Chapter 4
Health Communications: Predicting Behavior Change from the Brain

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Introduction

Factors influencing people's health behaviors are multiple and complex. Both individual differences and environmental influences interact to influence behavior. Approaches to influencing health behaviors in the public sphere vary, ranging from physician advice to tax incentives. In addition, one prominent tool in the public health toolkit is the delivery of persuasive health messages via the mass media. Understanding how health communications influence behaviors has been a significant goal for researchers across a wide range of disciplines. In this chapter, we discuss how social neuroscience, and the emerging subfield of communication neuroscience, contribute to our understanding of the effects of health communications. We focus particularly on how neuroscience evidence pertaining to attitudes, persuasion, social influence, and behavior change can help bridge gaps in knowledge in ways that are not readily apparent through traditional methodological approaches. In addition, this chapter discusses future directions and methodological considerations that should be made when integrating neuroimaging methodology to aid in our understanding of health communications.

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P. A. Hall (ed.), *Social Neuroscience and Public Health*,
DOI: 10.1007/978-1-4614-6852-3_4,

Social Theories

Our understanding of the effects of health communications and social influence on health behavior is informed by a long history of research on persuasion (Petty and Cacioppo 1986), conformity and compliance (Asch 1955; Deutsch and Gerard 1955), and socialization (Glanz 2008). Major social theories of persuasive message processing have integrated many important advances from the past century, pointing to message, recipient, and communicator effects that moderate persuasive communications (Allport 1935; Hovland 1949; Lazarsfeld et al. 1948; Petty and Cacioppo 1986).

One difficulty in predicting health behavior change, however, is the uncertainty in knowing who will successfully traverse the gap between attitudes, intentions, and behavior. A number of mature theories including Health Belief Model (Becker 1974; Rosenstock 1974; Rosenstock et al. 1988), Health Action Process Approach (Lippke et al. 2004; Schwarzer 2008; Sniehotta et al. 2005), Theory of Reasoned Action (Ajzen and Fishbein 1980), Theory of Planned Behavior (Ajzen 1985), and Social Cognitive Theory (Bandura 1989, 2004) provide a framework for linking constructs such as attitudes, intentions, social norms, and self-efficacy to behavior change.

Despite considerable theoretical advancement in the past century, predicting attitude and behavior change in response to persuasive message exposure remains a difficult task (Armitage and Conner 2001). Our current understanding of behavior change relies heavily on self-reports (Araujo-Soares et al. 2009; Cowell, Farrelly et al. 2009; Hagger et al. 2002; Skar et al. 2008; Webb and Sheeran 2006), but self-reports of attitudes, intentions, personality characteristics, and predicted social influence do not fully predict future behavior change. A meta-analysis examining the relationship between behavior and intentions found that large changes in intentions only translate to small to medium changes in behavior (Webb and Sheeran 2006). Although self-report provides valuable information concerning behavior, there remains a large portion of variance unexplained. This may be a function of participants giving socially desirable answers (Booth-Kewley et al. 2007), unconscious influences (Wilson and Nisbett 1978), or a disconnect between responses given in a laboratory setting and the mental processes that take place in the real world (Glassman and Hadad 2006; Klesges et al. 1995).

Neuroimaging

Knowledge gained from neuroimaging may complement what we know from self-reports about how people process persuasive messages. In turn, gaining a firmer grasp on these underlying neural mechanisms can enable scientists to more accurately predict future behaviors. Imaging techniques, including functional magnetic resonance imaging (fMRI), functional near infrared spectroscopy (fNIRS), and electroencephalography (EEG) have given scientists the ability to observe neural responses to persuasive messages in real time, without imposing the concurrent cognitive task of asking participants to self-report on how they are processing messages

(Falk 2010). As such, these techniques may provide useful insight into the mechanisms involved in persuasion. They may also offer a promising addition to current methodologies used to predict behavior change in response to persuasive messages, such as health communications. However, it is important to note that although neuroimaging may provide unique insight into psychological processes, it has limitations (Poldrack 2006, 2008). Thus, neuroimaging is not a replacement for existing methodologies; we have the most to gain when multiple techniques are combined to understand behavior (Fig. 1) (Berkman and Falk 2013). A full review of brain regions and their function in social contexts is beyond the scope of this chapter. For those who are interested in a more comprehensive review of these topics, the following readings are suggested (Cabeza and Nyberg 2000; Lieberman 2010).

