Political humor, sharing, and remembering: Insights from neuroimaging

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Abstract

Over the last two decades, news-oriented comedy programs have risen to compete with traditional hard news media as sources of information about politics. To the extent that a politically knowledgeable electorate is necessary for a thriving democracy, understanding the mechanisms underlying the extent to which political comedy facilitates or inhibits a well-informed citizenry is critical. Across two studies, we use behavioral experiments and neuroimaging to examine the causal effects of humor on the desire to share and the capacity to remember political information. We find that humor increases the likelihood to share political information with others and enhances people's memory for information. Humor also increases brain response in regions associated with understanding other people's mental states (i.e., mentalizing), which advances a theoretical view that humor may facilitate considerations of others' views (e.g., how other people will respond to shared political information).

Keywords: political humor, communication neuroscience, political knowledge, entertainment media, media psychology

Classic theories of representative democracy rest on the assumption that the electorate is well-informed about public affairs (Dewey, 1927; Mill, 1991). In recent years, there has been growing recognition that people's information environment plays an important role in facilitating or impairing their ability to acquire and retain accurate political information (Mondak, 1995; Delli Carpini, 2012). An important feature of the current information environment is the growing popularity of hybrid news-entertainment genres and news-oriented comedy programs as alternatives to traditional news outlets (Delli Carpini, 2012).

Indeed, a large body of work over the last two decades has examined the effects of comedy programs (e.g., *The Daily Show*, *The Tonight Show*) on the acquisition and retention of political information (Baumgartner & Morris, 2006; Delli Carpini, 2012; Hoffman & Young, 2011; Kim & Vishak, 2008). A prominent claim from this literature is that presenting political information within the context of humor can enhance the retention of this information in long-term memory (Young, 2017). Although humor can have many meanings, humor here is broadly defined as anything that people say or do that is perceived as funny (Martin & Ford, 2018). Within this context, the effect of humor on memory is theorized to be due to the higher levels of attention viewers direct to political information when it is delivered in a humorous versus a non-humorous format (Hardy, Gottfried, Winneg, & Jamieson, 2014; Kim & Vishak, 2008). Relevant work in psychology and neuroscience have provided evidence that information that elicits pleasure or reward enhances long-term memory for the information (Shohamy & Adcock, 2010).

In the research reported here, in addition to testing the causal role of humor in memory for political information, we extend this view to consider the possibility that political humor can also facilitate a politically knowledgeable citizenry in another way. Specifically, we examine the extent to which humor can increase the likelihood that political information is shared with other people.

Sharing political information is important because much of the information people encounter in their everyday lives is obtained second-hand through interpersonal channels (Hirst & Echterhoff, 2012). For example, individuals often learn political information from family, friends, and colleagues (Carlson, 2019; Katz, 1957; Katz & Lazarsfeld, 1955).

Why would humor facilitate social sharing of, and memory for, political information? Work in other domains has theorized that frames that lead individuals to consider how sharing or discussing information will benefit them, benefit others, and/or benefit their relationship will increase the likelihood of message sharing (Scholz & Falk, 2020). Political information framed in a humorous (vs. non-humorous) manner may work in a similar way by creating a positive impression of the person sharing (i.e., that the communicator is witty) (Mettee et al, 1971), by giving enjoyment to the receiver (Szabo, 2003), or because humor relies on a shared understanding between the communicator and receiver (Martin & Ford, 2018), potentially reinforcing their social bond (Manninen et al., 2017). Indeed, a vast literature across different disciplines suggest that humor (both political and not) serves many social functions (Kane et al., 1977; Long & Graesser, 1988; Young, 2017). For example, it can be used as tool to allow people to probe other people's attitudes and beliefs in a covert manner, gain approval from others, or elicit positive emotions from loved ones (Martin & Ford, 2018). To achieve these goals in deciding whether to share humorous content with others, individuals need to consider other people's mental states, a process often referred to as "mentalizing" (Frith & Frith, 2003). In addition, greater mentalizing may involve greater attention to the political information that will be shared since communicators need to assess which individuals are likely going to be receptive to the political information. This greater attention to information that will be shared, then, may lead to enhanced memory.

We provide empirical evidence for these arguments across two studies. Our primary goals are to: 1) examine the extent to which humorous political information is more likely to be shared with other people, 2) examine the extent to which humor improves the retention of political information (via increased mentalizing and/or reward-processing), and 3) identify the potential neuro-cognitive mechanisms (e.g., mentalizing or reward) underlying these effects of humor on sharing and memory, using non-invasive brain imaging (fMRI). FMRI affords us two unique advantages. First, it allows us to measure the simultaneous involvement of multiple neurocognitive processes as individuals evaluate political information conveyed in a humorous vs. non-humorous manner at the point in time when these processes are occurring (i.e., moment of exposure to the media content). Second, we can measure these processes unobtrusively without the need for participants to pause and interrupt their viewing experience to reflect and self-report on how they are thinking about the content.

Our study advances the political humor and broader entertainment media literatures in three ways. First, we argue that decisions about whether to share humorous information with others should increase mentalizing activity. We recognize that there are likely several mechanisms (that can occur simultaneously) that are associated with people's desire to share humorous information with others. We specifically focus on mentalizing here because it has been shown to be predictor of social sharing and memory in other domains (Scholz & Falk, 2017; Meyer et al., 2019). Yet, empirical work in political communication has largely not considered the role of mentalizing processes in explaining why individuals will remember or share political information.

Second, our approach employs an experimental design to isolate the causal effects of humor, using carefully constructed humorous/non-humorous news segments/conditions created by professional writers and actors that vary only in their humorous/non-humorous endings. Although

valuable, the few studies that have employed experimental techniques have used existing humorous/non-humorous clips (e.g., *The Daily Show* or evening news) as stimuli and therefore have not been fully able to control for other differences between stimuli such as prior knowledge about news hosts and the exact nature of the content and delivery (Kim & Vishak, 2008).

Finally, we use fMRI to simultaneously examine multiple neural processes as participants evaluate media content. Some scholars of political humor have called for the use psychophysiological techniques to shed light on the mechanisms underlying the effects of humor (Young, 2017). To put it simply, fMRI allows us to infer neuronal activity indirectly by measuring differences in blood flow across the brain (for an introduction, see Weber et al., 2015). Complex messages such as political humor will likely engage multiple psychological processes and fMRI can allow researchers to measure the neural substrates associated with these processes. The paradigm and analytical approach we use here can be used to examine message processing in other domains such as health news sharing (e.g., Baek, Scholz, O'Donnell, & Falk, 2017; Scholz et al., 2017), and other entertainment-based processing in domains such as science communication.

Understanding Political Humor through a Social Psychological and Neuroscientific Framework

News-oriented comedy programs have risen to compete with traditional hard news media as sources of information about politics and public affairs (Delli Carpini, 2012). To the extent that a knowledgeable electorate is necessary for a thriving democracy, understanding how political comedy facilitates or inhibits a well-informed citizenry is crucial. Political information conveyed in a humorous manner may facilitate a well-informed electorate by both increasing the likelihood that the information is shared to others and by enhancing memory for political information. Building on prior literature related to the social functions of humor (Kane et al., 1977; Long &

Graesser, 1988) as well as the neural precursors of information sharing (Baek, Scholz, O'Donnell, & Falk, 2017; Scholz et al., 2017), we hypothesize that humor might increase brain responses in regions implicated in understanding other people's mental states, and regions implicated in reward. We expand on each of these hypotheses below.

Mentalizing, Sharing, and Remembering

Why would people be more likely to share humorous than non-humorous political information? We suggest that it is useful to answer this question through the lens of interdisciplinary work on humor. Our central idea is that individuals can use humorous political information to accomplish social goals. Of relevance, a large body of theoretical and empirical work in psychology, comparative biology, and communication has converged on the idea that humor can serve social functions in human relationships (Kane et al., 1977; Gervais & Wilson, 2005, Lynch, 2002), and in this way, might help people achieve social goals. For example, people have used humor in a variety of ways such as a tool for self-disclosure (Davis & Farina, 1970), alleviating workplace tension (Vinton, 1989), increasing one's status (Bitterly et al., 2017), fostering an appearance of competence (Metteee et al., 1971), and promoting group cohesion (Robinson & Smith-Lovin, 2001).

Some of these social goals may be motivated by benefits to one's self. For example, people may share humorous information if they believe it will make them look witty. As another example, in the context of politics, people are often interested in knowing the beliefs and attitudes of acquaintances over political issues. For some issues, it can be difficult or uncomfortable to ask direct questions about these issues. Using humor can often be a more acceptable and indirect way of gaining such information (Martin & Ford, 2018). By making a humorous remark about certain

political attitudes or beliefs, and by observing whether others respond with laughter, individuals can infer whether others share similar views.

