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Evaluating Didactic and Exemplar Information: Noninvasive Brain Stimulation Reveals Message-Processing Mechanisms

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Abstract

People in their everyday lives encounter claims about various health, political, and economic issues. These claims are often supported by evidence based on didactic or exemplar information. In the research reported here, we use a noninvasive brain stimulation technique (transcranial Direct Current Stimulation [tDCS]) to examine the cognitive mechanisms underlying people's ability to support or refute claims conveyed by messages that contain didactic or exemplar information. Our results are consistent with the notion that the evaluation of didactic-based evidence engages more deliberative cognitive processes than the evaluation of exemplar information. Our study highlights the utility of tDCS in the study of message processing by demonstrating how it can be used to test the assumptions of message-processing theories.

Keywords

information processing and cognition, neurophysiology and the brain, neurophysiology, experiment, health and/or persuasive messaging

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During a speech in 2016, then-President Barack Obama claimed that racial disparities plagued the United States's criminal justice system. He supported his claim by using two types of evidence. First, he utilized general statistical evidence, citing data from various studies indicating that "African-Americans were shot by police at more than twice the rate of whites" (White, 2016). Second, he called upon the high-profile cases of Alton Sterling and Philando Castile, two African Americans who were fatally shot by police officers a few days earlier, to serve as specific examples.

In recent years, scholars in health, political, and science communication have examined when and how each of these two types of evidence is effective at influencing people's attitudes and behaviors (Boster et al., 2000; Brosius & Bathelt, 1994; Dixon, McKeever, Holton, Clarke, & Eosco, 2015; Kim, Bigman, Leader, Lerman, & Cappella, 2012). The first type is often referred to as "didactic" information. These are general/abstract expository reports that can either provide statistical evidence or express general professional opinion (Hampstead, Brown, & Hartley, 2014; Reinard, 1988). The latter type is referred to as an "exemplar." An exemplar is an illustrative representation of information highlighting a specific person or event. Exemplars can be descriptions of an individual's experience or personal opinions (Braverman, 2008) and are one key ingredient in narrative communication (Zillmann & Brosius, 2000).

Some studies find that exemplars are more effective than didactic information (Brosius & Bathelt, 1994; Reinard, 1988) while other studies find the opposite to be true (McKinley, Limbu, & Jayachandran, 2017). Collectively, the current literature suggests that the effectiveness of one type of evidence over the other can depend on various contexts and conditions (for a review, see Kreuter et al., 2007). Understanding the potentially different cognitive processes employed in responding to these types of evidence might help better understand the contexts and conditions where each type of message is likely to work best.

However, the literature has yet to extensively investigate the cognitive processes employed while individuals evaluate and reason about these two types of evidence (for exceptions, see Zillmann, 2006; Zillmann & Brosius, 2000). For example, do people engage qualitatively different cognitive processes when they evaluate and reason about didactic versus exemplar information? Or, do individuals use the same processes for both types of evidence? The answers to these questions are important, as they provide researchers with an understanding of why certain messages exert effects in the manner that they do. Identification of cognitive mechanisms may also help explain and predict why one type of evidence is more effective than the other given certain conditions.

In the research reported here, we examine the cognitive mechanisms underlying people's ability to generate arguments in order to support or refute the claims conveyed by messages that contain either didactic or exemplar information. Specifically, we explore whether people's capacity to respond to exemplar-based evidence is a well-practiced ability and, thus, requires less deliberative cognitive processes than evidence based on didactic information. Indeed, two prominent theories of media effects—exemplification theory (Zillmann & Brosius, 2000) and the heuristic processing of cultivation effects (Shrum, 1996)—suggest that exemplars are highly accessible and easily come to mind. This high level of accessibility, in part, is theorized to be due to frequent activation of exemplars as a consequence of media exposure (Busselle & Shrum, 2003).

We tested this hypothesis in a unique way by using a noninvasive brain stimulation technique (transcranial Direct Current Stimulation [tDCS]) as individuals were exposed to health and political messages that contained either exemplar-based or didactic evidence. Emerging evidence in the field of cognitive neuroscience and clinical psychology suggests that tDCS can be used to impair or enhance cognitive functions by applying a weak electric current at the area of the scalp under which the brain region (hypothesized to be involved in the implementation of a given cognitive function) is located (Nitsche et al., 2003; Vannorsdall et al., 2012). Thus, by applying a weak electrical current to a brain region that has been previously associated with deliberative cognitive processes, we aimed to disrupt people's ability to effectively engage deliberative processes as they evaluate and reason about exemplar and didactic information. To do so, we begin with a set of didactic- and exemplar-based messages that were pretested to be similarly easy to evaluate and reason about under normal circumstances. If the evaluation of didactic-based evidence relies more on deliberative processes compared to exemplar information, then disrupting deliberative processes using tDCS should impair people's ability to reason about didactic information more than exemplar information.

Our study advances the literature in several ways. First, we examine the extent to which frequent evaluation of exemplar-based evidence, as postulated by exemplification theory, has facilitated processing of this information in a manner that would not be disrupted by tDCS to regions implicated in cognitive deliberation. Although previous studies in communication have primarily used response times as a measure of deliberative processing (for a review, see Payne & Cin, 2015), our study introduces a different method for assessing the role of cognitive deliberation as individuals evaluate messages. The use of additional techniques is valuable within a converging methods approach. Second, our study introduces tDCS to communication scholars interested in examining the psychological mechanisms involved as individuals evaluate message information.

This article is organized as follows. The first section discusses the theoretical underpinnings of the claim that people's evaluation of exemplar-based evidence relies less on deliberative, cognitive processes when compared to didactic information. The second section discusses the putative neural regions associated with deliberative processes that are likely involved as people generate arguments in order to support or refute claims conveyed by didactic-or exemplar-based evidence. In particular, we describe a neural region—right dorsolateral prefrontal cortex (right DLPFC)—that is engaged when people attempt to generate arguments in order to bolster or refute claims. We then present an overview of tDCS and introduce our design. Finally, we present our results and discuss the broader implications of our findings for communication research.

Evaluating Didactic and Exemplar Evidence

People in their everyday lives encounter claims about various health, political, and economic issues, both interpersonally and across various forms of media (e.g., social media, TV, and radio). These claims are often accompanied by evidence based on didactic or exemplar information (Braverman, 2008; Zillmann & Brosius, 2000). When responding to these claims, people sometimes actively evaluate the veracity of the evidence presented to them (Kunda, 1990). There are at least two types of evaluative processes that people can engage in while determining the validity of evidence. First, individuals can generate reasons that corroborate or bolster the information conveyed in the evidence (Kunda, 1990). Hereafter, we refer to this as "confirmatory reasoning." For example, a White individual exposed to Obama's statement that African Americans are shot by police at twice the rate of Whites may retrieve from memory a related instance in which a Black friend was treated unfairly by police officers. Second, individuals can also generate arguments that denigrate, contradict, or refute the evidence they encounter (Festinger & Maccoby, 1964). Hereafter, we refer to this as "counterarguing." For instance, the same individual responding to Obama's statement might also reason that factors other than race may be the source of the police-shooting disparity.

