 3. An example of 'situations' in D3, shown as a red icon on the main screen (left); the detailed screen for the active situation (right).

ric could reflect a narrowness of search, participants could equally have a narrow focus on other features (e.g., climate change, cabinet members, implementing new policies, etc.), but this shows a propensity to focus narrowly on urgent/salient situations in particular. Thus, the ratio is indicative of repair service behavior as it shows the amount of time devoted to dealing with designated 'red icon' situations specifically.

Ideology

Operationalization of ideology was calculated following a three-step process, and consisted of a measure of the difference between stated (in the self-report scale) and implemented (through policy making in the game) ideology. First, personal ideology of participants was assessed using a non-intrusive four-item survey involving questions about positional public issues taken from the *2015 Canadian Election Study* (Fournier, Cutler, Soroka, & Stolle, 2015). Questions included in the four-item survey were as follows: 1) *Do you think that income inequality is a serious problem?*; 2) *How hard should we work closing the gap between rich and poor?*; 3) *How much should we help the status of women?*; and 4) *How much should we help the status of ethnic minority?* The first question was binary (yes or no), while the following questions required a response in the form of a Likert-type scale ranging from 'much less' to 'much more'. These were issues defined by their polarizing nature, and known for generating disagreement between individuals (see Nicholson, 2012). The data gathered from the four-item survey underwent suitability testing for factor analysis (FA). A Bartlett's test of sphericity suggested that it was appropriate to use a factor analytic model on this set of data, $\chi^2(6, N = 56) = 52.38$, $p < .001$. The Kaiser-Meyer-Olkin a priori measure of sampling adequacy (*MSA*) indicated that the strength of the relationships among variables was adequate for FA (KMO = .62). FA showed that the scale was sufficiently robust to capture a latent construct (i.e., personally held ideology), due to loadings ranging from 0.47 to 0.71 ($\geq |0.4|$). The reliability of the scale was deemed acceptable with a McDonald's Omega of .72 ($\geq$ .60) and a first eigenvalue of 2.00 ($\geq$ 1.00). A validation test was performed to ascertain the association between personally held ideology as determined by the four-item survey (latent) and self-reported ideology on a one-dimensional left-right scale (whereby political left corresponds to progressive, egalitarian, and socially-oriented policies, while political right is associated with upholding individual liberties, the principle of rewarding individuals based on their efforts and conservative policies). A moderate to strong positive association was found, $r(50) = .48$, $p < .001$.

The four-item survey allowed for the rating of participants on a one-dimensional left-right scale through the computation of the one-factor latent variable model. Based on this scale, ranging from 0 (far left) to 10 (far right), the personal ideology of participants ranged from 1.10 to 10.00 ($M = 4.82$, $SD = 1.89$). We acknowledge that some concerns have been raised about the limitations of one-factor models to capture the many aspects of ideology in the general public (e.g., Bauer, Barberá, Ackermann, & Venetz, 2017; Feldman & Johnson, 2014), with a number of researchers suggesting that ideology may be a combination of two (or more) preferences (e.g., Ashton, Danso, Maio, Esses, Bond, & Keung, 2005; Jost, Blount, Pfeffer, & Hunyaday, 2003; Treier & Hillygus, 2009). However, research also shows that for the best politically-informed individuals, these preferences highly correlate with each other (Jost, Federico, & Napier, 2009; Poole & Rosenthal 2007), which could be an indication that they can be reduced to a single dimension (see Carmines & D'Amico, 2014). Whether ideology is best represented by a single dimension, or a multidimensional space is still up for debate. We thus chose to rely on a one-factor model on account of this being the most widely used for assessing ideology (e.g., Jost, 2017), and for coding policies (e.g., Benoit & Laver, 2006). The ideology survey was integrated as part of the simulation and counterbalanced to ensure there were no carryover and order effects. As a validation probe, a question which asked participants to self-position on the one-dimensional left-right scale, was also included.

