

Neuroscience

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Given the complex nature of research questions addressing communication processes and effects, it is no surprise that theoretical advances have arisen out of scholarship from multiple disciplines, including communication studies, health, political science, economics, marketing, biology, and psychology. Recently this interdisciplinary approach has also expanded to include neural processes primarily examined through neuroimaging techniques, thus giving rise to a subfield: communication neuroscience. Communication neuroscience complements existing biological paradigms in communication studies by mapping neural mechanisms that are active during communication processes and treats neural activity as an outcome, predictor, mediator, or moderator of communication processes and outcomes. For example, communication neuroscience aims to understand how messages delivered via media or interpersonal communication influence individuals, groups, and populations; and it does so by examining the neural mechanisms associated with message-processing and subsequent behavioral outcomes (Falk, 2010).

The growth of communication neuroscience has been made possible by advances in methods for measuring and manipulating neural activity. Neuroimaging refers to a broad set of techniques such as functional magnetic resonance imaging (fMRI), magnetoencephalography (MEG), positron emission tomography (PET), electroencephalography (EEG), functional near-infrared spectroscopy (fNIRS), transcranial magnetic stimulation (TMS), and transcranial direct-current stimulation (tDCS). This entry focuses primarily on findings from fMRI as one of the most common methods currently used to study communication processes and effects. Furthermore, within different neuroimaging methodologies, there are also many different analytical approaches; for example, within fMRI analysis, one might report results from whole brain or region of interest (ROI) analysis, brain-mapping or brain-as-predictor paradigms, results from average activation in specific regions, or their dynamic interplay with other regions, as assessed through functional connectivity analysis—to name just a few possibilities. Details concerning the wide range of neuroimaging techniques and analysis methods are beyond the scope of this review; however, further readings are suggested at the end of the entry.

Benefits and limits of neuroimaging

As with any set of methodologies, it is important to understand what information neuroimaging techniques provide and how that information can be used to advance

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communication theory and practice. One major advantage of neuroimaging methods is that they can provide insight into mental processes that occur in real time without any need for participant introspection and potentially by circumventing certain social desirability biases (Lieberman, 2010). Neural measures can then be used as outcomes, direct predictors, mediators, or moderators of communication processes and effects. Modeling these neural processes can explain unique variance in behavior and can provide insight into underlying mechanisms that remain unaccounted for when using self-report and other methods. It is important to note, however, that neuroimaging is not a replacement for other methods but rather should be used in conjunction with them, in order to better understand phenomena important to communication scholars and provide a more holistic representation of communication processes and effects. The aim of this entry is to highlight recent examples of communication neuroscience that illustrate the approach. Selected studies of message-processing, social influence, idea retransmission, media violence, and processing political information serve to illustrate a range of possibilities within the communication neuroscience framework and lead into a discussion of how these findings contribute to communication theory.

Message-processing

Within communication studies, neuroscience has been most used to date in the study of persuasive message-processing and its links to behavior change. Building on past theories of behavior change such as the theory of reasoned action, the theory of planned behavior, social cognitive theory, and the health belief model, neuroimaging research attempts to explain variance that is not currently captured by variables in these theories. In addition, neuroimaging research aims to reveal which underlying cognitive and affective mechanisms, independently or jointly, produce persuasive outcomes; in this way it gives researchers access to processes of which individuals may not be consciously aware.

Neuroimaging research examining persuasive messages has begun by investigating differences in neural processing during exposure to persuasive health messages in relation to subsequent behavior change. For example, during persuasive message exposure, individual differences in neural activity within the brain's medial prefrontal cortex (MPFC) predicted 23 percent of the variance in behavior one week later, above and beyond self-reported attitudes and intentions (Falk, Berkman, Mann, Harrison, & Lieberman, 2010). Falk and colleagues' (2010) study demonstrates how neuroimaging data can predict unique variance in behavior that is currently not captured by other methods. From a theoretical perspective, the MPFC is a region commonly associated with self-processing, and the authors suggest that persuasive messages may be successful, at least in part when message content is incorporated into one's self-concept. In a follow-up study examining the relationship between MPFC activity during antismoking advertisements and smoking behavior, researchers found that increased activity in the MPFC was associated with reductions in smoking one month after the neuroimaging appointment (Falk, Berkman, Whalen, & Lieberman, 2011). Furthermore, research examining specific subregions of the MPFC—those

involved in self-processing and valuation—during antismoking messages found that increased activity in the MPFC was associated with reductions in smoking behaviors (Cooper, Tompson, O'Donnell, & Falk, 2015). In addition, the ability to predict behavior change was specific to MPFC activity during message exposure, not due to individual differences in recruiting the MPFC during a more general self-related processing task (Cooper et al., 2015). Building on these results, recent data have also used psychological techniques to manipulate neural activity within the MPFC; in a study of physical activity behavior change, researchers used self-affirmation to increase activity within the MPFC and observed that such increases were related to greater behavior change in the subsequent month (Falk et al., 2015).