In contrast, other social goals are altruistic or driven largely by concerns of benefitting others. For example, individuals may be motivated to share humorous political information with others because they want the person to experience feeling of joy or amusement. Furthermore, although many individuals are not interested in politics (Delli Carpini & Keeter, 1996; Prior 2019), political humor is often perceived as making politics accessible to a more general audience – even among those who are not interested in political affairs (Young, 2017). Indeed, watching political comedy programming on television can motivate people to engage in political discussions with others (Landreville, Holbert, & LaMarre, 2010).

In summary, if individuals can use humorous political information to accomplish more of their social goals than non-humorous political information, then it should elicit a greater likelihood of sharing. Formally, we postulate and preregistered the following hypothesis[1]:

> *H1:* Individuals will be more likely to share political information delivered in a humorous than non-humorous format.

It is important to note that, regardless of whether individuals are motivated by altruistic or self-interested goals, they need to determine the values, attitudes, knowledge, and intention of others as they consider whether to share political information with them, and this is particularly true in considering what others will find funny. In other words, to accomplish their social goals, individuals can engage in mentalizing in deciding whether to share humorous content.

Mentalizing is an umbrella term scholars use to describe thinking about mental states, beliefs, and intention of other people (Frith & Frith, 2003). Mentalizing has automatic and

[1] See supplemental materials for information about how the conceptual hypotheses presented here map on to the operational hypotheses described in the preregistration document.

controlled components and either or both can likely underlie individuals' decisions to share political content with others. Mentalizing can occur automatically if individuals spontaneously infer the mental states of others with little effort and intention (Frith & Frith, 2006; Lieberman, 2007). In the context of humor news, this could involve spontaneously thinking about how others might respond to the content (e.g., "Joe would love this!"). Evidence that mentalizing can occur automatically has come from preverbal infants who likely ascribe beliefs to others (Onishi & Baillargeon, 2005). However, mentalizing can also occur in a controlled, effortful, and deliberate manner (Luyten & Fonagy, 2015). People may engage in effortful and deliberate thinking when trying to ascribe traits, emotions, and thoughts to others. For example, in a pertinent neuroimaging study, participants were asked to simultaneously think about either two, three, or four of their friends and their personality traits (Meyer et al., 2012). The study found that as the number of friends participants thought about increased, so too did activity in brain regions associated with mentalizing. In the context of humor news, this could involve deliberating about how others might respond to the content (e.g., "I wonder what Joe would think about this?").

Of further interest in this study, then, is understanding the cognitive processes elicited by exposure to humorous versus non-humorous political information, with a particular focus on the neural regions that have been associated with mentalizing. Specifically, fMRI studies have identified several regions that are associated with people's ability to reason about other people's mental states. More broadly, these regions have been theorized to underlie people's natural capacity for social cognition and reasoning about the social consequences of one's actions, whether automatic or deliberative (Dufour et al., 2013; Frith & Frith, 2006). These regions include the dorsal, middle, and ventral medial prefrontal cortex (DMPFC, MMPFC, VMPFC), precuneus (PC), left and right temporoparietal junction (LTPJ, RTPJ), and right superior temporal sulcus

(RTPS) (Dufour et al., 2013). In addition, activation of mentalizing regions has also been associated with greater sharing of news in past studies (Baek, Scholz, O'Donnell, & Falk, 2017; Scholz et al., 2017).

If individuals are more likely to think about how political information can be used to fulfill their social goals when it is presented in a humorous manner, then they should be more likely to think about other people's mental states (with whom they may share information) when presented with humorous rather than non-humorous political information. We propose and preregistered the following hypothesis:

> *H2*: Humorous political information will be more likely to elicit greater activity in brain regions associated with mentalizing than non-humorous political information.

Greater mentalizing may also be positively associated with sharing. If sharing information with others involves thinking about the mental states of the people with whom an individual may share information, then greater mentalizing should be associated with greater instances of sharing. This may occur automatically if, for example, political information spontaneously brings to mind (on the part of the communicator) someone who may appreciate the information. This can also occur in a controlled manner if the sender assesses the potential responses of the receiver to the information, and/or possible consequences for the sharer's relationship with the receiver. Of relevance, there is evidence that greater activity in mentalizing regions predicts both individual (Baek et al., 2017) and aggregate-level (Scholz et al., 2017) sharing behaviors in the context of health news articles. We therefore propose and preregistered the following hypothesis:

> H3: Greater mentalizing activity will be associated with increased sharing of political information.

Additionally, what explains the potential memory-enhancing effects of political humor? In general, effects of humor on memory are theorized to be due to individuals directing higher levels

of attention to political information when it is delivered in a humorous versus a non-humorous format (Hardy, Gottfried, Winneg, & Jamieson, 2014; Kim & Vishak, 2008). One explanation as to why individuals will likely direct more attention, and therefore remember, humorous than non-humorous political information is people's emotional response to humorous information. Specifically, the personal emotional gratification one expects or experiences from humor facilitates cognitive engagement and effortful processing of political information. Indeed, the manner in which people evaluate political information is not only influenced by long-term dispositions or traits (e.g., partisanship, personality; Mondak, 2010) but also by short-term emotional states (Brader, 2006; Marcus, Neuman, & MacKuen, 2000).

Emotional states, in particular, are viewed as playing a critical role in what people pay attention to, and remember about, politics (Brader, 2006). For example, anticipating positive emotions such as expected feelings of joy and amusement have been theorized to promote attention and elaboration of information (Martin & Ford, 2018). This is because individuals have a strong preference for experiencing positive emotional states (Cacioppo et al., 1999; Watson et al., 1999; Diener & Diener, 1996) and are therefore likely to direct attention to sources that they expect will elicit positive emotions. Thus, both the expectation and experience of positive emotional states can lead to greater attention and memory for humorous information. Formally, we propose and preregistered that:

> H4: Individuals will be more likely to remember political information delivered in a humorous than non-humorous format.

Greater mentalizing may involve an increased likelihood of remembering political information. There is emerging evidence that individuals are more likely to remember social (e.g., actions that have interpersonal consequences) than non-social information (Meyer et al., 2019; Cassidy & Gutchess, 2012). One explanation for this enhanced memory is that social or

interpersonal information can be viewed as more meaningful, and thus capture greater attention, compared to non-social (and perhaps less meaningful) information (Cassidy & Gutchess, 2012). Furthermore, neuroimaging work suggests that interactions between brain regions involved in mentalizing (e.g., MPFC and TPJ) play a role in the stabilization of social information in long-term memory (i.e., memory consolidation; Meyer et al., 2019). Finally, greater mentalizing may involve greater elaboration or attention to the information that will be shared since this involves an assessment (either spontaneously or intentionally) of which individuals are likely going to be receptive to the political information. Obtaining an accurate assessment other people's mental states and determining whether one's social goals can be attained by sharing information may require attention to both the information that could be shared and the potential audience. Thus, if mentalizing involves greater elaboration of the information that will be shared, then an increase in mentalizing should also be associated with an increased likelihood of remembering the information. We therefore expect that greater mentalizing will be associated with greater memory for political information. We preregistered the following hypothesis:

> H5: Greater mentalizing activity will be associated with increased likelihood of remembering political information.

Reward, Sharing, and Remembering

Given that humorous information is likely to elicit positive emotions, processes related to reward and positive valuation may play an important role in processing humorous political information. Reward and positive valuation are closely linked processes. Indeed, "reward" is often conceptualized as the positive value that an individual ascribes to an object or stimuli (Schultz et al., 1997). In terms of reward/positive valuation, previous work has implicated the ventromedial prefrontal cortex (VMPFC) and ventral striatum (VS) as important brain regions involved in this type of reward processing (Kable & Glimcher, 2009; Rangel, Camerer, & Montague, 2008). The

VMPFC and VS have been linked to reward and/or anticipation and prediction of reward outcomes (for reviews, see Kable & Glimcher, 2009; Rangel et al., 2008; Knustson et al., 2008).

Indeed, previous work has associated the VMPFC with the pleasurable nature of humor comprehension (Goel & Dolan, 2001). For instance, a previous fMRI study found that people's funniness ratings of jokes was associated with greater activation in the VMPFC (Goel & Dolan, 2001). Similarly, converging evidence from animal and neuroimaging studies of humans suggest that the ventral striatum plays a critical role in people's capacity to predict or anticipate rewarding experiences (for a review, see O'Doherty, 2004). In the context of humor, previous fMRI work has found that funny cartoons tend elicit greater neural activity in the nucleus accumbens (a subregion of the ventral striatum) than non-funny cartoons (Mobbs, Greicius, Abdel-Azim, Menon, & Reiss, 2003). Thus, we postulate and preregistered the following hypothesis:

> *H6*: Humorous political information will be more likely to elicit greater activity in brain regions associated with reward than non-humorous political information.