Second, we asked an expert panel to assign a value to each in-game policy – available to the player via the 'Policy ideas' interface – on the one-dimensional left-right scale. Selected randomly across all thirty-two po-

litical science faculty members at Université Laval (Qc, Canada), an expert panel of 10 regular faculty professors of political science coded 83 policies via *Qualtrics* (Figure 4 shows the description of one of the policies that were to be rated by the panel). On average, the online questionnaire was answered within 30 minutes. Reliability between experts in the rating of available policies was then tested. Inter-rater reliability using the intraclass correlation coefficient (ICC) and a two-way random-effects model based on the mean-rating, was computed according to consistency (ICC[2,10]). The ICC for inter-rater reliability was 0.96, with a 95% confidence interval ranging from 0.95 to 0.97, and with the main effect being significant, $F(82, 738) = 25.2$, $p < .001$, which indicated a high degree of reliability between raters (based on the criteria proposed by Koo & Li, 2016). By means of this procedure, a single value ranging from 0 to 10 was assigned to each policy by averaging the ratings.

Third, we computed the 'attitudinal mean' for each participant (corresponding to the sum of the values associated with all the policies implemented by a participant during a game, divided by the total number of implemented policies). This procedure allows us to locate participants on the left-right scale according to their respective policy-making behavior. We then took the modulus (or absolute value) of the difference between the attitudinal mean and the value associated with the personal ideology of a participant, which resulted in a numerical indicator that could vary within a range of 0 (perfect ideological consonance) to 10 (perfect ideological dissonance). 'Deviation of Ideology' provided a useful way of representing the difference in attitude between personally held – real-world – ideology and policy-making behavior in the simulated environment.

Results

Goal attainment

Upon examining the distribution of the number of votes received, it was observed that no participant obtained a score in the upper quartile of the definition domain – with the number of votes received ranging from 1% to 68% ($M = 36.27$, $SD = 18.47$) – implying that the limit of 75% (percentage of votes) could serve as an empirical maximum.[1] Considering the domain [0, 75] – that is, the interval from the theoretical minimum to the empirical maximum – it was observed that the function exhibited a monotonic growth, yielding values that varied from 1 (when the theoretical minimum was used as input for the exponential function) to 11.18 (when the empirical maximum was used as input). Overall performance on the DDM task was found to be rather poor (see Table 1). Task performance was far from the empirical maximum on goal attainment and ranged from 1.01 to 6.16 ($M = 2.36$, $SD = 1.31$). Given the limitations of human cognition in performing DDM, a lower boundary in performance scores (right-skewed density distribution) was expected for both indicators (see Figure 5). Employing the median of the total time played as a cutoff point to differentiate players based on whether they invested more time in the task or completed it quickly, there was no significant difference in goal attainment between fast ($M = 2.27$, $SD = 1.3$) and slow players ($M = 2.44$, $SD = 1.35$), $t(54) = -0.49$, $p = .63$.

Repair Service Behavior

First, we considered the total active playtime of the participants. Next, the time spent processing information from 'problem' or salient situations was determined by replaying recordings of the D3 session (game sessions were recorded using Morae Recorder software which captures all audio, video, and on-screen activity). Problem situations were indicated in red on the policy situations screen, and clicking on one would call up a more detailed screen for the active situation (Figure 3). Each time a detailed screen was activated for a red 'problem' situation, its display duration was measured from onset to offset using Morae Manager software. The total of these durations for all 'red' situations was calculated for each participant. Expressed as a percentage ratio relative to total game time, repair service behaviors ranged from 0% to 13% ($M = 4.31$, $SD = 3.01$), indicating that participants on average did not devote much time to currently problematic situations.

Deviation of Ideology

Given that our main objective was to assess whether personal ideology had an influence on policy-making

[1] It was also noted that the participant who obtained the worst performance (i.e., 1%) was in close proximity to the theoretical minimum (i.e., 0%), which indicated that there was no need to establish an empirical minimum, thus allowing the use of the theoretical minimum as a lower limit.