There are reasons to believe that the processes that underlie confirmatory reasoning and counterarguing are different across the evaluation of didactic- and exemplar-based evidence. Specifically, the evaluation of didactic information might rely on greater deliberative processes than exemplar information. That is, the processes underpinning didactic-based reasoning may be relatively more effortful and require greater cognitive resources. Of course, we are not claiming that confirmatory reasoning and counterarguing directed at didactic information are driven *entirely* by deliberative cognitive processes. Complex and high-level social cognitive functions such as these are likely the product of multiple cognitive processes (Kahneman & Frederick, 2005; Satpute & Lieberman, 2006). Confirmatory reasoning and counterarguing involve multiple subcomponent processes (e.g., access of information in long-term memory, manipulating information in working memory, comprehension, and logical inferences). We theorize that some of these subprocesses will likely be more deliberative in nature when evaluating didactic than exemplar information.

This argument is based on a large body of empirical work in the skills acquisition literature showing that constant repetition of an action (e.g., practice) increases the likelihood of such action becoming automatized or requiring less effort and deliberation (for a review, see Logan, 1988). In particular, although the processes that support successful execution of a given task may begin as largely deliberative (e.g., learning to drive for the first time), this body of work has shown that consistent practice can lead to automaticity or a state in which executing the task requires less attention and effort to carry out (e.g., driving after several years; Anderson, 1992; Healy, Fendrich, & Proctor, 1990; Schendel & Hagman, 1982; Summala, 1988). Critically, practice can lead to automaticity for both basic psychological processes (e.g., motor and perceptual skills) and high-level cognitive functions (e.g., reading; for a review, see Neumann, 1984).

We theorize that most individuals are likely to have received more practice in evaluating and reasoning about exemplar than didactic information. Exemplars represent the type of information that people encounter in their day-to-day lives, given the prevalence of social interactions with other people. As a consequence, individuals are more likely to think and reason about individual people (friends, family members, coworkers) in their everyday lives. Furthermore, reasoning about exemplars usually does not require formal education and arguably can be present from very early in life (Kreuter et al., 2007). Indeed, prominent theories such as Zillmann's (2006) exemplification theory posits a set of cognitive heuristics or "processing automatisms" (p. 222) that underlie the evaluation and use of exemplars (e.g., quantification and representativeness heuristics).

In contrast, evaluating and reasoning about didactic information is relatively less well practiced and often requires formal education (Kreuter et al., 2007). For example, people have a difficult time reasoning about statistical information and often commit systematic errors when reasoning about them (Tversky & Kahneman, 1973). Thus, given the extensive practice that people have with evaluating exemplars versus didactic information, we explore the possibility that the evaluation of didactic information may rely on more effortful cognitive processes than evaluation of exemplar information.

Determining the extent to which evaluation of didactic and exemplar information rely on different cognitive processes is important as it allows one to derive predictions regarding the contexts in which messages that contain exemplar-based or didactic evidence will be more effective. The goal of this study, then, is to examine the cognitive mechanisms underlying people's ability to support or refute claims conveyed by messages that contain didactic or exemplar information.

Neural Regions Associated With Confirmatory Reasoning and Counterarguing

Of particular interest in this study is the brain region known as the prefrontal cortex given converging evidence from both brain-lesion and functional magnetic resonance imaging (fMRI) studies suggesting that it is essential for high-level cognitive processes that underlie different types of reasoning and problem-solving processes (Baker et al., 1996; Barbey, Colom, & Grafman, 2013; Duncan & Owen, 2000; Milner, 1963; Petrides, Alivisatos, Meyer, & Evans, 1993). The prefrontal cortex, in particular, implements cognitive processes collectively labeled "executive functions." These include attentional control, working memory, inhibitory control, fluid intelligence, planning, and so on (for a review, see Miller & Cohen, 2001)—the type of processes that are likely involved when people engage in confirmatory reasoning or counterarguing.

Indeed, preliminary evidence suggests that the dorsolateral prefrontal cortex (DLPFC) may underlie the deliberative processes that underlie confirmatory reasoning and counterarguing (O'Donnell, Coronel, Cascio, Lieberman, & Falk, 2018). The evidence for this link comes from an fMRI study in which participants were presented with nonthreatening statements that all begin with "People should . . ." (e.g., "People should do the crossword"). In separate blocks, participants were alternately asked to passively consider whether statements are true or false, or to actively generate reasons in favor or reasons against the statements (e.g., "doing the crossword can keep your mind active" [confirmatory reasoning]; or "time spent doing the crossword could be better spent doing other things" [counterarguing]). The researchers found that there was greater neural activity in a subregion of right DLPFC when participants were generating arguments against a nonthreatening statement than when they were generating arguments to support it. In addition, a nearby but distinct subregion of the right DLPFC was also associated with greater neural activity when participants were actively generating arguments to either support or counterargue these statements, compared to making quick, "gut level" decisions about the statements. Thus, different subregions of the right DLPFC may be critically involved with the deliberative cognitive processes that underlie both confirmatory reasoning and counterarguing.[1]

tDCS

tDCS is a noninvasive neuromodulatory technique that can be used to alter brain neurophysiology to impair or enhance specific cognitive functions (Woods et al., 2016). A typical tDCS study involves placing two electrodes on a participant's scalp over one's brain region of interest. A low-intensity (typically 1-2 mA) constant current then flows between the two electrodes and is assumed to pass through the brain region of interest. The electrical current employed in tDCS is too weak to cause neurons to fire directly. Rather, tDCS is theorized to incrementally modify the transmembrane potentials of large assemblies of neurons, which in turn modulates their excitability and overall firing rate (Wagner et al., 2007). In studies of motor physiology, application of the cathode over the cortex has been associated with subsequent inhibition of neuronal excitability, while application of the anode has been associated with increased excitability (Antal et al., 2004; Nitsche et al., 2008; Wassermann & Grafman, 2005). This has also been observed in numerous studies of more complex behavior, albeit not as reliably as reported in Jacobson et al. (2012). Although there are concerns about the extent to which tDCS modulates brain activity (Horvath, Forte, & Carter, 2015), recent meta-analyses have found that, across the literature, tDCS has significant effects on multiple measures of cortical physiology, and specifically indicating that cathodal stimulation has significant and consistent inhibitory effects on brain activity (Biabani et al., 2018; Dissanayaka, Zoghi, Farrell, Egan, & Jaberzadeh, 2017). The effects of tDCS on brain activity have also been observed in using fMRI (Li et al., 2019). Thus, in theory, cathodal and anodal tDCS can either impair or enhance, respectively, a cognitive function of interest by directing the electric current at the scalp over the brain region thought to implement the function.

A typical tDCS design compares a "sham" condition—a condition which involves activating the electrical current for a very short period of time in order to create the sensation of stimulation without the neuromodulatory effects (placebo)—with a stimulation condition (cathodal or anodal). Any observed differences, then, in participants' responses between the sham and stimulation conditions are interpreted as demonstrating the effects of brain stimulation. One particular advantage of tDCS is that it allows researchers to exogenously manipulate activity within a given brain region and examine resulting changes in cognitive function. Thus, this method can be used to test hypotheses regarding the causal role of specific cognitive processes in one's behavior of interest.