Increased reward processes may also be associated with increased remembering. There is substantial evidence that information that elicit reward enhances storage of the information in long-term memory for both animals and humans (Shohamy & Adcock, 2010). This can occur in instances in which people anticipate the reward value of information, and are thus likely to direct greater attention to it (for a review, see Miendlarzewska et al., 2016). The memory-enhancing effects of reward can also occur after exposure to information via increased likelihood that the information is reactivated or "replayed" and thus improving memory consolidation (Atherton et al., 2015). We propose the following hypothesis:

> *H7*: Greater reward activity will be associated with increased likelihood of remembering political information.

Finally, individuals may also be more likely to share political information that elicits greater feelings of reward. One possible reason for this prediction is from work showing that shared experiences are more enjoyable than solo ones (Wagner et al., 2014). Indeed, sharing experiences seem to amplify emotions – making positive experiences more positive (Shteynberg et al., 2014). This desire to experience greater feelings of enjoyment may increase people's motivations to share information with others. This prediction is also consistent our theoretical view about sharing humor as a means by which individuals can accomplish social goals. Specifically, if individuals want others to experience feelings of joy or amusement, then they may want to share information that brought about positive emotional states in themselves. We propose and preregistered the following hypothesis:

H8: Greater reward activity will be associated with increased sharing.

Methods

Preregistration and Replication

We conducted two studies that utilized the same stimuli and employed the same general design[2]. Study 1 is the behavioral version (we collected behavioral data but not fMRI data). Study 2 is the fMRI version (we collected both behavioral and fMRI data). Since we collected the same behavioral data across the two studies, we could examine the extent to which the behavioral effects of political humor on sharing and memory replicated across different participants and study contexts. We tested the hypothesized mentalizing and reward processes associated with humor using fMRI data obtained from study 2.

Participants

[2] This study is part of a larger project examining neural responses to political information. This is the first article from this project. Other data are not reported here and will be reported in a separate article.

For studies 1 and 2, we recruited participants from a large private northeastern university in the United States and the surrounding community. We compensated participants with money ($15 for study 1, $30 for study 2). For study 1, we recruited 40 participants (20 females, M_{Age} = 21.48, SD_{Age} = 2.77, range = 18 to 34, Democrat = 25, Independent = 11, Republican = 4).

For study 2, we recruited 52 participants. We excluded four participants due to excessive head motion during MRI scanning. We analyzed data from the remaining 48 participants (27 females, M_{Age} = 22.69, SD_{Age} = 4.25, range = 18 to 35, Democrat = 28, Independent = 17, Republican = 3). All participants in study 2, by self-report, had no history of neurological disorders, PTSD, coronary artery disease, arrhythmia, or uncontrolled hypertension, and were not currently using psychotropic medications.

Materials

Stimuli consisted of 128 six to eighteen second video clips simulating a television news segment, with two professional comic actors (white males; see Figure 1) playing the news anchors. Of the 128 clips, half (64) featured each actor, with each reading 32 humorous and 32 non-humorous versions. All scripts for the humorous versions were written by a professional comedy writer (see Table 1 for examples).

The script for each news clip consisted of two sentences. The relevant news information conveyed in the first sentence described a proposed state law or initiative. We intentionally selected issues that were unlikely to be associated with strong prior attitudes (e.g., traffic cameras at intersections, term limits for state judges), and did not select partisan issues (e.g., abortion, immigration, gun control) because we wanted to minimize differences in participants' prior knowledge/attitudes about the issues and perceptions that the humorous versions may be viewed as offensive. We selected actual state laws and modified them for our study. In half of the clips

(32 clips), the second sentence consisted of a joke about the proposed law, while the other half consisted of a non-humorous sentence which provided more information about the law. The jokes were a mix of surreal comedy ("bizarre" juxtapositions) and comedy that criticized the policy. We pre-tested our 128 clips with a sample drawn from Amazon's Mechanical Turk to ensure that the humorous clips (mean funniness rating = 3.06, SD = 0.36) were judged to be funnier than the non-humorous clips (mean funniness rating = 1.96, SD = 0.21), $t(126) = -20.91$, $p < .001$, $d = -3.7$)[3].

[TABLE 1]

Procedures

Both studies 1 and 2 consisted of a study phase (completed in the fMRI scanner for study 2), a memory test phase, and a sharing phase (see Figure 1). During the study phase, we told participants that they would watch clips of people's auditions for a local news anchor position: "For the first task, you're going to watch a series of video clips of two people who are auditioning for a news anchor position. The local news station auditioning the news anchors is trying a new format. They want to see if combining humor with regular news stories will change how viewers respond to the news." We provided these instructions to minimize the possibility that participants are surprised when they view the anchor delivering jokes.

We instructed participants to pay attention to these clips, as they would be asked questions about them at a later point. Each participant viewed 32 video clips in random order (16 humorous delivered by one anchor and 16 non-humorous delivered by the other, alternating which anchor delivered the humorous or non-humorous clips from participant to participant).[4]

[3] 375 participants on MTurk rated the clips ("How funny is this clip?" 1 = not at all funny, 6 = Extremely Funny. We then calculated the average rating for each of the 128 items. The Welch two sample t-test compares the humorous (64 items) and non-humorous clips (64 items).

[4] Participants in study 2 wore noise-cancelling headphones while in the MRI scanner (they were in the MRI during the study phase only).

A single trial consisted of a video clip (range of six to eighteen seconds) followed by a fixation cross (i.e., a point on the screen where participants direct their gaze, commonly used in fMRI research during rest periods). For study 1, the fixation cross was presented on the screen for 3 seconds. For study 2, the fixation cross was shown for two to fourteen seconds. Note that we expect mentalizing and reward-processes to occur during exposure to the humorous political information. As mentioned previously, individuals often use humorous information to accomplish social goals and thus may be likely to begin considering how humorous information can be used at the time of exposure to humorous political information (e.g., through reputational rewards of sharing; Meshi et al., 2013). Similarly, individuals experience feelings of pleasure upon hearing a funny joke.

After watching all the clips, participants were asked to solve arithmetic problems for 20 minutes as a distractor task. The arithmetic problems involved multiplication of a two-digit number by a two-digit number.

The memory test phase followed. First, participants took part in a recall test, in which they were asked to remember the policy propositions mentioned in the news clips. We gave participants 10 minutes to write down as many policy measures as they could remember. Next, the participants were given a recognition memory test. Participants were presented with 32 laws/initiatives that were mentioned in the news clips ("old" items), along with 32 laws/initiatives that shared conceptual/semantic features with the former, but were not actually presented to them during the study phase ("new" items or semantic lures). For example, participants exposed to the statement, "The state constitution may be amended so that the minimum age for serving in the state Senate is lowered to 18-years-old" during the study phase were shown both this statement and a semantic lure ("The state constitution may be amended so that the minimum age for serving in the state

Senate is set to 30-years-old") during the recognition memory test. Participants were asked if each was "old" or "new" (i.e., whether or not they had encountered either during the study phase).

The sharing phase followed the memory test phase. Participants re-watched each of the 32 video clips they had seen[5], and reported how likely they were to: (1) talk to another person about content of the clip; (2) email the clip to another person; and (3) share the clip on social media.[6] Furthermore, these type of self-report measures have been shown to predict actual sharing behaviors in real-world contexts (e.g., sharing health news articles on social media; Scholz, et al., 2017). In addition, they were asked the extent to which they: (4) supported or opposed the policy mentioned in the clip[7]; (5) perceived the policy mentioned in the clip as important[8]; and (6) perceived the clip as funny[9].

[FIGURE 1]

fMRI Image Acquisition

For study 2, neuroimaging data were acquired using a 3 Tesla Siemens Magnetom MRI scanner equipped with a 64-channel head coil. Two functional runs were acquired for each participant (360 volumes per run). Two functional images were recorded using a multiband sequence (TR = 1000 ms, TE = 32 ms, flip angle = 60 degrees, 56 axial slices, FOV = 208 mm, slice thickness = 2.5 mm; voxel size = 2.5 x 2.5 x 2.5 mm). We used a multi-band acceleration factor of 4. We also acquired a high-resolution T1-weighted image using an MP-RAGE sequence (TR = 1850.0 ms, 160 slices, voxel size = 0.9 x 0.9 x 1.0 mm) for use in co-registration and normalization. The first 6 volumes of each run were not collected from the scan.