Attitudes

Attitudes are individuals' evaluations of ideas, people, or messages within their environment and are often related to behaviors (Zimbardo and Leippe 1991). A large body of literature has characterized neural correlates of attitudinal processes, including intergroup evaluations (Amodio et al. 2008) and motivational goals (Cunningham et al. 2008). Neuroimaging findings demonstrate the complex cognitive processes that contribute to attitude change and maintenance. For example, neural networks work together, integrating new and old information in order to make evaluations and generate attitudes (Cunningham et al. 2007). The Iterative Reprocessing (IR) Model captures the complex interplay of neural networks involved in evaluative processes and offers a framework for integrating our understanding of how implicit and explicit cues come together to arrive at attitudinal judgments (Cunningham et al. 2007). The development of such neurocognitive models may provide a more complete and accurate understanding of attitudes.

Changing one's attitude often starts with an initial struggle between old habits or views and new goals or information, which is likely to produce

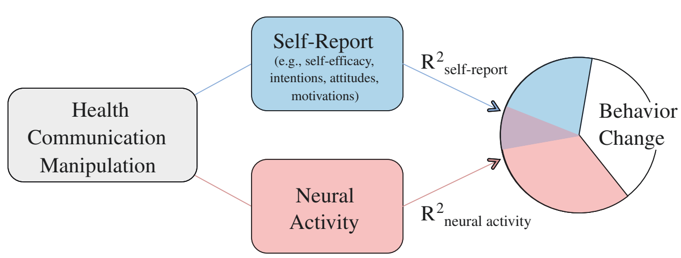

Fig. 1 Hypothetical model demonstrating the use of multiple methodologies to understand unique variance in behavior change in response to a health communication manipulation

dissonance. Dissonance refers to the anxiety produced from competing cognitions (Festinger 1957). Neuroimaging studies examining cognitive dissonance have found that increased activation of dorsal anterior cingulate cortex (dACC) and anterior insula (AI) are successfully associated with future attitude change (Jarcho et al. 2011; van Veen et al. 2009). These regions have been associated with conflict detection and negative affect, respectively (Carter and van Veen 2007; Lieberman et al. 2007). One interpretation of these data is that increases in negative affect resulting from competing cognitions may be an initial indicator of attitude change. If so, the information obtained from neural imaging techniques focused on activation in these brain regions may be useful in a variety of contexts, from initial message design to development of strategies to maintain healthy behaviors. For example, to the extent that the aversive state of cognitive dissonance is one key pathway to attitude change, health communication researchers may focus their efforts on refining the balance of this response and other factors within messages to maximally stimulate attitude change.

Indirect Effects

The research on dissonance described above, and the research that forms the basis for the IR model each contribute to our broader understanding of attitudinal processes, however, they do not speak directly to the core focus of this chapter (health-relevant media effects and the brain). Research on the power of messages to prime and influence individuals at the implicit level brings us a step closer. In examining non-deliberative media effects, Dal Cin and colleagues found that the more audience members identify with a smoking (vs. nonsmoking) version of the protagonist in a popular film, the stronger implicit associations between smoking and the self become (Dal Cin et al. 2007). This effect held true for both smokers and non-smokers, and extended to an increase in smokers' intentions to smoke (Dal Cin et al. 2007). These findings indicate that indirect health messages about smoking contained within mass media can relate to changes in individuals' self concept concerning smoking (Dal Cin et al. 2007).

Effects of mass media on implicit attitudes may also be a function of the media's role in shaping normative views. We engage in behaviors simply by being surrounded by the behavior of others (Bargh and Ferguson 2000). Watching someone else smoke at the bar can subconsciously entice a smoker to smoke more than usual (Conklin 2006). Additionally, getting caught up in the narrative of a character during a movie may have a similar effect (Dal Cin et al. 2007). Neuroscientists have found that when smokers watch scenes of smoking in a movie they show greater activity in the left anterior intraparietal sulcus and inferior frontal gyrus (IFG), regions associated with contralateral hand gestures (Wagner et al. 2011). One interpretation of these data is that environmental cues can serve as a trigger for habitual behaviors, such as smoking, in which we implicitly mirror the behaviors of others (Wagner et al.2011).