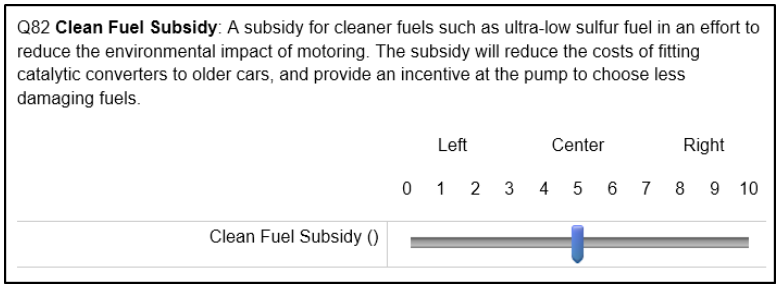

Figure 4. One of the policies submitted to the expert panel using *Qualtrics*.

Table 2. Descriptive Statistics and Correlations for Study Variables (N = 56).

		M	SD	1	2	3	4
1	Age	27.48	6.85	–			
2	Repair Service	4.32	3.01	−0.25	–		
3	Deviation of Ideology	2.15	1.60	−0.03	0.05	–	
4	Goal Attainment	2.36	1.31	0.12	−0.13	0.36**	–

Note. The table reports Pearson correlation coefficients. * = sig. at $\alpha = .05$ ** = sig. at $\alpha = .01$

(and to what extent it could affect goal attainment in the task), it was imperative that D3 system dynamics were not subject to bias. Thus, we tested D3 to assess whether available policies were biased in favour of a particular ideological position. This test was important to ensure that ideology implemented in the game could be assessed through a benchmark of ideology representing equilibrium between left and right – that is, a 'centrist' position (i.e., close to 5 on the one-dimensional scale). The average of all policies was 4.87 ($SD = 1.73$), suggesting that the combination of alternatives available to the participant was not ideologically biased (neither to the left, nor to the right), and that the underlying system dynamics of the game were not requiring a particular portfolio of policies to be enacted to secure votes (see Supplementary Information) for further details on the coding done by the expert panel). By calculating the difference between the attitudinal mean ($M = 4.70$, $SD = 0.68$) and the personal ideology of participants ($M = 3.00$, $SD = 1.89$), we derived the magnitude of the observed deviation between the two. This measure referred to as the 'Deviation of Ideology' spanned from 0.16 to 5.39 ($M = 2.15$, $SD = 1.60$).

Analyses

There was no relationship between goal attainment and repair service behaviors, $r(54) = -0.13$, $p = .34$. A Pearson correlation revealed that Deviation of Ideology and goal attainment were moderately positively correlated, $r(54) = .36$, 95% BCa CI = 0.12, 0.56, $p = .007$. Confidence intervals (CI) calculations were based on 2000 replicates, following the bias-corrected, accelerated (BCa) bootstrap CI method for small samples (for further details, see Tibshirani & Efron, 1993). Participants who complied with their personal ideology in the implementation of policies did not perform as well in terms of goal attainment as participants who adopted an 'ideologically-dissonant' stance towards policy-making. A similar pattern of results was found with the percentage of votes, $r(54) = .30$, 95% BCa CI = 0.03, 0.52, $p = .02$, indicating that 'ideologically-consonant' participants performed less well at the DDM microworld task. We then tested predictors for multicollinearity. Table 2 presents the partial correlation matrix which showed that Deviation of Ideology was not significantly associated with other potential confounders.

A linear regression model (GLM) was used to predict goal attainment based on Deviation of Ideology, repair service, and age (see Table 3). GLM was chosen above other approaches to linear regression, given that it allows the specifications of regression models whose outcome variable (residuals) follows distributions that may deviate from normality (see Pek, Wong, & Wong, 2018). Results indicated that the model was significantly ($p = .029$) able to account for 15.8% of the variance in goal attainment. Deviation of Ideology was found to contribute significantly to the model, $\beta = .30$, $p = .006$.[2]

Discussion

Participants performed a microworld simulation of political decision-making whereby the aim was to implement policies that would appeal to the greatest proportion of the electorate, to win the most votes and to subsequently be re-elected. When faced with complexity, cognitive shortcuts can provide a useful strategy to aid the decision-making process, but sometimes they can be detrimental to policy-making by failing to appreciate the broader implications of actions taken. Overall performance on the task was found to be poor, indicating that political DDM is complex and demanding. Correlational analysis revealed that there was no relationship – positive or negative – between repair service heuristics and goal attainment. However, participants whose decision-making was guided more by their ideology were found to perform significantly worse on the DDM task. This was despite clear instructions to be as objective as possible when playing the game, suggesting that ideology may be a powerful drive that pervades the decision-making process even without volition.

