



Rule-Governed Behavior and Climate Change: Why Climate Warnings Fail to Motivate Sufficient Action

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Abstract

Climate scientists warn of dire consequences for ecological systems and human well-being if significant steps to mitigate greenhouse gas emissions are not taken immediately. Despite these warnings, greenhouse gas concentrations continue to rise, indicating that current responses are inadequate. Climate warnings and reactions to them may be analyzed in terms of rules and rule-governed behavior. The literature on rule-governed behavior in behavior analysis has identified a variety of factors that can reduce rule following, including insufficient rule exposure, insufficient learning history and rule complexity, incomplete rules, instructed behavior not sufficiently learned, rules having weak function-altering effects, conflicting rules, lack of speaker credibility, rule plausibility and inconsistency with prior learning, and insufficient reinforcement for rule following. The present paper aims to analyze how these factors might impact responses to climate change, and possible solutions and strategies are discussed. Much of the theory and research on climate-change communication has come from outside of behavior analysis. Thus, the paper also aims to integrate findings from this literature with a behavior-analytic approach to rule control. Interpreting climate warnings and climate solutions in terms of rule-governed behavior may improve our understanding of why such rules are not more effective, and aid in the development of verbal and nonverbal strategies for changing behavior and reducing greenhouse gas emissions.

Keywords Rule-governed behavior · Climate change · Verbal behavior · Environmental sustainability

Human activities, mainly fossil-fuel use and agriculture and forestry practices, have warmed the planet by about 1 °C from pre-industrial times, and evidence shows that the planet will continue to warm unless mitigation steps are undertaken (IPCC, 2018). Global warming produces a cascade of catastrophic impacts that include

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dangerous high temperatures, sea level rise, flooding, drought, wildfires, poor air quality, acidification of oceans, the collapse of ecosystems, and species extinctions (Jay et al., 2018). Climate change will have major impacts on food production, water supplies, urban infrastructure, and security. Vulnerable populations will experience the greatest impacts. A 2021 Lancet Countdown on health and climate change found that the negative impacts of climate change on health are rising, and that the impacts are distributed inequitably—those in developing countries in economically disadvantaged communities experience worse health impacts (Romanello et al., 2021). Climate change disasters are also expensive; the number of billion-dollar weather and climate disaster events has increased significantly (NOAA, 2022). Climate change will have major impacts on human societies. As climate changes, vulnerable groups will be increasingly driven from places that can no longer sustain human communities (IPCC, 2018). If global warming increases to 4 °C, it is predicted that social systems will fail, and people will need to move to places on the globe that remain capable of sustaining human populations (Lynas, 2020).

There are actions that can limit the worst of these impacts. The IPCC states, “Future climate-related risks would be reduced by the upscaling and acceleration of far-reaching, multilevel and cross-sectoral climate mitigation and by both incremental and transformational adaptation” (2018, p. 5). Addressing the climate crisis therefore necessitates significant changes in human behavior. As stated in the fourth National Climate Assessment, “Future impacts and risks from climate change are directly tied to decisions made in the present, both in terms of mitigation to reduce emissions of greenhouse gases (or remove carbon dioxide from the atmosphere) and adaptation to reduce risks from today’s changed climate conditions and prepare for future impacts” (Jay et al., 2018, p. 60). People must cut carbon emissions and it must occur on a global scale. The United Nations Secretary General Antonio Guterres has stated, “Nothing less than our future and the fate of humankind depends on how we rise to the climate challenge” (Guterres, 2018, 22:22) and that “Every day we fail to act is a day that we step a little closer towards a fate that none of us wants—a fate that will resonate through generations in the damage done to humankind and life on earth” (26:57).

Climate scientists have known about the negative effects of carbon emissions for decades (Weart, 2008), as have fossil fuel companies (see Oreskes & Conway, 2010), but not enough has been done to combat the growing crisis (Thompson, 2010). A landmark step occurred in 2015, as countries from across the globe pledged to reduce emissions and keep temperature rise well below 2 °C in an international treaty known as the Paris Agreement (UNFCCC, 2015). Although the agreement was a monumental step, to date, few countries have taken adequate steps to meet their commitments. In a review of national policies to accomplish pledges, Roelfsema et al. (2020) conclude, “Unless governments increase ambition, the collective effort of current national policies significantly stays short of the objectives of the Paris Agreement” (p. 6). An acceleration of local efforts to reduce greenhouse gas emissions is also needed. The fourth US National Climate Assessment states that since 2014, “a growing number of states, cities, and businesses have pursued or expanded upon initiatives aimed at reducing greenhouse gas emission, and the scale of adaptation implementation across the country has

increased. However, these efforts do not yet approach the scale needed to avoid substantial damages to the economy, environment, and human health expected over the coming decades” (Jay et al., 2018, p. 60). As Leiserowitz concluded in a 2006 study on climate-change perceptions, and which still appears largely true today, “climate change currently lacks a sense of urgency” (p. 64).

For climate scientists it is puzzling why, given the dire nature of the problem (climate change is an *existential* threat), climate-change warnings do not motivate greater action. Much research by psychologists, often in the domain of environmental risk perception, social and cognitive psychology, environmental psychology, and communications, has sought to answer this question (e.g., Corner, & Clarke, 2016; Gifford, 2011; Hornsey & Fielding, 2020; Moser, 2016; Markowitz, & Guckian, 2018; Stoknes, 2015; Weber & Stern, 2011; and see Center for Research on Environmental Decisions [CRED], 2009). Many factors thought to influence risk perception have been proposed, including cognitive, emotional, social, cultural, experiential, and socio-demographic factors, yet there have been few attempts to integrate the understanding of climate-change risk perception into a single framework (see van der Linden, 2017). Behavior analysts could contribute more to this work. Alavosius and colleagues (2016) argue that interpreting the influence of climate warnings in terms of the operant and associative conditioning, including relational responding, may help improve climate messaging. Moreover, behavior analysts can provide a cohesive theoretical framework for understanding the human response to climate change.

The present paper aims to apply a behavior-analytic account of rules and rule-governed behavior to responses to climate warnings to help understand reasons why such warnings fail to motivate sufficient action. While doing so, it aims to integrate findings from diverse research areas into an operant framework. Behavior analysts have a long history of analyzing verbal behavior and rules, with advancements evident in applications (e.g., Fryling et al., 2020; Greer & Ross, 2007). Furthermore, psychologists have shown that verbal stimuli can be important in altering pro-environmental behaviors (see Lehman & Geller, 2004; Osbaldiston, & Schott, 2012). Analyzing reactions to climate warnings as rule-governed behavior may help us understand the failure of climate warnings to motivate behavior, and aid the development of better behavior-change strategies, including verbal strategies (see Alavosius et al., 2016).

Indirect Contingencies and Rule-Governed Behavior

The accumulation of greenhouse-gas (GHG) emissions in the atmosphere can be understood as a *macrocontingency*, or the cumulative outcome of behavior of many individuals and organizations (i.e., *macrobehavior*) (Glenn et al., 2016), mainly fossil fuel use by people in developed countries. Part of the challenge to understanding and addressing climate change is that, as a macrocontingency, GHG concentration is not a direct outcome of the behavior of any one individual and organization. Actions of individuals have no noticeable climate impact. Another challenge to the public understanding of climate change comes from the fact that greenhouse gases

are invisible (Weber & Stern, 2011), and that climate change is not a discrete, salient event. As noted by Weber (2010), because climate change is gradual and embedded in random weather fluctuations (and because remembering is fallible), “climate change is not easily detected by personal experience” (p. 333). Even when people observe climate trends or directly experience climate disasters, for those who are not climate scientists, the connection to human action seems impossible to discern.

Verbal behavior is what provides the “link” between climate-relevant actions and the aggregate product of climate change (see Glenn et al., 2016). As Weber and Stern note, “for most Americans, exposure to ‘climate change’ has been almost entirely indirect, mediated by news coverage, Internet postings, informal conversations, and documentaries and video footage of events in distant regions (such as melting glaciers in Greenland) that describe these events in relation to climate change” (2011, p. 320). Thus, the human response to climate change may be understood as a social, or more specifically, as a verbal process. Verbal responses that link human behavior to climate-change may be described as rules, and responses to them may be described as rule-governed behavior.

Rules and Rule-Governed Behavior

B.F. Skinner (1957) proposed that verbal behavior could be analyzed in terms of the roles of speakers and listeners. Speakers engage in verbal behavior as a result of reinforcement provided by listeners, who collectively are called the verbal community. Listeners (which include readers) react to verbal stimuli produced by speakers, and their reactions reinforce speaker behavior. Specific forms of verbal behavior by speakers may be effective in altering the behavior of listeners because they specify consequences for the listener for engaging in action. Skinner (1969) described these verbal responses as *rules* or *contingency-specifying stimuli*. Rules may take the form of commands, instructions, warnings, or advice. Rule following in listeners is reinforced by the verbal community, and as listeners learn stimulus relations and experience many forms of reinforcement for rule following, rule following becomes generalized and effective rule following can occur even under novel verbal stimuli.

Many benefits for speakers and listeners result from establishing a repertoire of rule following (Skinner, 1969). For example, rules can alter behavior without direct exposure to contingencies, and can establish behavior quickly without the need for prolonged shaping. Rule control may also hasten contact with reinforcement, and allow listeners to avoid punishing stimuli without the need to contact those stimuli. Rule following allows listeners to respond adaptively when consequences are too temporally remote, small, or probabilistic to directly control responding (see Malott, 1988). One potential disadvantage of rule following though, is that behavior may show rigid rule control and insensitivity to consequences (i.e., is inflexible) (e.g., Fox & Kyonka, 2017; Hackenberg & Joker, 1994; Shimoff et al., 1981).

Rules allow behavior of speakers who are socially, physically, and temporally distant to impact listeners. Rules also allow verbal behavior of speakers to impact multiple listeners. Thus, through rule control, effective behavior can spread across members of a culture (Baum, 1995; Palmer, 2012; Skinner, 1969).

Once a person has learned to respond as both a speaker and listener, a person may react as a listener to their own verbal behavior (Skinner, 1957). Speakers may learn to emit self-rules which influence their own subsequent behavior (Skinner, 1969). Self-rules may be learned from others, may be occasioned by exposure to contingencies, or occasioned by stimulus associations (derived relational responding) (Pelaez, 2013). Self-rules may be useful in problem solving (Skinner, 1969), but also can lead to insensitivity to contingencies and contribute to maladaptive behaviors (see McEntegart, 2018).

Learning by Rules

Skinner (1969) proposed that rules alter behavior in listeners as discriminative stimuli, signaling consequences for action (p. 148). For example, a rule such as “Turning down your thermostat will save electricity and money on your electric bill” may alter behavior by signaling reinforcement for adjusting the temperature on the thermostat. Citing limitations of a discriminative-stimulus account of rules, other conceptualizations have been offered. Schlinger (1993) and Schlinger and Blakely (1987) proposed that rules may be better understood as function-altering stimuli, or verbal stimuli that change the discriminative, reinforcing, eliciting, or motivating effect of stimuli. Consider again the rule, “Turning down your thermostat will save electricity and money on your electric bill.” The rule may influence behavior by altering the stimulus function of the actual thermostat (such as by establishing the thermostat as a conditioned reinforcer), changing the stimulus function of the current temperature reading (establishing the numerical value as a discriminative stimulus for lowering the setting), and changing the stimulus function of the new temperature reading (establishing the lower numerical value as a conditioned reinforcer for the adjustment).