[5] Participants had to re-watch the clips prior to making sharing ratings because having them rely on their memory for the clips would introduce a confound if participants were more likely to remember humorous than non-humorous clips.
[6] All measured on a 7-point scales ranging from 1 = Very Unlikely to 7 = Very Likely.
[7] Measured on a 5-point scale ranging from 1 = Strongly Oppose to 5 = Strongly Support.
[8] Measured on a 5-point scale ranging from 1 = Not at all important to 6 = Very important.
[9] Measured on a 6-point scale ranging from 1 = Not funny at all to 6 = Very funny.

fMRI Data Preprocessing

Functional data were pre-processed and analyzed using FSL and Statistical Parametric Mapping (SPM8, Wellcome Department of Cognitive Neurology, Institute of Neurology, London, UK). Data were corrected for differences in the time of slice acquisition using sinc interpolation, spatially realigned to correct for head motion, and co-registered to the structural image. Data were then normalized to the skull-stripped Montreal Neurological Institute (MNI) template provided by FSL (FMRIB Software Library; MNI152_T1_1mm_brain.nii). Functional images were smoothed using a Gaussian kernel (8 mm full width at half maximum). For pre-whitening, the first level models used the SPM8 default of AR(1) prewhitening and a high pass filter at 128.

fMRI Data Analysis

We adopted a region of interest approach to investigate the relationship between parameter estimates of neural activity during exposure to the news clips. Analyses were conducted using brain activation extracted from sets of a priori theory-driven regions of interest implicated in mentalizing and reward during the time period when participants were exposed to each news clip. To harmonize our fMRI data with other data that pertains to our hypotheses (e.g., recall data and sharing data), we created design matrices for each participant in SPM8, modeling activity that was greater during exposure to each video clips in the scanner, than during rest/fixation periods, with a single boxcar regressor for each video clip of varying durations, with the ultimate goal of using these estimates in further analyses that relate activation to each clip to outcomes of interest such as later recall and sharing. We extracted parameter estimates from ROIs associated with reward and mentalizing processes during exposure to each video clip for each participant using MarsBaR

(Brett, Anton, Valabregue, & Poline, 2002) and converted them to percent signal change[10], resulting in 32 values (one for each video) for each of the brain regions (VMPFC, VS, regions associated with the mentalizing network) for each participant. Six rigid-body translation and rotation parameters derived from spatial realignment were also included as nuisance regressors in all first-level models.

We then estimated mixed-effects regressions using the lmer package in R to account for repeated observations nested within individuals. Hypotheses 2 and 6 treat extracted estimates of brain activity associated with each of the 32 video clip per participant in mentalizing or reward regions as the dependent variable, and humor (e.g., humor = 1, non-humor = 0) as the independent variable. Hypotheses 3, 5, 7, and 8 treat neural activity as the independent variable and recall and sharing measures as the dependent variables, respectively.

Content Analysis of Recollected Material

For both studies 1 and 2, two coders (blind to the study's hypotheses and conditions) independently coded all the participants' responses for recall accuracy of the general semantic content of an issue. For example, a response of "judges having limits" would be counted as a successful memory retrieval of "Lawmakers will create term limits for judges on the state Supreme Court." Intercoder reliability was high for both studies (study 1 Krippendorff's alpha = .81; study 2 Krippendorff's alpha = .89). The two coders disagreed on 6.7% of the cases in study 1 and 4.5% of the cases in study 2. We used a third coder (blind to the study's hypotheses and conditions) to resolve the cases in which the original two coders disagreed.

Statistical Analyses and Key Variables

[10] Percent signal change is calculated as percent change in neural signal as compared to a baseline. Here, the baseline is defined as the residual value in the first level GLM in SPM. In other words, here the baseline is the mean signal value if the regressors (humor, non-humor, and motion parameters) were set to zero.

We used either a linear or logistic mixed-effects models for all regression analyses. We utilized a random intercepts model for participants and policy issues to account for the non-independence of each participant's responses to multiple stimuli items. Our primary independent variable is the humor condition (coded as humor = 1, non-humor = 0).

The three key dependent variables related to sharing were the participants' self-reported intention to share the news clip (via a face-to-face conversation, email, or social media; coded from 1 to 7; Very Unlikely to Very Likely). The key dependent variables related to memory were (1) people's ability to accurately remember each of the 32 policy positions (gist recall; recall = 1, no recall = 0) and (2) d-prime as a measure of recognition memory. For recognition memory, we calculated the hit rate (proportion of items correctly classified as "old") and the false alarm rate (proportion of new items incorrectly classified as "old"). Recognition memory was assessed using the discriminability index d-prime, which takes into account information about hit and false alarm rates (MacMillan & Creelman, 2005)[11]. A d-prime score above 0 suggests that participants are able to reliably discriminate old and new items (instances in which the hit rate is greater than the false alarm rate). A score of 0 suggests that participants are unable to discriminate between old and new items (instances in which the hit rate is equal to the false alarm rate). We also conducted parallel analyses using the non-parametric measure A-prime (see supplemental materials).

The key variables for neural activity were the six mentalizing regions. Specifically, we examined activity in six regions that were previously defined by a large-scale study of mentalizing (Dufour et al., 2013). This network is comprised of the right temporoparietal junction (RTPJ), left temporoparietal junction (LTPJ), dorsal and middle components of the medial prefrontal cortex

[11] In the memory literature, item recognition z-ROCs (i.e., a plot of the z-transformed hit rate vs. the z-transformed false alarm rate) are typically linear (Ratcliff, Sheu, & Gronlund, 1992) suggesting that the signal and noise parameters (assumed by d-prime analyses) follow a normal distribution. As such, we used d-prime analysis in the study.

(DMPFC and MMPFC), precuneus (PC), and right superior temporal sulcus (RSTS; see Figure 2). For reward, we used neutral activity in two regions that comprise the ventral medial prefrontal cortex (VMPFC) and ventral striatum (VS) as defined by a meta-analysis of the neural correlates of subjective value (Bartra et al., 2013; see Figure 2).

[Figure 2]

Results

Manipulation Check

We examined the extent to which participants perceived the humorous news stories to be funnier than non-humorous news stories, using their self-reported ratings of the news clip. For study 1, consistent with our pre-testing, the self-report data revealed that humorous news stories (M = 3.1, SD = 1.1) were more likely to be perceived as funny compared to the non-humorous news stories (M = 1.94, SD = 0.88), $Z = -3.9$, $p < .001$; $r = .62$). Similarly, in study 2, humorous news stories (M = 3.4, SD = 1.08) were more likely to be perceived as funny compared to the non-humorous news stories (M = 1.98, SD = 0.88), $Z = -4.9$, $p < .001$; $r = .72$[12].

Preregistered Analyses

Sharing Humorous vs. Non-Humorous Political Information (H1). We used data from the sharing phase to test our hypothesis that individuals will be more likely to share news stories delivered in a humorous than non-humorous format (H1). We estimated three regression models for each of the studies with humor as the independent variable and three self-reported intentions to share as dependent variables[13]. As predicted, both participants in study 1 and study 2 were more likely to share humorous than non-humorous news clips via email and social media (Table 2).

[12] All paired tests in studies 1 and 2 use a non-parametric Wilcoxon signed-rank test.
[13] Note that we have an n of 47 participants in our sharing analyses given that our survey platform (Qualtrics) failed to record the responses of one participant.

There were no differences in their likelihood of sharing humorous and non-humorous news clips via face-to-face conversations for both studies. We obtained substantively similar results with a model using co-variates (e.g., ratings of actor attractiveness, extent to which video clips were confusing; see supplemental materials). Overall, we found support for the hypothesis that individuals will be more likely to share news stories delivered in a humorous than non-humorous format.

[TABLE 2]

Mentalizing for Humorous vs. Non-Humorous Political Information (H2). To test our hypothesis that humorous news stories will be more likely to elicit greater activity in brain regions associated with mentalizing (H2), we used humor as an independent variable and neural activity in each of the six regions associated with the mentalizing networks as dependent variables[14]. As can be seen in Table 3, we found some support for Hypothesis 2. Consistent with our expectations, humorous news stories elicited greater neural activity in the left temporoparietal junction (LTPJ) and right superior temporal sulcus (RSTS) compared to non-humorous news stories. Contrary to our expectations, humorous news stories elicited less neural activity in the precuneus (PC) compared to non-humorous news stories. Finally, there were no differences in the neural activity in the right temporoparietal junction (RTPJ), and dorsal and middle components of the medial prefrontal cortex (DMPFC and MMPFC) between the humorous and non-humorous news stories. Thus, we found some support for the hypothesis that political information conveyed in a humorous manner elicited greater neural activity in regions chosen for their role in mentalizing (LTPJ, RSTS) than non-humorous information.

[14] Note that the VMPFC has also been implicated in the set of regions associated with metalizing. For this study, we included the VMPFC within our measure of valuation/reward processing, and hence excluded it from the mentalizing map.

[TABLE 3]

Association between Mentalizing Regions and Sharing (H3). Next, we tested the extent to which greater mentalizing activity was associated with increased sharing (H3). Each of the six neural regions associated with mentalizing were our independent variables. For our dependent variable, we focused on participants' self-reported intentions to share the news clip by either email, or social media (dependent variables), as these outcomes were greater for humorous than non-humorous news clips. As can be seen in Table 4, greater activity in the LTPJ, RTPJ, and RSTS was associated greater rates of intention to share via social media. We found some support for the hypothesis that greater mentalizing activity will be associated with increased sharing (H3).