Scores on the *D3* microworld were quite low overall, indicating that it is difficult for decision-makers to comprehend the underlying complexity of the task in order to make strategic decisions and win the game. This is in keeping with previous research that shows humans are generally poor at dealing with complexity (Stadler, Niepel, & Greiff, 2016). Despite research efforts to support decision-makers in the management and control of complex environments (e.g., Cronin, Gonzalez, & Sterman, 2009; Karakul & Qudrat-Ullah, 2008; Tremblay et al., 2017), the ability to fully understand such problems, predict their evolution over time, and to make far-sighted logical decisions is severely

[2] All data were analyzed in the *R* programming environment, Version 3.6.3 (source code is available from the corresponding author upon request). Data analysis was carried out using the *psych* package (Revelle, 2021).

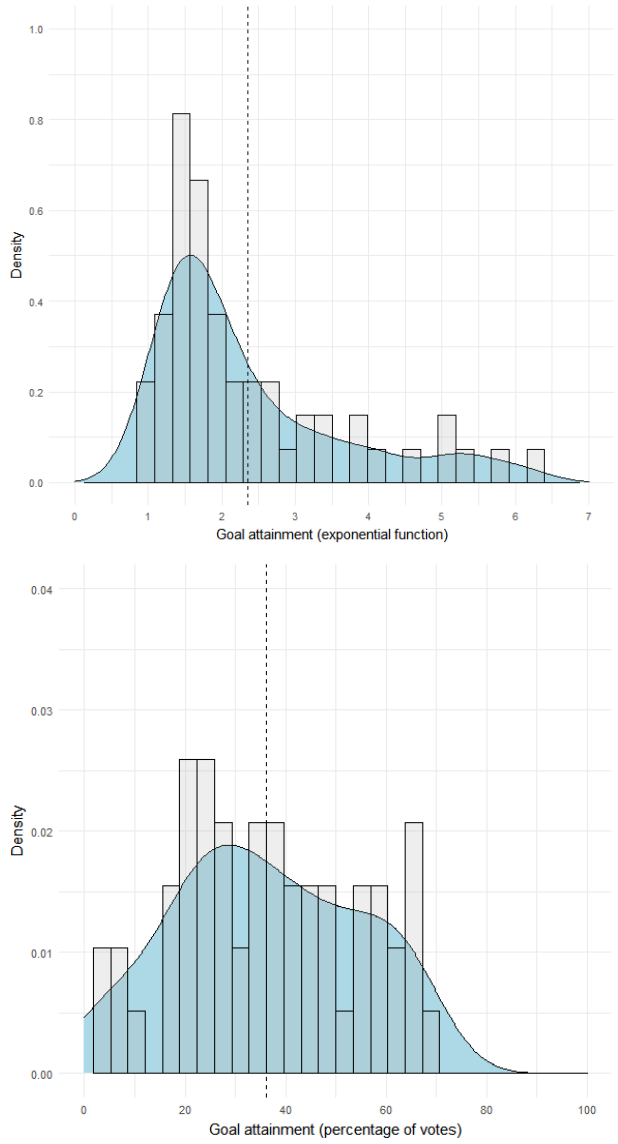

Figure 5. Distributions of goal attainment. Top panel shows the distribution modeled by the exponential function. Bottom panel shows the distribution according to the percentage of votes.

limited (see, e.g., Dörner & Güss, 2022). The microworld retained the complexity of real-world political issues including the need to solve several problems simultaneously, balance conflicting and inter-related goals, as well as to deal with the dynamic evolution of situations and delayed feedback of actions. The participant has to make deductions from incomplete information and test predictions according to their own comprehension of the task environment. Complex problem-solving may also require participants to take what might seem like a step back from the goals to attain, in order to reap greater rewards at a later point. For example, it may be better in the long run to implement a policy that is initially unpopular (e.g., raising taxes to invest in public infrastructure, such as roads, bridges, and transportation), but one which may be accepted over time once tangible benefits are apparent (e.g., economic growth, improved road safety, reduced fuel emissions).