Schlinger and Blakely’s (1987) account provides a functional definition of rules—verbal stimuli are defined as rules if they alter the functional relationship between stimuli and behavior. In a similar vein, Palmer (2007) has argued that many verbal sequences can “condition the behavior of the listener with respect to some stimulus, complex of stimuli, condition, or state of affairs” (p. 167). The function of the structure of verbal responses, he suggests, is the modification of the behavior of listeners. Similarly, Pelaez (2013) states that the primary function of a rule is to alter the behavior of the listener in a way specified by the verbal stimuli provided by the speaker. Conditioning produced by verbal stimuli appears to occur even when the stimuli do not explicitly specify all parts of a reinforcement contingency. Thus, rules may be better described as verbal stimuli that influences listener behavior, rather than verbal stimuli having a specific structure, i.e., contingency-specifying (see discussions in Baum, 1995; Palmer, 2007; Schlinger, 1993; Törneke, 2010).

The mechanisms behind the conditioning effect proposed by Schlinger and Blakely (1987) was not detailed, but as Skinner (1957) speculated in a section of *Verbal Behavior* titled “Conditioning the behavior of the listener” (p. 357), conditioning by verbal stimuli appears to require a specialized history of reinforcement within a verbal community. Schlinger (2008) has argued that when verbal stimuli or rules evoke discriminative or motivated behavior then indeed no special account

seems warranted, but a different analysis is needed when listeners engage in behaviors that are verbal, such as when they emit echoic and intraverbal responses, verbal conditioning can occur.

Two other theoretical approaches have offered accounts for complex rule control, Naming (e.g., Horne & Lowe, 1996) and Relational-Frame Theory (RFT; Hayes et al., 2001). These accounts share the assumption that rule control stems from a history of reinforcement within a verbal community that establishes generalized operant behavior that underlie rule control (i.e., Naming, relational responding). Naming theory assumes that verbal communities establish bi-directional speaker-listener responding, such that the establishment of one type of responding enables the other. Relational-Frame Theory assumes that verbal communities establish patterns of relating stimuli (relational responding), and that contextual cues come to evoke specific patterns of relating stimuli and transformations of the function of those stimuli (see Barnes-Holmes et al., 2004; Harte et al., 2020; Hughes & Barnes-Holmes, 2016; O’Hora & Barnes-Holmes, 2004). These learning histories allow listeners to react appropriately to even novel rules.

Consider the rule on energy use described above, “Turning down your thermostat will save electricity and money on your electric bill.” A RFT account might assume that this rule will alter behavior if there is a previously learned stimulus association (frame of coordination) between the words and objects (e.g., thermostat and actual thermostat; money and actual money), money is reinforcing, and the behavior of changing thermostats previously learned. The rule may invoke a previously learned “if–then” relational frame such that the reinforcing effect of money establishes the behavior of lowering the actual thermostat as reinforcing.

Although much remains to be understood about these verbal processes and stimulus–stimulus relations, an account of rule control that conceptualizes rules as verbal stimuli that alter behavior–environment relations in listeners in ways that depend on prior social learning can provide a framework for analyzing human responses to climate change.

Categories of Rule Following

Although a rule may alter stimulus–behavior functions, this does not necessarily imply that a listener will behave in ways that correspond to the rule (e.g., O’Hora et al., 2014). Rule following may also depend on the reinforcement experienced by the listener for rule following, which may come from various sources (Pelaez, 2013). Skinner (1984) argued that rules may be followed because of reinforcement provided by the natural contingencies for behavior. He states, “The reinforcers contingent on prior stimulation from maxims, rules, or laws are sometimes the same as those which directly shape behavior” (Skinner, 1984, p. 587). Once rule following is reinforced, it may occur in the presence of similar but novel stimuli. Skinner (1984) noted, “We tend to follow advice because previous behavior in response to similar verbal stimuli has been reinforced” (p. 587). Alternatively, he notes that rules may be followed because of consequences provided by the speaker. Such additional consequences may be needed when natural consequences are deficient, such as when

outcomes are delayed or probabilistic. In those cases, additional consequences, such as engineered aversive stimuli (punishers), may be necessary.

Zettle and Hayes (1982) (and see Hayes et al., 1989), proposed three categories of rule following: *pliance*, *tracking*, and *augmentals* (or augmenting, see Törneke 2010). Pliance refers to rule following produced by social reinforcement (or more specifically, speaker-mediated consequences, see Kissi et al., 2017). Thus, a person may follow a rule because doing so has produced social approval, whereas failing to do so has produced disapproval. For example, if a person is a member of an environmental organization in which members state, “Using public transportation is better for the environment,” the listener may take the bus instead of driving because doing so produces praise from group members. The rule may be called a *ply*. Pliance is likely to come under stimulus control such that stimuli signaling enforcement and nonenforcement of rule following may influence action.

Tracking refers to rule following produced by reinforcement from the correspondence between the rule and the environment. For example, if your friend tells you “Using public transportation will save money from parking” you may follow a rule because in the past following your friend’s advice resulted in better financial outcomes. Rules that control behavior via natural contingencies are called *tracks*. Tracking relates to what Pelaez (2013) refers to as *accuracy of a rule*. Accurate rules that correspond to contingencies are likely to generate greater rule following.

Pliance and tracking bear some resemblance to concepts developed by social psychologists: injunctive and descriptive social norms (Cialdini et al., 1991). *Injunctive norms* refer to evidence (such as by rules) of what behavior is socially approved. Behavior change produced by injunctive norms resembles pliance. Cialdini (2003) gives an example of an injunctive norm for park preservation, a sign stating “Please don’t remove the petrified wood from the Park, in order to preserve the natural state of the Petrified Forest,” along with a picture of a visitor taking wood under a red circle-and-bar. The phrase “Please don’t” likely has been correlated with social disapproval for noncompliance, and thus rule following may be socially mediated. *Descriptive norms* refer to evidence of what people commonly do. Descriptive norms may indicate what behavior typically produces reinforcers, and thus behavior change produced by descriptive norms resembles tracking. Cialdini (2003) gives an example of a descriptive norm, a sign stating “Many past visitors have removed petrified wood from the Park changing the natural state of the Petrified Forest” with a picture of three visitors taking wood. The latter sign was less effective at deterring wood theft. If the rule encouraged behavior because of a history of nonverbal reinforcement for imitating others, then the behavior may be described as tracking.

Augmenting refers to rule-governed behavior controlled by the altered extent to which stimuli function as reinforcers or punishers. That is, rules may function as motivational operations that have both value-altering and behavior-altering effects (see Michael, 1993). Rules with motivational effects are called *augmentals*. Augmenting can occur in conjunction with tracking and pliance (Törneke, 2010). Augmentals can be formative or motivative (Hayes & Wilson, 1993). Formative augmentals create new reinforcers or punishers, whereas motivative augmentals alter the relative reinforcing or punishing value of consequences. Consider the rule “To reduce greenhouse gas emissions, use public transportation.” If greenhouse gas

(GHG) emissions has been established as aversive stimuli, then the rule, as a motivational augmental, may increase the use of public transportation as a reinforcer and behavior of using public transportation may increase in probability.

Rule-governed behavior maintained by social reinforcers obtained by failing to comply with a rule may be viewed as a form of counterpliance (Hayes et al., 1989). Rules may motivate counterpliance (including doing the opposite of the rule) if the rules are overly prescriptive and aversive, or come from disliked authority figures, such that breaking the rule would produce reinforcing social disapproval in the speaker. For example, rules may generate counterpliance if they instruct listeners to engage in non-preferred activities or to emit effortful behavior. This motivating effect on behavior has been described by other psychologists as *reactance* (e.g., Brehm, 1966).

Some scholars have questioned whether these categories of rule control improve prediction and control of rule-governed behavior (Harte & Barnes-Holmes, 2022; Kissi et al., 2017), with some suggesting that the effects may be more productively incorporated into alternative conceptual frameworks (e.g., Harte et al., 2020). Nonetheless, the terms may be helpful here in distinguishing sources of rule control.

Climate-Change Knowledge as Rules

Skinner (1957) argued that scientific knowledge can be understood as verbal behavior. According to Skinner (1974), scientific knowledge is a “corpus of rules for effective action” (p. 235). Scientists tact relations observed in data, or produced through intraverbal processes, and construct rules about relationships (Schnaitter, 1980). The rules specify contingencies, including if–then relations that characterize scientific activities (see Lee, 1985). Some of the relationships tacted by scientists may be transformed into graphs or models, and such behavior is also reinforced by the altered behavior of listeners. Verbal reports, graphs and models created by climate scientists can thus be interpreted as rules and reactions to them described as rule-governed behavior.

Climate-change reports, warnings, and climate models, like other scientific knowledge, may be analyzed as rules. They may have the structure of contingency-specifying stimuli if they describe outcomes for continuing to release GHGs into the atmosphere or for curbing carbon emissions, and more importantly, may serve as function-altering stimuli if they change the psychological function of climate-relevant verbal and nonverbal stimuli and alter listener behavior.

Consider the following statement from the IPCC (2022): “Global warming, reaching 1.5 °C in the near-term, would cause unavoidable increases in multiple climate hazards and present multiple risks to ecosystems and humans (very high confidence)” (p. 15). The sentence associates global warming (caused by humans burning fossil fuels) with dangerous outcomes, and thus may alter the function of burning fossil fuels. The sentence, “Near-term actions that limit global warming to close to 1.5 °C would substantially reduce projected losses and damages related to climate change in human systems and ecosystems...” (IPCC, 2022, p. 15) relates pro-climate actions to harm reduction and may therefore establish pro-climate actions as

reinforcing. The IPCC 2021 report describes various actions that can reduce emissions, including electrification and switching from fossil fuels, retrofitting buildings for energy efficiency, reducing travel demand, carbon storage, and changing land use, among others. The evaluation that “Regions and people with considerable development constraints have high vulnerability to climatic hazards (high confidence)” (IPCC 2022, p. 14) may alter the function of stimulus relations concerning climate justice.

Nonfiction climate-change books and extended narratives also may have a rule function if they condition reader behavior. Books such as *The Sixth Extinction*, *The Uninhabitable Earth*, and *Our Final Warning: Six Degrees of Climate Emergency* detail the human causes and consequences of climate change and may condition behavior, whereas others may alter behavior by offering solutions (e.g., *Drawdown; Saving Us*). Documentaries, films, podcasts, and TEDtalks on climate change (e.g., *Breaking Boundaries: The Science of Our Planet; Before the Flood, An Inconvenient Sequel: Truth to Power, Don't Look Up, Years of Living Dangerously*, Great Thunberg's Ted Talk, 2018, etc.), can establish new stimulus functions by associating climate-relevant behaviors with many kinds of ecological and health impacts.