[TABLE 4]

Memory for Humorous vs. Non-Humorous Political Information (H4). Next, we tested whether individuals were more likely to remember political information delivered in a humorous than non-humorous context (H4). We used humor as an independent variable and people's ability to accurately remember each of the 32 policy positions as a dependent variable. Across both studies, a significant and positive effect of humor (study 1 B = .60, SE = .19, $p < .01$; study 2 B = .65, SE = .19, $p < .01$) suggests that participants were more likely to remember policy information when it was conveyed in a humorous than non-humorous manner (see Table 2)[15].

In terms of recognition memory for study 1, we found that participants were more likely to discriminate between old and new policy issues that were conveyed in a humorous (Mean d-prime = 1.66, SD = 0.99) than non-humorous format (Mean d-prime = 1.4, SD = 0.82), $Z = -2.3$, $p = .01$; $r = .37$. In study 2, participants were no more likely to discriminate between old and new policy

[15] We also obtained substantively similar results with a model using co-variates (e.g., ratings of actor attractiveness, extent to which video clips were confusing; see supplemental materials).

issues that were conveyed in a humorous (Mean d-prime = 1.35, SD = .89) and non-humorous format (Mean d-prime = 1.26, SD = .86, $Z = -.65$, $p = .51$; $r = .09$. An analysis using A-prime yielded substantively similar results (see supplementary materials). Overall, we found support for the hypothesis (H4) that individuals will be more likely to remember political information delivered in a humorous than non-humorous context.

[TABLE 2]

Association between Mentalizing Regions and Memory (H5). Next, we tested the extent to which greater mentalizing activity was associated with increased likelihood of remembering information (H5). We found either no statistically significant associations or negative associations (MMPFC, PC) between mentalizing regions and people's tendency to remember political information (see supplemental materials). We therefore did not find support for the hypothesis that greater mentalizing activity will be associated with an increased likelihood of remembering information (H5).

Reward Responses for Humorous vs. Non-Humorous Political Information (H6). To test our hypotheses that humorous news stories would be more likely to elicit greater activity in brain regions associated with reward (H6), we used humor as an independent variable and neural activity in the VMPFC and the ventral striatum as dependent variables. As can be seen in Table 3, and contrary to our expectations, humorous news stories elicited less neural activity in the VMPFC compared to non-humorous news stories. There were no statistically significant differences in neural activity in the ventral striatum between the humorous and non-humorous news stories (although the sign of the coefficient is in the predicted direction).

Associations between Mentalizing Regions and Sharing and Memory (H7, H8). We found no support for the hypothesis that greater reward activity was associated with increased likelihood of remembering information (H7) and sharing (H8; see supplemental materials).

Comparison of Effects across Levels of Funniness within the Humor Condition. Finally, we consider the possibility that the humor/non-humor conditions are confounded with instances in which participants' expectations about appropriate behaviors are violated/not-violated. Under this account, people usually do not expect anchors auditioning for news stories to insert jokes in the middle of their auditions. In other words, the humor condition could constitute trials in which participants' expectations are violated and the non-humorous condition could constitute trials in which the participants' expectations are *not* violated. The effects, then, on sharing and memory may be due to processes elicited when participants' expectations about appropriate behaviors are violated/non-violated instead of the humor/non-humor manipulation.

To address this alternative explanation, we conducted exploratory analyses restricted to trials in which the anchor inserted jokes (i.e., the humor condition). We then estimated mixed-effects regression models in which we used participants' funniness ratings as the independent variable and participants (1) self-reported sharing intentions and (2) gist recall as dependent variables. Since these analyses involve a comparison of participants' funniness ratings *within* the humor condition (i.e., trials in which the anchor inserted a joke), violation of expectation cannot explain any observed effects of the funniness ratings on sharing and memory.

As can be seen in Table S3 (see supplemental materials), an increase in funniness ratings were positively associated with all three sharing measures across both studies 1 and 2. Funniness ratings were also marginally and positively associated with gist recall for study 2 (but not study

1). Taken together, these results are consistent with the explanation that perceptions of humor/funniness are driving the results.

Summary. We found support for our first four hypotheses. Specifically, humorous, as compared to non-humorous, political information is more likely to be shared with others (H1) and elicit greater activity in some brain regions associated with mentalizing, including LTPJ and RSTS (H2). Furthermore, greater mentalizing activity in LTPJ, RTPJ, RSTS is associated with increased sharing (H3). Individuals were also more likely to remember humorous than non-humorous political information (H4).

We did not find support for our last four hypotheses. In particular, greater mentalizing activity was not associated with accurate memory (H5). Humorous political information did not elicit greater activity in reward regions (H6). Finally, greater activity in reward regions was not associated with increased remembering (H7) and sharing (H8).

[Table 4]

Exploratory Whole-Brain Analyses

We also conducted a series of exploratory whole-brain searches for regions in which neural activity was greater for the humorous condition than non-humorous condition[16]. Overall, we found support for our theoretical expectation that regions previously involved in mentalizing would also be associated with humor.

In our whole brain search, we observed greater activity in sub-regions of TPJ and DMPFC, as well as bilateral STS for humorous > non-humorous stimuli. Outside of our planned regions of interest, we only observed activations in a small number of additional regions, suggesting that

[16] Whole-brain maps used 3dClustSim simulation (Version AFNI_16.2.02)

global changes in activation do not explain the main phenomenon described above. Specifically, we found greater activity in regions comprising the supplementary motor area (SMA) and the globus pallidus during the humorous than the non-humorous condition. Finally, we observed greater activity in the cerebral crus in the humor than non-humor condition.

[FIGURE 3]

Discussion

The primary aim of this study was to examine the extent to which individuals were more likely to share political information conveyed in a humorous than a non-humorous manner and whether brain activity in regions chosen for their role in understanding other people's mental states – mentalizing – and reward, is associated with sharing political information with others. We used fMRI to measure simultaneously activity within brain regions chosen for their roles in mentalizing and reward processes as individuals were exposed to humorous and non-humorous news stories. Furthermore, we utilized carefully constructed news segments created by professional writers and actors in order to isolate the causal effects of humor on brain activity, information sharing, and memory.

Individuals were more likely to share news stories delivered in a humorous than non-humorous format (H1). Across studies 1 and 2, data from people's intention to share ratings indicate that participants were more likely to share humorous than non-humorous news clips via email and social media. There were no differences in their likelihood of sharing humorous and non-humorous news clips via face-to-face conversations in both studies 1 and 2. This difference across media may due the nature of our stimuli (short video clips) as it is likely easier to share short videos via electronic media.

Humorous news stories elicited greater activity in brain regions associated with mentalizing than non-humorous news stories (H2). In particular, our analyses revealed that humorous news stories elicited greater neural activity in the left temporoparietal junction (LTPJ) and right superior temporal sulcus (RSTS) compared to non-humorous news stories. Likewise, our whole brain analysis we found that humorous clips elicited greater activity than non-humorous clips in several regions implicated in mentalizing, including LTPJ, RTPJ, RSTS and DMPFC. Furthermore, consistent with recent neurally-grounded theories of information sharing (Baek, Scholz, O'Donnell, & Falk, 2017; Scholz et al., 2017), we found that activity in the LTPJ, RSTS, and RTPJ was positively associated with intentions to share information about the news clips via social media.

In prior work, different regions within the mentalizing system have been associated with distinct aspects of mentalizing and social cognition more broadly. For example, the LTPJ has been suggested to play a particular role in reflecting on another person's beliefs (Saxe & Powell, 2006) while the DMPFC plays a more general role as in when individuals assess social information such as personality traits (Beer & Ochsner, 2006; Mitchell, Cloutier, Banaji, & Macrae, 2006), social status (Muscatell et al., 2012), and emotional facial expression (Brunet-Gouet & Decety, 2006). We found support in both our planned region of interest and exploratory whole brain search that humorous clips activated LTPJ and RSTS more than non-humorous clips. Although we did not observe robust support for an association between humor and DMPFC in our planned region of interest analyses, we did observe activations in a sub-cluster of DMPFC in a whole-brain search. Thus, it is possible that perspective taking (more robustly associated with LTPJ and RSTS) is a key component of mentalizing relevant to processing humorous news clips and deciding whether to share them, or that the DMPFC subregion of the mentalizing system consists of neurons which

respond to humor, as well as other neurons which don't. As a result, in a large region of interest that averaged across sub-regions that were more and less responsive to humor, we did not detect a significant effect, whereas the whole brain analysis did identify a more focal cluster in DMPFC which responded to humor. These findings are consistent with the notion that thinking about the mental state of others with whom to share information is indexed by neural activity in these regions (for a review, see Falk & Scholz, 2018).