Persuasion

Although many effects studied by health communications researchers interested in mass media represent indirect media effects, there is a growing body of literature that examines neural processes underpinning persuasion and intended message effects. Neuroimaging research on persuasion has examined the differences in neurological activity associated with persuasive versus unpersuasive messages (Falk et al. 2009). Neural processes believed to be involved in mentalizing and perspective talking play a role in persuasive message processing (Falk et al. 2009). For example, activation of several key regions in the mentalizing system (Frith and Frith 2006), including the dorsal medial prefrontal cortex (DMPFC), posterior superior temporal sulcus (PSTS), temporal pole, and the left ventral lateral prefrontal cortex (VLPFC), are more active in response to messages that participants rate as persuasive, compared to those that they find unpersuasive (Falk et al. 2009).

However, understanding the differences in neurological activity between persuasive and unpersuasive messages is not the entire story. Differences in message presentation can alter this process. Messages can be specific to an individual by tailoring the message, or can be general, intended for mass viewing. Health communication studies in a number of domains show that tailored messages have a larger positive impact on behavior than untailored messages (Noar et al. 2007; Strecher 1999). Neuroimaging findings examining smoking cessation messages found that tailored messages involve brain regions associated with self-referential processing, specifically the rostral medial prefrontal cortex (MPFC), and precuneus/posterior cingulate (Chua et al. 2009). One possible interpretation of these findings is that self-referential processes are important to the success of smoking cessation messages (Chua et al. 2009). Authors suggest that self-referential processes allow smokers to personally evaluate their intentions and goals concerning quitting smoking (Chua et al. 2009).

Message source also contributes to the persuasion process (Petty and Cacioppo 1986). Effective persuasive messages have been tied to the expertise of the communicator (Petty and Cacioppo 1986). The effectiveness of expert source on persuasion depends on one's ability and motivation when processing a message (Petty and Cacioppo 1986); however, in general expert sources are more persuasive than non-expert sources (O'Keefe 2002; Petty and Wegener 1998). Neuroimaging studies have enhanced our understanding of messages delivered by an expert source compared to a source with low expertise (Klucharev et al. 2008). Expert influence was associated with increased left lateralized brain activity, medial temporal lobe, and caudate nucleus activity (Klucharev et al. 2008); these regions are believed to be involved in semantic elaboration, memory formation, and trusting behavior, respectively (Klucharev et al. 2008). Thus, these findings suggest that neural mechanisms associated with attention to expert sources may influence attitudes and memory in response to persuasive messages.

A study examining the "Message sensation value" (MSV) of public service announcements (PSAs) compared differences between PSAs with high versus low MSV, revealing that high MSV PSAs were associated with occipital cortex activity while low MSV PSAs were associated with increased prefrontal and temporal activation (Langleben et al. 2009). Behavioral findings show that low MSV PSAs also lead to a higher rate of recognition, suggesting that low MSV PSAs lead to higher cognitive processing (Langleben et al. 2009).

Neuroimaging research has contributed to understanding persuasion by examining differences in neurological activity for persuasive versus unpersuasive, different heuristic cues, and diverse cognitive factors that influence the outcomes of persuasion. However, current neuroimaging studies have yet to systematically manipulate cognitive resource availability, and hence have been unable to speak to: (1) whether central versus peripheral processing is supported by a common neural mechanism engaged to varying degrees or if these routes represent the result of distinct neural networks, and (2) whether neuroimaging provides differing degrees of predictive insight about the process of attitude change under conditions of high versus low cognitive resources. Answering these questions will improve our ability to predict future attitudes in response to persuasive messages, will uncover knowledge about concordance between brain and self-report, and will enhance our knowledge of persuasion more broadly.