Graphs and figures included in climate reports may also have a function-altering effect. The well-known “hockey stick” figure (Mann et al., 1999), illustrating the exponential increase in northern hemisphere temperature rise, linked with carbon emissions, may have altered the psychological function of the words “carbon-emissions” and associated stimuli. Figures from IPCC reports, such as those that directly illustrate the near-linear relationship between cumulative carbon emissions and global surface temperature (i.e., SPM. 10, IPCC 2021, p. 28), may have a comparable function-altering effects. Graphs that show projections of sea level rise, drought severity, storm frequency with temperature increases may also alter behavioral relations with respect to climate-relevant stimuli.

As described above, rule following has many benefits for listeners, and these benefits apply to warnings about the climate crisis. That is, climate rules have the potential to influence the behavior of multiple people (i.e., cultural behaviors) and guide actions to limit future global warming and avoid its worst impacts.

Climate-Change Warnings as Ineffective Rules

Years of climate warnings, however, have not produced the necessary behavior change. As early as 1896, Svante Arrhenius predicted the greenhouse effect resulting from burning fossil fuels (Arrhenius, 1896/2012). Concern about CO₂ concentrations increased in the 1960s and 1970s as evidence increased, and greater public awareness followed the media coverage of James Hansen's 1988 congressional testimony on global warming (BoyKoff & BoyKoff, 2004; Weart, 2008). To address growing concerns, in 1988 the IPCC was formed, and in 1990 it released its First Assessment Report indicating that the planet was warming and that the warming could be caused by human activities. Each successive IPCC report has attributed global temperature increase to human activities with greater certainty and warnings became stronger. The Summary for Policy Makers from *Climate Change 2021: The*

Physical Science Basis (IPCC, 2021) notes, “It is unequivocal that human influence has warmed the atmosphere, ocean and land” (p. 4) and that, “Global warming of 1.5 °C and 2 °C will be exceeded during the 21st century unless deep reductions in CO₂ and other greenhouse gas emissions occur in the coming decades” (p. 14). In 2017, Over 15,000 scientists jointly signed “World scientists’ warning to humanity: a second notice” (Ripple et al., 2017) in which the authors reflected on the lack of progress in solving environmental challenges, especially climate change.

Across the globe, there are individuals (e.g., Johnson & Wilkinson, 2021), cities (see Markolf et al., 2020), and nations (see Climate Action Tracker, 2021) who are taking action and making changes to lead communities and countries toward net-zero carbon emissions. Yet, progress is inadequate. Concentrations of greenhouse gases continue to steadily rise (NOAA Global Monitoring Laboratory, n.d.). Markoff et al. report that slightly less than half of the largest US cities have established GHG reduction targets. Emission pledges by nations are insufficient, GHGs in the atmosphere are increasing, and current estimates place temperature increases by the end of the century at 2.7 °C (Climate Action Tracker, 2021).

Climate-change rules are failing to generate sufficient action. To help understand this failure of rule control, the following section seeks to apply a behavioral approach to rule following to climate-change warnings and solutions and identifies factors that may influence rule following. The paper draws from prior scholarship on variables impacting rule following (Barnes-Holmes et al., 2001; Pelaez, 2013; Stapleton, 2020; Törneke, 2010), and like the approach taken by Stapleton (2020) to understand responses to COVID-19 rules, applies these to climate-change messages. The factors sometimes overlap, and represent only some of the variables likely to impact rule following. Possible solutions and strategies for increasing rule control are also discussed. The paper incorporates research from environmental psychology, risk and decision making, cognitive and social psychology, and climate-change communication, as the bulk of climate-psychology research has come from outside of behavior analysis. The hope is to help connect diverse research areas and theoretical approaches.

1. Insufficient Exposure to the Rule

Climate warnings may fail to motivate action because people are not sufficiently exposed to accurate information about the causes of climate change, its risks, and the steps needed to mitigate climate disasters. Gifford (2011) calls this the barrier of “ignorance” and is part of what Hornsely and Fielding (2020) describe as the “deficit model” of climate communication—that inaction is attributable to a lack of exposure to the problem. Climate change surveys in the United States (US) suggest, however, that there is growing awareness of anthropogenic climate change. Polls suggest that about 76% of adult Americans believe that climate change is happening and a majority (60%) believe it is human caused (Leiserowitz et al., 2021a). Leiserowitz et al. (2022) have found that in the US, 33% of the population can be categorized as alarmed, 25% as concerned, 17% as cautious, 5% as disengaged, 10% as doubtful, and 9% as dismissive of climate change. Thus, over half of all Americans

can be categorized as alarmed or concerned about the climate crisis. Leiserowitz et al. (2021a) showed, however, that Americans rarely discuss (61%) climate change, and a little more than half (57%) hear about climate change each month. People also significantly underestimate the scientific consensus on climate change (only 59% of those polled believe scientists agree that climate change is happening) and underestimate personal risk from climate-change (Leiserowitz et al., 2021a). A study by Ranney and Clark (2016) found that only 12% of participants showed a partial understanding of the mechanism of global warming. An international survey found that most people reported that they needed a little more information to form an opinion about climate change (Leiserowitz et al., 2021). Thus, although a growing number of people are aware of climate change, there may be insufficient exposure to information about the severity or urgency of the problem.

A lack of media coverage on climate change may be partly responsible. A study investigating media reporting on climate change found that across 10 countries sampled, only 0.53% of newspaper articles in top papers in a given month (2006–2018) focused on climate change (0.63% in the US; Hase et al., 2021). Even with increasing frequencies and severity of extreme weather events and environmental disasters, reports of those events may not heighten concern if they are not associated with climate change. Hassol et al. (2016) have argued that, “Even as occurrences of certain classes of extreme events have increased, the media in some countries have not kept pace in communicating the scientific understanding of the connection between climate change and extremes” (p. 5).

People may also have insufficient exposure to information about climate-harming activities or pro-climate solutions. For example, people may not know about the high greenhouse-gas emissions of red meat production (e.g., Camilleri et al., 2019), or know about benefits of reducing air travel compared to actions such as waste reduction (e.g., Wynes et al., 2020).

Possible Solutions and Strategies for Change

One solution to the lack of information and insufficient rule exposure is to increase opportunities for people to learn about causes, risks, and solutions to the climate crisis. Even brief information about climate change has been shown to influence climate-change acceptance (Ranney & Clark, 2016). Ballew et al. (2019) argue that greater media coverage, increasing interpersonal conversations, and enhanced educational strategies, may improve awareness and concern.

Media reports that describe climate change may motivate action. The framing of such media stories, however, may be important to its impact. Reports that focus on benefits for climate action may improve engagement, but reports that focus on uncertainties are likely to reduce action (see discussion in Bolsen & Shapiro, 2018). A challenge to greater media reporting, however, is the increasing polarization of news sources and the growing use of online sources that present inaccurate or biased climate coverage.

Increasing informal conversations on climate change may require interventions that counteract punishment. People may avoid discussing climate change because of the risk of social disapproval (punishment) from listeners with opposing views

(e.g., Maibach et al., 2016). Skinner (1957) defined the *audience* as listeners who serve a discriminative function over speaker behavior. Punishment may establish listeners as *negative audiences* (discriminative stimuli for punishment, see Skinner, 1957). Mixed (positive + negative) or novel audiences also may weaken the likelihood of climate-change conversation. Thus, increasing discussions about climate change may require educational interventions that alter audience control and create opportunities for reinforcement. A study by Geiger and Swim (2016) showed that when participants who were concerned about climate change were told that an audience was also concerned about climate change (i.e., was not a negative audience), the reported tendency to talk about climate change increased. Thus, sharing information about the proportion of people who are concerned about climate change may increase talking about the topic. Listeners who effectively challenge speaker's statements on climate change may punish discussion. Geiger and colleagues (2017a) showed, however, that when participants were educated about climate change, they reported that they were more capable and willing to discuss it.

Studies have shown that educating people about causes and impacts of climate change also can increase engagement (e.g., Geiger et al., 2017b; Ranney & Clark, 2016). Efforts have been made to promote teaching climate change in schools across content courses from the sciences to the humanities (e.g., Beach et al., 2017; Shepardson et al., 2017). The teaching of climate change, however, has been attacked by political interests (e.g., Branch et al., 2016). Research has found that middle and high school teachers do not devote much time to the topic, and about a third emphasize both human and natural causes (Plutzer et al., 2016). To enhance education on climate change, advocacy for teaching climate-change content in schools and universities is needed, as well as resources for teachers wanting to include climate change in their classes (for examples see Beach et al., 2017; Fretz, 2015, and for behavioral approaches see *Sustainability & Behavior Analysis Sample Course Units* at the Behaviorists for Social Responsibility website <https://bfsr.abainternational.org/>).

Educating the public about the individual actions that are likely to have the most impact on carbon emissions is also needed. People may have poor “carbon numeracy” in that they do not know the relative GHG emissions produced by different activities (e.g., Wynes et al., 2020) (see Rules are Incomplete, below).

As noted by Geller (1992) and many others (e.g., Blake, 1999; Bulkeley, 2000; McKenzie-Mohr, 2000; Staats et al., 1996; and see Nisa et al., 2019), simply educating or informing the public on environmental problems may be insufficient to promote significant or lasting behavior change. Van der Linden (2017) notes that knowledge about human-caused climate change may be necessary but not sufficient for climate concern (and action). Educational strategies may need to be combined with other interventions.

2. Insufficient Learning History (Lack of Understanding by Listeners) and Rule Complexity

Climate scientists, in presenting data and results of climate models, use technical and scientific jargon which may be unfamiliar to lay audiences (Hassol, 2008;

Stoknes, 2015). Consider the following statement drawn from a passage in the Summary for Policymakers by the IPCC (2007), “It is more likely than not that anthropogenic forcing has increased the risk of heat waves” (p.10). Although terms are carefully defined within reports, statements such as these (especially taken out of context), may fail to generate effective listener behavior. The general public may not react appropriately to the unfamiliar term “anthropogenic forcing” nor the probability of the statement “more likely than not.” Budescu and colleagues (2009) found, for example, that when people read sentences from the 2007 IPCC report, they often misinterpreted the probability statements of climate scientists.

Broadly speaking, what may be called, “understanding” of a rule is dependent on a specialized history of socially mediated reinforcement. Pre-requisite skills for rule control may include the establishment of: listener behavior (e.g., auditory-to-visual conditional discriminations), echoic control, observing behavior, or arbitrarily applicable relational responding (see Tarbox et al., 2020). Rule following depends on the prior establishment of discriminative, conditioned reinforcing, and eliciting functions of verbal and nonverbal stimuli. Scientists, including climate scientists, are taught to tact scientific observations using precise, technical terms, and emit intraverbals in accordance with scientific principles. They are also taught listener skills necessary to respond appropriately to statements by other scientists. Statements made by climate scientists may fail to generate appropriate responses in lay audiences because they lack a comparable verbal reinforcement history. The view that inaction on climate change is attributable to a lack of scientific background in listeners is the second part of the “deficit model” of climate communication (Hornsey & Fielding, 2020).