Finally, activity in the MPFC during health message exposure in a sample population has been shown to predict population-level media effects. In one study smokers were shown three different quitline help campaigns (10 messages in total) during an fMRI session and were asked to report how effective they felt each campaign was. Increased MPFC activity during message exposure predicted the volume of population-level calls to the quitline with greater accuracy than self-reported message evaluations (Berkman, Lieberman, & Falk, 2012). In addition, a second study examined neural activity in self-related processing regions during exposure to antismoking messages in 50 smokers. The team used this neural activity to predict population-level click-through rates from an antismoking e-mail campaign (Falk, O'Donnell, et al., 2014). Overall, these studies highlight the role of self-related processing and valuation in persuasive message-processing in ways that have not been emphasized by prior theory.

Social influence

Social influence can alter attitudes and behaviors under a variety of circumstances. For example, social norms are modeled during interpersonal communication, in advertisements, public service announcements, and television shows, and on social network sites. Individuals are often unaware, however, of the extent to which social information influences their behavior. Thus gaining a better understanding of the mechanisms that drive social influence may give new theoretical insights, which extend beyond a participant's conscious knowledge. Converging evidence suggests that brain systems associated with valuation and conflict detection are core drivers of conformity (Casio, Scholz, & Falk, 2015; Izuma, 2013).

Sensitivity to conflict and social threats

Initial studies on conformity find that increased activity in the dorsal anterior cingulate cortex (dACC), a region implicated in conflict detection, and in the anterior insula (AI), a region often implicated in negative arousal, is associated with updating one's behavior in response to information that one's opinion is misaligned with that of the group. In order to test whether conflict detection is a core component of social influence, processing researchers examined whether conformity would take place when conflict detection regions were interrupted (Klucharev, Munneke, Smidts, & Fernández, 2011).

Using TMS, a technique that can stimulate the brain in order to increase or decrease activity in particular regions, researchers were able to downregulate (reduce) activity in a region of the cortex that includes the dACC during a social influence task, and this resulted in significantly less conformity (Klucharev et al., 2011). Overall, these studies are consistent with the idea that perceiving opinions that differ from one's own elicits a conflict signal and an associated arousal, which in turn motivates individuals to update their behavior so as to align with the group (even if more research is needed in order to establish a causal order between environmental distress, neural conflict signals, and behavior change). Additional research also suggests that individual differences in neural sensitivity to exclusion within conflict-sensitive regions predict susceptibility to influence (Falk, Cascio, et al., 2014): those who are more sensitive to negative social experiences may conform in order to maintain group harmony. This is consistent with the idea that conformity and compliance serve to maintain group harmony.

Sensitivity to social rewards and value

Although conflict detection systems seem to play a crucial role in conformity, evidence suggests that reward or valuation systems, including the ventral striatum (VS) and the ventral medial prefrontal cortex (VMPFC) also play an integral role in updating one's behavior toward alignment with group opinions. For example, in one study of conformity, agreeing with expert opinions on music was correlated with reward processing (Campbell-Meiklejohn, Bach, Roepstorff, Dolan, & Frith, 2010). Reward activity has also been linked to conforming to indirect social norms. For example, a study examining the social norms conveyed by price found that VMPFC activity positively correlated with the price of wine, despite the fact that participants tasted the same wine on each trial (Plassmann, O'Doherty, Shiv, & Rangel, 2008)—in other words, the social cue (price) influenced the perceived reward associated with consuming the wine. Overall, these studies suggest that individuals internalize the value that others place on a stimulus, whether direct or indirect. Having such sensitivity to social threats and rewards, which in turn motivates attitude and behavior change, may reinforce social connections with others.

Retransmission

The research above focuses on neural activity associated with being influenced. This section directs attention to the equally important question of neural processes associated with sharing or retransmitting ideas to others. Such word-of-mouth recommendations are found during face-to-face interpersonal communication and throughout the current media environment. Although neuroimaging research in this area is relatively new, consistent findings are already beginning to emerge among studies that have examined communicators who effectively influence others. Specifically, these studies find increased activation in the temporoparietal junction (TPJ) to be associated with being a good "idea salesperson" (Dietvorst et al., 2009; Falk, Morelli, Welborn, Dambacher, & Lieberman, 2013); TPJ is a region commonly associated with perspective-taking

and considering the intentions of others, which is termed “mentalizing.” In one fMRI investigation, researchers examined neural activity during exposure to television-show ideas that participants later described to others. Results from this study demonstrated that participants who displayed greater activity in the bilateral TPJ during initial exposure to the ideas later showed greater success in effectively persuading others to have the same opinions during the retransmission part of the task. The authors concluded that those who successfully propagate their opinions to others may be engaging in greater perspective-taking or mentalizing during initial idea-encoding (Falk et al., 2013).