The complexity of policy-making is such that it is common to use cognitive shortcuts rather than to try to project multiple future positions and eventualities to select one logical outcome (Hartwell, 2022; Vis, 2019). While these shortcuts can save time and mental resources – and often result in adequate solutions – we tested whether there may also be pitfalls to such decision biases by assessing the influence of repair service behavior and ideology. Repair service behavior is when policy-making is driven by fixing things in the system that appear to be problematic. Of course, this could often be a good rule of thumb, for example to take action in response to an incident that reveals an inadequacy in the current system (e.g., by implementing new safety laws). However, just because an issue is salient does not mean that its resolution should be paramount. Saliency could derive from recent events, or public opinion, and it can be easy to take on these causes because attention is drawn towards them. However, in doing so there is the risk that politicians fixate on issues that are relatively trivial in the broader picture of societal challenges, and in fact it could be more prudent to prioritise issues for which there is a greater need, or which would have a greater impact. Furthermore, implementing new policies as a quick response to salient events without due consideration of the full political landscape could later result in undesirable secondary effects or longer-term impacts. Repair service behaviors are thought to be detrimental to complex problem-solving (Dörner, 1981), however in the current study we found that the scores of participants with a greater tendency towards repair service behaviors were no worse than those who did not adopt this strategy. On the whole, use of a repair service strategy was fairly low amongst our participants (only around 13% of policies were driven by 'firefighting' or repair service behaviors), and so it is possible that a detrimental impact on goal attainment may have been observed had this strategy been used more often. Although our results may seem at odds with previous work, it is also worth noting that most, if not all, reports of a repair-service bias are anecdotal (Dörner, 1981; Deming, 2018) or from qualitative research (Dörner & Güss, 2022), and so the behavior of interest had not previously been operationalised in an empirical protocol to test effects on performance. Given the lack of controlled study in this area and the lack of a standard measure for such behavior, it may be that the way in which repair service behavior was operationalised in D3 was not sensitive enough. Future research is needed to establish a sensitive and objective measure, based on observable and quantifiable behavior within the microworld, in order to better determine the impact of this heuristic on policy-making.

Despite clear instructions to keep the decision-making process as objective as possible, ideology was still found to have an influence over participants' policy-making and hindered goal attainment. Ideology is inherent in politics; it is central to voting behavior, and can be used to guide policy-making when faced with the complex interplay of economic, environ-

Table 3. Regression Analysis: Age, Repair Service, and Deviation of Ideology (N = 56).

Predictor	Estimate	*SE*	95% CI	*p*
(Intercept)	1.16	0.80	[−0.45; 2.77]	.15
Age	0.02	0.03	[−0.04; 0.07]	.47
Repair Service	−0.05	0.06	[−0.16; 0.06]	.35
Deviation of Ideology	0.30	0.10	[0.10; 0.52]	.006**
$R^2 = .16$, $R^2_{adj} = .11$, Resid. SE = 1.24, $F(3, 52) = 3.25$*				

Note. * = sig. at $\alpha = .05$ ** = sig. at $\alpha = .01$

mental, and societal challenges. Such decision-making strategies play an important role in simplifying the intricacies of the political environment, reducing the need for complete information, and enabling the prioritisation of actions in the face of conflicting goals. However, the current study demonstrates that too much of a reliance on ideology can be detrimental to problem-solving and may skew logical decision-making to the detriment of overall task goals. If the broad aim of politicians is to ensure the success of the country and to improve quality of life (health, safety, economic prosperity, human rights, etc.) for the greatest number of people, then this might not always be achieved using a single, narrowly-fixated, ideological approach. While people may have differing opinions and be ideologically guided in terms of how these goals can be best achieved, logical decision-making occurs when participants are able to engage in systemic thinking, make deductions, future projections, and appreciate the broader implications of potential actions. Perhaps ideologically-consonant individuals are more prone to a confirmation bias or a 'myside bias' (Mercier, 2017) by which decisions are based on too little information, and only information that confirms their personal worldviews. On the other hand, ideologically-dissonant individuals may adopt a broader approach to information processing in the various aspects pertaining to DDM (e.g., understanding nonlinearity, recognizing and assessing side effects, anticipating feedback and delays), which could run through all aspects of their decision-making and result in more logical decisions.