We also found support for our hypotheses linking brain activity in LTPJ, RSTS and RTPJ to sharing (H3). Specifically, we found that increased activation in brain regions that showed greater activation to humorous clips, including LTPJ and RSTS, along with RTPJ, were positively associated with participants' intentions to share the clips online. This is consistent with the idea that considering other people's possible reactions to content is associated with motivation to share (Scholz et al., 2017; Baek et al., 2017; Tamir & Meshi, 2015). However, activity in these brain regions does not allow us to infer the target of mentalizing activity (e.g., family member or friends of participants) nor the reasons for why they may wish to share information (e.g., whether driven by self-interest such as wanting to look good or persuade another person or altruistic reasons such as wanting to make them laugh or stay informed). Further, as described in more detail below, activation within these brain regions does not correspond in a one-to-one manner with mentalizing. For example, consistent with prior theoretical views that humor increases attention to information (Hardy, Gottfried, Winneg, & Jamieson, 2014; Kim & Vishak, 2008), activity in LTPJ has also been associated with attention-reorientation (Corbetta et al., 2008), which could occur as a result of social or non-social processes.

We found support for Hypothesis 4: Individuals were more likely to remember political information delivered in a humorous than non-humorous fashion. This positive effect of humor on

memory performance was observed in the recall test in study 1 and the finding was replicated in study 2. For the recognition memory test, we observed a positive effect of humor on memory performance for study 1 but we found no difference in people's recognition memory for the policy information across the humorous and non-humorous conditions in study 2. Given that the recall exercise tested people's ability to remember gist-like representations of the policy issues (e.g., the general topic discussed) and the recognition test measured people's ability to remember more specific details about the policies, our findings suggest that the memory-enhancing effects of humor on gist memory may be more robust to differences in learning contexts than memory for specific details of political information.

We did not observe positive associations between any of our focal regions of interest related to mentalizing and recall (H5). Although we did observe that decreased activity in brain regions that were less active to humorous (vs. non humorous) clips, including PC and MMPFC, were also associated with reduced recall.

We did not find that humorous news stories were more likely to elicit greater activity in regions of ventral striatum and VMPFC (chosen for their role in reward processing) than non-humorous news stories (H6). In addition, neural activity in reward regions were not associated with increased remembering (H7) and sharing (H8).

In the case of the ventral striatum, and contrary to previous studies in other domains examining the neural regions associated with responses to humor (Mobbs et al., 2003), there were no differences in the neural activity between the humorous and non-humorous news stories (although the sign of the regression coefficient is in the predicted direction). One likely explanation for this result is that our sample found the humorous news stories to be only mildly funnier than the non-humorous news stories. Thus, it is possible that clips perceived as highly funny (such as

clips taken from actual news shows) would show effects in these brain regions. This is a possibility that future research can explore.

Collectively, our findings are consistent with the theoretical view that humor may increase considerations of others beliefs or mentalizing given the social goals that can be accomplished by sharing information with others. Furthermore, to our knowledge, the role of mentalizing processes has not been emphasized in theoretical models that explain why individuals are likely to direct higher levels of attention to political information when it is delivered in a humorous versus a non-humorous format (Baum, 2003; Hardy et al., 2014; Kim & Vishak, 2008). Considerations of the role played by mentalizing processes are important given emerging empirical evidence from other domains suggesting that information conveyed in a humorous manner can have positive effects on internet virality for some types of social information (Taecharungroj & Nueangjamnong, 2015). In addition, much of the information people encounter in their everyday lives is obtained second-hand through interpersonal channels (Hirst & Echterhoff, 2012).

Despite the promising results, however, the findings should be interpreted in light of the study's limitations. The participants across both studies were not a nationally representative sample. Our samples consisted mainly of individuals who self-identified as Democrat or liberal. This is important given emerging work suggesting that liberals and conservatives differ in the types of humor they perceive as funny (Young, 2019; Young et al., 2019). For example, conservatives are less likely to appreciate exaggerated and ironic form of humor compared to liberals (Young et al., 2019). Our stimuli primarily consisted of ironic humorous juxtapositions – which were perceived as funny by a largely liberal sample. Conservatives, then, may be less likely to share this type of humorous information than non-humorous information, compared to liberals. Furthermore, if people of different political orientations find different types of stimuli funny, then humor type

may moderate the relationship between mentalizing and sharing. Future work should investigate the extent to which the effects we observe here are also obtained for an ideologically-balanced sample of people, and the extent to which variability in humor type might moderate these effects.

In this study, our primary goals were to examine the extent to which humor can causally increase mentalizing, memory, and sharing of political information. Thus, we intentionally did not choose well-known, highly partisan/affectively charged issues (e.g., gun control, affirmative action, immigration, abortion) because we wanted to minimize the effects of differences in participants' prior knowledge about the issues and perceptions that the clips are offensive. The stimuli, therefore, are not representative of the broad array of policies that populate the political environment and cannot speak to contexts in which the use of humor in conveying political information may be more likely to be perceived as inappropriate or offensive (see Nabi, Moyer-Guseé, & Byrne, 2007).

Similarly, we controlled for many factors that would not exist in naturalistic contexts and are likely to change how humor affects people's memory for political information. For example, people tend to have prior knowledge about news anchors and viewers may have positive/negative affective associations tied to specific anchors. Existing shows (e.g., The Daily Show) may also be funnier than our clips and, thus, could produce stronger reward responses at the moment of exposure and while anticipating engagement with humorous content.

Our interpretation of brain activity and its relationship to cognitive processes is also based on reverse inference (see Weber et al., 2015). That is, we hypothesize that humor should elicit greater levels of mentalizing, and then operationalize greater mentalizing in terms of brain activity in specific regions (e.g., e.g., TPJ, DMPFC). Within this context, we treat activation in hypothesized brain regions as being due to engagement of a specific psychological process (e.g.,

mentalizing). However, alternative processes (ones other than mentalizing) may also be indexed by the brain activity we observe in our task. For example, activation within LTPJ has also been associated with attention-reorientation (Corbetta et al., 2008). In other words, reverse inference limits our ability to make definitive conclusions about the psychological processes observed (Poldrack & Wagner, 2004). Note that issues associated with reverse inference are not exclusive to fMRI as they are also applicable to other survey-based, behavioral (e.g., response times) and psychophysiological techniques (e.g., skin conductance response) used by communication scholars (Coronel & Falk, 2017). With this limitation in mind, it is still important to note that we find activation in brain regions that are consistent with our pre-registered and theory-driven hypotheses about underlying psychological processes, adding evidence to the line of research.

Despite these limitations, our studies highlight the utility of combining multiple measures to examine cognitive and affective processes involved as people are exposed to media content. fMRI allowed us to simultaneously examine multiple neurocognitive processes as individuals were exposed media content. Future work can utilize the paradigm and analytical approaches we developed here to study the involvement of multiple processes -- such as the activation of brain systems implicated in mentalizing and reward -- in message processing of other entertainment-based content. For example, future studies can examine the extent to which other message formats, such as narratives, or other forms of humor, may increase activation in similar or different regions. In addition, studies can use fMRI to study other mechanisms, beyond those targeted here, that can underlie sharing of humorous political information.

Although we focused on mentalizing here, there are other theoretical views that may provide other explanations for why individuals are more likely to share humorous political information. For example, broaden-and-build theory (Fredrickson, 2001) postulates that positive

emotions broaden individuals' momentary thoughts and actions, leading them to pursue a wider range of thoughts and behaviors. These larger repertoires of thoughts and actions have been theorized to have evolutionary usefulness because they can allow individuals to build a variety of resources including friendships and social support networks. In the context of sharing media content, previous work has used broaden-and-build theory to explain why individuals may share pro-social media content with others (Clayton et al., 2019). Other scholars have theorized that emotional shifts that occur over the course of consuming media content (e.g., shift from a neutral to a happy state) may also create a desire to share the content with others (Nabi & Green, 2014). These different processes may occur simultaneously and future work can examine their individual and joint involvement in social sharing of political information.

In terms of other future work, we expect this process of mentalizing to occur generally, across different contexts, intended audience, and modality, because individuals need to consider how people will respond if a communicator shares a particular piece of humorous information with an audience. For example, mentalizing may occur at the time of exposure to a humorous political message, as communicators begin to consider with whom they may share the joke in order to fulfill a social goal. Or, they can engage in mentalizing at a later point -- long-after exposure to the message -- if a context arises in which sharing humorous political information would accomplish a social goal. Furthermore, mentalizing in response to humor should occur regardless of whether the intended audience is a single individual (in a face-to-face conversation) or a broad audience such as one's network on social media (although the base levels of mentalizing are greater for narrow vs. broadcasting; Scholz, et al., 2019, we expect that humor would increase these levels in both cases). In addition, future research that examines ways of increasing mentalizing (and in turn memory and sharing) beyond the use of humor could also be fruitful.