The role of a listener’s learning history in rule control relates to Pelaez’s (2013) discussion of rule *complexity*: Rules vary in complexity of stimulus dimensions and derived relations from lower to higher. Compared to simpler rules, rule control by complex rules requires more advanced listener skills and as a result, complex rules may be less likely to produce effective listener behavior. To illustrate, compare the rules, “To reduce carbon emissions, people should reduce air travel” to the rule, “Flying produces greater carbon emissions than riding a bus, taking a train, and driving except when the car has only a single passenger in which case flying may produce lower emissions per person, depending on whether or not the plane is flown near capacity.” The second is more complex than the first because it involves a greater number of stimulus relations, including a higher-order class of relations, where relations are conditional upon other relations (see Robertson & Pelaez, 2018). From a relational frame perspective, it might be said that the former rule involves fewer derived relational operants. As a result of its greater complexity, the second rule may fail to alter travel behavior. Rules about climate change may fail to generate appropriate behavior because of their complexity. Exposure to complex rules may even be aversive. De Vries, Rietkerk, and Kooger (2020) argue that if information about sustainable actions is complex or difficult to understand, it may generate a negative stress reaction leading people to ignore it.

Possible Solutions and Strategies for Change

Solutions to the problem of insufficient verbal history may include educating listeners and establishing audience control of scientific verbal behavior. Educating listeners will require a multi-faceted approach that includes expanding climate-change curriculum in K–12 schools and universities and expanding climate-science coverage in the media (see above for challenges of bringing climate change education to schools). Educational efforts have been shown, for example, to produce more willingness to discuss climate change (e.g., Geiger et al. 2017a).

Scientists could also be better trained in public outreach so that climate communication comes under audience control. Skinner (1957) argued that one function of audiences was to serve as discriminative stimuli for word choice or jargon. The verbal behavior of climate scientists, like all scientists, has been shaped for precision and has come under control of scientific audiences. Effective repertoires for lay audiences, though, may be lacking. Climate scientists could be trained to translate climate expressions or describe the science with terms familiar to lay audiences (Hassol, 2008), such as by replacing “anthropogenic” with “human-caused.” Budescu et al. (2009) recommended that climate reports use exact percentages instead of words to describe likelihoods. Consistent with this, Myers, Maibach, Peters, and Leiserowitz (2015) showed that participants’ ratings of the scientific consensus on climate change was greater when consensus was first described numerically (e.g., “97%”) rather than non-numerically, (e.g., “an overwhelming majority”). Behavior analysts have made analogous arguments for communicating the science of behavior analysis to the public, noting that non-technical terms are better understood and may generate more positive reactions in listeners (e.g., Cihon et al., 2016; Critchfield et al., 2017; Jarmolowicz et al., 2008). Using stories may also be effective by presenting information in formats that are not only engaging, but that allow listeners to react more effectively to the content (Grant, 2007).

Simplifying rules may increase climate-relevant actions. For example, researchers have shown that clear labels on commodities to highlight their GHG emissions can increase people’s understanding of the relative GHG emissions of purchases and improve choices (e.g., Camilleri et al., 2019). There are also many ways to reduce carbon emissions, and presenting many at once may reduce rule following. Gardner and Stern (2008) argue that pro-environmental information should focus on a small number of specific actions that have a large impact on emissions.

Improved education and better science communication alone, however, may be unable to generate sufficient climate action or engagement. Correlational work, for example, has found that education is not a strong predictor of belief in climate change (Hornsey & Fielding 2020), suggesting that scientific illiteracy is unlikely to fully explain why climate warnings do not motivate action.

3. Incomplete Rules

The *specificity* of a rule may influence rule following. (Pelaez, 2013; Robertson & Pelaez, 2018). *Explicit* or complete rules specify all parts of a reinforcement

contingency (antecedent, behavior, and consequence), whereas *implicit* rules fail to include some part. The more explicit the rule is, the more likely it will produce rule following. For instance, Kaufman, Baron, and Kopp (1966) showed that specific instructions about reinforcement contingencies (even if inaccurate) produced different response rates than minimal instructions. Similarly, Presbie (1970) showed that specific (vs. vague) instructions produced more effective patterns of avoidance in humans.

Lack of rule completeness or specificity may hinder action on climate change. Climate warnings may fail to describe how people can mitigate climate change, or which actions are most effective. Gifford (2011) describes this barrier to climate action as another element of ignorance—people may not know what to do to address the climate crisis. Consider the statement, “Failure to address global warming will result in more severe droughts.” Although the statement associates droughts with global warming, the rule lacks concrete steps listeners can take to avoid warming. Gardner and Stern (2008) note that the documentary *An Inconvenient Truth*, although effective in highlighting the urgency of addressing climate change, failed to provide much guidance to viewers about what to do. De Vries (2020) makes a similar point about the documentary *Our Planet*. Media coverage of behaviors that can impact climate change has also been lacking. Hart and Feldman (2014), in an analysis of network news stories between 2005 and June 30, 2011, found that TV news rarely discussed impacts from climate change together with actions that could mitigate climate change. A comment to a *New York Times* article by reader #BirdsAreNotReal (2022) stated, “I’ve trusted and believed the climate science for three decades, for the last decade and a half I’ve been asking, so what do you want ME to do about it?”

De Vries (2020) argues that some action recommendations for mitigating climate-change are too vague. Simply telling people that they should reduce their carbon emissions provides insufficient stimuli for action. Gardner and Stern (2008) note, “From a householder’s perspective, a desire to reduce carbon emissions, even combined with knowledge that doing so has net financial and environmental benefits, is insufficient to yield effective action unless that person knows which actions will produce the benefits” (p. 14).

Actions also vary in their climate impact, and information about actions that are most effective may be lacking. For example, people may be more likely to (incorrectly) believe that recycling is more effective at mitigating climate change than energy use or meat consumption (Whitmarsh, 2009). If rules do not clarify high-impact actions, people may engage in behaviors that are most convenient. This effect is related to the problem Gifford (2011) calls *tokenism*: Individuals who are motivated to act on climate change may simply choose actions that are easiest to do, even if they have a low impact.

Information about effective community interventions is also needed. Commenting on initiatives by cities to limit green-house gas emissions, Markolf and colleagues (2020), note that, “Whereas top-level abstract targets are available, what is equally or even more needed is detailed information about which policies are being put into place, which initiatives are working and which are failing” (p. 22).

Rules may also fail to establish effective or enduring stimulus control. For example, a rule that states, “Reducing home energy use can reduce your carbon emissions” is not explicit about what nonverbal stimuli should function as discriminative stimuli for energy saving actions and about what actions are required to reduce home energy consumption. Similarly, “Support businesses with net-zero emission targets” may be too vague to generate climate-friendly purchases.

Possible Solutions and Strategies for Change

Climate communication should clearly specify reinforcement contingencies, including the most effective actions for mitigating climate change. Hart and Feldman (2016) found that exposure to news stories that described actions one could take to mitigate climate change increased a person’s stated efficacy to fight climate change and willingness to act, compared to exposure to stories that only described climate impacts. Kotcher et al. (2021) found that descriptions of climate impacts, a solution, and appeals for calls to action (positive social norms, which could signal social approval) were all influential features of advocacy messages, although solution information was the most important.

Information that is specific or tailored to an individual, group, or setting may be especially effective (see Lehman & Geller, 2004). For example, information about reducing energy use that is tailored to a household’s energy use patterns and installed appliances (see Abrahamse et al., 2007) may be more useful than general recommendations on energy saving.

Rules about solutions, such as those promoting individual action, should be explicit about which actions should be prioritized (e.g. Gardner & Stern, 2008). Rare’s Center for Behavior and the Environment identified 30 of the 80 most impactful actions to address the climate crisis listed in the book *Drawdown* (Hawkins, 2017) that involved behavior change (Heller, 2019) and created a list of seven behaviors with the greatest potential to reduce emissions (namely purchase electric vehicles, reduce air travel, eat a plant rich diet, offset carbon, reduce food waste, tend carbon-sequestering soil, and purchase green energy) (Rare and California Environmental Associates, 2019). Actions with the greatest emissions impact could be given priority in climate communications, and given greater emphasis in psychological research (see Nielsen et al., 2021). Electrification, for example, is key to reducing GHG emissions (Griffith, 2022). Thus, a message campaign to reduce transportation emissions could state, “To reduce your household carbon emissions your next vehicle purchase should be an electric vehicle.”

Rules about the effectiveness of climate-change behavioral interventions also need to be widely communicated. Markolf et al. (2020) suggest that new platforms and mechanisms could be developed for sharing effective city-wide interventions. One information-sharing website for community interventions can be found at the *Community-Based Social Marketing* website <https://cbsm.com/>.

Rules should also specify actions that can change practices of organizations that produce GHG emissions. Twenty fossil fuel companies are responsible for a third of all carbon emissions (see Matthew & Watts, 2019). Yet, Mann (2021) has argued that fossil fuel industries have made significant attempts to shift blame from corporate actions to individual behaviors to avoid regulations and revenue loss. The concept of

the personal carbon footprint gained popularity after a large advertising campaign by the oil company BP (see Yoder, 2020). Thus, rules could describe how to be a climate voter and support politicians who will create policies to regulate fossil-fuel extraction and GHG emissions in corporations. Wynes and colleagues (2021) have proposed the development of statements that indicate the impact on GHG emissions from voting for different political candidates (given the policies they support) and that indicate an individual's GHG impact from voting. Rules could also clarify how to engage in collective action (see Ardila Sánchez et al., 2020; Ardila Sánchez et al., 2020; Mattaini, 2013). McKibben (cited in Hayhoe, 2021) has argued that, "The most important thing an individual can do now is not be an individual" (p. 185).

4. Instructed Behavior Not Sufficiently Learned

As Barnes-Holmes et al. (2001) suggest, the extent to which instructed behavior has been shaped and reinforced in a listener will influence rule following. A person may be able to react as a listener to rules such as, "Weathering your home will reduce GHG emissions," or "Switching to green energy can protect the environment," but may not engage in the instructed behavior because the necessary behaviors are not sufficiently learned. People may not know how to weatherize a home or how to switch to green energy. A campaign in the Netherlands designed to increase energy efficiency with home insulation failed in part because of confusion in the public about how (and when) to act (Schalkwijk, 2017 as cited in de Vries, 2020).

Possible Solutions and Strategies for Change

Community-based social-marketing research indicates that an important step in designing an intervention is to identify the barriers (as well as benefits) to action (McKenzie-Mohr, 2011). One possible barrier is skill deficits. Climate communicators and those designing climate-relevant interventions should evaluate whether listeners know how to engage in the target behavior. If the target behavior has not been learned, the instructed behavior may need to be taught via further instructions, modeled, or shaped via successive approximations. For example, home owners could be given free energy audits and home visits could be used to demonstrate how to best weatherize their homes. Advertisements on TV, influencers on social media, or teachers in schools could model green actions. Incentives for climate-friendly actions (e.g., taking public transportation, becoming involved in environmental groups, composting, etc.) could be provided for increasingly complex behaviors.