Indeed, tDCS in the past decade has been used to investigate the causal role of specific brain regions—and the cognitive processes they implement—in the context of social functioning (for a review, see Sellaro, Nitsche, & Colzato, 2016). Furthermore, tDCS can be used to complement or provide converging evidence for other methods, such as response times, employed by communication scholars. Studies in communication employing response time measures (e.g., implicit association test [IAT], priming tasks) assume that slower responses within a given task (e.g., making a choice, retrieving information from memory) indicate that a greater level of deliberation is underlying the responses (Arendt, 2010; Ramasubramanian, 2007). Although valuable, response times index the sum of multiple processes (visual, cognitive, motor processing) and it is difficult to make inferences regarding which stage of processing is likely producing differences in response times (Schiller et al., 2016). The use of tDCS over a specific brain region to causally alter its function is useful as one can intervene to determine the causal role of specific brain areas in outcomes of interest. In particular, we can use the wealth of information we have about particular brain regions (e.g., DLPFC), such as the cognitive functions they support (e.g., executive functions). We can then test whether experimental manipulation of the hypothesized brain regions causally alters outcomes of interest. In the current study, we tested whether using cathodal stimulation of the right DLPFC impairs "high-level" executive functions (e.g., working memory and reasoning; Barbey, Koenig, & Grafman, 2013), but not low-level processes such as visual and motor processing (as these are implemented by different brain regions), which resulted in diminished ability to reason about different types of persuasive messages (i.e., exemplar vs. didactic messages).

The Current Study

We took advantage of previous findings suggesting that the prefrontal cortex is critical for high-level cognitive processes that underlie different types of reasoning and problem-solving processes and a preliminary study showing that the right DLPFC is associated with the deliberative aspects of confirmatory reasoning and counterarguing. We also took advantage of previous studies showing that cathodal tDCS can impair a specific cognitive process by disrupting activity in the brain region theorized to implement the cognitive process. In our study, we randomly assigned participants to persuasive messages that contained either didactic or exemplar information, which were pretested to be equally easy to reason about under normal circumstances (i.e., outside of a tDCS experiment). Then, within the tDCS experiment, we asked participants to generate arguments that either supported the claim conveyed in the message (confirmatory reasoning) or refuted the claim contained in the message (counterarguing) under stimulation that would inhibit their ability to employ deliberative cognitive reasoning or sham. If the evaluation of didactic information is based on greater deliberative cognitive processes in comparison to the evaluation of exemplar information, then confirmatory reasoning and counterarguing against didactic information should require use of right DLPFC more than exemplar-based evidence. Thus, cathodal stimulation of the right

DLPFC, when compared to sham, should selectively impair people's ability to generate arguments for didactic than exemplar information. Formally, we test whether

> cathodal stimulation to the right DLPFC will have a negative effect on people's ability to generate arguments for didactic, but not exemplar-based information.

We test this claim in the context of individuals (all smokers) who were randomly assigned to evaluate anti-smoking (and other) messages that presented either exemplar or didactic information. Participants were asked to engage in both confirmatory reasoning and counterarguing in response to these messages while undergoing cathodal tDCS. All participants also underwent the same procedure under sham stimulation (order of the tDCS vs. sham within participants was counterbalanced). Although we examined the evaluation of anti-smoking messages by smokers, we designed the study such that participants were exposed to other health-related and political messages in either exemplar or didactic form. This allowed us to examine the generality and robustness of any observed effects of tDCS and type of evidence across different issue domains and to increase our overall power to detect the hypothesized basic cognitive effects.

Method

Participants

We recruited a total of 85 participants who were recruited from a large northeastern city in the United States. All were smokers, indicated that they had no intention to quit at the time of enrollment, and smoked at least five cigarettes a day for a year or more.[2] Participants were compensated with US$80 for taking part in the study. All participants, by self-report, were right-handed, not pregnant, and had no history of psychiatric or neurological disorders, and none was using psychoactive medications. We excluded participants if they participated in only one of the two experimental sessions (two participants), encountered extensive technical problems with the stimuli presentation computer[3] (13 participants; for example, program crashed or stopped recording participant responses), did not understand the task (three participants), or encountered issues with the tDCS setup (e.g., high impedance; two participants). We excluded a total of 20 participants. We analyzed data from the remaining 65 participants (21 females; age: M = 36, SD = 14.1, range = 18-63 years; median level of education = 1-2 years of college; level of education mode = high school degree; Race: White = 32%, Black = 48%, Asian = 6%, Latino = 3%, Mixed = 6%, Other = 5%; see Table 1).

Materials

The stimuli consisted of 256 two-sentence statements that encouraged either a specific healthy behavior or support for a political issue. The statements covered four health domains (quitting smoking, healthy eating, physical exercise, and healthy sleeping habits) and four political domains (gun control, universal health care,

Table 1. Distribution of Demographic Variables by Exemplar and Didactic Conditions.

Variable	Didactic condition $n = 34$	Exemplar condition $n = 31$
Sex		
Male	67.6%	67.7%
Female	32.4	32.3
Education		
High school	50.0%	35.5%
Associate degree	0	0
1 to 2 years of college	26.5	19.4
3 to 4 years of college	5.9	19.4
Bachelor's	14.7	16.1
Master's	0	0
Doctorate	2.9	9.6
Race		
White	29.4%	35.5%
Black	50.0	45.1
Asian	5.9	6.5
Latino	3.0	3.2
Mixed	2.9	6.5
Other	8.8	3.2

legalization of marijuana, and affirmative action). Each issue domain was associated with 32 statements. Among the 32 statements, 16 were exemplar messages while the other half were didactic messages (see Table 2 for examples). The exemplar and didactic messages were matched in form (two sentences, the first introducing the topic and the second expanding upon it) and information content. Furthermore, half of the exemplar and didactic messages were framed such that they conveyed the benefits of either pursuing a healthy behavior or supporting a political issue while the other half were framed such that they conveyed the harms of either *not* pursuing a healthy behavior or supporting a political issue. The length of each statement ranged from 10 to 28 words and the exemplar and didactic statements on average had the same number of words (exemplar: $M = 17.98$, $SD = 3.9$; didactic: $M = 17.83$; $SD = 3.61$). Finally, given that we expected our sample of smokers to be likely be on the low end of the education spectrum (Hiscock, Bauld, Amos, Fidler, & Munafò, 2012), we designed the didactic messages such they did not contain particularly complex scientific or statistical information (see Table 1) to decrease the likelihood that our participants encountered words that they could not understand and to make the didactic and exemplar messages comparable in terms of the use of nontechnical words. We pretested the messages with a different group of participants such that they were comparable in terms of the number of reasons they generated, so that any effects observed could be attributed to the effects of tDCS to DLPFC on reasoning, rather than other qualities of the messages themselves.[4]

Table 2. Examples of Didactic and Exemplar Messages.