Social Influence/Conformity

Beyond effects of expertise, individuals are also highly influenced by the attitudes and norms expressed by others. Neuroscience research suggests that social norms affect neural responses differently depending on the value assigned to stimuli by peers. Research examining the social value of wine found that as the ostensible price of a sample of the same wine increased, activity in a region involved in encoding pleasant experiences (medial orbital frontal cortex (OFC), ventral medial prefrontal cortex(VMPFC) also increased, despite the wines actually being identical (Plassmann et al. 2008). Additionally, a study examining participants' preferences of symbols peers rated as popular, unpopular, or unrated found that the MPFC was activated more when viewing socially tagged versus unrated symbols (Mason et al. 2009). Findings suggest that the MPFC plays a role in tracking socially relevant information (Mason et al. 2009). Furthermore, using transcranial magnetic stimulation (TMS) to disrupt posterior medial frontal cortex processing has been shown to reduce conformity by reducing conflict monitoring associated by having differing opinions to a normative group (Klucharev et al. 2011).

Further supporting the role of the brain's reward system (Fig. 2) in promoting conformity, neuroimaging studies examining how the opinion of others affects our own valuations found that ventral striatum (VS) activity increases both when our preferences align with others and when receiving a reward (Campbell-Meiklejohn et al. 2010). Additionally, it is found that when viewing stimuli peers rate higher versus lower than participants there is increased activity in the VS and OFC, brain regions associated with reward (Zaki et al. 2011). It is thought that the VS responds to violations in expected rewards, whereas the VMPFC has been implicated in the

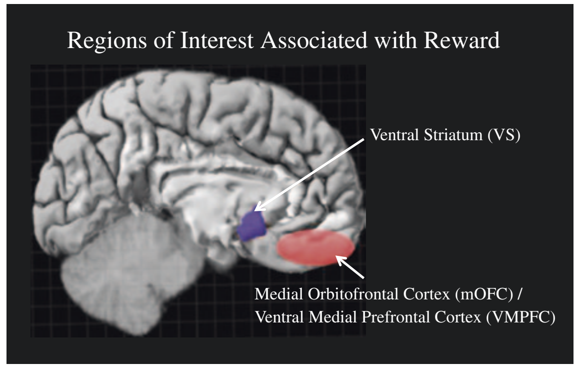

Fig. 2 Regions of interest associated with reward, consisting of the ventral striatum (VS) and medial orbitofrontal cortex (mOFC)/ ventral medial prefrontal cortex (VMPFC). Allen Brain Atlas Resources. Seattle (WA): Allen Institute for Brain Science. ©2009. Available from: http://www.brain-map.org

processing of the value of a reward (Berns et al. 2001; McClure et al. 2003; Schultz et al. 1997). Additionally, holding views that conflict with social norms has been found to (a) activate the rostral cingulate zone, a region involved in conflict or error monitoring of unfavorable outcomes (Klucharev et al. 2009), and (b) deactivate the VS, a key component of the brain's reward system (Klucharev et al. 2009).

Although persuasive messages can influence attitudes and behaviors, individuals have the ability to buffer their responses to persuasive message influences. When examining the effects of media influences on tobacco and alcohol use among adolescents, it is found that adolescents who score high on self-control measures are less influenced by media to use tobacco and alcohol than children who score low on self-control measures (Wills et al. 2010). Self-control reflects the ability to focus attention, delay gratification, and stick with a task until it is completed (Wills et al. 2010). Furthermore, brain regions associated with cognitive control, including VLPFC, DLPFC, MPFC, dACC, and precuneus may also aid in controlling affective responses, which may in turn reduce susceptibility to social influence (Lieberman 2010). Preliminary data examining the relationship between neural responses to exclusion and risky teen driving behavior in the presence of a peer suggests that increased activation of the social pain network (AI, subgenual ACC) in adolescents during social exclusion predicts risky driving behavior while in the presence of a peer in a separate session (Falk et al. Under Revision). However, response inhibition regions (right IFG, basal ganglia) appear to buffer social influence in some social contexts (Cascio In Prep).