It is worth noting the power of ideology in the current study in that it appeared to occur, to some extent, beyond volition. The goal of the game was to introduce policies that overall would have the greatest positive impact on the country, therefore gaining the greatest support and winning the most votes. The game was tested for ideological bias and was found to be unbiased. Participants were specifically instructed to suspend any personally held beliefs and to think critically and holistically to make 'logical' policy decisions towards the goal of game. However, the strength of commitment to personal ideology was such that it appeared to go even beyond deliberate efforts to maintain critical and holistic thinking in performing political DDM. Personally held ideology seems to be deeply ingrained in the processing of information that guides decision-making.

Future research assessing the role of ideology in policy-making would benefit from a comprehensive measure of the dimensionality of political attitudes. Although a one-factor model for measuring stated (real-world) ideology is the most widely used in assessing ideology, a number of researchers favor the use of a two-dimensional space in which economic preferences form one dimension, and social preferences form the second (e.g., Ashton et al., 2005; Treier & Hillygus, 2009). Thus, future studies should consider the use of multi-factor models in assessing the various dimensions of ideology. Additionally, enhanced granularity and careful examination of the social and political priorities that shape the ideology of decision-makers could be beneficial to understanding the intrinsic connection between policy-makers' concerns and the implementation of public policy decisions. It would also be worth considering replicating a collaborative decision-making task using D3 as a research microworld to study complex problem-solving from a distributed cognition perspective. Given that political decision-making involves close collaboration among multiple actors, this approach would presumably offer valuable insights into the dynamic of teamwork within government cabinets and other state-level decision-making interfaces. Ultimately, the empirical examination of repair service continues to present a considerable challenge. In this study, we operationalized it by focusing on the narrowness of search related to information gathering on urgent/salient situations. Our findings indicated limited time devoted to information collection of such situations, raising possibilities that, for instance, the behavior might not be widespread, or that there could be further refinements needed in the operationalization of the concept. Additional measures could improve our understanding of such behavior in large organizations like governments. Given the fragmented evidence across disciplines, we encourage researchers to take a greater interest in this behavior and document its operationalization to facilitate further investigation.

This study has important implications for the psychology of political decision-making in general, and the role of ideology in DDM in particular. Ideas and values, and ideals for a better world, are the raw material of politics. While democracy is (and should be) about ideology, policy-making in complex environments seems to require more than just 'good intentions' and a mere 'willingness' to act logically. Politicians should be aware of the pitfalls of a narrow ideologically-driven approach, and also be aware of the power of this approach to pervade decision-making processes. Political DDM in complex environments—where large quantities of data must be processed, whilst maintaining acceptable response times – will remain one of the biggest challenges of the digital age (see Mocker, Weill, & Woerner, 2014). The leaders of tomorrow will need to improve understanding of the underlying dynamics of political complexity, in or-

der to better tackle issues of critical importance in the modern world, such as climate change (see Aron, 2019), and global pandemics (see Jackson, 2020). Finally, our methodology in using a microworld task supports recent calls for a better understanding of politics and democracy through a complex systems approach (Eliassi-Rad et al., 2020; Rollwage et al., 2019). It is argued that in research into ideology, for example differences in particular parameter combining behavioral tasks and formal computational models, the field can move beyond qualitative data and conceptual labels to one that maps tangible cognitive processes onto political viewpoints. This can furthers can help to understand which cognitive processes (e.g., overconfidence, inflexibility, intolerance of uncertainty) may be associated with more polarized political viewpoints, which in turn can contribute to targeted interventions to counteract extreme and radical beliefs (Rollwage et al., 2019).

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