Issue	Didactic	Exemplar
Quitting smoking (harm)	Smokers can harm other people. Every year, a lot of nonsmokers die from heart disease caused by secondhand smoke.	Joe has never smoked cigarettes in his life. He has heart disease because he was exposed to secondhand smoke from his father.
Eating healthy (harm)	Eating lots of sugars can make you gain weight. Weight gain can give you type 2 diabetes.	Kathy is obese and has type 2 diabetes. She would eat lots of sugary food after school.
Physical exercise (benefit)	People who exercise regularly reduce their risk of stroke. They increase the blood flow to the brain.	To prevent stroke, Sheila has taken to exercising regularly. This helps her get the blood flowing to her body.
Healthy sleeping habits (benefit)	Metabolism improves when people get enough rest. People can lose weight with good sleep programs.	Kyle's metabolism improved with rest. He is losing weight with help of a sleep program.
Gun control (harm)	Trigger locks prevent a gun from accidental firing. States that do not require trigger locks have more accidental gun deaths than states that require it.	Tina lives in LA. Gun crime in her city is high because there aren't regulations on gun use.
Universal health care (harm)	Without health insurance, people pay out of pocket. Medical costs are too costly for many people to afford them.	David cannot afford to see a doctor. To see a doctor, the out-of-pocket costs are more than his weekly salary.
Legalization of marijuana (benefit)	Marijuana has pain-relieving effects. Its current legal status prevents people from getting it who need it for pain relief.	Helen cannot get pain relief from medication. Marijuana would ease her pain, but she cannot have it because it is illegal where she lives.
Affirmative action (benefit)	There are thousands of situations where people of color and women have gained access to opportunities through affirmative action. Many of them occur in academic institutions.	Renisha is an African American woman. She was recently accepted into a biomedical science graduate program.

Procedure

Participants were randomly assigned to either the didactic or exemplar condition (between-subjects manipulation). Participants then took part in two sessions (Session 1, Session 2) that occurred in two different days. Participants were randomly assigned to receive either active stimulation or sham condition in Session 1. The sham condition involves activating the electrical current for 30 seconds (as opposed to 20 minutes for the stimulation condition) in order to create the perception of stimulation among participants. Inclusion of this condition strengthens the realism of the placebo condition. If participants were assigned to the stimulation condition in Session 1, they were assigned to the sham condition in Session 2 and vice versa (stimulation/sham is a within-subjects manipulation).

A single session consisted of three phases: (1) pretask questionnaire, (2) arguing task, and (3) post-task questionnaire (see Figure 1). During the pretask questionnaire, participants read brief descriptions of four health-related behaviors (quitting smoking, eating healthy, physical exercise, and healthy sleeping habits) and four political policies (gun control, universal health care, legalization of marijuana, and affirmative action; for example, "Healthy sleeping involves keeping a consistent sleep schedule, and getting 7-8 hours of sleep every day," "Gun control generally refers to laws or policies that restrict the manufacture, sale, transfer, possession, modification, or use of firearms"). They then indicated the extent to which they were motivated to engage in a specific healthy behavior and their level of support or opposition to a specific policy. They used a 101-point slider scale to indicate their level of motivation or support (0 = *not at all motivated/oppose*, 100 = *highly motivated/highly support*). Then, they were asked to indicate the importance of each health and political issue (e.g., "How important is it to do physical activity?" "How important is the issue of universal health care?" 1 = *very important*, 4 = *not at all important*).

The arguing task followed next. For this task, participants were shown the two-sentence messages (see Table 1) that encouraged either a specific healthy behavior or support for a political issue. The task was implemented in PsychoPy (Peirce, 2007). Above each statement was the word "agree" or "disagree." Participants were instructed to generate arguments that would support the claim conveyed in the message if they see the word "agree" (confirmatory reasoning). For example, if the message states "Smokers can harm other people. Every year, a lot of nonsmokers die from heart disease caused by secondhand smoke," an argument that would support the claim would be "It isn't fair for people who don't choose to smoke themselves to have to breathe secondhand smoke." In contrast, participants were instructed to generate arguments that would denigrate the claim conveyed in the message if they see the word "disagree" (counterarguing). For instance, using the same previous example, a reason that would refute the claim would be "None of the people I know that I have been exposed to secondhand smoke has gotten sick from it." Participants were instructed to say these arguments out loud and to simultaneously press the spacebar on the computer for each reason they generate. Participants were given 60 seconds to generate arguments for each message. We delivered either actual stimulation or sham while participants were performing the arguing task (see the "Stimulation Parameters" section).

All participants were shown the messages that encouraged them to quit smoking. For the remaining three issues, the experimenter selected two political issues and one other health issue based on participants' responses to the pretask questionnaire during Session 1. Specifically, for the political issues, the experimenter selected one issue that participants supported (>50 on the slider scale) and one issue that participants opposed (<50 on the slider scale). Furthermore, if more than two issues met

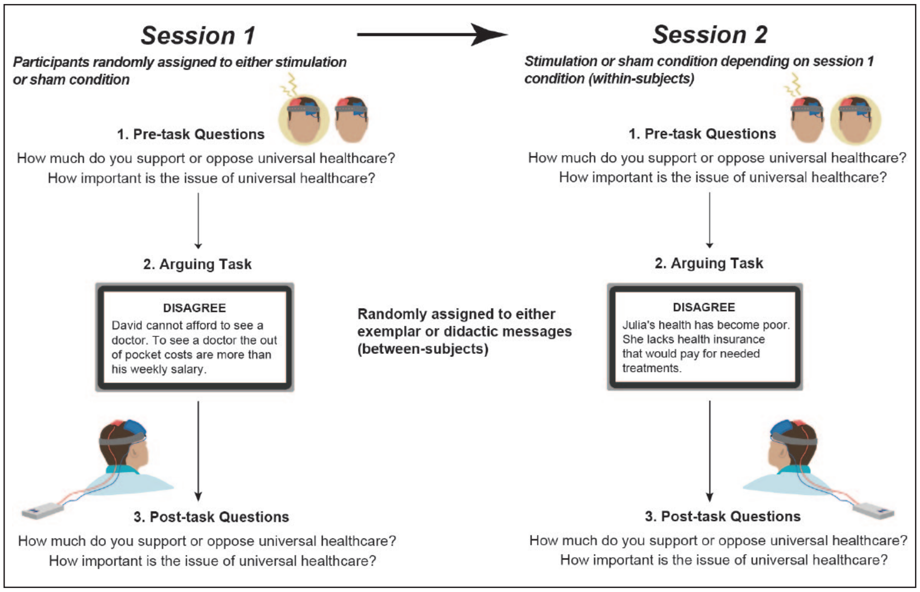

Figure 1. Schematic of the tDCS experimental design.
Note. tDCS = transcranial Direct Current Stimulation.

the support/oppose criteria, the experimenters selected the ones that were rated highest on importance. The other (nonsmoking) healthy behavior had to be one that participants had a positive rating toward. If none of the health behaviors and political satisfied the support/oppose criteria, then issues that were rated highest on importance were selected.