5. Rules Have a Weak Function-Altering Effect (Rules do not Function as Augmentals)

As described above, many events obtain their reinforcing (or punishing) function from rules (see Torneke, 2010), an effect described in terms of their *augmentive* function. Climate-change rules may fail to motivate action because the stimuli

specified in the rule do not alter the reinforcing value of stimuli (the rules are not motivative augmentals), or because the rules fail to create new reinforcers (are not formative augmentals). For example, the statement, “To reduce the melting of the Greenland ice sheet, we need to cut GHG emissions” may fail to establish steps to reduce GHG emissions as negative reinforcers if melting ice sheets are not aversive stimuli.

Studies on risk perception have identified “emotion” as an important factor in risk judgements (see van der Linden, 2017), and climate researchers have analyzed the motivating effect of climate-relevant stimuli in terms of their ability to engage the “rational” versus “emotional” brain (e.g., Marshall, 2015). Engaging the emotional brain is said to motivate climate action. In behavior analysis, emotional reactions are not interpreted as causes but changes in operant and respondent behavior produced by motivating variables and eliciting stimuli (Skinner, 1953). Rules that associate emotional-stimuli with other climate-relevant stimuli can therefore produce function-altering effects. For example, if coral reefs are reinforcers for a listener, then rules about how climate change will cause mass die-offs of coral reefs (an eliciting stimulus and negative reinforcer) might establish climate-change mitigation as reinforcing and motivate action.

Lack of an augmenting effect of climate-change rules and warnings may stem from the different learning histories of scientists and nonscientists with verbal stimuli included in the rule. That is, if words in climate rules are unfamiliar, have not been associated with other stimuli or reinforcers (are not part of established relational networks), or have little evocative effect, they may fail to motivate action. Weber and Stern (2011) provided a health-related example from Sinaceur, Health, and Cole (2005) showing that reports about “bovine spongiform encephalitis (BSE)” or “Creutzfeldt-Jacob disease” elicited less fear (and presumably were less motivating) than reports using more familiar terms, “mad cow disease” (p. 320).

One example of terms lacking motivating effect may be the words “climate-change” itself. Although the words “climate change” may be preferred to “global warming” by scientists because “climate change” is more descriptive of the broad changes produced by GHG concentrations, the words “climate change” may have a lower motivating effect. In a memo about recommended communication strategies, the Republican strategist Luntz wrote that Republicans should use the term “climate change” instead of “global warming” because, “climate change” is less frightening than “global warming,” and that “While global warming has catastrophic connotations attached to it, climate change suggests a more controllable and less emotional challenge” (Luntz, 2002, p. 142).

The stimulus function (or relational networks) of climate-change terminology may also differ between climate scientists and lay audiences. If a climate scientist, for example, describes an event as causing a “positive feedback loop” (such as melting Arctic permafrost), it may not function as an aversive stimulus to the lay public because the term “positive feedback” may be associated with good events (Hassol, 2008). Thus, warnings about positive feedback loops may not have an augmentive function.

Weber (2016) also argues that climate change risk may fail to motivate action in politicians and the general public due to its statistical nature. Consider a statement

from the IPCC (2018) that notes, “Model-based projections of global mean sea level rise (relative to 1986–2005) suggest an indicative range of 0.26 to 0.77 m by 2100 for 1.5 °C of global warming, 0.1 m (0.04–0.16 m) less than for a global warming of 2 °C (medium confidence).” For nonscientists, the quantitative nature of the comparisons of sea level rise at 1.5 °C and 2 °C degrees, may fail to motivate avoidance behavior. Numbers alone may not be very compelling.

Counterpliance is also a risk if rules come from government or partisan speakers (for a health-related example see Irmak et al., 2020). For example, government regulations about fossil-fuel use or rules from environmentalists about eating less meat may heighten energy use or meat consumption in listeners for whom these behaviors are highly reinforcing (and speakers distrusted).

The framing of climate impacts may also reduce their augmentive function. Rules can specify immediate or temporally remote outcomes, certain or probabilistic ones, and consequences for the self or distant others. The delay, probability, and social (and spatial) closeness of an event (i.e., who it impacts) has to be described as its *psychological distance* (Trope & Liberman, 2010). Outcomes that are more immediate, likely, and personal/local are likely to be more potent as consequences. The temporal discounting that can occur with instructed reinforcers relates to what Pelaez (2013) identifies as the *timing* of the contingencies specified in the rule. Rules can specify immediate or delayed contingencies. A large body of research on discounting shows that as reinforcers become more delayed from choice, more probabilistic, or the recipient more socially distant, the lower their value (e.g., Green, & Myerson, 2004; Jones & Rachlin, 2006; Madden, & Bickel, 2010; Rachlin et al., 1991). Furthermore, research has shown that delayed and probabilistic environmental events (and environmental impacts on others) are discounted in ways similar to that of other types of consequences (e.g., Hardisty & Weber, 2009; Kaplan et al., 2014; McKerchar et al., 2019).

Climate change is often described as having its most dire outcomes for future generations, as being probabilistic, and impacting only select populations (e.g., low-lying nation states). Thus, lack of effectiveness of climate warnings may be attributed in part to temporal, probability, and social discounting (e.g., Hirsh et al., 2015; Gifford, 2011; Weber & Stern, 2011). Stoknes (2015) calls this barrier to climate action the barrier of distance. Spence, Poortinga, and Pidgeon (2012) found a significant correlation between concern about climate change and dimensions of psychological: those rating climate change impacts as having lower psychological distance (sooner, more likely, local and with personal impacts) showed greater concern about climate change (and see Maiella et al., 2020).

Consider a climate statement, “By the end of this century, what have been once-in-20-year extreme heat days (one-day events) are projected to occur every two or three years over most of the nation” (Melillo et al., 2014, p. 39). Such a temporally distant outcome may fail to motivate much action. Polar bears are the most iconic image of climate-change messaging, yet polar bears and melting Arctic ice are socially and spatially distant from most people. Thus, verbal stimuli linking ice loss and declining polar bear populations to climate change may not be especially motivating.

Climate warnings about sea level rise for island nations, or warnings about prolonged droughts decreasing food production in the Global South, may fail to generate significant action in some listeners in more developed countries because of the social/spatial distance of those impacts. It is interesting to note that a US climate survey that found that only 50% of the public thought that climate change would harm themselves personally (Leiserowitz et al., 2021a). This suggests that in the US, climate-impacts may often be framed as socially distant in the media.

Impacts of climate change are described as probabilistic, and thus warnings may fail to raise concern. A key strategy of climate-change denialists aiming to protect the financial interests of fossil fuel corporations has been to frame the presence of climate change and its human cause as scientifically uncertain (see discussion in Weber & Stern, 2011). Cushman (1998) described a leaked draft of a proposal by industry groups (especially fossil fuel corporations) to oppose a treaty on climate change. The proposal was to train specially recruited scientists to “help convince journalists, politicians and the public that the risk of global warming is too uncertain to justify controls on greenhouse gases.” By emphasizing the uncertainty, industry groups hoped to dissuade action on climate change. Research has shown that when people are told that there is scientific disagreement about an environmental hazard, even if a very small proportion of scientists disagree, support for regulation decreases (Aklin & Urpelainen, 2014).

Images used in the media may also enhance discounting of climate change. O’Neill (2013) examined 1500 images attached to climate stories in 2010 in US, UK and Australian papers and found that images not only focused on people, especially political figures, thereby highlighting climate change as a political and contested issue, but also depicted climate change as geographically distant (e.g., ice imagery) or personally distant (e.g. smokestack images).

Possible Solutions and Strategies for Change

The motivating or augmental function of climate-change warnings could be improved to maximize reinforcer or (punishment) value of climate-relevant stimuli and reduce psychological distance of climate impacts and solutions to motivate action. Van der Linden et al. (2015) offer several “best practices” about climate change communication, and conclude that, “in order to improve public engagement with the issue, policymakers should emphasize climate change as an experiential, local and present risk; define and leverage relevant social group norms; highlight the tangible gains associated with immediate action; and last, but certainly not least, appeal to long-term motivators of pro- environmental behavior and decision making” (p. 761). The first point is about discounting: the augmenting function of climate rules may be enhanced by using stimuli that reduce temporal, social and geographical, and probability discounting (i.e., reduce psychological distance). Spence, Poortinga, and Pidgeon (2012) argue that “...in order to promote concern about climate change, risk communications should focus on making climate change psychologically closer and make potential climate change impacts relevant to individuals’ social group, locality, and lifetime” (p. 13). Similarly, climate communicators suggest that it is important to make the distant,

global, and nebulous threat of climate change personally relevant (e.g., CRED, 2009; Hayhoe, 2021; Van Leuvan et al., 2022; Weber, 2016; Stoknes, 2015).

Behavioral strategies that reduce temporal discounting (see review in Rung & Madden, 2018) may also be effective at improving climate-relevant decisions. One strategy is having people imagine their future selves, i.e., episodic future thinking (see Kaplan et al., 2016). Nalau and Cobb (2022) describe a variety of future visioning manipulations designed to increase engagement on climate change. Other tools for reducing discounting of climate impacts are films and stories. People have reported that reading climate-change fiction reduced temporal distance of climate impacts (Schneider-Mayerson, 2018).

Emphasizing local impacts can reduce social and geographical discounting. Research has shown that describing local impacts was more effective in increasing concern about climate change than describing impacts in distant places (e.g., Jones et al., 2017). Visualization tools (i.e., edited images) that show possible climate-impacts for local places and landscapes can improve engagement and encourage action (Sheppard et al., 2011).

One way to reduce probability discounting is to use messages that clarify the scientific certainty of climate change (i.e., *consensus messaging*). Studies have shown that consensus messaging can increase climate-change concern and climate-change policy support (van der Linden et al., 2015; Van der Linden, Leiserowitz, & Mai-bach, 2019).

Using emotionally engaging text might increase the motivating impact of climate messages (e.g., CRED, 2009; Weber, 2016). Descriptions of indigenous communities losing sacred land to sea level rise or a community's successful installation of a community solar garden may be more persuasive than climate statistics. Vivid imagery may also motivate behavior (O'Neill & Smith, 2014). For example, images of coral reef bleaching, shrinking glaciers, superstorm damage, or perhaps images of new windfarms or solar arrays might engage behavior (see O'Neill et al., 2013). Analogies could also improve motivation by using familiar stimuli. Gonzales and colleagues (1988) give an example for encouraging weatherstripping for energy conservation. Energy auditors, they state, instead of just describing the cost-effectiveness of weatherstripping, could say, "If you were to add up all the cracks around and under the doors of your home, you'd have the equivalent of a hole the size of a football in your living room wall" (p. 1052).

