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Neuroimaging

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DOI
10.1002/9781119678816.iehc0600

Publication date
2023

Document Version
Author accepted manuscript

Published in
The International Encyclopedia of Health Communication

Link to publication

Citation for published version (APA):
Wang, X., Scholz, C., Falk, E. B., & Lydon-Staley, D. M. (2023). Neuroimaging. In E. Y. Ho, C. L. Bylund, & J. C. M. van Weert (Eds.), *The International Encyclopedia of Health Communication* (Vol. 4). (The Wiley Blackwell-ICA International Encyclopedias of Communication series). Wiley Blackwell. https://doi.org/10.1002/9781119678816.iehc0600

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Please cite as:

Wang, X., Scholz, C., Falk, E.B. and Lydon-Staley, D.M. (2022). Neuroimaging. In The International Encyclopedia of Health Communication (eds E. Ho, C. Bylund and J. van Weert). https://doi.org/10.1002/9781119678816.iehc0600

Neuroimaging

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Neuroimaging

Health communication is a complex, multi-determined process, a full understanding of which necessitates a consideration of biological, psychological, and sociocultural phenomena (Huskey et al., 2020). Communication neuroscience is a burgeoning subfield that complements a long history of biological approaches to communication. By considering the neural processes relevant to communication (Cascio & Falk., 2016; Coronel & Falk., 2017; Schmälzle & Meshi, 2020), communication neuroscience emphasizes that communication is an embodied process, occurring in, through, and to bodies (Cappella, 2020). For example, when media content designed to change health behavior is deployed in the context of behavior change interventions (Wakefield et al., 2010; Zhang et al., 2015), the content must be processed by an individual's brain before it can impact their behavior. Neuroimaging provides a tool to examine the mediating role of the brain in this health behavior change process (Falk et al., 2016; Schmälzle et al., 2020). To introduce communication scholars to the uses of neuroimaging in health communication, this entry will first provide an overview of neuroimaging methods used to measure brain activity, before highlighting opportunities and difficulties associated with the use of neuroimaging. Throughout, we present examples of recent communication neuroscience research applied to health communication.

Overview of Neuroimaging Methods

Neuroimaging refers to a suite of techniques that allow the direct or indirect observation of brain anatomy and function and includes electroencephalography (EEG), magnetoencephalography (MEG), positron emission tomography (PET), functional near-infrared spectroscopy (fNIRS), and functional magnetic resonance imaging (fMRI). Different neuroimaging techniques are distinguished by the temporal and spatial resolution of the resulting images they produce, their invasiveness, and the extent to which they provide direct access to the biological processes of interest (Bunge & Kahn, 2009). fMRI is increasingly used in communication science. As such, we focus our attention on this modality. fMRI is based on MRI, a neuroimaging method that uses strong magnetic fields and radio waves to produce images of the body. In its use in communication neuroscience, MRI captures images of three major components of anatomical structure: grey matter, white matter, and the ventricles of the brain. fMRI captures an indirect measure of neural activity occurring atop these anatomical structures, namely, changes in blood flow resulting from task-induced or spontaneous modulation of neural metabolism (Glover, 2011).

fMRI has several advantages over other neuroimaging methods that may account for its popularity in communication neuroscience. It is non-invasive and does not require injection of a radioisotope (e.g., as PET does), rendering it a relatively safe form of neuroimaging. It also has a relatively high spatial resolution (but note that it is unable to capture individual neurons and instead provides information about clusters of thousands of neurons) and provides insight into whole-brain function. Although fMRI has a slower temporal resolution relative to some neuroimaging approaches (e.g., <1 ms temporal resolution with EEG) due to its reliance on the dynamics of blood flow to capture neural activity, temporal inferences in the 100ms resolution range can be achieved with appropriate designs and analysis methods (Ogawa et al., 2000).

The technological marvels associated with fMRI, and neuroimaging in general, allow health communication researchers to peer inside the human head to gain insight into brain function. There are many ways to leverage the rich output available through fMRI. The diverse neuroimaging efforts applied to health communication to date can be described as approaches designed to identify the neural correlates of phenomena of interest, identify neural mechanisms mediating behavior change, and brain-as-predictor approaches. We discuss these three approaches in depth.

Neural Correlates of Health Communication Processes

fMRI and other neuroimaging tools may be used to identify the neural correlates of psychological processes at the heart of theories of health communication. Studies of neural correlates provide insight into how the brain responds during health communication processes and where in the brain the response may be localized. For example, by exposing participants in the fMRI scanner to arguments designed to persuade the adoption of health behaviors (e.g., flossing, smoking cessation, physical activity), scholars are providing insight into where in the brain persuasion processes occur (Cacioppo et al., 2018; Falk et al., 2011). Through careful variation of health communication message characteristics in the neuroimaging setting, the field is gaining a rich understanding of how the brain responds to a range of message characteristics, such as message sensation value (Langleben et al., 2009), argument strength (Wang et al., 2013), and fear appeals (Mostafa, 2020).

Most early studies searching for the neural correlates of health communication processes took the form of functional localization studies, examining average activity within individual brain regions. More recent studies have expanded to focus on distributed patterns of activity across the brain (Cosme et al., 2020; Dore et al., 2017), as well as how regions work together in networks, for example, to predict receptivity to health messages (Cooper et al., 2019). The emerging field of network neuroscience considers interactions between brain regions, responsive to the notion that individual regions seldom work in isolation (Bassett & Sporns, 2017). With fMRI data, the extent of interaction between brain regions is defined based on statistical similarities in the blood oxygen level dependent time series of clusters of neurons within putative functional areas (i.e., when activity in one region increases, activity in another region of the brain also increases; Friston, 2010; Power et al., 2011). These statistical similarities in how activity in multiple regions of the brain move together across time are theorized to represent communication or coordination among brain regions, though this interpretation is not without its controversies (Fingelkurts et al., 2005). Network neuroscience provides an important complement to localization approaches focusing on activity in individual regions, given the complex interplay among many neural systems that likely support health communication processes. We refer interested readers to Fisher et al. (2020) for a practical introduction to network neuroscience for communication researchers.