The messages were shown in blocks such that the first two blocks had one health (not quitting smoking) and one political issue and the remaining two blocks also had one health (messages associated with quitting smoking was always the fourth block since this timing corresponds to the highest effectiveness of the tDCS stimulation and was the strongest focus of our investigation) and one political issue. For each issue during a single session, participants were shown eight messages. During Session 2, we used the same issues from Session 1, but participants encountered different messages. Thus, the messages to which participants were exposed were always unique across the two sessions (counterbalanced across individuals).

Finally, the posttask questionnaire followed the arguing task. During the posttask questionnaire, participants again indicated the extent to which they were motivated to engage in each specific healthy behavior and their level of support or opposition to each specific policy. They also indicated the importance of each health and political issue. This phase employed the same exact questionnaires as the pretask questionnaires during Phase 1.

Stimulation Parameters

We delivered tDCS by using a constant-current battery-operated stimulator unit (Magstim Eldith 1 Channel DC Stimulator Plus, Magstim, Whitland, UK) that employed two 5 × 5 cm electrodes soaked in a saline solution. All participants received both cathodal and sham stimulation for 20 minutes in two separate sessions. The target electrode was placed over F4 using the 10-20 International EEG system, a region corresponding to the right DLPFC. The reference electrode was placed over the left supraorbital region. Cathodal stimulation was delivered at 2 mA for 20 minutes with a gradual ramp up and down of the current for 30 seconds. During sham stimulation, current was ramped up to 2 mA and then back down to 0 mA in the first 30 seconds, which remained at 0 mA for the rest of the 20-minute period—giving an initial sensation of tDCS while minimizing stimulatory effects. The order in which subjects received real and sham stimulation was counterbalanced. Participants were blinded to the type of stimulation applied during each session.

Results

We tested whether cathodal stimulation to the right DLPFC has a negative effect on people's ability to generate arguments more so for didactic than exemplar information. Specifically, following our pretests and matching of stimuli, we predicted that under sham, people would be equally able to reason about didactic- and exemplar-based information. However, we predicted that applying tDCS to DLPFC would diminish people's ability to reason about didactic information (but not exemplar-based information). We tested this interaction hypothesis in the context of several relevant outcome measures. Specifically, we (1) measured participants' button presses that correspond to the number of arguments (either based on confirmatory reasoning or counterarguing) they generated to each message and (2) transcribed the spoken reasons provided by each participant and counted the number of reasons they generated. We used the number of button presses to each message and number of spoken reasons as dependent variables (see Table 3 for examples of the types of arguments participants generated associated with each button press). The use of the two dependent variables allowed us to provide a more accurate estimate of the number of reasons generated for each message.[5] We also describe two additional, convergent measures of processing ability (response time and disfluent fillers) below.

We then estimated mixed-effects models using the "lme4" (Bates, Maechler, Bolker, & Walker, 2015) and "lmerTest" (Kuznetsova, Brockhoff, & Christensen, 2016) packages for the *R* statistical program (R Core Team, 2016). The variables labeled stimulation condition (cathodal stimulation = "1," sham = "0") and message type (didactic = "1," exemplar = "0") were our independent variables. We modeled stimulation condition, message type, and the interaction between the two as fixed effects and participants and specific messages as random effects. Our study was originally conceptualized with a basic science goal in mind (related to reasoning in response to didactic- and exemplar-based information broadly) and an

Table 3. Examples of Generated Reasons to Support or Counter the Exemplar and Didactic Messages.

Exemplar messages	Participant responses
Joe has never smoked cigarettes in his life. He has heart disease because he was exposed to secondhand smoke from his father.	I disagree with this statement because there is no proof that Joe became sick from secondhand smoke from his father.
Ian lost his dad in a gun incident. This could have been prevented if guns were controlled.	You can't be sure that that would've prevented an accident like that, just because there are gun controls. People could still decide to hurt other people
Barbara has broken several bones over the past few years. Her bones are brittle because she doesn't exercise.	Barbara is probably a senior citizen. That's probably why her bones are broken.
Fred is a patient at risk of opioid addiction. He could use medical marijuana but must use a weak pain medication that does not work properly.	Letting Fred use medical marijuana would make him feel better than the weak pain medication.
Didactic messages	**Responses**
Quitting smoking will make your heart healthy. Heart rate and blood pressure drops back to normal in less than 20 minutes after smoking.	Some people will be less stressful when they smoke regardless.
Trigger locks prevent a gun from accidental firing. States that do not require trigger locks have more accidental gun deaths than states that require it.	There are those that would argue that it's not the trigger lock itself—it's the effectiveness and proper use of the trigger lock which result in fewer accidental gun deaths.
People who exercise regularly reduce their risk of stroke. Exercise increases the blood flow to the brain.	Exercising prevents you from getting obesity which is one of the leading causes of getting strokes.
Not legalizing marijuana can increase homicides. Money from illegal marijuana fuels violent drug cartels.	There's no solid proof that money from illegal marijuana fuels violent drug cartels.

Note. Each response is from a unique participant.

applied/ health question, related to the effects on smokers who received anti-smoking messages. We report data from all messages (all health and political messages) in the article and we report analysis for each specific issue in the supplementary materials.

For the analysis involving all messages (Table 4), there was a significant stimulation by message type interaction ($B = -0.31$, $SE = .07$, $p < .001$) for the button presses and significant interaction for the spoken reasons ($B = -0.28$, $SE = .07$, $p < .001$). To probe further this two-way interaction, following the recommendations of

Brambor, Clark, and Golder (2006), we include a marginal effects plot to investigate interactions, using data across all the issues. They recommend examining a plot of $\partial Y/\partial X$ and its 95% confidence interval (CI) over the range of the moderator Z. If the CI does not include zero for any value of Z, one should conclude that X and Y are statistically associated at that value of Z. As can be seen in Figure 2a, there were two main results. First, stimulation impaired people's ability to generate arguments among didactic messages. The estimated 95% CI for the stimulation coefficient was below zero (in terms of estimated average button presses, stimulation *M* for didactic messages = 2.66, 95% CI = [2.22, 3.11] and sham *M* = 2.98, 95% CI = [2.53, 3.42]; for spoken reasons stimulation *M* for didactic messages = 2.79, 95% CI = [2.36, 3.22] and sham *M* = 2.96, 95% CI = [2.53, 3.38]),[6] providing evidence that participants generated significantly fewer arguments under stimulation than sham, in the didactic condition. Second, stimulation when compared to sham had no impact on the number of arguments among exemplar messages for button presses. The estimated 95% CI for the stimulation coefficient intersects zero (stimulation *M* for exemplar messages = 3.04, 95% CI = [2.57, 3.50], and sham *M* = 3.04, 95% CI = [2.58, 3.50]), failing to provide evidence for an association between button presses for stimulation condition and the exemplar condition. However, unexpectedly, stimulation elicited a greater number of reasons (counted verbally) for stimulation than sham for exemplar messages. The estimated 95% CI for the stimulation coefficient is above zero (for spoken reasons, stimulation *M* for exemplar messages = 2.96, 95% CI = [2.51, 3.41], and sham *M* = 2.84, 95% CI = [2.40, 3.30]).