Finally, future work can examine the use of humor to convey information about highly partisan issues and contexts where sharing humorous information may be perceived as inappropriate. Mentalizing is relevant in these contexts because a communicator's assessment of whether it is appropriate or inappropriate to share humorous political information with a specific person, likely requires that they assess the receiver's values and attitudes to determine whether the receiver will find the information funny or offensive (e.g., "this person has strong feelings about immigration and will likely not find jokes about immigration funny, and may even get angry"). Our study, then, compels further investigations into mentalizing and its role in social sharing for political information that individuals possess a high level of knowledge and emotional associations (i.e., highly partisan issues).

In summary, our results show that conveying information in a humorous than a non-humorous format can increases people's considerations of others' beliefs and likelihood of sharing information with others. Furthermore, delivering information in a humorous manner can enhance memory for political information. Critically, humor has important causal effects on increasing brain activity in key brain regions involved in social cognition, improving memory for political information, and increasing people's tendency to share information with others.

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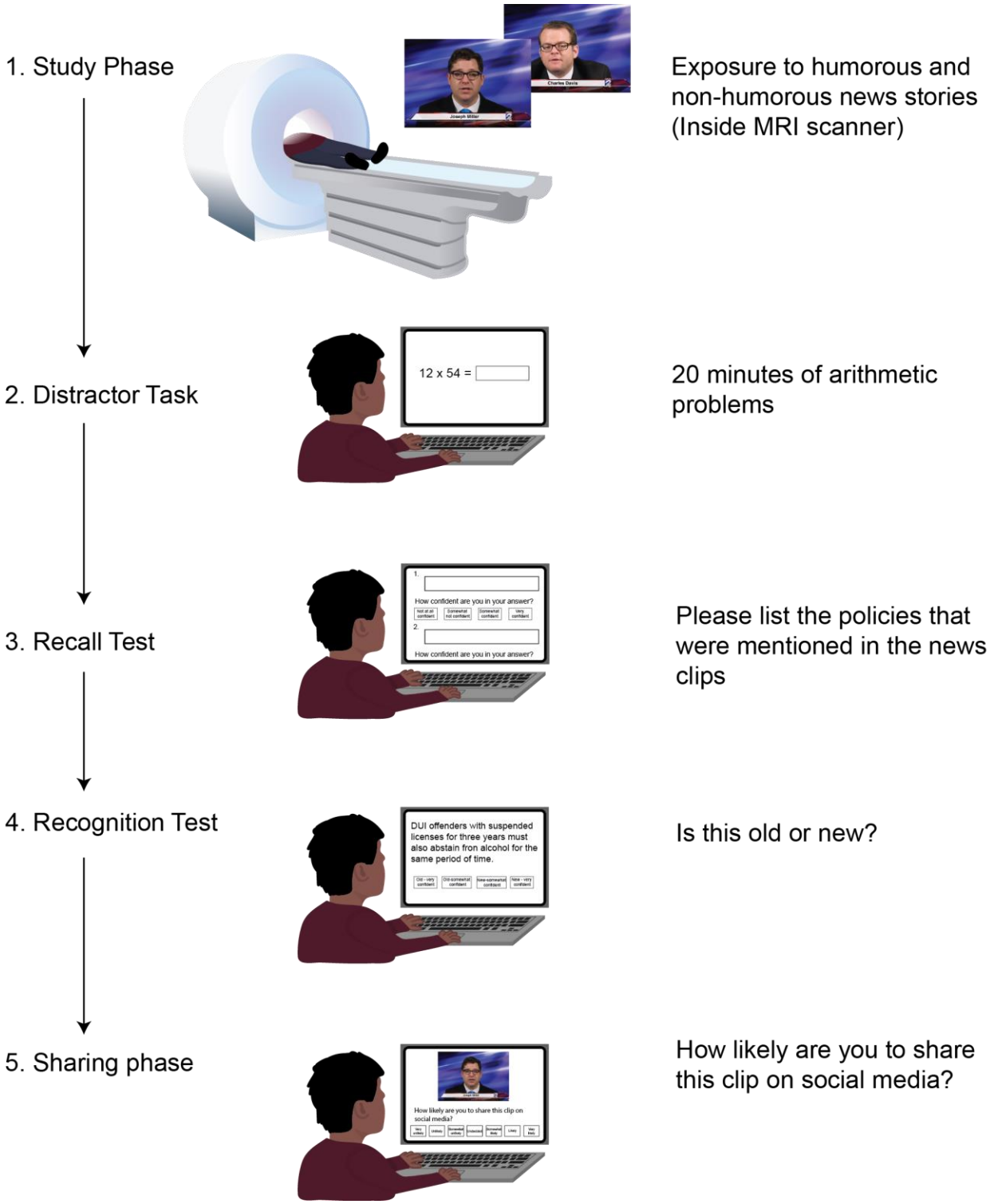


Figure 1

Schematic design of study. Note: In study 1, all phases took place seated at a computer in a behavioral lab. In study 2, the "study phase" took place inside an MRI scanner.

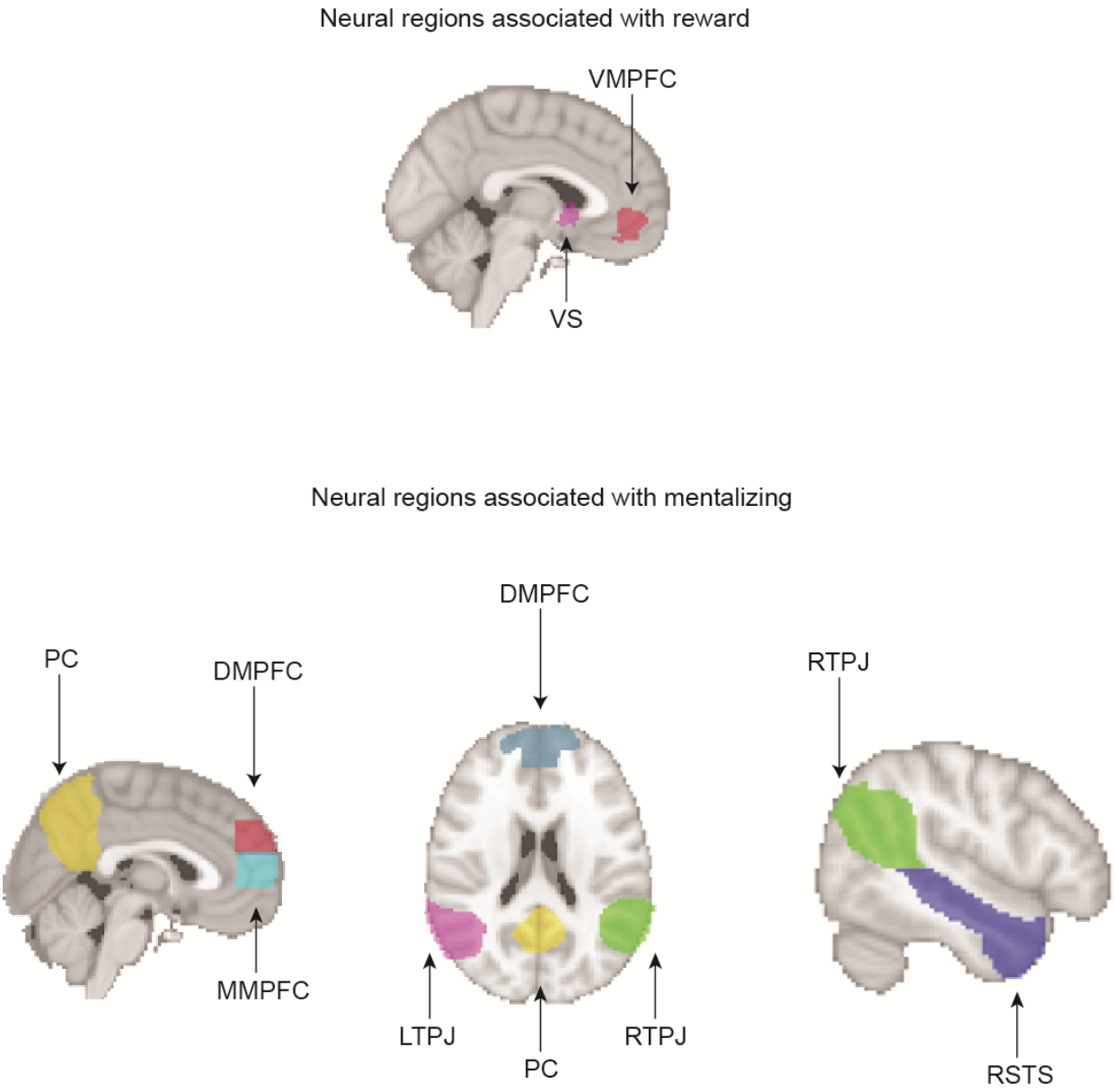
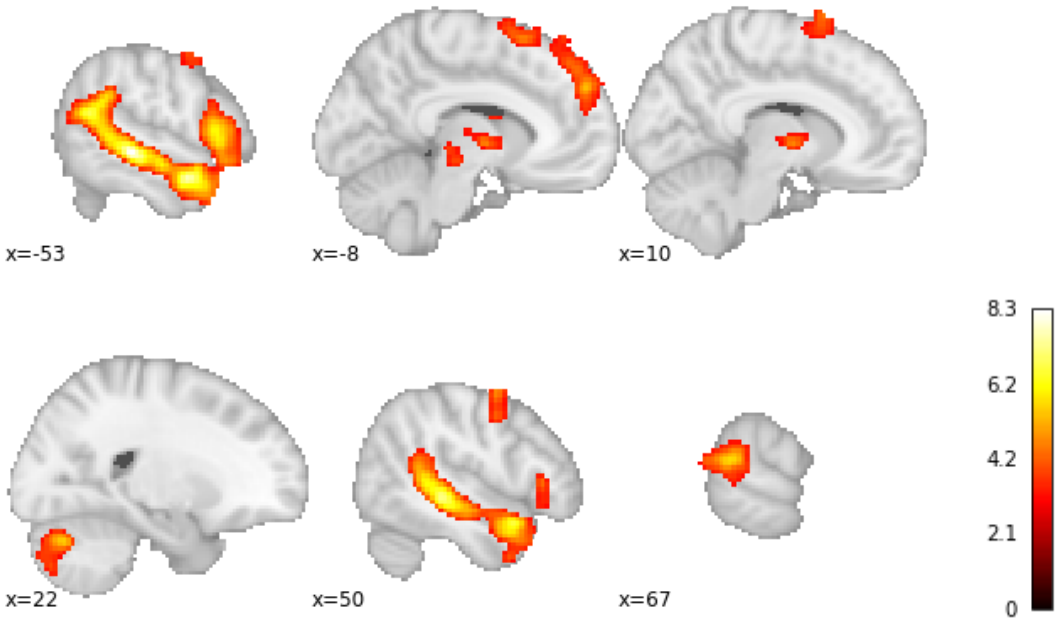