In addition, research examining the effectiveness of a salesperson’s ability to take his or her customers’ perspectives found that increased activity in the bilateral TPJ and in the MPFC was associated with an increased likelihood of mentalizing about customers’ cognitive states, which was also correlated with increased sales performance (Dietvorst et al., 2009). This study in particular is important for two reasons. First, it supports the idea that successful retransmission of ideas and information to others can be attributed in part to one’s ability to take the perspective of others. Second, it provides an example of how to effectively integrate self-report methodology with neuroimaging in order to better understand a real-world phenomenon.

Finally, research has also examined the intersection of social influence and retransmission—how the opinions of others can influence our own recommendations. In one study (Cascio, O’Donnell, Bayer, Tinney, & Falk, 2015)—which is convergent with the neural correlates of conformity to social influence against one’s own preferences—greater activity in valuation regions was associated with a greater likelihood to conform to peer opinions when making recommendations to others. In line with neural correlates of retransmission, individual differences in right TPJ activity predicted the likelihood that participants would use social information to update their recommendations (Cascio, O’Donnell, et al., 2015). Overall, these studies suggest that increased mentalizing is associated with more effective propagation, as well as with susceptibility to social influence in recommendation contexts.

Media violence

One of the most widely studied areas of media effects research is media violence. Studies examining media violence exposure have found evidence for both short, and long-term links to aggression. However, despite empirical evidence, some scholars contend that the link between violent media exposure and aggression is not straightforward. Neuroimaging may be uniquely positioned to inform this discussion. For example, neuroimaging methods can be used to examine the underlying processes that take place at the time of violent media exposure, thus helping to determine whether violent media alter mechanisms that contribute to future aggressive behaviors. Current neuroimaging research on video-game play has found that exposure to violent by comparison with nonviolent video-game play is associated with increased activity in the dACC—a region associated with conflict detection—and with decreased activity in the amygdala and rostral anterior cingulate cortex (ACC)—regions implicated

in emotional salience and regulation (Weber, Ritterfeld, & Mathiak, 2006). Further neuroimaging research examining violent video games found that exposure to them is correlated with decreased activity in cognitive control regions during a response inhibition task (Hummer et al., 2010). Although these studies cannot directly speak to changes in aggressive behavior due to violent media exposure, together they both suggest that viewing violent media is associated with changes in emotional regulation and cognitive control. In addition, these data are consistent with a desensitization account of media violence effects, though substantially more work is needed to link this activity to relevant affective, cognitive, and behavioral outcomes.

Political information-processing

Vast amounts of money are spent on political campaigns, and one important question is whether exposure to different issue positions taken by political candidates shapes voter behavior, even if voters don't remember specific facts. Current research explored this question by examining whether voters who cannot remember candidates' issue positions can still vote intelligently. More specifically, researchers examined voting behaviors of healthy adults and of amnesic patients with hippocampal damage (Coronel et al., 2012). Hippocampal damage renders amnesic patients unable to remember factual details like issue position but does not affect their ability to experience and form emotional memories. Participants were exposed to experimentally manipulated issue positions where one candidate's positions were manipulated to be congruent with the participants' political beliefs, a second candidate was made to look incongruent, and a third irrelevant. Findings indicated that amnesic patients consistently voted for congruent candidates and against incongruent candidates, despite not being able to remember issue positions. These data confirm the theoretical claim that voters can implicitly tally affective information, which in turn influences their behavior even in cases where the voter cannot remember specific issue positions (Coronel et al., 2012). Although this is not a traditional neuroimaging study, this alternative neuroscience method represents a unique approach to advancing communication theory that would not be possible by using other methods.

Conclusion

This entry highlighted examples of findings in communication neuroscience and discussed how empirical findings can be used to help advance research questions within communication studies. Building on past traditions of utilizing biological measurement in communication studies, neuroscience methods, including neuroimaging, are beginning to benefit our understanding of media effects research and have potential to contribute to a wide range of questions in interpersonal and mass communication research more broadly. Overall, using multiple methods such as self-report, behavioral observation, psychophysiology, and neuroimaging will ultimately lead to a greater understanding of interpersonal communication and media effects and processes.