Creating social norms can also promote engagement (e.g., CRED, 2009; Van der Linden et al., 2015; Van Leuvan et al., 2022). As noted above, injunctive norms may impact behavior by signaling social consequences for behavior, whereas descriptive norms may impact behavior by signaling what behavior is effective under prevailing contingencies (see Huber et al., 2018). As an example, people provided with information about their energy consumption relative to their neighbors (descriptive norms) and given smiley faces for lower usage (injunctive norms) showed energy-use reductions (see Allcott, 2011). Huber et al. found that people who were given information about government policy on corporate carbon offsets and information about social norms (descriptive and injunctive norm) showed greater willingness to pay, and payment of carbon offsets, for driving compared to a control group.

Sparkman and Walton (2017) showed that dynamic descriptive norms about a growing number of people eating less red meat reduced meat consumption.

Some have suggested that climate-change warnings that describe dire outcomes for failures to act—“fear” messaging—may cause disengagement (e.g., CRED, 2009; Van Leuvan et al., 2022). Mann (2021) makes a similar point about “doomist” messages that imply it is too late to avoid climate catastrophe. Positive frames (e.g., Morton et al., 2011) and humorous messages may also increase engagement (see Kaltenbacher & Drews, 2020). A recent meta-analysis, however, found that negative or loss framing (i.e., losses that can be prevented) was more likely to lead to behavior change than positive framing (gains from action) (Homar & Cvelbar, 2021). Given the mixed findings in the literature, Hornsey and Fielding (2020) argue that a diversity of messages may be warranted. It seems likely that the impact of framing may depend on the audience, what is being lost or gained, and whether effective action is proposed.

Rules that associate climate-relevant actions with established reinforcers may also motivate action (i.e., augmentals). Honsey and Fielding (2020) argue, “...rather than persisting with data-driven arguments that do not speak to people’s underlying motivations, the goal is to identify what their motivations are, and to present arguments that align with them,” (p. 15) a strategy they call *value-based messaging*. Interventions focused on value statements have been shown to impact decision making (e.g., Jackson et al., 2016), and can be applied to climate-relevant behaviors (see discussion in Newsome & Alavosius, 2011).

Climate communicators have promoted connecting climate change solutions to values such as community, equity, security, or health (e.g., Corner & Clarke, 2016; CRED, 2009; Hayhoe, 2021; Stoknes, 2015; Van Leuvan et al., 2022). Climate solution statements could also describe co-benefits of addressing climate change, such as improved housing and employment (e.g., Jennings et al. 2020). A study by Wolstenholme et al. (2020) investigated the impacts on meat consumption of messages about improved health, environmental benefits, both, and control messages, and found that all but the control group showed reduced consumption. What functions as a reinforcer (what one values) of course differs across individuals, and thus climate communication should come under audience control. Republicans, who tend to show less concern about the climate crisis, have been shown to react positively to climate statements when messages are targeted to their values, e.g., security (Goldberg et al., 2021). Religious leaders may motivate action in faith-based groups by connecting climate action to religious values. Highlighting the connection of climate change to social justice also can motivate action (see Moser, 2016).

Stories may also influence climate action (Grant & Forrest, 2020). Stories present problems or disruptors that function as motivating operations for resolution or return to equilibrium (Grant, 2007). This motivative function of climate fiction (e.g., *Parable of the Sower*, *Water Knife*, *The Ministry for the Future*) may be used to increase climate-change engagement. Jones (2014) investigated the effects of vignettes (short fiction stories) on support for climate policy. The study found that narratives were more persuasive than statements of climate facts, and that the level of positive affect for the hero was positively associated with increases in support for the policy

solution described in each narrative. Stories and films that use satire and humor, such as *Don't Look Up*, may also increase climate action.

Messaging strategies can minimize the aversiveness of climate rules and reduce counterpliance. Climate researchers could borrow communication strategies from reactance research on health-related persuasive messaging such as by using empathy, providing choices for action, or using narratives and other-referencing statements (Reynolds-Tylus, 2019). For example, Gardner and Leshner (2016) found that using stories describing the benefits for other people (loved ones) for rule following increased compliance with health messages.

Corner and Clarke (2016) and others (e.g., de Vries, 2020; Dietz, 2013) have argued that to increase public engagement with climate change, climate communication should be less “top-down” and more participatory. “Top-down” engagement strategies may fail because they do not consider the unique values (i.e., motivators) of listeners. Instead, climate communication should be an ongoing dialogue. Climate-change conversations should be inclusive to allow diverse individuals to formulate shared values. Such participatory public engagement, might lead to the creation of rules based on shared community values that could guide broad classes of climate-relevant actions.

6. Conflicting Rules

Rules may be ineffective if listeners are exposed to multiple, conflicting rules. For example, the function-altering impacts of the statement “climate change is human caused,” oppose those of the statement by climate-change denials, “climate change is a natural process.” People may have been told that global warming is not happening, it is a hoax, there is no scientific consensus that it is human caused, or that it is too expensive to address. These rules are inconsistent with rules of climate experts. Climate messages may also conflict with self-generated rules. For example, people may state rules such as, “There is nothing I can do to stop climate change,” which conflicts with rules by climate scientists about climate-change mitigation.

When rules conflict, the control exerted by one rule may supersede the other. One rule may be more consistent with a listener’s prior learning history, or the listener may have experienced greater reinforcement for following rules from one of the speakers. Effects of conflicting rules also may sum algebraically (see discussion on multiple control in Skinner, 1953), resulting in a weaker response to the more influential rule than if presented alone. A study by van der Linden, Leiserowitz, Rosenthal, and Maibach (2017) measured belief in the scientific consensus on climate change in a pre-post design. They found that in participants given a consensus message on climate change (a pie chart with the message, “97% of climate scientists have concluded that human-caused climate change is happening”), belief in the scientific consensus on climate change increased. In participants given a counter-message (that there was disagreement among scientists about the evidence for human caused climate change), belief decreased. In participants shown the consensus message and then counter-message, there was no change in belief, indicating that the effects of the two statement counteracted each other.

Conflicting rules by Republican and Democratic political leaders may have impacted climate-change concern. Research by Brulle and colleagues (2012) indicated that in the US, when partisanship of climate change decreased in 2006 and 2007 and Republicans and Democrats both supported addressing climate change, climate concern increased, but after 2008 when Republican anti- environmental voting increased, concern for climate change decreased.

The use of conflicting (or false) rules to minimize the impact of climate warnings has been explicit and purposeful. Leaders of fossil fuel corporations and associated think tanks designed and implemented messaging campaigns to cast doubt on climate science by using corporate-hired scientists who described the science as uncertain (Oreskes & Conway, 2010; Weber & Stern, 2011). Some of the same individuals who were hired to create doubt about the evidence linking tobacco to cancer and heart disease were involved. This misinformation about the scientific consensus reduced engagement. The distinction between actual scientific agreement on human-caused climate change (97%) and people's belief in the scientific consensus (67%) is known as the *consensus gap* (Cook et al., 2018). The consensus gap is a result of the conflicting information from climate scientists and scientists who aim to create controversy and doubt.

News media have also been part of presenting conflicting information. Boykoff and Boykoff (2004) describe how the media, in an attempt to provide “balanced” reporting, gave equal time to climate-change deniers and climate scientists, despite the high consensus in the scientific community. They examined climate reporting by four prestigious US newspapers (from 1988 to 2002) and concluded that “[A] dherence to the norm of balanced reporting leads to informationally biased coverage of global warming. This bias, hidden behind the veil of journalistic balance, creates both discursive and real political space for the US government to shirk responsibility and delay action regarding global warming” (p. 134).

Economic contingencies were likely responsible for the false statements about climate-change. Skinner (1957) described lies as distorted (or impure) tactics. *Distorted tactics* are those which are not entirely under discriminative stimulus control, but rather are impacted by motivational variables or added generalized conditioned reinforcement. Tactics may be distorted by the operant behavior of listeners. In other words, people may lie because doing so alters the listeners response in a way that is reinforcing. Lies about causes of climate change by corporations may have been maintained by decreased support for climate-mitigation policy in voters and politicians. Tactics may also be distorted by generalized conditioned reinforcement from listeners (attention). Lies about the reality of climate change may have generated greater attention and approval from listeners than climate facts, perhaps because the topic or solutions are aversive.

Possible Solutions and Strategies for Change

Consensus messaging is one method of overcoming the weakening effect of misinformation about scientific consensus on climate change on climate change action (Cook et al., 2018). For example, van der Linden, Leiserowitz, and Maibach (2019)

found that telling participants that “97% of climate scientists have concluded that human-caused global warming is happening” increased belief and worry about climate change, and support for action. Van der Linden, Leiserowitz, Feinberg, and Maibach (2015) argue that belief in scientific agreement is, a “gateway belief” that underlies public opinion about climate change and influences support for action (but see Hornsey & Fielding, 2020). Using satire and humor may also increase belief. A study by Brewer and McKnight (2017) found that participants who watched a satirical video segment from *Last Week Tonight with John Oliver*, “A statistically representative climate change debate,” in which three climate change skeptics debated 97 climate scientists (instead of inaccurate balanced reporting) showed an increase in belief in global warming.

Another proposed solution to conflicting messages is to warn people that they may be told lies. This approach has been described as *inoculation* (van der Linden, Leiserowitz, Rosenthal, & Maibach, 2017). Van der Linden et al. showed that when participants were given a consensus message, warned that politically motivated groups were trying to convince them that there was no agreement, and then shown a countermessage (that there was no scientific consensus), belief in scientific consensus on climate change still increased.

7. Lack of Speaker Credibility

Speaker credibility will influence rule following. Speaker credibility may be influenced by factors such as the speaker’s expertise and trustworthiness (e.g., Wiener & Mowen, 1986). Skinner (1957) notes that a listener’s belief in a speaker will “vary between speakers (to reflect the listener’s judgment of the speaker’s accuracy, honesty, and so on)” (p. 88). Considerable research in communication has shown that source credibility can influence persuasive messaging (Pornpitakpan, 2004).

Barnes-Holmes et al. (2001) argue that credibility of a speaker can be established directly through reinforcing experiences, but also indirectly via generalization from similar speakers, or through verbal processes, such as through rules given by others. For example, simply noting a person’s political affiliation may impact credibility. Similarly, Törneke et al. (2010) argued that “The speaker’s credibility can be based on the listener’s actual experiences of following rules uttered by this speaker, or on derived stimulus functions. An example of the former would be following a piece of advice from a lifelong partner or close friend who has earlier given counsel that was helpful. An example of the latter is the way in which we normally follow rules given by various experts or, for that matter, when we do not follow this type of rule because we follow the rule ‘So-called experts are usually wrong’” (p. 117).

Research has shown that the experience following the rule of a speaker can influence rule following. For example, Hackenberg and Joker (1994) found that participants followed rules when the instructed response pattern maximized reinforcement, and continued when instructions were made increasingly inaccurate, but that rule following eventually decreased when benefits decreased. An example of possible generalization comes from a study by Penner et al. (1973) that found that when the experimenter appeared more competent, rule following

increased. Hale and colleagues (2018) exposed participants to speakers who described themselves in ways indicating that they were reliable or irresponsible. They found that research participants were more likely to follow the advice of the speaker described as reliable, likely because of prior experience following rules from similar speakers.