Figure 2

Neural regions of interest associated with (top) reward/ valuation identified in a meta-analysis of positive valuation, and (bottom) mentalizing, chosen from a large-scale study of mentalizing.



Region	R/L	X	Y	Z	Peak Stat	k
MTG	L	-53	-32	-5	8.33	3414
LSTS	L	-53	1	-20	7.72	
IFG	L	-46	21	-10	7.21	
LTPJ	L	-53	-57	-18	6.89	
MTG	R	50	-32	-5	7.29	1864
RSTS	R	52	8	-20	7.12	
RTPJ	R	67	-42	18	5.78	
Cerebellum	R	22	-72	-30	5.58	290
DMPFC	L	-8	53	33	5.40	316
Thalamus	L	-6	-7	3	4.75	331
Globus Palidus	R	10	-5	0	4.67	

Note. BA = Brodmann area, R = right, L = Left, M = Medial, X, Y, and Z coordinates correspond to the Montreal Neurological Institute (MNI) standard brain. Peak Stats are t-statistics. K = number of voxels per cluster. Only positive associations for HUMOR > NON-HUMOR are shown. Thresholded at $p < 0.005$ uncorrected and $K > 281$ based on 3dClustSim simulation, corresponding to p<.05, corrected. DF = 1, 47, Voxel size = 2.5 x 2.5 x 2.5 mm. *Peak voxel within cluster. MTG = Middle Temporal Gyrus; TPJ = Temporoparietal Junction; LSTS = Left Superior Temporal Sulcus; RSTS = Right Superior Temporal Sulcus DMPFC = Dorsal Medial Prefrontal Cortex. Peak Stat values are t-statistics.

Figure 3
Exploratory Whole Brain Search

Table 1

Sample of News Stories.

Humorous	Non-Humorous
Lawmakers want to take speed camera technology statewide by installing 170 new traffic cameras over the next five years. *This is being touted as an alternative to the previous policy of having drivers simply take selfies whenever they break the law.*	Lawmakers want to take speed camera technology statewide by installing 170 new traffic cameras over the next five years. *This is being touted as an alternative to the previous policy of relying on the state police to ticket speeders.*
An initiative will soon bar the government from transferring tax funds to businesses except for the purchase of property, goods or services. *So, you know, everything you use money for.*	An initiative will soon bar the government from transferring tax funds to businesses except for the purchase of property, goods or services. *This limits almost everything tax funds are used for.*
Gambling will soon be legal 24 hours a day and seven days a week, so that 20 percent of the revenue can be used to fund community colleges. *This is outrageous. If gambling is legal all day every day, who is going to have time for college?*	Gambling will soon be legal 24 hours a day and seven days a week, so that 20 percent of the revenue can be used to fund community colleges. *Some have called this measure outrageous. Some are worried that it may increase gambling from students.*
Any contributions to elected officials exceeding 250 dollars will have to be posted on the official's website, along with the donor's name. *Finally, a way to publicly brag about having more than 250 dollars.*	Any contributions to elected officials exceeding 250 dollars will have to be posted on the official's website, along with the donor's name. *This will publicly recognize people who give more than 250 dollars.*
State agencies are now permitted to sell advertising space on their websites or property. *Because nothing makes you take the government seriously like seeing a Taco Bell commercial.*	State agencies are now permitted to sell advertising space on their websites or property. *Some are worried that people may not take the government seriously if they have commercial ads on their websites.*
The state will soon shift taxes from small business owners on to homeowners. *Honey and kids, if you're watching this at home, I think now would be a good time to incorporate. I'll see you at home. I mean at the office*.	The state will soon shift taxes from small business owners on to homeowners. *Some are worried that this law might increase fraud. In particular, some homeowners might falsely claim their homes as the location of their businesses.*

Table 2

Intention to Share and Memory Accuracy

	Sharing						**Memory**	
	Face to Face		Email		Social Media		Recall	
	Study 1	Study 2	Study 1	Study 2	Study 1	Study 2	Study 1	Study 2
Humor	0.12 (0.15)	0.12 (0.12)	0.21* (0.10)	0.20** (0.07)	0.29** (0.11)	0.22*** (0.08)	0.60** (0.19)	0.65*** (0.19)

Note. Linear mixed-effects regression coefficients are shown with standard errors in parentheses for sharing analyses. Logistic mixed-effects regression coefficients with standard errors in parentheses are shown for memory analyses. For the dependent variable in the memory analyses, accurate memory = 1 and inaccurate/no memory = 0. Humor is the independent variable (humorous = 1, non-humorous = 0). *$p < .05$, **$p < .01$, ***$p < .001$.

Table 3

Neural activity in Mentalizing and Reward Regions

	Mentalizing Regions						**Reward Regions**	
	LTPJ	RTPJ	DMPFC	MMPFC	PC	RSTS	VMPFC	VS
Humor	0.009**	0.002	0.005	-0.0003	-0.01**	0.012**	-0.01**	0.0008
	(0.003)	(0.003)	(0.004)	(0.004)	(0.004)	(0.003)	(0.005)	(0.003)

Note. Brain regions chosen for their role in mentalizing include: the right temporoparietal junction (RTPJ), left temporoparietal junction (LTPJ), dorsal and middle portions of the medial prefrontal cortex (DMPFC, MMPFC), the precuneus (PC), and right superior temporal sulcus (RSTS). Regions associated with reward include: the ventromedial prefrontal cortex (VMPFC) and the ventral striatum (VS). Linear mixed-effects regression coefficients are shown with standard errors in parentheses. Humor is the independent variable (humorous = 1, non-humorous = 0). *$p < .05$, **$p < .01$.

Table 4

Neural activity in Mentalizing Regions and Associations with Intentions to Share

	Intentions to Share	
	Email	Social Media
LTPJ	0.75 (0.54)	1.35* (0.57)
RTPJ	0.65 (0.57)	1.33* (0.60)
DMPFC	-0.02 (0.36)	0.41 (0.39)
MMPFC	-0.40 (0.37)	0.28 (0.40)
PC	-0.13 (0.38)	0.35 (0.40)
RSTS	0.52 (0.55)	1.19* (0.59)

Note. Note that the models are liner mixed-effects regressions, focused on outcomes which were responsive to humor (i.e., showed differences between humorous and non-humorous conditions). Mentalizing regions include the right temporoparietal junction junction (RTPJ), left temporoparietal junction (LTPJ), dorsal and middle portions of the medial prefrontal cortex (DMPFC, MMPFC), the precuneus (PC), and right superior temporal sulcus (RSTS). As specified in the preregistration document, these models were estimated with the humor variable (humor = 1, non-humor = 0) as a covariate. *$p < .05$.