We also estimated additional models that included additional variables given the possibility of omitted variable bias in the sparser model specifications. Specifically, we included whether the responses were ones in which the participant was engaging in confirmatory reasoning ("agree") or counterarguing ("disagree") ("agreement" variable). We also included each participant's level of support for a given issue (0-100 scale; 100 = *greatest support*) and participant's assessment of the issue's importance (1-4; 1 = *very important*). We included each participant's level of education as a control variable (1-7; 1 = *high school education*, 7 = *PhD*) as it may influence the participant's ability to generate arguments. The preponderance of our sample did not obtain a 4-year college degree (median level of education = 1-2 years of college; level of education mode = high school degree). We include age and sex as other control variables. Table 1 shows the distribution of these demographic variables across the didactic and exemplar conditions.

Finally, we created a variable that indicated whether a participant was able to guess correctly which session was the stimulation condition (correct guess = 1, wrong guess = 0). Overall, 80% (52/65) of our participants were able to correctly identify which session was associated with the stimulation condition likely because assignment to stimulation/sham was a within-subjects manipulation. Inclusion of these additional variables did not change our substantive results for the analysis involving all messages given the negative and significant stimulation by message interactions (see Table 4).

Table 4. Main and Interaction Effects of Stimulation and Message Type on Number of Generated Reasons for Health and Political Messages.

	Number of button presses				Number of spoken reasons			
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
Stimulation	−.16***		−.0005	−.002	−.03		.10*	.11*
(sham = 0, stimulation = 1)	(.03)		(.05)	(.05)	(.03)		(.04)	(.04)
Message type		−.21	−.06	.02		−.02	.11	.21
(exemplar = 0, didactic = 1)		(.32)	(.32)	(.33)		(.31)	(.31)	(.33)
Stimulation × Message Type			−.31***	−.31***			−.28***	−.28***
			(.07)	(.07)			(.07)	(.06)
Agreement				−.27***				−.23***
(agree = 0, disagree = 1)				(.03)				(.03)
Level of support				.0001				.00,006
				(.0008)				(.0007)
Issue importance				−.06*				−.04
				(.03)				(.03)
Education				.16†				.13
				(.09)				(.09)
Age				.0005				−.004
				(.01)				(.01)
Female				.28				.36
				(.36)				(.37)
Correctly guess stimulation				−.57				−.51
				(.42)				(.41)

Note. Coefficients with standard errors in parentheses are estimated using a mixed-effects regression. Independent variables were modeled as fixed effects and participants and stimuli were modeled as random effects.
†$p < .10$. *$p < .05$. ***$p < .001$.

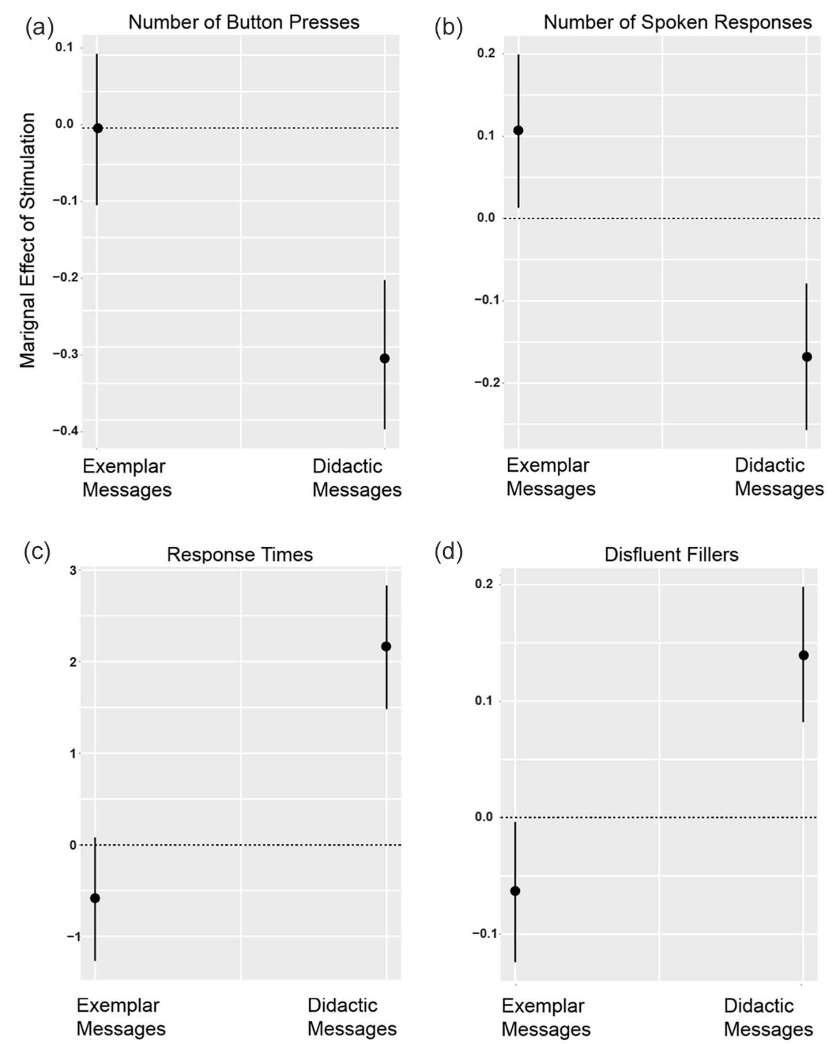

Figure 2. Marginal effect plots for combined messages show consistent evidence that tDCS of DLPFC disrupts the ability to reason for didactic-based, but not exemplar-based, messages.

Note. Error bars are 95% confidence intervals. *Y*-axes represent the marginal effect of stimulation on four dependent variables. Results indicate (a) fewer button presses (reflecting reasons) for stimulation compared to sham for didactic messages. For exemplar messages, there was no difference in number of button presses between stimulation and sham. (b) There were fewer spoken reasons for stimulation compared to sham among didactic messages but greater reasons for stimulation than sham for exemplar messages. (c) There were longer response times for stimulation compared to sham for didactic messages and no difference between stimulation and sham for exemplar messages and (d) greater disfluent fillers (um, uh) for didactic messages but fewer disfluent fillers for stimulation compared to sham for exemplar messages. tDCS = transcranial Direct Current Stimulation; DLPFC = dorsolateral prefrontal cortex.