Behavior Change

The neuroimaging studies reviewed above have demonstrated preliminary evidence for relationships between brain activity and social processes, including susceptibility to persuasion and social influence. Separate studies have examined the relationship between neural responses to health communication and the behavior change that follows. For example, work in this area has used neural signals in MPFC to predict changes in sunscreen use one week following exposure to persuasive messages concerning sun exposure (Falk et al. 2010). Neural signals in MPFC predicted an additional 23 % of the variability in behavior above and beyond what self-report measures, such as intentions and attitudes, explained alone (Falk et al. 2010). In addition, a whole brain search for additional regions associated with behavior change revealed significant associations with the precuneus, PSTS, temporal parietal junction, and temporal pole, areas implicated in considering the mental states of others (Falk et al. 2010). These results suggest that incorporating neural data with self-report measures may provide additional information to develop predictive models. These findings also extend the use of neuroimaging to predict other types of behavior, as opposed to simply predicting immediate effects (Berkman and Falk 2013).

Extending the findings in the sunscreen study, Falk and colleagues examined smokers' neural responses to antismoking ad campaigns and subsequent smoking behavior (Falk et al. 2011). Consistent with the findings of the sunscreen study, research examining neural responses to antismoking advertisements found that MPFC explained 20 % of the variance in exhaled CO (a biological proxy for recent tobacco smoking) one month after initial fMRI and self-report measures (Falk et al. 2011). Thus, activation of the MPFC may serve as an indirect marker of future behavior change (Falk et al. 2011). Indeed, activity in the same region of MPFC that predicted individual behavior change during message exposure predicted population level behavior in response to health messages, and provided information that was not conveyed by participants' self-reports (Falk et al. 2012). These results extend previous findings to a more complex behavior than increasing sunscreen use and are also of practical importance, given that antismoking ad campaigns are a popular and common method for promoting smoking cessation (Popham et al. 1993; Vallone et al. 2011).

An important question in understanding the relationship between health communications and health behavior change is: What is the most effective way to deliver a health message? Technology has provided the field of health communication with a platform to reach larger audiences and to tailor the experience toward individual needs. This is in contrast to traditional mass media techniques that target a more general audience. At the same time, social neuroscience has provided techniques for researchers to explore the differences in how individuals neurologically process general versus tailored smoking-cessation messages. This is important in understanding what makes a tailored message more effective than a general persuasive message (Chua et al. 2011). Recall that tailored messages activate neural regions that are also activated in self-related processing, including regions of DMPFC identified in a localizer task (Chua et al. 2011). These studies have laid a foundation for understanding the links between health communications and associated behaviors, however, substantial work remains to be done to determine the precise psychological functions of brain regions involved.

Maintaining Behavior Change

Predicting the long-term success of quitting unhealthy habits is important to health professionals. Brain responses may be able to identify these characteristics. Social neuroscientists interested in the link between smoking cravings and smoking behavior have found that neural regions associated with response inhibition, right IFG, pre-supplementary motor area, and basal ganglia, were associated with decreased link between smoking cravings and smoking behavior—in other words, people who showed more activity in cognitive control regions during a basic response inhibition task also did not give into their cravings as easily during a real-world quit attempt (Berkman et al. 2011). Researchers examining smoking cessation found that neural activity in response to emotional and smoking related pictures predicted the long-term success of smoking cessation (Versace et al. 2011). Using ERPs it was found that smokers with lowered brain activity to pleasant stimuli had less success in abstaining from smoking in the long-term (Versace et al. 2011). Neuroimaging studies examining the mechanisms that support successful quitting provide health professionals with insights into intervention strategies that promote health behavior change and maintain a healthy lifestyle which may not be readily apparent with other methodologies (Grusser et al. 2004; Hester and Garavan 2004; Ray et al. 2008).

Future Directions

Neuroimaging augments our understanding of neurocognitive processes that respond to persuasive health messages. This understanding can help to predict future health behavior change. Findings from neuroimaging studies have explained variance above and beyond what traditional self-report explains, consistent with the idea that factors outside an individual's conscious awareness play an important role in understanding the effects of health communication. Studies have characterized a variety of individual and contextual factors that affect neural processing of persuasive messages and subsequent behavior. However, several open questions remain.

Currently, very little is known about the conditions in which brain, self-report, and indirect measures predict similar versus different outcomes. Additional exploration of the role of implicit versus explicit processing as well as affective versus cognitive processing will help to more accurately understand neural processes involved in persuasion.