Public trust in the risk communicator is a critical determinant of responses to risk (e.g., Slovic, 1999). Thus, the credibility of climate scientists and climate communicators can determine the impact of climate-rules. Trust is especially relevant for communicating climate change because public understanding comes from verbal reports (Weber, 2010). In support of this, Malka et al. (2009) found that the relation between knowledge and concern about global warming depended upon trust in scientists, and political party identification. In the US, people report distrust in climate scientists, particularly Republican voters, and therefore are less likely to believe their warnings (e.g., Hamilton et al., 2015).

Part of the polarization of climate-change in the US has been attributed to people following “elite” cues—rules and actions of group leaders. These people may serve as trustworthy rule sources. For example, Republican voters may trust rules from Republican political leaders. A study by Brulle and colleagues (2012) reported that, “The most important factor in influencing public opinion on climate change, however, is the elite partisan battle over the issue. The two strongest effects on public concern are Democratic Congressional action statements and Republican roll-call votes, which increase and diminish public concern, respectively” (p. 185). Rinscheid et al. (2021) also showed that elite cues, endorsements of climate-mitigation policy, influenced policy support; when cues came from a trusted source (political leaders from the respondent’s political party), climate policy support increased, but when cues came from an untrusted source (political leaders from the opposite party), support for climate policy decreased. This finding supports suggestions by Merkley and Stecula (2018) that Republican party members formed negative opinions on climate science because Democrat elites supported it.

Possible Solutions and Strategies for Change

Many have suggested that to enhance the efficacy of climate-change messages, messages should come from sources the audience trusts (e.g., CRED, 2009). Brewer and Ley (2013) found that science media (T.V., websites) were trusted more than news sources. Medical professionals can also be a trusted source on health impacts of climate change (e.g., Romanello et al., 2021). Messages could come from speakers whose political ideologies are congruent with the audience. Bolsen et al. (2019) found that Republicans were more likely to view climate change as a national security threat when that threat was communicated by either Republicans or military leaders (trusted speakers). When the messages came from Democrats, they showed an increase in belief that climate change was a hoax (see also Motta et al., 2021). Faith-based groups may trust messages from religious leaders or from speakers with shared religious values. Hayhoe, Bloom, and Webb (2019) found that a lecture on climate change framed from an evangelical

Christian perspective shifted climate opinions in undergraduate students at evangelical institutions.

Celebrities, such as Leonardo DiCaprio, as role models, may function as trusted sources of climate information (i.e., a source of stimulus control). Greta Thunberg, a climate activist who began protesting inaction on climate change when she was 15 years old, gained media attention with the “Fridays for Future” campaign and inspired further climate activism (see, for example, Sabherwal et al., 2021). Several documentaries have featured celebrities with the goal of encouraging climate action (e.g., *Years of Living Dangerously*, *Before the Flood*). After reviewing the literature on celebrity endorsements, however, Olmedo et al. (2020) argued that better evaluations of the efficacy of celebrity involvement in environmental campaigns are needed.

A challenge of this messaging strategy is determining who is a trusted source for a specific audience. Bolsen and Shapiro (2018) argue that one solution to source credibility is to bring together scientists and communicators who hold diverse values and ideologies to communicate climate change facts. Others have recommended that climate communicators build trust through social interactions, such as by being transparent, making themselves vulnerable, and acknowledging limitations (Goodwin & Dahlstrom, 2014).

8. Implausibility of Rule and Inconsistency with Prior Learning

Törneke (2010) noted that rules may not be followed even if understood because “...the rule is incoherent or contradictory in relation to the listener’s learning history” (p. 117). Barnes-Holmes et al. (2001) describe this effect on rule following as the *plausibility* of the rule. Grant and Forrest (2020) make a similar point about stories, arguing that the stories that are most influential are those that have coherence (internally consistent) and fidelity (similar to other stories established as true).

Plausibility of a rule may be described as people’s *belief* in a rule. Belief stems from a history of reinforcement. Skinner (1957) has noted that “Frequency of effective action accounts in turn for what we may call the listener’s ‘belief’-the probability that he will take effective action with respect to a particular verbal stimulus. In general this will vary between speakers . . . and between responses (depending upon the plausibility of the response in connection with the rest of a given situation)” (p. 88).

Climate warnings may fail to generate action because warnings or solutions are implausible, i.e., they contrast with prior learning experiences. For example, people may disbelieve climate change warnings that describe catastrophic events such as mass extinction, 30 m sea level rise, or civilization collapse, because they contrast with everyday experiences. Similarly, rules about global warming may be inconsistent with observations of local weather patterns which show little obvious change.

Denial messages may have been effective because, in some verbal communities, climate warnings likely oppose reinforced stimulus associations (relational networks) and stimulus functions. A common finding from climate-change risk

perception research is that individuals who identify as Democrats show more concern about climate change than Republicans (e.g., Hornsey & Fielding, 2020; Leiserowitz et al., 2021b). For Republicans, climate-rules may conflict with existing stimulus associations. For example, if a political verbal community has established opposing relations between “free-markets” (as good) and “government regulation” (as bad), then climate change warnings, which are associated with calls for increased government regulations, are also likely to motivate avoidance (cf. Lewandowsky et al., 2013). Similarly, if the word “tax” is equated with economic harm, then “carbon taxes” are likely to be rejected.

Environmental psychologists investigating climate-change perceptions have identified multiple ideological factors (cultural values) that are correlated with climate skepticism, including individualistic and hierarchical values, and free-market ideologies (e.g., Lewandowsky et al., 2013; and see Hornsey & Fielding, 2020). Such beliefs and attitudes may be understood as verbal responses shaped by the reinforcing practices of verbal communities (Guerin, 1994). Climate rules that contrast with learned verbal associations are unlikely to be followed. In a study investigating the relationship between climate change skepticism and beliefs across different countries, Hornsey et al. (2018; and see Hornsey & Fielding, 2020) found that only in some countries (namely Brazil, Australia and Canada and most strongly, the US) was climate skepticism correlated with ideologies such as political conservatism, individualistic values (individuals over society), hierarchical values (hierarchical over egalitarian power structures), free-market ideologies, and belief in conspiracies. Hornsey et al. (2018) found that the relationship between climate-change skepticism and ideology was most pronounced in countries with considerable fossil fuel emissions, suggesting a possible influence on verbal behavior of associated economic costs of addressing climate change. A study by McCright and colleagues (2013) indicated that partisan rejection of science was not generalized to all science, but only to science that warned of negative impacts of economic development. Although climate skepticism is linked to contrasting verbal relations in political conservatives, research has shown that in the US, both liberals and conservatives deny scientific information that contrasts with their prior beliefs (Washburn & Skitka, 2018; and see Ditto et al., 2019).

The implausibility of addressing climate change through individual action may hinder action. That is, if people may have learned that climate change is a global problem requiring global solutions, then rules about actions individuals can take to address climate change may be doubted. For members of religious communities who are told that nature is controlled by supernatural forces, rules about human interventions also may be viewed as implausible. Environmental psychologists have discussed such barriers to climate action in terms of “self-efficacy” or “perceived behavioral control” (e.g., Gifford, 2011). If people do not believe that their actions will be effective, they will not act.

Climate-relevant rules which imply loss of specific valued reinforcers may also be rejected. For example, in verbal communities in which gasoline cars are highly valued, rules about replacing gasoline cars with electric cars may fail to influence behavior. A study by Vainio and Hartikainen (2018) found that messages about climate and health benefits for consuming more plant-based meat were ineffective in

those with positive beliefs about red meat. One might also predict that people who rely on fossil-fuel revenue for income would be more likely to reject climate change science and climate-change mitigation strategies. Consistent with this, a survey of mining company employees and local government employees in Australia found that government employees had greater concern and belief in climate change (Loechel et al., 2013).

Possible Solutions and Strategies for Change

Climate rules could be targeted to audiences in such a way that the rules align with prior learning. One strategy is context framing (e.g., CRED, 2009). For example, in groups for whom “doomist” messages of climate change are implausible, messages that frame climate-change mitigation as “insurance” or “risk management” may be more impactful (see discussion in Stoknes, 2015). Rules that use words with more positive associations may also be effective. Hardisty et al. (2009) found that framing a carbon tax as an “offset” increased climate-friendly purchase preferences in Republicans and Independents.

As discussed above, scholars have argued that climate communications may be more effective if messages correspond rather than conflict with existing values (e.g., CRED, 2009; Hayhoe, 2021; Hornsey & Fielding, 2020; Stoknes, 2015). In the US, climate messages could be designed to align with liberal or conservative values, depending on the audience. For example, although climate warnings about dire ecological impacts of global temperature rise may be viewed as implausible in some conservative group, rules about economic benefits of green energy transitions may be persuasive. Emphasizing free-market solutions to reducing GHG emissions might be effective in groups who oppose government regulation of industry. Rules about the health impacts of addressing GHG emissions might be motivating across broad audiences. Fortunately, in the US, climate skepticism has decreased across time, and Leiserowitz et al. (2022) have reported that in the latest US poll to date only 9% of responders were categorized as dismissive of climate change. However, they also find that 29% still say global warming is either “not too” (15%) or “not at all” (15%) personally important (Leiserowitz et al., 2021a).

9. Insufficient Reinforcement for Rule Following

Rule following will depend on the short-term social and nonsocial consequences of compliance. Laboratory studies have shown for example, that rule following is influenced by the relative reinforcement for following or not following rules (e.g., Galizio, 1979; Hackenberg & Joker, 1994), and reinforcement for compliance and punishment (response cost) for noncompliance (Fox & Pietras, 2013; Nergaard & Couto, 2021). Rule following may be unlikely if reinforcement for compliance is relatively small in magnitude, probabilistic, or delayed, or if punishment for non-compliance is small or probabilistic, or has no specified time of occurrence (see Malott, 2010). Furthermore, rule following may be unlikely if behavior has high costs/effort, or produces social disapproval. Thus, climate warnings and rules for

climate solutions may fail to generate sufficient action because the reinforcement contingencies do not support responding, or because they support opposing actions.

Contingencies impacting responses to climate warnings may be analyzed at both the individual and group (or organizational) level. Lack of rule following by individuals may occur because contingencies may be insufficient to support rule following. As described above, rule following may be maintained by nonsocial (tracking) and/or social (pliance) consequences. Decisions to following rules about taking public transportation to work, for instance, may vary as a function of reinforcer delays, effort, and reinforcer quality for each transportation mode. For people who enjoy red meat, rules about reducing meat consumption may be ignored if plant-based meat substitutes are lower-valued reinforcers. Financial barriers may limit adoption of energy-saving technologies (Gardner & Stern, 2008). For many consumers, solar panels, energy-saving appliances, or electric cars are unaffordable. Social reinforcers for compliance with climate mitigation strategies, such as praise for switching to renewable energy, carpooling, or diet shifts may be lacking or insufficient compared to the effort/costs. Alternatively, social disapproval for such actions may suppress rule following, such as in verbal communities whose values statements (about personal freedoms, automobiles, or red meat) conflict with climate-change mitigation actions.