Exploratory Analyses

Finally, we also conducted exploratory analyses to examine the extent to which response times (to the button presses) were influenced by both stimulation and message type. If evaluation of exemplar-based evidence relies less on deliberative cognitive processes (supported by DLPFC) compared to didactic information, then cathodal stimulation to the right DLPFC will increase the time it takes for individuals to generate arguments more so for didactic than exemplar information. We estimated a mixed-effects model in which we modeled stimulation condition, message type, and the interaction between the two as fixed effects and participants and specific messages as random effects. Our dependent variable was the average amount of time it took participants to press the buttons (corresponding to the reasons they generate) in response to the messages.[7] We found a significant stimulation by message type interaction ($B = 2.73$, $SE = .49$, $p < .001$; see supplementary materials). As can be seen in Figure 2c, stimulation (vs. sham) was associated with longer response times for the didactic condition—providing evidence that participants were slower when they were generating arguments under stimulation than sham (95% CI for stimulation coefficient above zero; stimulation M for didactic messages = 20.52, 95% CI = [18.30, 22.74], and sham M = 18.40, 95% CI = [16.16, 20.59]). By contrast, stimulation when compared to sham had no impact on the average amount of time it took participants to press buttons for exemplar messages (95% CI for stimulation coefficient intersects zero; stimulation M for exemplar messages = 16.71, 95% CI = [14.40, 19.03], and sham M = 17.30, 95% CI = [14.98, 19.61]).

We also examined the extent to which stimulation and message type influence the number of disfluent fillers (e.g., “ums” “uh”), generated by each participant. One view of filled pauses is that they reflect difficulties individuals experience while attempting to retrieve the appropriate while speaking (Finlayson & Corley, 2012). Indeed, such filled pauses are more likely to occur near the beginning of sentences (where planning is higher; Boomer, 1965) and when speaking of topics that are unfamiliar (Bortfeld, Leon, Bloom, Schober, & Brennan, 2001). If evaluation of didactic-based evidence relies more on deliberative processes compared to exemplar information, then cathodal stimulation to the right DLPFC will disrupt people’s ability to engage in deliberative planning of utterances and, thus, increase the amount of filled pauses in the spoken responses more so for didactic than exemplar information.

We transcribed audio recordings of participants’ responses to the messages using trained research assistants who were blind to the study hypotheses.[8] We performed linguistic analysis on these transcribed responses by identifying the number of disfluent fillers (um, uh) present in each response. We estimated a mixed-effects model in which we modeled stimulation condition, message type, and the interaction between the two as fixed effects and participants and specific messages as random effects. Our dependent variable was the average amount of filled pauses to each message. We found a significant stimulation by message type interaction ($B = 0.20$, $SE = .04$, $p < .001$; see supplementary materials). As can be seen in Figure 2d, stimulation increased the amount fillers for the didactic condition indicating that participants generated more fillers in their arguments under stimulation than sham (95% CI for stimulation coefficient above zero; stimulation *M* for didactic messages = 0.84, 95% CI = [0.56, 1.12], and sham *M* = 0.70, 95% CI = [0.42, 0.98]). However, unexpectedly, there were fewer disfluent fillers in the stimulation than sham condition for the exemplar messages (95% CI for stimulation coefficient is below zero; stimulation *M* for exemplar messages = 0.61, 95% CI = [0.32, 0.91], and sham *M* = 0.68, 95% CI = [0.38, 0.97]).

In sum, we found convergent evidence across the number of button presses and the number of verbal arguments counted from transcripts slowed reaction times and increased the number of disfluent fillers, suggesting that disruption of DLPFC using tDCS selectively impaired our participants' abilities to reason about didactic evidence more so than exemplar-based evidence.

Discussion

We investigated the extent to which people require the use of deliberative, cognitive processes while evaluating and reasoning about didactic versus exemplar information. We took advantage of previous findings suggesting that the prefrontal cortex is important for cognitive processes that underlie different types of reasoning processes and a preliminary study showing that the right DLPFC is associated with the deliberative aspects of confirmatory reasoning and counterarguing. We used cathodal stimulation to the right DLPFC to impair the cognitive reasoning processes underlying confirmatory reasoning and counterarguing as participants were exposed to health and political messages that contained either exemplar- or didactic-based evidence. We reasoned that if didactic-based evidence relies more on deliberative cognitive processes compared to exemplar information, then people's ability to generate arguments in response to didactic information should show greater impairment than exemplar information.

Our study revealed two main findings. First, cathodal stimulation, when compared to sham, impaired people's ability to generate arguments (measured using button presses and spoken reasons) while engaged in confirmatory reasoning and counterarguing for didactic messages. This effect is particularly striking given that our didactic messages did not contain particularly complex scientific or statistical information. In contrast, cathodal stimulation had no effect on people's ability to generate arguments while engaged in confirmatory reasoning and counterarguing for exemplar messages among button presses. However, stimulation improved people's ability to generate spoken reasons among exemplar messages. Furthermore, our exploratory analyses revealed that cathodal stimulation decreased the speed at which individuals generated reasons (measured via response times) and increased disfluent fillers when evaluating didactic information. In contrast, stimulation, when compared to sham, had no effect on average response times to exemplar-based information, and decreased the average amount of disfluent fillers in the exemplar condition. Collectively, the observed patterns in the data across our four different measures—button presses, spoken responses, response times, amount of disfluent fillers—are consistent with the idea that the evaluation of didactic information relies more on deliberative, cognitive processes than exemplar information.[9]

Furthermore, our unexpected results indicating that stimulation seemed to have improved people's ability to generate spoken reasons and enhanced their ability to speak fluently (decrease in disfluent fillers) among exemplar messages rule out the explanation that the observed effects of tDCS were due to the electric current distracting our participants from performing the arguing task. One intriguing possibility that could be tested in future research is that under some circumstances (e.g., exemplar-based reasoning), inhibition of DLPFC may reduce people's inhibition, allowing them to generate more ideas. Our data cannot directly speak of this explanation, but previous work has shown that cathodal stimulation to the prefrontal cortex (and impairment of executive functions) can improve performance for some tasks such as the flexible use generation task (Chrysikou et al., 2013).

Our study has both substantive and methodological contributions. First, our study provides evidence that the evaluation of didactic information engages processes associated with executive functions of the type executed in DLPFC than the evaluation of exemplar information. Theories of media effects such as exemplification theory (Zillmann & Brosius, 2000) and the heuristic processing of cultivation effects (Shrum, 1996) suggest that the high level of accessibility for exemplars can, in part, be due frequent activation of exemplars as a consequence of media exposure (Busselle & Shrum, 2003). Our results are consistent with the idea that the frequent evaluation of exemplar-based evidence has facilitated less-deliberative processing of this information.

This finding is important and advances the literature as it can provide information regarding the contexts in which messages that contain exemplar-based or didactic evidence might be more effective. For example, individuals have increasingly engaged in media multi-tasking—dividing their attention between the media source and an unrelated task (see Wang, Irwin, Cooper, & Srivastava, 2015, for a more thorough discussion of the concept of media-multitasking). According to limited capacity models of media processing (Lang, 2000), a cognitive resource such as attention is limited. Thus, an individual's performance in two or more tasks will be impaired if the mental capacity required to perform the tasks is greater than the amount of available capacity. Accordingly, one prominent view of automatic processes is that these processes proceed with very little (or no) attention (for a review, see Logan, 1992). The findings in our study suggest that in these contexts, individuals may more easily generate arguments in favor of, or opposition to, exemplar than didactic information given its less demanding use of attentional resources.