More Than Brain Mapping

Studies of neural correlates provide rich insight into how the machinery of the brain supports health communication processes. By peering into the brain and gathering physiological data, communication neuroscientists often go beyond brain mapping to test competing theories and generate new hypotheses. Such uses of neuroimaging are supported by the neural correlates work within health communication neuroscience but also a broader and older cognitive and affective neuroscience literature that has mapped cognitive and affective processes to the brain (Raichle, 2009; Yarkoni et al., 2011; though see discussion on the problem of reverse inference below).

For example, several decades of psychological and communication research demonstrated powerful effects of social norms on conformity (for a review, see Cialdini and Goldstein, 2004). However, in that line of work, questions remained about the degree to which people actually updated their own valuations of objects and ideas in response to social influence, or merely reported doing so due to social desirability concerns. A series of neuroimaging papers demonstrated that, beyond just public compliance, learning that others ascribed higher or lower value to a range of objects and ideas (i.e., music choice, phone app recommendation, rating of art) changed the participants' underlying valuation signals in the brain (Campbell-Mikeljohn et al., 2010; Cascio et al., 2015; Klucharev et al., 2009; Welborn et al., 2016; Zaki et al., 2011). This also applied to social influence on healthy food choices (Nook & Zaki., 2015). A growing body of research has also highlighted the importance of interpersonal influences in amplifying media effects on health behaviors (Jeong & Bae., 2018). Recent neuroimaging research, for example, highlights that two key psychological processes, self-relevance and social-relevance, feed into a common value signal that predicts whether health information (e.g., health news) is shared with others (Scholz et al., 2017). Thus, in addition to identifying neural correlates of health communication process of interest, peering into the brain has allowed novel insights into how successful health communication occurs.

Brain as Predictor and Health Communication

As well as providing insight into the neural correlates of health communication processes and providing physiological data that may be used to test competing theories and generate novel hypotheses, a brain-as-predictor approach has emerged as a useful application of neuroimaging in health communication (Berkman & Falk, 2013). The brain-as-predictor approach treats neuroimaging variables, such as neural responses to persuasive messaging, as independent variables that may be used to predict health communication outcomes of interest, including attitude and behavior change (for a review, see Falk & Scholz, 2018). In a small group of smokers who were exposed to graphic warning label-type anti-smoking messages while in the fMRI scanner, Falk et al (2016) discovered that activity in the medial prefrontal cortex, a region implicated in self-referential processing, was associated with population-level responses to these messages in a large-scale e-mail campaign . When exposed to anti-cannabis public service announcements (PSAs), Weber et al. (2015) observed that high-drug-risk individuals' message effectiveness ratings could be predicted by neural predictors identified in a smaller, independent sample. In a final example, Schmälzle et al. (2020) found that the success of online banner advertisements (operationalized as their click through rates when the banners aired online) associated with The Truth Initiative's *Ex* smoking cessation campaign could be predicted by message-evoked neural responses in theoretically relevant brain regions observed in a small, independent sample of cigarette smokers who were shown the banners while undergoing fMRI.

Notably, in many brain-as-predictor applications, neuroimaging indices are often predictive of health-relevant behaviors above and beyond self-reports, explaining previously unaccounted for variance in behavioral outcomes (Falk et al., 2016). This speaks to the additional information gained by examining neural responses to health communications. This additional information may partly reflect the ability for neuroimaging indices to overcome some limitations of self-reports, including social desirability effects (Booth-Kewley et al., 2007) or a lack of conscious access to factors implicated in behavior (Nisbett & Wilson, 1977). The ability to predict real-world health communication campaign success with neural responses in relatively small samples of participants suggests that the brain-as-predictor approach may be a useful tool in constructing media campaigns with the greatest potential to produce the desired health behavior change.

Neuroimaging Challenges and Opportunities in Health Communication

Like all tools, neuroimaging is not without its challenges. In addition to challenges health communication researchers may face related to the costs of neuroimaging and access to scanners, the inferences that neuroimaging approaches allow are not straightforward. Perhaps the most pernicious inference-related challenge in the field of neuroimaging is the difficulty with making reverse inferences. Standard, forward inferences from neuroimaging occur when the researchers ask the question “what part of the brain activates during a particular process”? Researchers design a task to trigger that process and analyze the obtained neuroimaging data to identify neural correlates of that process (Schmälzle & Meshi, 2020). Reverse inference, in contrast, infers the involvement of an unmeasured process from observed brain activation. The issue with this type of interpretation is that a brain region can be activated by many processes, not just the process the researcher is inferring is occurring (Poldrack, 2005). Increasingly, however, researchers are developing tools to aid in our inferences. For example, the Neurosynth database allows researchers to easily aggregate data from published neuroimaging papers in order to conduct meta-analyses of associations between terms used in the papers and activation. This allows for the creation of forward inference maps (i.e., what brain regions tend to be more activated by process X) and association maps of how likely it is that a particular psychological process was evoked, given observed patterns of brain activity. This type of neural “decoding” lends itself nicely to future integration with content analyses in health communication research, and other research examining where in the brain different processes unfold, how to explain health communication effects, and prospectively predicting future influence. In these ways, neuroimaging is one approach health communication researchers may use to capture the embodied nature of communication as a process occurring in, through, and to bodies and their associated wet wear (Cappella, 2020).

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