Second, given the consistent finding across studies that MPFC and VMPFC are associated with conformity and behavior change, additional investigation of the psychological function(s) of these regions within the persuasion context is warranted. The MPFC has been implicated in multiple studies indicating it may be associated with implicit preferences (McClure et al. 2004), self-relevant future goals and perspective taking (D'Argembeau et al. 2010), and rating of current stimuli in relation to an expected outcome (Knutson et al. 2001). Future work should isolate the implicated cognitive processes in order to further understand how the MPFC and VMPFC relate to persuasion and behavior change.

Third, health communications and health behavior change may affect individuals, groups, and populations differently with the influence of new media. For example, social neuroscientists examining new media, such as smartphones and social networking sites, may be interested in how neurocognitive processing of health communications are modified by technology. This is important as new media can change the way we are exposed to health communications, allowing for more efficient and effective communication.

Methodological Considerations

A complete review of neuroimaging methods and advances are beyond the scope of this chapter. Readers interested in different types of imaging methods, along with their strengths and weaknesses are referred to (Harmon-Jones and Beer 2009). However, across imaging modalities, several methodological considerations should be taken into account when planning future neuroimaging studies. One goal should be to increase sample size for studies that are concerned with between subjects differences (Lieberman and Cunningham 2009; Mumford and Nichols 2008). Having enough power is vital to detecting group differences, and many imaging studies are underpowered for this purpose (Desmond and Glover 2002).

Future studies can also benefit from the availability of new data analysis techniques. Building on past brain-mapping studies, *brain-as-predictor* approaches in which a priori ROI are targeted as predictors in statistical models (Berkman and Falk 2013) may improve our ability to predict behavior change and ultimately, to design and select optimally effective health messages. More sophisticated analysis techniques such as pattern classifiers can also be implemented. One such technique is multi-voxel pattern analysis (MVPA), which can examine differences in neural activation across brain regions as well as patterns within an ROI. MVPA may provide a sensitive method to detect neural network differences (Norman et al. 2006), which can be applied in a number of social and health-relevant domains. Detecting neural network differences allows researchers to differentiate different patterns within the same region, something that traditional univariate, general liner model-based fMRI analysis cannot achieve.

Finally, reverse inference problems make interpreting psychological processes from neuroimaging data difficult (Poldrack 2006). Reverse inference refers to the practice of inferring cognitive function based on activation of particular brain regions, which is different than measuring brain activity in response to cognitive tasks carried out in the scanner (Poldrack 2006). Using localizer scans–scans that define cognitive processes prior to the cognitive tasks of interest in order to pre-define regions of interest functionally can strengthen inferences (Lieberman 2010). TMS offers a way to disrupt neural processing during a neuroimaging task (e.g., during the time when certain persuasive messages are presented) (Hallett 2000), allowing researchers to examine if neural regions are necessary versus sufficient for cognitive processes of interest.

Conclusion

A growing body of research suggests that examining neural responses associated with processing health communications can aid in our understanding and prediction of attitude and behavior change. Pairing neuroimaging data with self-report, implicit, behavioral, and/or genetic measures ultimately will give scientists a more complete and potentially more efficient predictive model of behavior. Furthermore, neuroimaging can also inform psychological models of behavior change. In addition to health communications and health behavior change, this methodology may be of interest in the study of broader determinants of health including community violence, politics, education, and workplace dynamics.

Highlights

- Despite the success of prominent behavior change models in explaining the impact of health messages on behavior change, they are still limited. One difficulty in predicting health behavior change is the uncertainty in knowing who will successfully traverse the gap between attitudes, intentions, and behavior.
- Knowledge gained from neuroimaging may complement what we know from self-reports about how people process persuasive messages. In turn, gaining a firmer grasp on the underlying neural mechanisms involved can enable scientists to more accurately predict future behaviors.
- A growing body of research examining neural responses to health communications and other basic laboratory tasks has found that neural signals predict variability in behavior above and beyond what self-report measures explained alone.
- Neuroimaging is not a replacement for existing methodologies; we have the most to gain when multiple techniques are combined to understand behavior. This integration can be key in developing and strengthening theoretical knowledge and real-world applications.

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