In terms of our methodological contribution, our study introduces tDCS in the toolbox available to communication scholars interested in examining the psychological mechanisms involved as individuals evaluate message information. tDCS is a noninvasive and safe brain stimulation technique that can provide unique information regarding the causal involvement of a brain region—and by implication, the cognitive function implemented by that region—to one's task of interest. Although previous studies in communication have primarily used response times as a measure of deliberative processing (for a review, see Payne & Cin, 2015), our study introduces a different method for assessing the necessity of deliberative cognitive processes in a specific task context. The use of additional techniques is valuable within a converging methods approach.

Limitations

As with all studies, our experiment has several important limitations. Although the evidence suggests that cathodal stimulation of DLPFC, using parameters employed in this investigation, is likely to significantly downregulate the executive functions supported by DLPFC (Barbey et al., 2013), several open questions remain about the method more broadly. First, the heterogeneity of results seen across the tDCS literature suggests that tDCS effects in the brain cannot be viewed monolithically. The direction and robustness of tDCS effects seems to be influenced by a number of parameters, including, but not limited to, polarity, intensity, duration, location of stimulation, domain of brain function being interrogated, and the state of the brain at the time of stimulation (Gill, Shah-Basak, & Hamilton, 2015; Karuza et al., 2016). Given the number of variables that can potentially impact the effect of stimulation, the question of whether tDCS of a given polarity delivered at a particular intensity to a particular site in conjunction with a particular task is an empirical one. However, viewed in this context, documenting the results of our investigation adds a data point against which the results of this specific approach can be tested.

Our participants are also not a representative sample. They are on the lower end of the continuum in terms of level of education and socioeconomic status. We also did not obtain information related to our participants' healthy habits (e.g., amount of time exercising, number of hours slept), why they tried to quit smoking in the past, or the extent to which they primarily exposed to exemplar or didactic health messages in their actual information environments. People's habits, previous attempts to quit smoking, and prior exposure to different types of health messages may have influenced their ability to generate arguments, a topic which could be investigated in future research.

For some of our control variables (attitude toward the issue/healthy behavior) and perceptions of importance, we used single-item measures given that we were also concerned about participant burden and fatigue, given our focus on executive function. Finally, we obtained small effect sizes for our stimulation manipulation.

Future Research

Future research should consider the use of other neuromodulatory techniques in order to examine the specific functions of subregions of the right DLPFC when people are exposed to exemplar and didactic information. A limitation of tDCS is that it lacks precision in its ability to target a specific region (Stagg et al., 2013). Given that preliminary fMRI evidence showing that both confirmatory reasoning and counterarguing involve neighboring regions of right DLPFC (O'Donnell et al., 2018), techniques with more spatial precision could help disentangle these effects. Thus, converging evidence from other methods is especially critical. Another promising stimulation method is transcranial magnetic stimulation (TMS) which allows better precision and specificity in modulating a specific brain region (for a review, see Luber & Lisanby, 2014). Future research could use TMS to target the subregions associated with confirmatory reasoning and counterarguing and selectively impair these processes over the course of message processing.

Given the small effect sizes and the recognition that the exact mechanisms underlying the effects of tDCS on confirmatory reasoning/counteraguing are still not well known, future work is needed in this area. There are also ethical issues that arise in any future attempts to use tDCS on confirmatory reasoning/counterarguing in clinical settings. Although, current evidence suggest that tDCS is extremely safe (Been, Ngo, Miller, & Fitzgerald, 2007), not much is known about the long-term effects of repeated tDCS use. Future work may reveal unexpected side effects or risks.

Future work could also investigate whether prior exposure to exemplar or didactic information in participants' real-world information environments may have influenced why participants pursued certain types of healthy behaviors. Researchers should also investigate other behavioral outcomes that could potentially be modulated by stimulation. For example, people's ability to remember didactic or exemplar messages may be influenced by tDCS. Finally, in this foundational study, we specifically designed the messages to reflect the natural structure of everyday conversations. Future research should investigate that the effects of tDCS on the right DLPFC on messages that are structured as logical arguments. Our study provides the conceptual and methodological foundations for future research in this domain.

Conclusion

In summary, our results suggest that people's ability to reason and evaluate didactic information relies more on deliberative cognitive processes relative to exemplar information. This study contributes to the existing literature by testing the assumptions of prominent theories of media effects such exemplification theory (Zillmann & Brosius, 2000) and the heuristic processing of cultivation effects (Shrum, 1996) using a novel and alternative method for assessing deliberative processing—an important contribution to future work employing a converging methods approach. In addition to testing the assumptions about the chronic accessibility of exemplar-based information, our study advances a theoretical view suggesting that exemplars are less likely to rely on the types of executive functions supported by DLPFC. Open questions remain regarding how differences in the deliberative evaluation of exemplar and didactic information influence attitudes and behaviors in certain contexts (e.g., media-multitasking) or for certain individuals (e.g., individuals trained/untrained in abstract or statistical reasoning for a given domain). These are important areas for future research to explore. As politicians, journalists, and others populate the information environment with didactic and exemplar-based messages, the mechanisms that determine people's capacity to evaluate and process these messages continue to be an important topic to study.

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Supplemental Material

Supplemental material for this article is available online.

Notes

1. Of course, we are not suggesting that the right dorsolateral prefrontal cortex (DLPFC) is only involved in confirmatory reasoning and counterarguing. Brain regions implement many cognitive functions and the specific function they implement may change across different tasks and contexts.
2. Approximately 63% self-reported that they tried to quit in the past.
3. An average of 16 trials across six participants were repeated in Sessions 1 and 2. These trials were removed from analysis.
4. We recruited 144 individuals from Amazon's Mechanical Turk. Each participant generated reasons (confirmatory reasoning, counterarguing) for the exemplar and didactic messages. We conducted an item-level analysis with number of responses as the dependent variable and message type (didactic, exemplar) and arguing task (confirmation reasoning, counterarguing) and the interaction between the two as independent variables. We estimated a mixed-effects logistic regression with the issues modeled as random effects. We did not obtain a significant message type by arguing task interaction, $B = -0.05$, $SE = .12$, $p = .63$.

5. In particular, it allowed us to capture instances in which participants provided a spoken reason but forgot to press the button or instances in which participants accidentally pressed a button but did not provide a spoken response.
6. The reported means and 95% confidence intervals were estimated from the mixed-effects models (Table 4, Model 3 and Model 7).
7. We measured response time as the amount of time in between the start of one button press and the start of the next button press. There are issues with interpreting response time results given that the responses times will be influenced by the number of words of the spoken reasons (and as discussed in this section, stimulation can increase the number of disfluent fillers in spoken reasons to didactic messages).
8. The computer failed to record audio from three participants. Thus, analyses involving spoken responses involve 56 participants. There were also instances in which transcribers were unable to hear people's responses. Approximately 8.5% of responses could not be transcribed.
9. Note that in our data, there was no main effect of message type in that participants generated the same number of button presses and spoken reasons for both didactic and exemplar messages. This is likely because the didactic and exemplar messages were comparable in terms of the use of nontechnical and nonscientific words—suggesting that, overall, both message types were similarly easy to process.

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