The physical infrastructure, economic systems, and social systems may create barriers to climate action. For example, the sprawl of cities and communities create travel requirements. Renewable energy sources may be unavailable. Limited housing or food options may restrict sustainable choices. Social and economic contingencies may encourage high levels of resource consumption and energy use. Individuals in developed countries may have a considerable reinforcement history for GHG-producing behaviors (especially in wealthier groups). Whitmarsh (2009) has noted that energy consumption patterns are habitual and (at least in developed countries) an integral part of people's lives. Rules derived from these contingencies likely also play a role in maintaining harmful behaviors.

Contingencies operating at the group level have been described as *metacontingencies* (Glenn, 2004; Glenn et al., 2016). A metacontingency describes a relationship between (a) interacting contingencies of individuals (interlocking behavioral contingencies, IBCs) functioning as a unit and yielding a product, and (b) environmental conditions (or the product itself) which influences the future probability of the IBCs. Climate warnings may be ineffective in the context of metacontingencies that favor practices that oppose climate action.

For example, consider responses by fossil-fuel corporations to warnings by climate science to cut GHG emissions. By some estimates, to keep within the a 1.5 °C carbon budget, by 2050, 60% of oil and fossil methane gas and 90% of coal must remain in the ground (Welsby et al., 2021). Yet, fossil-fuel production is a billion-dollar industry: In 2021, 28 of the largest oil and gas companies made \$183.9 bn in profits (Milman, 2022). Corporations that halt operations will face enormous losses, as will their investors. The economics of fossil fuel extraction illustrate why actions of oil and gas companies and related industries are resistant to efforts to address climate change. Reductions in fossil fuel production are unlikely to happen without changes to these metacontingencies.

Rapid declines in fossil fuel production may have economic repercussions for national economies (Halttunen et al., 2022), which may dissuade politicians from acting. That is, political actions by citizens and corporations faced with economic losses from government climate policies may function as a metacontingency selecting political actions of governments that are too incremental or unsubstantial to adequately address the climate crisis.

Transitioning to green energy may also be cost-prohibitive for some communities or countries. Under the Paris Agreement, wealthy countries pledged to provide financial assistance to developing countries to aid with green energy development (and climate adaptation) given its costs, although they have not yet met their commitments (Timperley, 2021). Few contingencies at the international level support compliance with such pledges.

Possible Solutions and Strategies for Change

Contingencies of reinforcement for climate-relevant behaviors need to be aligned with recommendations of energy and climate experts to increase individual actions and group practices (cultural behaviors) that limit global warming. That is, reinforcers for following climate-relevant rules and punishers for breaking them need to be established.

Changing contingencies for individuals and households can have significant impacts on GHG emissions. In what they call the “behavioral wedge,” Dietz and colleagues (2009) argued that 7.4% of national emissions could be reduced by behavioral interventions at the household level (home weatherization, using fuel efficient vehicles, changing driving behaviors, and using energy-saving appliances). To overcome financial barriers to energy-use reduction, Gardner and Stern (2008) proposed a short list of curtailment (rather than purchase) actions that individuals could take to reduce carbon emissions that involved little cost. Examples include carpooling, turning down the water heater temperature, line-drying clothes, etc.

Applied behavior analysis, community-based social marketing, and environmental psychology have developed successful interventions for changing environmentally relevant behavior (see Abrahamse et al., 2007; Cone & Hayes, 1980; Lehman & Geller, 2004; McKenzie-Mohr, 2011; McKenzie-Mohr, Lee, Schultz, & Kotler, 2011; Steg & Vlek, 2009; Van Leuvan et al., 2022). Strategies include increasing reinforcement (e.g., feedback and incentives) and social reinforcement (praise) for pro-environmental behaviors and creating “nudges” that decrease effort and cost for those actions. Commitment responses or goal-setting have been used to create conditioned reinforcers and punishers. Social norms have been used to signal and motivate pro-environmental action. Schneider and Sanguinetti (2021) describe a wide variety of learning principles that are applicable to climate-relevant behavior change, including shaping and intermittent reinforcement schedules. Better dissemination of these strategies is needed, however, to produce greater levels of behavior change (see Biglan, 1995). Communication strategies using value-based messaging could be implemented along with contingency manipulations to motivate engagement with interventions and maintain public support.

Although the behavioral sciences have identified effective methods to change individual and household behaviors by manipulating individual-level reinforcement contingencies, altering conditions responsible for the replication of contingencies across a group, contingencies that yield problematic macrobehavior, may produce large-scale behavior change (Biglan & Glenn, 2013). The distinction between individual versus replicated contingencies is what Malagodi and Jackson (1989) describe as troubles (problems for individuals) versus issues (contingencies experienced by many across society). Analyses are needed of the environments that support macrobehaviors that generate GHGs and metacontingencies that influence problematic group behavior, and those environments and metacontingencies could be altered through a process of intentional cultural design (e.g., Biglan & Glenn, 2013).

For example, carbon pricing or carbon taxes have been proposed to decrease GHG emissions. Such laws can change macrobehaviors and metacontingencies by increasing costs for consumers of fossil-fuel use and lowering profits for corporations that produce fossil fuels and generate GHG emissions. Thus, they can promote the adoption of renewable energies. Laws could also be put in place to penalize actions (such as methane release or deforestation) that increase GHG concentration. Co-benefits of such actions, such as better air quality and improved public health, may help maintain such practices.

As with rule following more generally, monitoring and strict enforcement of laws will be needed to ensure compliance, and penalties for noncompliance need to be significant. As laboratory research has shown (e.g., Azrin & Holz, 1966), to maximize punishment efficacy, punishment should be certain and large in magnitude. Rules describing monetary penalties for methane emissions from gas wells or illegal deforestation, for example, are unlikely to be followed if there is little oversight or if the fine is small (for an analysis of punishment for environmental crimes, see Lynch et al., 2016). Similarly, carbon pricing may be ineffective if the price is too low.

To maintain public support and prevent counterpliance, policies that establish penalties for GHG emissions must be fair and equitable (see the Citizens' Climate Lobby Carbon Fee and Dividend, <https://citizensclimatelobby.org>). Policies and regulations also could be coupled with strategies to help employees in fossil-fuel and related industries minimize losses. Public participation in policy development may be important.

Contingencies that promote pro-climate actions across a culture could be identified and manipulated. Such manipulations may be less likely to produce counterpliance. Examples include incentives for organizations to switch to clean energy or to develop renewable-energy technologies, and subsidies for household or organizational purchases of electric appliances can change macrobehaviors. Infrastructural investments, such as for community solar or public transportation, could lower costs and effort and increase their adoption and use. Griffith (2022) has argued that electrifying everything through renewable energy will simplify the behavior changes needed to reduce emissions and allow for rapid reductions in GHGs. Thus, policies could subsidize and support widespread electrification. Unchecked consumption and continuous economic growth are unsustainable (see Raworth, 2017) and contribute to the degradation of the climate. Thus, contingencies are also needed to support

cultural behaviors that do not involve buying or consuming goods (see Grant, 2010). Again, messaging campaigns employing augmentals that alter the value of climate-relevant actions could work in conjunction with those contingency changes to establish new verbal practices that support pro-climate macrobehaviors (see examples in Biglan & Glenn, 2013).

Although global institutions may be able to create rules and create infrastructures that alter contingencies for climate action that are broad in scope and influence, to date, progress by such institutions has been slow. Thus, Ostrom (2009) has argued for a polycentric approach in which smaller organizational units act at various scales. Their cumulative effect could yield significant reductions in GHG emissions. For example, smaller political and organizational units (e.g., communities, county and state governments, universities, corporations), could create rules for guiding climate action and establish contingencies supporting pro-climate behaviors. Groups with practices that support collaboration and coordination with related groups may be especially effective at producing change (see Wilson et al., 2013).

Leaders of organizations have an important role in changing pro-climate behaviors. They can help construct rules that guide climate-relevant actions of organizations (e.g., mission statements), and ensure that organizational actions are socially responsible (see Alavosius et al., 2016; Houmanfar et al., 2015). Promoting prosocial decisions in organizational leaders will require analyzing contingencies that impact their decision making (Houmanfar et al., 2015).

Behavior analysts also can have an important role in the process of cultural change. They can contribute to efforts to promote climate action by working with organizations to analyze nonverbal and verbal contingencies influencing climate-relevant behaviors, create measurement systems, and empirically evaluate interventions designed to change behavior on a broad scale (e.g., Biglan, 1995; Biglan, 2016; Cihon & Mattaini, 2020; Alavosius & Houmanfar, 2020).

An example in the United States of a government policy that creates incentives and penalties for climate-relevant individual behaviors and organizational practices is the Inflation Reduction Act (Inflation Reduction Act, 2022). Among other actions, this legislation establishes incentives (e.g., tax credits or rebates) for individual consumers who make green purchases (e.g., heat pumps, electric vehicles, solar panels), grants to communities for carbon reduction plans, as well as incentives for companies to construct carbon capture technologies and to produce renewable energy, including in underserved communities. The legislation also adds a penalty for methane emissions by oil and gas companies in the form of a methane fee that increases across time. By changing individual contingencies and metacontingencies across the nation, laws such as this can produce large shifts in climate-relevant actions.

A challenge to changing contingencies through laws and policies, such as a carbon price, are actions of powerful special-interest groups who are able to sway governmental climate policy. Altering those dynamics and motivating government action may require political mobilization and activism. Behavior analysts (e.g., Ardilla Sánchez et al., 2020; Ardila Sánchez et al., 2020; Mattaini, 2013) have described how the science of behavior analysis can be applied to collective action, and how behavior analysts can become involved in collective action to promote the application of the science to societal problems, including climate change. Greta Thunberg has argued,

“Today we use 100 million barrels of oil every single day. There are no politics to change that. There are no rules to keep that oil in the ground. So we can’t save the world by playing by the rules because the rules have to be changed. Everything needs to change and it has to start today” (2018, 10:29).

Conclusion

As the world prepares for the 6th IPCC report, it is uncertain whether the significant efforts of its authors will finally generate necessary climate action. If past reports are an indication though, it may not. Researchers from behavioral and social sciences have sought to understand why climate communication is not more effective at promoting necessary public engagement. This work has produced valuable insights and strategies for action, and shows that effective climate communication requires attention to psychological variables. The approach in the present paper here has been to highlight some of that work and, following Newsome and Alavosius (2011), show how diverse literatures can be integrated through the framework provided by verbal behavior and rule-governed behavior. It is hoped that such an approach might clarify factors impacting the human response to climate warnings and aid the development of new strategies for changing climate-relevant behaviors.

As Weber (2010) concludes, direct experience with climate catastrophes will likely motivate action on climate change, but a better strategy is to try to avoid those dire consequences before they occur. Avoiding worse-case climate-change scenarios will therefore require, among many other strategies, rules and verbal stimuli that effectively guide and motivate climate action, and reinforcement contingencies that support such behavior.

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Conflict of interest The author declares no conflict of interest.

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