SEE ALSO: Attitude; Behavior, Behaviorism, and Behavioral Sciences; Biology; Persuasion and Social Influence; Psychology

References and further readings

- Berkman, E. T., Lieberman, M. D., & Falk, E. B. (2012). From neural responses to population behavior: Neural focus group predicts population-level media effects. *Psychological Science, 23*(5), 439–445.
- Campbell-Meiklejohn, D. K., Bach, D. R., Roepstorff, A., Dolan, R. J., & Frith, C. D. (2010). How the opinion of others affects our valuation of objects. *Current Biology, 20*(13), 1165–1170.
- Cascio, C. N., O'Donnell, M. B., Bayer, J., Tinney, F., & Falk, E. B. (2015). Neural correlates of susceptibility to group opinions in online word-of-mouth recommendations. *Journal of Marketing Research, 52*(4), 559–575.
- Cascio, C. N., Scholz, C., & Falk, E. B. (2015). Social influence and the brain: Persuasion, susceptibility to influence and retransmission. *Current Opinion in Behavioral Sciences, 3*, 51–57.
- Cooper, N., Tompson, S., O'Donnell, M. B., & Falk, E. B. (2015). Brain activity in self- and value-related regions in response to online antismoking messages predicts behavior change. *Journal of Media Psychology, 27*(3), 93–108.
- Coronel, J. C., Duff, M. C., Warren, D. E., Federmeier, K. D., Gonsalves, B. D., Tranel, D., & Cohen, N. J. (2012). Remembering and voting: Theory and evidence from amnesic patients. *American Journal of Political Science, 56*(4), 837–848.
- Dietvorst, R. C., Verbeke, W. J. M. I., Bagozzi, R. P., Yoon, C., Smits, M., & van der Lugt, A. (2009). A salesforce-specific theory of mind scale: Tests of its validity by multitrait-multimethod matrix, confirmatory factor analysis, structural equation models, and functional magnetic resonance imaging. *Journal of Marketing Research, 46*(5), 6653–6668.
- Falk, E. B. (2010). Communication neuroscience as a tool for health psychologists. *Health Psychology, 29*(4), 346–354.
- Falk, E. B., Berkman, E. T., Mann, T., Harrison, B., & Lieberman, M. D. (2010). Predicting persuasion-induced behavior change from the brain. *The Journal of Neuroscience, 30*(25), 8421–8424.
- Falk, E. B., Berkman, E. T., Whalen, D., & Lieberman, M. D. (2011). Neural activity during health messaging predicts reductions in smoking above and beyond self-report. *Health Psychology, American Psychological Association, 30*(2), 177–185.
- Falk, E. B., Cascio, C. N., O'Donnell, M. B., Carp, J., Tinney, F., Bingham, C. R., ... Simons-Morton, B. G. (2014). Neural responses to exclusion predict susceptibility to social influence. *Journal of Adolescent Health, 54*, S22e–S31.
- Falk, E. B., Cascio, C. N., O'Donnell, M. B., Shumaker, K., Tinney, F., Kang, Y., ... Strecher, V. (2015). Self affirmation alters the brain's response to health messages and subsequent behavior change. *Proceedings of the National Academy of Sciences, 112*(7), 1977–1982.
- Falk, E. B., Morelli, S. A., Welborn, B. L., Dambacher, K., & Lieberman, M. D. (2013). Creating buzz: The neural correlates of effective message propagation. *Psychological Science, 24*(7), 1234–1242.
- Falk, E. B., O'Donnell, M. B., Tompson, S., Gonzalez, R., Dal Cin, S., Strecher, V. J., Cummings, K. M., & An, L. (2015). Functional brain imaging predicts public health campaign success. *Social Cognitive and Affective Neuroscience, nsv108*.
- Hummer, T. A., Wang, Y., Kronenberger, W. G., Mosier, K. M., Kalnin, A. J., Dunn, D. W., & Mathews, V. P. (2010). Short-term violent video game play by adolescents alters prefrontal activity during cognitive inhibition. *Media Psychology, 13*(2), 136–154.

- Izuma, K. (2013). The neural basis of social influence and attitude change. *Current Opinion in Neurobiology*, 23(3), 456–462.
- Klucharev, V., Munneke, M., Smidts, A., & Fernández, G. (2011). Downregulation of the posterior medial frontal cortex prevents social conformity. *Journal of Neuroscience*, 31(33), 11934–11940.
- Lieberman, M. D. (2010). Social cognitive neuroscience. In S. T. Fiske, D. T. Gilbert, & G. Lindzey (Eds.), *Handbook of Social Psychology* (5th ed., pp. 143–193). New York, NY: McGraw-Hill.
- Plassmann, H., O’Doherty, J., Shiv, B., & Rangel, A. (2008). Marketing actions can modulate neural representations of experienced pleasantness. *Proceedings of the National Academy of Sciences*, 105(3), 1050–1054.
- Weber, R., Ritterfeld, U., & Mathiak, K. (2006). Does playing violent video games induce aggression? Empirical evidence of a functional magnetic resonance imaging study. *Media Psychology*, 8(1), 39–60.

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